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Alpine Medicinal and Aromatic Plants in the Western Himalaya, India: An Ecological Review

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Abstract: The Indian Himalayan region arbours rich array of Medicinal and Aromatic plants (MAPs) owing to its diverse topography and climatic conditions. However, under the contemporary changes in the Himalaya, *viz.,* excessive resource use, changing climate, increasing developmental and tourism activities, a little is known about the alpine vegetation response to these changes. Hence, there is a need to assess the availability, quality, sufficiency and directionality of past and ongoing research on MAPs of the alpine region of Western Himalaya). Over 300 research articles to consolidate the knowledge on population status, ethno-botany, biotechnology, anthropogenic pressure, information gaps and future scope for research we scrutinized. The results reveal that there are 350-400 MAPs reported from the alpine region of the Uttarakhand state of which *ca*.30-35 species are in high use and commercially traded. There are over 82 alpine meadows range in size from a few to 400 km^2, however, most of the studies (45%) are site-specific covering <8% of the total reported meadows. Modern technology based studies has dominance over field based studies having maximum 23% study on chemical extraction and secondary metabolite (biochemistry) followed by *in-vitro* cultivation (biotechnology-12.2%) and ethnobotany (9.4%). The abundance (individuals meter^{-2}) of 31 MAPs were assessed in a few meadows so far having only 1-2 individuals meter^{-2}. About 16 species have been attempted for *in-vitro* cultivation however, none of them has succeeded in producing seedling at large scale. Limited information on extent (geo-spatial distribution), habitat suitability, demand and supply ratio, climate change impact, lack of clear management and monitoring strategies for MAPs are identified as areas of immediate concern and future scope of research.

Keywords: Alpine, Medicinal plants, Population status, Diversity, Conservation

In the Indian Himalayan region (IHR), alpine ecosystems are important for economic growth and human well-being, as they provide numerous public goods and services *viz.,* fresh water, food, energy, and medicinal plants (Tewari et al 2017). Medicinal and aromatic plants (MAPs) have been utilized in various forms since the earliest days of humankind (Kandari et al 2012). Historically, collection of MAPs offered a mode of subsistence for the indigenous people of alpine region and presumably, such operations were occurring at low-impact levels. Subsequently, MAPs began to play a more important role in commercial income generation and employment in many ethnic groups and cultures of indigenous people (Runk 1998). This led to improvements in the economic status of the collectors, whereas, there is widespread over-exploitation of the MAP resources in the wild. Often the level of extraction increased exceeding sustainable levels, threatening the prospects of long-term revenue generation (Kala 2005). Currently in India, the pharmaceutical sector is using about 280 MAPs, of which 175 species are reported in the Indian Himalayan Region (Dhar et al 2000). Of the total plant species used, more than 90% are harvested from the wild, most of them are from the sub-alpine and alpine region of the Himalaya (Singh and Rawat 2011). The MAPs collected by the Ayurvedic physician from the high-altitude region constitute 35.7% of all the plant species of alpine and sub-alpine region of the Himalaya (Ratha et al 2012). In the Indian Himalayan region, Western Himalaya (WH) including Uttarakhand, Himachal Pradesh, and Jammu & Kashmir is rich in MAPs resources. Over 1123 species of MAPs are available in Kashmir Himalaya (Tali et al 2019), 964 species from Uttarakhand (Kala 2010) and 360 species from Himachal Pradesh (Badola 2001). In the WH, Jammu and Kashmir has richest MAPs diversity, where highest contribution by alpine region of the state. The alpine zone of the state is represented by about 24.11% (12900 km^2) of the total geographical area, of that 8524 km^2 area is under vegetation, rest is permanent snow area (Lal et al 1991). Medicinal plants of the alpine region of WH are facing various anthropogenic (*viz.,* over exploitation, grazing, trampling, construction of roads and unregulated tourism) and natural threats (*viz.,* low population growth, small population size, narrow distribution range, invasion by exotic species, climate change and genetic drifts) (Kala 1998, Kala 2000).

Ever increasing demands of MAPs in international market requires time-to-time assessment of existing information, status, and to assess possible challenges in demand and supply ratio. Documentation of knowledge helps in planning and re-orientation of the strategies for conservation and management of any area. Lack of data restricts resource managers and decision makers to take accurate evaluation for interventions for the biodiversity conservation (Proenca et al 2016). The information from the literature also facilitates comparison among and between different studies to understand landscape-level changes in distribution and population trends (Kandel et al 2016). The importance of secondary data must not be underestimated, as acquiring new data is costly and time consuming. Keeping all these points into consideration, the major objectives of the present review paper are: i) to assess the current state of knowledge on MAPs of the alpine region covering various disciplines, ii) to find out the major research and information gaps along with scope for future work.

MATERIAL AND METHODS

Study area: The study was conducted in the alpine region of Uttarakhand between 3000-5300 m asl (8524 km^2 area) (Fig. 1). Uttarakhand has an international border at its northern (Tibet Autonomous Region) and eastern (Nepal) extremities. In the northwest and west it meets with the mountains of Himachal Pradesh and with the plains of Uttar Pradesh in the south. It offers a range of climate and forest types from subtropical to alpine. The average rainfall varies considerably from 1800mm in mid hills to less than 500mm in the cold dry zone. The entire state is divided into thirteen administrative districts of which, six districts namely Pithoragarh, Bageshwar, Chamoli, Rudraprayag, Tehri and Uttarkashi represents alpine region. *The alpine region forms the uppermost catchment of the Himalayan rivers which support millions of people in the downstream. In the state of Uttarakhand, alpine region is separated by a distinct treeline where forests of Betula utilis- Rhododendron campanulatum (Birch- Rhododendron),* Abies spectabilis *(fir) and* Quercus semecarpifolia (Brown oak) terminate. *Based on altitude, aspect, moisture availability and duration of the growing season, six types of alpine meadows are recognised in WH* viz., *tall forbs, mixed herbaceous formations or short forbs, matted shrubs/shrubberies,* Danthonia *grasslands,* Kobresia sedge meadows and cushionoid vegetation (Rawat 2005). There are about 82 alpine meadows known to the state of Uttarakhand (Rawat 2005) having the most extensive and prominent meadows (in term of area) around basins of Nanda Devi, Panchachuli, Kedarnath, Gangotri and

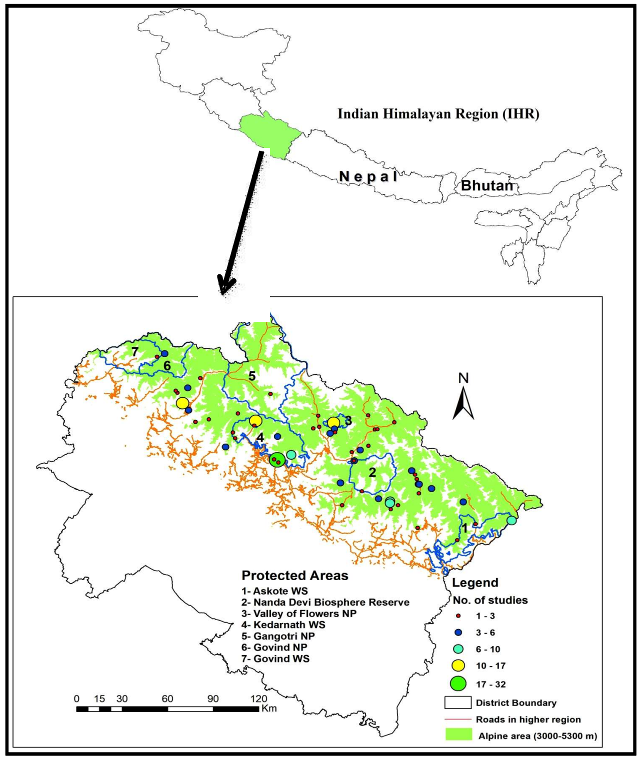

Fig. 1. Study area (3000-5300m) with distribution of publication

Bandarpoonch. These meadows range in size from a few to 400 km^2. The life of the local inhabitants in high altitudes is intimately associated with the alpine meadows as evident from a large number of folklores. A large number of migratory and local pastoral communities use these alpine pastures as summer grazing grounds.

Data collection and analysis: A systematic literature review was carried out to assess the MAPs of the alpine region of Uttarakhand. 'Science Direct, 'Google Scholar', and Research Gate web-based searches, using specific keywords 'Medicinal plant' independently and also combined with other terms *viz.,* alpine landscape, Himalaya, Western Himalaya, population, ethnobotany, biotechnology, biochemistry, diversity, threats etc. The information that did not appear with these search terms or were in the form of hard copies (*viz.,* books) collected from various libraries and personnel interact with the authors. A total of 300 peer-reviewed articles were used for analysis. Once all the information was collected, articles chronologically arranged in a Microsoft Excel sheet and analysed for the following sub-categories: study sites, publication year and disciple of the publications. The published information until 2018 was included for the review. To understand the past distribution (occurrence) of MAPs in the alpine region, various herbarium *viz.,* Wildlife Institute of India (WII), Botanical Survey of India (BSD), Forest Research Institute (DD), Kumaun University

(KU), Regional Ayurvedic Research Institute (RARI), Almora were also consulted.

RESULTS AND DISCUSSION

Medicinal plant studies and diversity: The availability of diverse medicinal plants in the Himalaya has been recorded in ancient Indian scripts as far back as 1000 BC. Strachey and Winterbottom (1846-49) were the two-army officers who first started systematic inventorisation of alpine plants including MAPs from the WH. Duthie (1906) revised and supplemented Strachey and Winterbottom's original catalogue, known as 'Catalogue of the plants of Kumaun and the adjacent portion of Garhwal and Tibet'. Smythe (1938) surveyed the Valley of Flowers and adjacent areas including MAPs. Intensive studies on MAPs of alpine region were undertaken by Gupta (1955, 1957, and 1962) in the Bhilangana valley and described the MAPs from subtropical forests to alpine meadows. There were very few publications on MAPs from alpine region of WH until 1960. During the late 20^{th} century and beginning of the 21^{st} century, there was an exponential increase in the number of studies. About 70-75% of the total studies carried out between 2001 to 2018 (Fig. 2).

There are 1350-1400 plant species (80% of total alpine flora of WH) reported from the alpine region (3000-5300 m) of Uttarakhand, of which 350-400 species are expected to have medicinal properties (Rawat 2005), of which 90% are herbaceous followed by shrub (5%) and tree (5%) species. Herbarium consultation reveals that, first alpine medical plant (*Aconitum heterophyllum*) was collected by Raizada (1903) from the alpine region of Bandarpoonch in Uttarkashi district and deposited in the Forest Research Institute, Dehradun herbaria. In the past, inaccessibility to the alpine region had made most of the studies site-specific (Sinha 1954, Rao 1960, Singh and Kumar 1978, Singh 2008) covering only one or a couple of meadows of the area/valley. These studies mainly focused on the listing of MAPs from the alpine meadows. Of the reported MAPs, 14 species namely *Aconitum balfourii, A. heterophyllum, A. leave, Allium stracheyi, Nardostachys jatamansi*, *Angelica archangelica, A. glauca, Meconopsis aculeata, Rheum australe, Rhodiola heterodonta, Rhododendron anthopogon, R. campanulatum, Saussurea gossypiphora* and *S. obvallata* are under different threat categories at global level (IUCN). Whereas, about 27 species are also categorised under various threat categories at regional level (Ved et al 2003).

Population status of alpine MAPs: Studies on MAPs abundance in the alpine region started after the year 2000 and most of them were species-specific and site-specific. The population status of only 50 species has been assessed across meadows including two landscape level studies. Highly studied top ten species in maximum meadows/areas are *Angelica glauca* (21 meadows), *Picrorhiza kurroa* (12), *Dactylorhiza hatagirea* (11), *Aconitum heterophyllum* and *Malaxis muscifera* (10 each), *Fritillaria roylei* and *Rheum australe* (9 each), *Aconitum ferox* (8), *Arnebia benthamii* and *Aconitum balfourii* (7 meadows each). Rest of the species are studied in less than 7 meadows for population estimation (Bisht et al 2010, Bhatt et al 2014). The studied species showed patchy distribution with average density range between 0.1-3 individuals m-^{2}. Other than *Nardostachys jatamansi,* which had shown exceptionally high density (17.5 individuals m^{-2}) in Pindari area (Airi et al 2000), five MAPs with highest population density are *Malaxis acuminata* (8 individuals m^{-2}) from Dronagiri area, *Aconitum violaceum* (7.8) in Panwali Kantha, *Podophyllum hexandrum* (4.8) around Tungnath, *D. hatagirea* (4.7) in Ralam valley and *P. kurroa* (3.7) in Laspa/Poting area (Table 1). It is observed that, studies conducted before the standardisation of medicinal plant population estimation technique (Rawat et al 2004), authors have reported higher density of MAPs, indicating the sampling bias on laying plots only on the available populations of the species. At the landscape level, 14 woody and 36 herbaceous MAPs assessed in over 80 alpine meadows of WH (Rawat 2005). Similarly, population status and geospatial extent of 50 high altitude MAPs have estimated in 15 forest divisions of Garhwal Himalaya (Rawat et al 2012). In the state, elevation zone between 3000 and 4500 m provides the most suitable habitats for MAPS and has a rapid declining trend above 4500m elevation. There are < 5% MAPs are reported above 4500m reflects the snowy, severe climatic conditions and the shorter growing period for medicinal plants.

Ethno botanical status and socioeconomic changes of alpine MAPs: In the state of Uttarakhand, Jaunsari (Koltas), Garhwali and Kumauni (Khash), Bhotiya (Jadhas, Marcha, Tolchas and Saukas) and Raji are the major ethnic group and

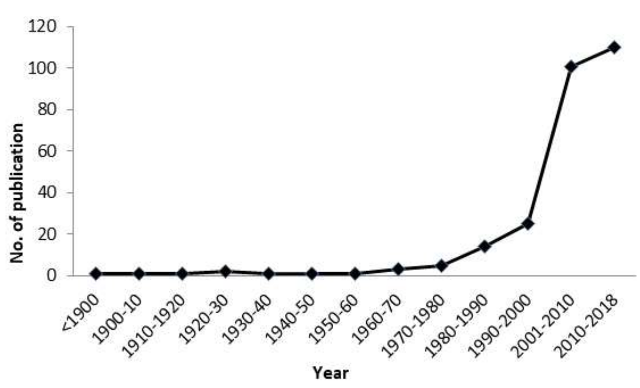

Fig. 2. Temporal pattern of publications on MAPs of alpine region of Uttarakhand, WH

sub-groups (Jakhmola 2018) directly dependent on the subalpine and alpine MAPs resources. These communities possess traditional knowledge of medicinal plants (Rawat and Pangtey 1983, Nautiyal et al 2003, Rawat 2005). Dollard (1840) documented the traditional knowledge on MAPs from Kumaun region. However, detailed investigation dealing with Indian ethnobotany was done only in 1990s (Jain 1981). Overall, 156 species of ethnobotanical uses are enumerated

Table 1. MAPs studied across alpine meadows and available density in Uttarakhand, WH

MAPs name	Studied meadows (total)	Density range: lowest to highest (individuals m^{-2})	Key references
Aconitum balfourii	7, 17, 21, 29, 37, 47, 48 (7)	Har ki Doon (0.8)-Dayara (2.4)	Nautiyal et al. (2002)
A. ferox	11, 17, 27, 29, 33, 34, 37, 39 (8)	Laspa (0.6)-Madhmaheshwar (1.3)	Bhatt et al. (2014)
A. heterophyllum	11, 17, 21, 27, 29, 33, 34, 37, 39, 47 (10)	Phurkia (0.7)-Tungnath (2.6)	Bhatt et al. (2014), Nautiyal et al. (2002)
A. violaceum	*8, 18, 21, #26, 37 (5)	Devikund (0.2)-Panwali Kantha (7.8)	Nautiyal et al. (2002), *Sekar and Rawat (2011), #Rawat (2005)
Aconogonum tortuosum	23 (1)	Kuti (0.1)	Rawat (2005)
Allium wallichii	26, 33, 41 (3)	Kyarki (0.01)-Ralam (0.3)	Rawat (2005)
Angelica glauca	5, 13, 38, 43, 28, *46, *39, #11, #27, #33, #34, #39, #45, @2, @7, @21, @47, @25, @37, @44, @48 (21)	Lata Kharak (0.2)- Valley of Flowers (1.5)	Kandari et al. (2011), *Bisht et al. (2010), #Arya et al. (2015), @Vashistha et al. (2006)
Arnebia benthami	5, 13, 28, 38, 43 (5)	Lata Kharak (0.2)- Garpak (1)	Kandari et al. (2011)
Bergenia strecheyi	40, *16, #47 (3)	Gori valley (1.1)- Tungnath (3.2)	Chowdhary et al.(2012), *Uniyal et al. (2000), #Semwal et al. (2007)
Carum carvi	23, 33 (2)	Kuti (0.3)-Martoli (0.1)	Rawat (2005)
Chaerophyllum villosum	27 (1)	Laspa (0.4)	Rawat (2005)
Corydalis govaniana	24, 26, 33 (3)	Martoli (0.01)- Khatling (0.05)	Rawat (2005)
Dactylorhiza hatagirea	9, 21, 28, 35, 40, 48, *15, *33, *36, @41, #47 (11)	Panchachuli (0.02)- Ralam (4.7)	Bhatt et al. (2005), *Rawat (2005), @Uniyal et al. (2002), #Semwal et al. (2007)
Fritillaria roylei	7, 10, 21, 25, 44, 47, 48, *19, *26 (9)	Kyarki (0.1)- Kedarnath (4.2)	Chauhan et al.(2011), *Rawat (2005)
Habernaria intermedia	6, 14, 29, 42, 44 (5)	Chopta (1.2)- Rudranath (1.5)	Chauhan et al. (2007)
Iris kumaonensis	19, 24, 26, 41 (4)	Khatling (0.5)-Ralam (3.7)	Rawat (2005)
Malaxis muscifera	1, 6, 7, 10, 25, 29, 30, 37, 44, 47 (10)	Chopta (0.6)- Dronagiri (8)	Chauhan et al.(2008)
Meconopsis aculeata	8 (1)	Devi Kund (0.3)	Sekar and Rawat (2011)
Nardostachys jatamansi	20, 40, 46 (3)	Kafni (10.5)-Pindari (17.5)	Airi et al. (2000)
Paeonia emodi	31, 39 (2)	Maliyadhaura (1.60)- Phurkia (2.4)	Rawal et al. (2014)
Parnassia nubicola	15, 19, 26, 33, 36 (5)	Panchachuli (0.2)- Kyarki (0.8)	Rawat (2005)
Picrorhiza kurrooa	3, 4, 12, 27, 33, 34, 45, *15, *26, *41, #47, @8 (12)	Ralam (0.3)- Laspa (3.7)	Arya et al. (2013), *Rawat (2005), #Semwal et al. (2007), @Sekar and Rawat (2011)
Pleurospermum angelicoides	5, 13, 28, 38, 43 (5)	Lata Kharak (0.3)- Garpak (0.6)	Kandari et al. (2011)
Polygonatum verticillatum	7, 47, *15, *24, *33, (5)	Khatling (0.1)-Tungnath (2.8)	Bhatt et al. (2014), *Rawat (2005)
Polygonatum cirrhifolium	7, 47 (2)	Tungnath (1.7)- Dayara (2.3)	Bhatt et al. (2014)
Podophyllum hexandrum	36, 15, *47 (3)	Gidara (0.3)-Tungnath (4.8)	Rawat (2005), *Semwal et al. (2007)
Rheum australe	5, 13, 28, 38, 43, *41, #36(7)	Panchachuli (0.1)-Chipkon (0.8)	Kandari et al. (2011), *Uniyal et al. (2000), #Rawat (2005)
R. moorcroftianum	23, 33, *41 (2)	Kuti (0.01)- Martoli (0.05),	Rawat (2005), *Uniyal et al. (2000)
R. webbianum	8 (1)	Devikund (1.2)	Sekar and Rawat (2011)
Swertia chirayita	15, 23, 24, 26, 33, 36, 41, *47 (8)	Kuti (0.04)-Khatling (2.4)	Rawat (2005), *Semwal et al. (2007)
Trillidium govanianum	22, 33, 47 (3)	Martoli (1.5)-Tungnath (3.9)	Chauhan et al. (2017)

1=Baniya Kund, 2=Bharnala, 3=Bilju, 4=Burfu, 5=Chipkon, 6=Chopta, 7=Dayara, 8=Devi Kund, 9=Donidhar, 10=Dronagiri, 11=Dwali, 12=Ganghar, 13=Garpak, 14=Ghimtoli, 15=Gidara, 16=Gori valley, 17=Har ki Doon, 18=Hemkund, 19=Jeolinkong, 20=Kafani, 21=Kedarnath, 22=Khaliya top, 23=Kuti, 24=Khatling, 25=Kunwari Pass, 26=Kyarki, 27=Laspa, 28=Lata Kharak, 29=Madhmaheshwar, 30=Maggu, 31=Maliyadhura, 32=Mandani, 33=Martoli, 34=Milam, 35=Nagtal, 36=Panchachuli, 37=Panwali Kantha, 38=Phagti, 39=Phurkia, 40= Pindari, 41=Ralam, 42=Rambara, 43=Rishikund, 44=Rudranath, 45=Sumdum, 46=Sunderdhunga, 47=Tunganth, 48=Valley of Flowers.

from the alpine region of Uttarakhand (Rawat 2005). Asteraceae and Polygonaceae occupies the highest number of medicinal plant species (14 species each), followed by Ranunculaceae (11 species), Apiaceae and Lamiaceae (10 species each), Rosaceae and Liliaceae (6 species each). Various parts of these plants are used in preparation of herbal formulations *viz.,* fruits, bark, leaves, roots, flowers, seeds, stem etc. The underground plant parts (root, rhizome, bulb and tuber) are used alone in the majority of cases (53 species), followed by leaf (33 species). The local communities use the whole plant of 41 alpine MAPs inhabiting in alpine region of Uttarakhand. These plant species are used in curing about 95 ailments, of which the highest number of plant species alone used in healing cut and wounds and tonic/appetizer (16 each) followed by cold and cough (13 species), skin ailments (12 species), fever (10 species) and rheumatism (8 species). Generally, most of the plant species are used to cure more than one ailment. Ethno-medicine plays a significant role in curing of various ailments in remote rural areas of the Himalaya, where there is limited access by road and medical facilities. However, only 27 studies are conducted on ethnobotany covering various ethnic groups of the region (Table 2). Of which, 50% of the studies are conducted in and around of Nanda Devi Biosphere Reserve (NDBR) (Nautiyal et al 2001, Nautiyal et al 2003, Rana et al 2013) and in the Pithoragarh district (Rawat and Pangtey 1983, Negi et al 2017, Pandey et al 2017). Among the notable ethnobotanical studies in the

Table 2. Ethno botanical studies conducted in the alpine region of Uttarakhand, WH

Study area	Purpose of work	Species enumerated	References
Alpine region of Kumaun	Ethnobotany	148	Rawat and Pangtey (1983)
Byas valley	Traditional knowledge	53	Negi et al 2017
Dhauli ganga area	Ethnobotany	50	Kandari et al 2012
Madhmaheshwar	Traditional knowledge	152	Bhat et al 2013
Gori valley	Ethnobotany	28	Jalal and Kumar (2006)
Devikund	Ethnobotany	62	Sekhar and Rawat (2011)
Sunderdunga	Ethnobotany	76	Rawat et al (2013)
Johar valley	Ethnobotany	22	Pandey et al (2017)
Tungnath-Chopta	Ethnobotany	71	Ratha et al (2017)
Niti valley	Ethnobotany	86	Phondani et al (2010)
Pindari area	Ethnobotany	242	Rawal and Rawat (2012)
Uttarakhand	Ethnobotany -orchids	12	Jalal et al (2008)
Buffer zone of Nanda Devi Biosphere Reserve , (17 villages)	Ethnobotany	21	Dangwal et al (2011)
17 villages of NDBR& 7 villages in Pithoragarh and Bageshwar districts	Ethnobotany	173	Nautiyal et al (2003)
Rishi ganga catchment (NDBR)	Ethnobotany	100	Nautiyal et al (2001)
Chamoli ,high altitude village	Ethnobotany	160	Rana et al (2013b)
Buffer zone of NDBR (47 village 34 in Chamoli, 10 Pithoragarh, 3 Bageshwar)	Ethnobotany	90	Rana et al (2013a)
In some parts of NDBR	Ethnobotany	41	Tewari et al (2010)
Seven villages of Niti valley	Ethnobotany	38	Kumar et al (2015b)
Entire Buffer Zone of NDBR	Ethnobotany	101	Silori and Badola 1999
Five villages of Pithoragarh District	Socio-economic	12	Silori and Badola 2000
Rawain valley	Traditional healthcare practices	63	Negi et al (2011)
Bagori and Berpur villages in Uttarkashi District	Ethnobotany	39	Balodi et al (2018)
In parts of Uttarakhand	Indigenous uses	18	Kala et al (2004)
Kedarnath wildlife sanctuary	Ethnobotany	126	Singh and Rawat (2011)
Entire alpine and sub-alpine region	Ethnobotany	139	Singh and Dixit (2017)
Tons valley	Ethnobotany	32	Jain and Saklani (1991)

alpine region of WH, include enumeration of 148 plant species from Kumaun, used by various ethnic groups *viz.,* Jadhas, Marcha, Tolchas and Saukasto cure various ailments (Rawat and Pangtey 1987). Similarly, 173 species recorded from in and around of NDBR (Nautiyal et al 2001), 126 ethnobotanical species from Kedarnath Wildlife Sanctuary (Singh and Rawat 2011) and recently about 139 species of ethnobotanical importance from alpine and subalpine region of Uttarakhand (Singh and Dixit 2017).

Bio-phytochemical analysis of alpine MAPs: A total, 29 alpine MAPs have studied covering various bio-phytochemical aspects, which comprises 23% studies of alpine region (Table 5). Aconites (*A. balfouri, A. ferox, A. heterophyllum* and *A. violaceum*) is the highly studied group for enzyme characterization (Kuniyal et al 2001), secondary metabolites (Rawat et al 2013) and alkaloids (Pandey et al 2008). Essential oil composition/profiling of various alpine MAPs is done *viz.,Selinum vaginatum* (Chauhan et al 2014), *Valeriana jatamansi* (Bhatt et al 2012), *Acorus calamus* (Raina et al 2003), *Saussurea lappa* (Negi et al2013), *Picrorhiza kurroa* (Bahuguna et al 2012), *Moringa longifolia* (Chauhan et al 2011), *Angelica archeangelica* (Chauhan et al 2016), *A. glauca* (Purohit et al 2015) and *Juniperus communis* (Lohani et al 2010) from the state. *Podophyllum hexandrum, Saussurea obvallata* and *Valeriana jatamansi* are the highly studies alpine MAPs for various bio-phytochemical analysis.

Anthropogenic pressure on alpine MAPs: Grazing by livestock (nomadic and local), exploitation of MAPs and developmental activities (eg., road construction) are the important biotic factors which alters the vegetation composition and phytomass of alpine region of western Himalaya. The history of livestock grazing (sheep/goats) in alpine region of western Himalaya dates back to a few centauries (Kala and Rawat 1999). However, grazing by buffaloes, cattle and horses/mules is a recent practice. There are over 1.57 lakh sheep/goats and 7.95 thousands buffaloes, cattle and horses graze in alpine pasture of the state (Rawat 2005). However, in the recent time, the number of horses/mules has increased many folds in the tourism-

Table 3. Various biotechnological studies on alpine MAPs of Uttarakhand, WH

MAPs	Disciplines	References
Aconitum balfouri	In-vitro propagation	Rawat et al (1992), Kuniyal et al (1998), Pandey et al (2004), Bisht et al (2011), Sharma et al (2012)
A. heterophyllum	Somatic embryogenesis	Giri et al (1993)
A. violaceum	In- vitropropagation	Rawat et al (2013)
Angelica glauca	Vegetative propagation	Bisht et al (2006,2008), Vashista et al(2009)
	Somatic embryogenesis	Bisht et al 2015
Arnebia benthami	In- vitropropagation	Majkhola and Dhar (2002)
A. euchroma	Organogenesis, embryogenesis	Majkhola et al (2005)
Dactylorhiza hatagirea	In vitro propagation	Giri and Tamta(2012)
	Organogenesis plantlets, somatic embryo	Lata and Nautiyal (1999)
Fritillaria roylei	In- vitro bulblet regeneration	Joshi et al (2007)
Habenaria edgeworthii	In vitro propagation	Giri et al (2012)
Lilium polyphyllum	Propagation	Dhyani et al (2014)
Nardostachys jatamansi	Shoot, bud regeneration	Mathur (1992)
	Callus, somatic embryos, plantlets	Mathur (1993)
Podophyllum hexandrum	Mass propagation	Nadeem et al (1997), Nadeem et al 2000
	Organogenesis plantlets, somatic embryo	Lata and Nautiyal (1999)
Picrorhiza kurroa	Root culture	Mishra et al (2011)
	Propagation	Chandra et al (2006)
	Cryopreservation	Sharma and Sharma (2003)
	Regeneration	Nanda and Anuja (1996)
	Tissue culture	Rawat et al (2013)
Saussurea obvallata	In- vitropropagation	Joshi and Dhar (2003)
Selinum wallichianum	In- vitro propagation	Pandey et al (2010)
Swertia chirayta	Micro-propagation	Balaraju et al (2009)

dominated valleys. The loss of biomass due to grazing livestock is 22 to 26% in various habitats *viz.,* camping sites, undulating mass and steep slopes and trampling shows reduction rate by 10%. There are several studies conducted on effects of livestock grazing on alpine structure and composition (Ram et al 1989, Apollo et al 2018) diversity and biomass (Rawat and Uniyal 1993, Sundriyal 1995). However, there are only seven studies focusing the impact of grazing on alpine MAPs (Table 4). Most of them (4) are in the fringes of Kedarnath Wildlife Sanctuary covering Tungnath and Rudranth meadows (Nautiyal et al 2004, Sundariyal and Joshi 1990). The demand of alpine MAPs of Uttarakhand is quite high and many of these plants grow only in the Himalayan states. About 15 alpine MAPs growing in the state are traded in high volume (>100 metric tones per year (Ved and Goraya 2008). *Aconitum heterophyllum, A. ferox, Bergenia ciliata, Ephedra gerardiana, Juniperus communis,Jurinea dolomiaea*, *Nardostachyus jatamansi*, *Arnebia benthamii*, *Parmelia perlata, Picrorhiza kurroa*, *Rheum australe*, *Rhododendron anhopogon, Viola* spp., *Swertia chirayita* and *Taxus wallichiana* are some of the important MAPs in high volume trade (Kala 2015). Although, under the biological diversity act (2002), the collection of five alpine MAPs *viz., Aconitum heterophyllum, A. ferox, A. violaceum* and *N. grandiflora* is banned in the state, however the illegal collection of these species is continued and declining their population in the wild. Non-sustainable method of collection also posed serious threats to these species. Excessive uprooting of the underground part of *A. glauca, A. heterophyllum, P. kurroa* and *P. hexandrum* has eclipsed their life support system has resulted population loss in several meadows (Badola and Aitken 2003). Recent, development/widening of roads in the alpine region (Pithoragarh, Chamoli and Uttarkashi districts) has increased the threats on habitats of alpine MAPs. Scanty information exists on the impact of anthropogenic pressure on MAPs of alpine region.

Propagation of alpine MAPs using tissue culture techniques: Advancement in plant tissue culture provides new means for conservation and propagating the valuable, rare and endangered medicinal plants. Plant tissue culture promises an efficient and reliable production system for phytochemicals as well as plants as a whole (Davies and Deroles 2014). In the alpine region of WH, most of the biotechnological studies are conducted only after the year 2000 (Table 3). Till now covers 12.2% of total studied conducted in the region. Several protocols are developed for propagation of alpine MAPs through tissue culture; however, the propagation of these species at the commercial level is meagre. *Aconitum balfourii* is perhaps the pioneer alpine MAP propagated through tubers using the biotechnological techniques (Rawat et al 1992). Subsequently, somatic embryogenesis was done from a callus in *Nardostachys jatamansi* (Mathur 1992) and *Aconitum heterophyllum* from callus culture (Giri et al 1993). The notable work was also done by Pandey et al (2004), Manjkhola and Dhar (2002), Joshi and Dhar (2003) on in vitro propagation of various alpine MAPs. Out of the total MAPs, only 20 species have attempted using tissue culture technique, whereas *Picrorhiza kurroa* is the widely studied species by several workers. There are limited studies on the vegetative propagation of Himalayan alpine MAPs, only *Picrorhiza kurroa*, *Aconitum balfourii, Heracleum candicans*, *Angelica archangelica* are vegetatively propagated for commercial means. At places, local communities successfully cultivate some MAPs (*Allium humile*, *Angelica glauca, Rheum australe*) in their fields in the high-altitude villages of Uttarakhand.

Management strategies for alpine MAPs: Protected areas (PAs) are an *in-situ* opportunity to conserve representative ecosystems and to focus on the sustainable management of MAPs and threatened species. There are four national parks (Valley of Flower, Nanda Devi, Gangotri and Govind), three Wildlife Sanctuaries (Askote, Kedarnath and Govind) and

Table 4. Various anthropogenic studies conducted on alpine MAPs of Uttarakhand, WH

Study area	Area of work	Species enumerated	References
Tungnath	Livestock grazing	29 (3grass, 2 sedge & 24 forbs)	Nautiyal et al. (2004)
Khiron valley	Livestock grazing	21	Kala and Rawat (1999)
Western Himalaya	Livestock grazing	198(Sub-alpine), 175 (Lower alpine) 140 Higher alpine GHNP. 209(Sub-alpine), 194 (Lower alpine) 153 Higher alpine VOFNP	Kala et al.(2002)
NDBR, Buffer Zone	Anthropogenic pressure	35	Silori (2001)
Tungnath	Grazing	25 (4 Grass, 21 forbs)	Sundariyal and Joshi (1990)
Rudranath	Anthropogenic pressure	41 (3 grass, 3 sedge, 35 forbs)	Bisht and Bhatt 2011
Tungnath	Anthropogenic pressure	10 MAPs	Chauhan (2014)

Table 5. Biochemical study conducted across alpine region of Uttarakhand

Species	Work accomplished	References
Aconitum atrox	Emzyme characterization	Kuniyal et al (2011)
	Biochemical variation	Kuniyal et al (2002)
A. balfourii	Aconite alkaloid	Pandey et al 2008
	Thidiazuron-induced induced variation	Gondwal et al
A.violaceum	GA syanthesis	Chandra et al2003
	secondary metabolite analysis	Rawat et al2013
A.heterophyllum	Auxin effect on rooting	Nautiyal and Dhyani (1994)
	Aconite alkaloid	Pandey et al2008
Selinum vaginatum	Essential oil composition	Chauhan et al
Podophyllum hexandrum	Seed biochemistry	Lata et al 1996
	Podophyllotin content (altitude wise)	Nadeem et al 2007
	Chemical composition in leaf, stem	Pandey et al 2003
	Podophyllotin content	Pandey et al 2007
	Variation in podophylloresin and Podophyllotoxin conten	Purohit et al 1999
	GA3 induced flowering	PAndey et al 2001
	podophyllotoxin content in rhizome and root	PAndey et al 2015
Polygonum	Biochemical attributes	Prakash et al 2001
Valeriana jatamansi	Essential oil composition	RAina and Negi 2015
	Essential oil composition	Bhatt et al 2012
	Quantification of valeric acid	Singh et al 2006
	Molecular characterization	Pant et al 2009
Acorus calamus	Phenolic content	Bahukhandi et al 2013
	Essential oil composition	Raina et al 2003
	Antioxidant properties	Bahukhandi et al 2010
Saussurea lappa	Methanol extraction	Negi et al 2013
Picrorhiza kurroa	Variation in picrotin and picrotoxin content	Bohra et al 2015
	Chemical content	Bahuguna et al 2012
Allium waliichi	Pharmacognostic	Tewari et al 2014
A. stracheyi	extraction of genomic DNA	RAnjan et al 2010
Tanecetum longifoloum	Volatile Composition	Chauhan et al 2016
	Antifungal activity	Joshi 2013
Fritillaria roylei	biochemical variability	Chauhan et al2011
	Germplasm	
	Chemical constituent	Bisht et al 2003
Morina longifolia	Essential oil composition	Chauhan et al 2011
Dactylorhiza hatagirea	Morphobiochemical Variability	Chauhan et al 2014
Saussurea obvallata	Genetic variation	Semwal 2014
	Nutrient analysis	Semwal et al 2013
	Antibacterial potential	Mishra et al 2017
	Phytochemical extraction	Semwal et al 2014
Satyrium nepalense	Chemical profile	Mishra et al 2018
Angelica archangelica	Variation in the essential oil composition	Chauhan et al 2016
	Chemical stimulation of seed germination	Vashista et al 2009

Cont...

Table 5. Biochemical study conducted across alpine region of Uttarakhand

Species	Work accomplished	References
A. glauca	essential oil composition	Purohit et al 2015
	essential oil profiling	Rawat et al 2018
	Chemical constituent	Khetwal et al 2004
Betula utilis	Chemical profiling	Pal et al 2015
Hippophae salicifolia	Antibacterial activity	Gupta et al 2011
Hyssopus officinalis	Composition of the Volatiles	Mohan et al 2012
Juniperus communis	Essential oil composition	Lohani et al 2010
Rheum emodi	Quantification of Mineral Elements	Singh et al 2010
	Seed effect	Badoni et al 2009
	Quantification of Antioxidant potential	Rajkumar et al 2011
Saussurea costus	Effect of chemical on growth	Chaturvedi et al 2009
Selinum tenuifolium	Chemical Accession	Chauhan et al 2017
Nardostachys jatamansi	Chemical constituent	Purohit et al 2015
	Chemical variability in population	Chauhan et al 2011

one Biosphere reserve (Nanda Devi) covering entire and partial alpine area of the state. Except Valley of Flowers National park, most of them are mandated to conserve faunal diversity. However, there are seven medicinal plants conservation area (MPCA) designated by State Medicinal Plant Board (SMPB) across the state having 250 hectares area in each. Two MPCAs namely, Kandara and Khalia top situated around 3500m elevation for *in-situ* conservation and promotion of alpine MAPs, although, there management plan is lacking. The State Government has the policy to promote the cultivation of MAPs through Herbal Research Development Organisation (HRDI), with an aim that increased cultivation will reduce the demand for the material collected from the wild (Jain and Rao 2015). However, there is hardly any correlation between collection and cultivation. Even if a large number of farmers adopt cultivation, collection from the wild is likely to continue. Therefore, it is advised to promote more *in-situ* conservation and sustainable utilization of MAPs from the alpine region (Rawat 2005). A comprehensive database of MAPs needs to establish at the State Medicinal Plant Board (SMPB) and Forest headquarter for further research, monitoring and identification of future MPCAs. *In-situ* conservation will be the best approach for the conservation of medicinal plants in their natural habitats by setting up medicinal plants Conservation & Development Areas (MPCDAs), as well as strengthening of existing Medicinal Plants Conservation Areas (MPCAs) through survey inventory, documentation, protection and mainstreaming medicinal plants in habitat management approaches.

Information gap and scope for future research: The majority of studies on alpine MAPs focused on biochemistry (23%), followed by biotechnology (12.2%), ethnobotany (9.35%), population and distribution (8.27%), anthropogenic pressure (~3%) and Climate change (~2.4%) (Fig. 3). Most of them are conducted after year 2000, and are restricted to lab based and confined to the chemical extraction and micro-propagation of MAPs. For such studies, researcher visits easily accessible sites (*eg.,* Tungnath, Pindari) to get the plant material/sample**.** There are more than 82 alpine meadows reported from Uttarakhand state (Rawat 2005) however, large number of studies (45%) are confined to only 10 meadows (Fig. 4).

Based in the regress review following information gaps have shorted for future work:

(I) Lack of information on extent of MAPs: Much of research on high altitude MAPs so far focused on the listing of species from various meadows. Only a few species (<31 species) have studied for status assessment, distribution patterns, analyse economic implications of elite identification (in terms of producing biomass and availability of secondary metabolites), *in vitro* propagation, mass propagation through conventional (vegetative and seeds) methods, development of agro techniques and understanding reproductive biology. However, there are limited landscape level studies on the status of MAPs to draw a conclusive strategy for the management and conservation in the alpine region of WH. Quantitative information on the micro-habitat preferences, extent of distribution and population status of alpine MAPs is virtually lacking from the Himalayan region. Studies on these

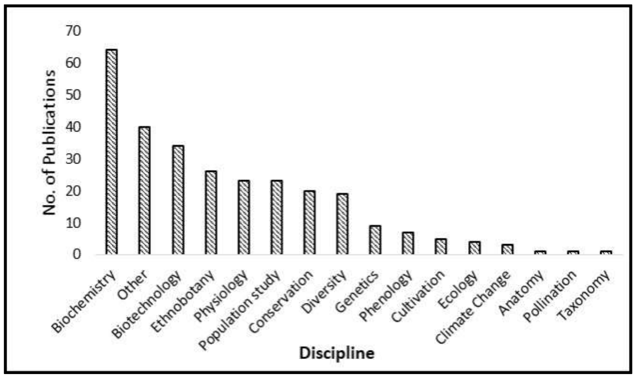

Fig. 3. Subject focus of publications in the alpine region of Uttarakhand, WH

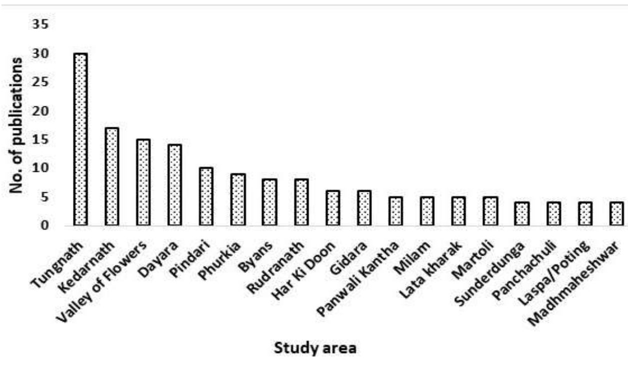

Fig. 4. Number of published publications across alpine meadows of Uttarakhand, WH

aspects of commercially useful plants would be very vital in understanding the ecology of such species and formulating the conservation plans for the areas. A population status of a species should provide not only their natural relationship with habitats but also indicate the trend of loss of individuals in degraded areas due to anthropogenic factors. Such studies are few and localised (Uniyal et al 2002).

(ii) Impact of climate change and habitat alteration: The distribution and growth of MAPs directly related to the specific climate and geography of their ecological niches (Badola and Aitken 2003). The more specific the climatic and habitat requirement, the more restricted becomes the species distribution along altitudinal or latitudinal gradient. In the mountain ecosystems, widely distributed species are relatively more resistance to changing environmental conditions, while species of narrow distribution are highly susceptible to climate and habitat change (Dhar 2002). With changing socio-economic dynamics and developmental initiatives in the alpine region there is a growing opportunity to initiate studies for addressing effects of climate change on phenology, species range shifts, habitat alternation and secondary metabolite production of high-altitude medicinal plants. Most of the work under elevated CO^2 conditions in India being carried out only on crop plants, whereas the alpine plants remain untouched for such studies (Upreti et al 2006). The understanding of climate dependant adaptive mechanisms is crucial to the development of the cultivation programme of medicinal plants.

(iii) Impact of herbivory: There are many potential causes of rarity in MAPs. Despite these, studies are lacking on the impact of wild herbivores on MAPs populations including the impact of domestic animals. Therefore, it is imperative to carry out detailed investigations on the habitat utilization patterns, feeding ecology, geographical distribution patterns and impact of herbivores on the medicinal plant population. Similarly, most of the documentation and research on indigenous uses of medicinal plants is focused on the human aspect. Animal husbandry is the backbone of the economy in the Himalayan region. Since there are many medicinal plant species used in curing various animal-related disorders and diseases, research should also be carried out and emphasized on the uses of medicinal plants for curing livestock diseases.

(iv) Declining traditional knowledge: Traditionally information on the use of plant species for therapeutic purpose passed from one generation to the next through oral tradition. There are indications of declining this knowledge of therapeutic plants through the lack of recognition by younger generations and shift in attitude and ongoing socio-economic change (Kala 2000), however the rate of its decline and corrective measures are not investigated in detail.

CONCLUSION

The available information on the MAPs of the alpine region of the WH broadened our knowledge on species distribution, composition, abundance and traditional knowledge and utilization pattern by the local communities in general. Most of the studies are site specific and the primary objective of several publications was listing of MAPs occurring in the area. Except for scattered information often, severely limited to certain parts of the landscape, no attempts have made to provide cumulative data on MAPs of the alpine region of WH. The checklist of species for some areas, including protected areas (Govind Wildlife Sanctuary) are not available, whereas some areas (Kedarnath Wildlife Sanctuary and Valley of Flowers) are intensively studied by several authors. Furthermore, often this information is not easily accessible or translated into the action because it is either unpublished, archived at various sources such as libraries or private collections. Alpine meadows of WH is not a single gregarious habitat, there are six major habitat types reported namely, tall forbs, mixed herbaceous meadows (short forbs), *Danthonia* grassy slopes, *Kobresia* sedge meadows, cushionoid and matted shrub, however, the extent of these habitats, their status in terms of suitability of MAPs is not known. The study reveals that, most of the available information on various aspects of the alpine MAPs collected from the easily accessible areas. These areas are also highly accessible to the local people for the collection of MAPs for indigenous use facing high pressure of MAPs decline. Therefore, despite the national, state and scattered local initiatives on the management, conservation and sustainable utilization of MAPs, there still exists gap in our knowledge and understanding in the availability of MAPs resource base in the alpine region of WH. It is feared that if the exploitation rate is not checked and conservation measures are not taken seriously, important MAPs may be extinct from the Himalayan region in the near future.

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Structural Diversity and Regeneration Pattern of Forest Communities in Parbati Valley, North Western Himalaya, India: Implications for Conservation

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Abstract: The Indian Himalayan Region is the most complex and diversified mountain ecosystem in the world. Topogeographical variations and features causes immense floral and faunal diversity. The present study has been conducted in Parbati Valley to assess the floristic diversity and regeneration of delineated plant communities. Eighty one sites were sampled for compositional and structural diversity of vegetation between 1524-3407 m amsl in each and every accessible aspects and habitats following standard ecological methods. Thirty forest communities were identified based on Important Value Index. These mainly represented by broad leaved evergreen and deciduous, coniferous evergreen and deciduous and mixed type of communities. In the delineated forest communities total density was ranged from 40.00-800.00 Ind ha^{-1}; species diversity 0.01-1.90; Concentration of dominance 0.13-0.84 and total basal area of 0.08-126.29 $m^2 ha^{-1}$. Of the identified plant communities, 12 communities showed highest regeneration of dominant species, 2 with highest regeneration of co-dominant species, 6 showed no/poor regeneration and 10 mixed communities with highest regeneration of one of the dominant species. Decrease in species richness was noticed with increasing altitude. Altitudinal shift of some species clearly states the impact of climate change. Unscientific exploitation of forest resources affected the forest ecosystem, thus, adequate planning, continuous monitoring and appropriate management of them is required to understand and conserve the natural ecosystem.

***Keywords*:** Diversity, Distribution, Density, Plant communities, Regeneration, Parbati valley, Conservation and management

Mountains are the most remarkable land forms on the earth surface with prominent vegetation zones based mainly on altitudinal and climatic variations. Discrepancy in topogeographical features as well as discrete geographical and ecological entity causes immense miscellany in Indian Himalayan Region (IHR) made the territory as one of the richest habitats meant for floral and faunal diversity. The IHR is one of the most complex and diversified mountain ecosystem in the world and globally recognized as a cornerstone of healthy ecosystem. It occupies only 18% of the geographical area of India and accounts for > 50% of India's forest cover. The Indian Himalayan Region (IHR) forms the major part of Himalaya and stretches from Arunachal Pradesh in the east to Jammu and Kashmir in the northwest (Rodger and Panwar 1988). The richness of the biological diversity is due to its unique climatic conditions, topography and diverse habitats (Samant et al 1998a). The entire region is endowed with a wide range of physiography, climate, soil and biological wealth. It has wide altitudinal range with rich diversity of habitats providing a range of microclimate and niches not only for plants but also for animals (Samant et al 2002, Joshi 2002). The vegetation along an altitudinal gradient comprises of tropical, sub-tropical, temperate, sub-alpine, alpine and tundra types and supports a great variety of forests with unique species that vary from east to west and from low to high altitudes. The vegetation of the Parbati Valley are full of potential biodiversity including medicinal and aromatic plants, wild edibles, rare, endangered, native, endemic and wild relatives of crop plants. These forests have traditionally played a key role in safeguarding the ecology and environment of the subcontinent (Samant et al 2002, Joshi 2002). The Indian Himalayan Region (IHR) is very well known for its representative, natural, unique and socio economically important plant diversity (Samant et al 1998a, 2007a). It is designated as one of the Biodiversity Hot Spots. Geo-dynamically, the young mountains of these region is still unexplored for floristic diversity especially qualitatively or quantitatively (Barman et al 2016). The high potential instability and inherent vulnerability of mountain ecosystems renders the area as one of the most ecologically fragile biogeographic zones in India. Demographic, economic and social changes, therefore, have important consequences on conservation of natural resources of Parbati Valley. Opening up the previously inaccessible terrain due to road building and deteriorating pasture quality, threatens the large number of plants (Nayar and Sastry 1987). Massive extraction of ecologically and economically noteworthy plant species have resulted in desertification and loss of biodiversity in the dynamic and wealthy Parbati valley. Huge anthropogenic pressure and genetic erosion coupled with soil erosion may retard prospects of economic development and welfare of the people in near future. In general, various workers in the State (Samant et al 1998a, 2007a, 2002, Singh and Rawat 2000, Arya et al 2017, Devi et al 2018, Devi et al 2019, Lal et al 2020, Rana et al 2020, Joshi 2002, Joshi and Samant 2004, Dasila et al 2021, Pant and Samant 2012, Singh et al 2021, Paul et al 2019, Singh and Samant 2020, etc.) have carried out floristic studies. However, any intensive study on the diversity, distribution and regeneration of forest communities has not been carried out so far in the valley specifically. Therefore, the present attempt has been made to assess and understand the pattern of regeneration in the forest communities in relation to climate change.

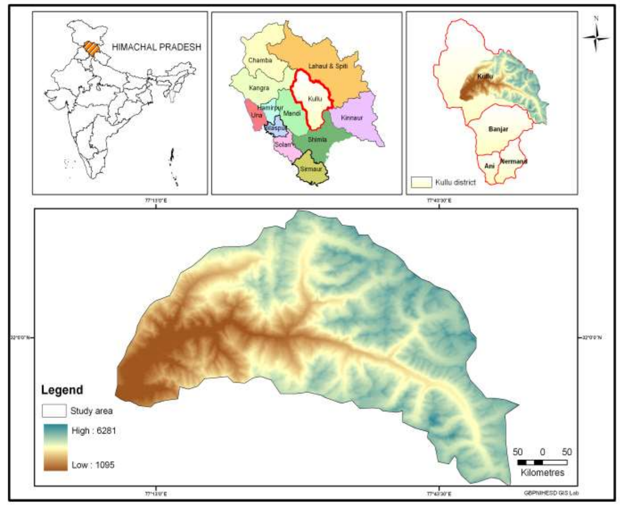


Fig. 1. Map of the study area

MATERIAL AND METHODS

Study area: The Parbati Valley is located between 31°53′48.41″ - 32°04′22.70″ N Lat. & 77°09′01.81″ - 77°18′34.41″ E Long., having elevation range from 1113-6632 m amsl (Fig. 1) and is known for its healthy climate. It also experiences considerable deviations in rainfall and temperature due to varying aspects, altitude and precipitation. The valley falls under Parbati Forest Division and well recognized for wealthy biodiversity. The area is mainly dominated by sub–tropical, temperate, sub-alpine and alpine vegetation. Sub-tropical forests are mainly subjugated by *Pinus roxburghii*, temperate and sub-alpine forests are mainly dominated by broad leaved deciduous and evergreen coniferous species, and meadows are dominated by alpine shrubs and herbaceous species. These forests are home to a large number of mammals, birds, insects, reptiles, fishes, amphibians etc. Most of the area falls under alpine zone, which remains snow covered during winter months (November-March). Broadly, three seasons can be recognized for the area Viz., summer, (April to June), rainy (July to September) and winter (October to March). Winter experiences severe cold and main precipitation is in the form of snow. Rains are mostly confined to summer monsoon. The underlying rock found in the area are quartzite, schist, phyllite, dolomite, limestone, shale, slate, gneisse and granites, which are responsible for a variety of coniferous and broad leaved vegetation. The valley has a large altitudinal range and inhabited by a number of villages in all the accessible aspects and habitats. The residents are largely dependent on natural resources for their sustenance. But due to various and massive anthropogenic activities in the area biodiversity richness is decreasing rapidly.

Identification and selection of sites and habitats: The sites were selected and surveys were conducted on each and every accessible aspects between 1524-3407m amsl. The habitats were identified based on physical characters and dominance of the vegetation. Plots having closed canopy with high percentage of humus and moisture were considered as moist habitats, whereas low percent of the same as dry habitats. The plots having >50% boulders of the ground cover were classified as bouldery habitat. The plots near to water bodies were considered as riverine. The plot which has a slope ≥ 50º and maximum vegetation is on the rocks were considered as rocky habitat and those facing high anthropogenic pressures were classified as degraded habitat.

Survey, sampling, identification and analysis of data: For the qualitative assessment of the floristic diversity rapid sampling of the species from each and every aspect and habitat was done. Information pertaining to locality, local name, habitat, life form, phenological characters, etc. for each species was gathered. Latitude, longitude, altitude, aspect, slope of each site were recorded with the help of Global positioning system (GPS), Abney level and compass. In addition, specimens of each species were collected and identified with the help of local and regional flora (Chowdhery and Wadhwa 1984, Aswal and Mehrotra 1994, Dhaliwal and

Sharma 1999, Singh and Rawat 2000).

The field surveys and samplings were conducted in the selected sites along an altitudinal gradient. In each site, a plot of 50 X 50m was laid. Trees, saplings and seedlings were sampled randomly by 10 quadrats of 10 X 10m area, shrubs by 20 quadrats of 5 X 5m area and herbs by 20 quadrats of 1 X 1m area. For the collection of data from these quadrats standard ecological methods (Saxena and Singh 1982, Singh and Singh 1992, Dhar et al 1997, Joshi and Samant 2004, and Samant and Joshi 2004) were followed. The circumference at breast height (CBH), at 1.37m from the ground for each individual tree was recorded. Based on circumference at breast height, the individuals were considered as trees, seedlings and saplings if the cbh is ≥ 31.5 cm, between 10.5-31.4 cm and <10.5 cm, respectively. Shrubs were considered as woody species having several branches arising from the base (Saxena and Singh 1982), and herbs were considered as those species having aerial parts surviving for one season, through their underground parts, i.e. roots/rhizomes/bulbs, etc. maybremain alive during the other seasons. Samples of each species were collected from each site and identified with the help of floras and research papers (Polunin and Stainton 1984, Chowdhery and Wadhawa 1984, Dhaliwal and Sharma 1999, Singh and Rawat 2000). Each site was geo referenced with the Global Positioning System (GPS). Three vegetation layers, i.e. tree, shrub and herb were analyzed for species richness, diversity, frequency, density, abundance, Basal Area (BA), Total Basal Area (TBA), Important Value Index (IVI) and regeneration of tree species. Relative dominance of a species was determined by total basal area (TBA) of tree species. For data analysis Curtis and McIntosh (1950), Kersaw (1973), Mueller-Dombois and Ellenberge (1974), Singh and Singh (1992), Dhar et al (1997), Samant et al (2002), Samant and Joshi (2004) and Joshi and Samant (2004) were followed. The abundance data of different sites were pooled to get community averages in terms of density, total basal area and IVI. Data analysis has been done following Kersaw (1973), Dhar et al (1997) and Samant et al (2002).

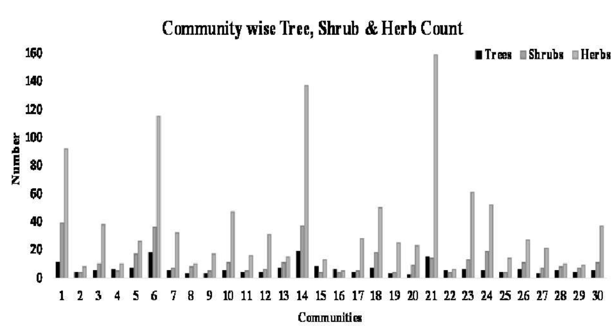


Fig. 2. Species richness in the identified forest communities

Altitude wise mapping of communities: SRTM DEM (Digtal Elevation Model) of 30m resolution were used to identify the elevation ranges in study area. GPS location of forest community incorporated into DEM to identify the elevation ranges of forest communities. The maximum forest communities lies in altitude of 2500-3400m amsl, which is quite evident from Digital elevation model. Sub-alpine communities have less forest cover then temperate forest of study area.

RESULTS AND DISCUSSION

Site and habitat characteristics: Total 81 sites were randomly selected and assessed from different accessible aspects and habitats for the assessment of forest vegetation and to understand the regeneration trend in the forest communities. The experimental site was of diverse and a range of habitats and aspects. The study sites were sampled to categorize and delineate the forest communities representing 7 key habitats namely shady moist (32 sites), dry (28 sites), rocky (12 sites), riverine (10 sites), degraded (3 sites), bouldery (2 sites) and shady (1 site). The dominant shady moist habitats were found in the maximum forest communities and that simply states that vegetation prefer to grow in moist condition of the soil. Moisture content of the soil is received from the seasonal precipitations in the form of snow and rain. Varied range of aspects were found. Twenty three sites were represented in northwest aspect, 18 on north, 13 on northeast, 9 on east and southeast, 7 on southwest and west and 2 on south aspect. North and northwest facing slopes are sunny and receives a major part of monsoon and hence more floristically diverse. South, southeast and southwest facing slopes are relatively drier than other aspects because they receives a small part of monsoon rainfall. Snow melt water of the hilltops are the main source of soil moisture content in these aspects. Variation of slope was ranged from 5-65º. The range of altitudinal gradient lies between 1524-3407m amsl. Site/habitat characteristics, dominant species, altitude, slope and aspect of the sampled sites in Parbati Valley are presented in Table 1.

Community diversity and distribution pattern: Thirty forest communities were identified. The community types, altitudinal distribution, sites and habitat representation and major tree associates are presented in Table 2. *Picea smithiana* community was found maximum in 17 sites, followed by *Cedrus deodara* and *Abies pindrow* (11 sites,

Table 1. Physical characteristics and geo-references of the sampled sites in Parbati valley

Site	Altitude (m)	Habitat	Slope (°)	Aspect	Latitude (N)	Longitude (E)	Dominant Species
1	2962	Shady moist	55	NE	31°59.43"	77°30.17"	*Abies pindrow*
2	2977	Rocky	40	NE	31°59.43"	77°30.03"	*Taxus wallichiana & Abies pindrow*
3	3094	Degraded	58	N	31°59.41"	77°29.92"	*Abies pindrow*
4	3244	Shady	54	SW	31°59.32"	77°29.91"	*Abies pindrow*
5	3250	Dry	58	E	31°59.32"	77°29.91"	*Pinus wallichiana*
6	3214	Shady moist	32	NE	31°59.25"	77°29.87"	*Abies pindrow*
7	2788	Shady moist	34	NW	31°59.68"	77°30.39"	*Pinus wallichiana*
8	2850	Shady moist	20	SE	31°59.63"	77°30.29"	*Abies pindrow*
9	2899	Shady moist	27	NW	31°59.58"	77°30'18"	*Abies pindrow*
10	2864	Shady moist	48	NW	31°59.52"	77°30.44"	*Pinus wallichiana*
11	2910	Shady moist	42	NW	31°59.43"	77°30.30"	*Taxus wallichiana*
12	2980	Shady moist	49	NW	31°59.34"	77°30.86"	*Betula utilis*
13	3198	Shady moist	48	NE	31°59.01"	77°33.08"	*Abies pindrow*
14	3260	Shady moist	42	N	31°58.97"	77°32.99"	*Betula utilis*
15	3407	Rocky	48	N	31°58.27"	77°35.28"	*Betula utilis*
16	3340	Dry	52	NW	31°58.43"	77°34.72"	*Abies pindrow*
17	3170	Shady Moist	40	NW	31°58.60"	77°34.12"	*Abies pindrow*
18	3157	Dry	38	NE	31°59.11"	77°32.69"	*Pinus wallichiana*
19	2993	Shady Moist	42	N	31°59.51"	77°31.17"	*Abies pindrow*
20	2552	Rocky	48	NE	31°59.88"	77°29.53"	*Corylus jacquemontii*
21	2517	Dry	58	NW	31°00.08"	77°28.47"	*Picea smithiana*
22	1663	Shady Moist	23	N	32°00'19"	77°19'12"	*Cedrus deodara*
23	1584	Dry	48	N	32°00'31"	77°18'22"	*Cedrus deodara*
24	1544	Riverine	14	SE	32°'00'37"	77°17'46"	*Pinus wallichiana & Pinus roxburghii*
25	1666	Dry	48	SE	32°00'56"	77°19'21"	*Pinus wallichiana & Cedrus deodara*
26	2222	Dry	38	N	31°59'47"	77°26'42"	*Quercus floribunda*
27	2265	Dry	12	N	31°59'36"	77°26'13"	*Cedrus deodara*
28	2309	Shady Moist	24	N	31°59'30"	77°26'39"	*Quercus floribunda & Abies pindrow*
29	1595	Shady Moist	54	NE	32°00'10"	77°24'40"	*Aesculus indica & Cedrus deodara*
30	2269	Rocky	45	N	32°00'02"	77°23'18"	*Abies pindrow & Aesculus indica*
31	1732	Dry	48	NE	31°59'40"	77°14'18"	*Cedrus deodara*
32	1551	Shady Moist	34	NW	32°00'20"	77°16'52"	*Cedrus deodara*
33	1524	Rocky	18	N	32°00'23"	77°16'58"	*Pinus roxburghii* & *Toona ciliata*
34	1600	Dry	48	NE	32°00'45"	77°18'56"	*Cedrus deodara*
35	1618	Rocky	29	NW	32°00'49"	77° 19'25"	*Cedrus deodara*
36	1622	Rocky	48	N	32°01'31"	77°20'54"	*Pinus wallichiana*
37	1813	Rocky	48	NW	32°01'22"	77°21'25"	*Pinus wallichiana*
38	1586	Rocky	28	E	32°00'47"	77°19'02"	*Cedrus deodara*
39	1605	Shady Moist	45	NW	32°01'05"	77°19'47"	*Cedrus deodara*
40	1711	Rocky	22	E	32°01'16"	77°21'91"	*Pinus wallichiana*
41	1715	Rocky	38	E	32°01'34"	77°21'29"	*Pinus roxburghii*
42	2480	Riverine	45	W	31°58'16"	77° 24'57"	*Picea smithiana, Pinus wallichiana & Populus ciliata*
43	2411	Bouldery	30	NW	31°58'13"	77°24'55"	*Juglans regia & Ulmus villosa*
44	2471	Dry	35	E	32°00'20"	77° 27'15"	*Pinus wallichiana*
45	2206	Shady moist	20	NW	31°59'45"	77°27'46"	*Cedrus deodara & Picea smithiana*

Cont...

Table 1. Physical characteristics and geo-references of the sampled sites in Parbati valley

Site	Altitude (m)	Habitat	Slope (°)	Aspect	Latitude (N)	Longitude (E)	Dominant Species
46	2342	Shady moist	10	NW	31°59'40"	77°26'12"	*Cedrus deodara*
47	2213	Shady moist	25	N	31°59'33"	77°28'15"	*Quercus floribunda*
48	2293	Riverine	60	NE	31°59'10"	77°27' 10"	*Picea smithiana*
49	2145	Riverine	15	W	31°59'20"	77°27' 13"	*Pinus wallichiana*
50	2320	Shady moist	20	N	32°00'00"	77°27'43"	*Picea smithiana*
51	2308	Shady moist	35	NW	31°59'52"	77°27'16"	*Picea smithiana*
52	2240	Dry	30	N	31°59'51"	77°27'01"	*Acer cappadocicum & Salix daphnoides*
53	2142	Riverine	5	SW	31°59'54"	77°26'45"	*Populus ciliata*
54	2225	Dry	30	S	31°59'58"	77°26'59"	*Pyrus pashia*
55	2062	Riverine	15	SE	32°00'00"	77°25'06"	*Acer acuminatum & Picea smithiana*
56	2165	Degraded	25	SE	31°59'57"	77°22'57"	*Salix acutifolia*
57	2226	Dry	50	W	31°59'46"	77°22'55"	*Aesculus indica*
58	2135	Riverine	25	NW	32°00'08"	77°23'44"	*Picea smithiana*
59	2057	Bouldery	45	NE	32°00'07"	77°24'41"	*Aesculus indica*
60	2062	Dry	55	SW	32°00'12"	77°24'45"	*Quercus floribunda*
61	2019	Riverine	45	SW	32°00'20"	77°23'29"	*Cedrus deodara*
62	2493	Shady moist	40	E	32°03'31"	77°15'09"	*Hippophae salicifolia*
63	2651	Shady moist	60	NW	32°05'32"	77°17'23"	*Abies pindrow*
64	2611	Dry	55	W	32°04'42"	77°16'30"	*Picea smithiana*
65	2557	Shady moist	65	NW	32°04'29"	77°16'22"	*Picea smithiana*
66	2761	Dry	60	SE	32°05'51"	77°17'36"	*Quercus semecarpifolia*
67	2590	Dry	50	SE	32°05'05"	77°16'41"	*Ulmus villosa*
68	2518	Dry	50	E	32° 04'25"	77°16'14"	*Picea smithiana*
69	2704	Shady moist	40	NW	32°03'08"	77°16'22"	*Picea smithiana*
70	2833	Shady moist	45	NW	32°03'41"	77°16'37"	*Picea smithiana*
71	2357	Dry	60	S	32°03'16"	77°15'40"	*Pinus wallichiana*
72	2067	Dry	35	NW	32°02'51"	77°15'34"	*Pinus wallichiana & Cedrus deodara*
73	2091	Dry	15	SE	32° 02'56"	77°15'30"	*Pinus wallichiana*
74	2261	Shady moist	60	N	32°03'12"	77°15'47"	*Pinus wallichiana & Cedrus deodara*
75	2262	Dry	45	W	32°03'34"	77°16'10"	*Juglans regia & Ulmus villosa*
76	2753	Shady moist	40	N	32°03'16"	77°14'56"	*Picea smithiana & Taxus wallichiana*
77	3137	Dry	60	NE	32°03'00"	77°14'23"	*Quercus semecarpifolia*
78	3128	Dry	45	E	32°03'08"	77°14'27"	*Quercus semecarpifolia*
79	2608	Dry	35	SE	32°05'06"	77°16'41"	*Quercus semecarpifolia*
80	2640	Dry	55	SW	32°05'13"	77°16'44"	*Picea smithiana*
81	2556	Dry	45	SW	32°04'12"	77°16'20"	*Cornus macrophylla & Ulmus villosa*

Abbreviations used: E=East, N=North, NE=North East, NW=North West, S=South, SE=South East, SW=South West, and W=West

each), *Pinus wallichiana* (10 sites), *Quercus semecarpifolia* (4 sites) and *Quercus floribunda* (3 sites), and rest of the communities showed less representation of sites. *Abies pindrow, Aesculus indica, Betula utilis, Cedrus deodara, Hippophae salicifolia, Pinus wallichiana, Picea smithiana, Quercus floribunda* and *Quercus semecarpifolia* communities showed a wide altitudinal range.

Species richness of the identified communities: Maximum species richness was found in *Picea smithiana* community (218 species; Trees: 15 Shrubs: 44 and Herbs: 159) followed by *Pinus wallichiana* (193 species; Trees: 19, Shrubs: 37 and Herbs: 137), *Cedrus deodara* (172 species; Trees: 18, Shrubs: 39 and Herbs: 115), *Abies pindrow* (142 species; trees: 11 shrubs: 39 and herbs: 92), *Quercus floribunda* (85 species; trees: 5, shrubs: 19, and herbs: 61), *Quercus semecarpifolia* (76 species; trees: 5, shrubs: 19, and herbs: 52), *Pinus wallichiana- Cedrus deodara* mixed (75 species; trees: 7, shrubs: 18, and herbs: 50), *Hippophae salicifolia* (63 species; trees: 5, shrubs: 11, and herbs: 47), communities (Fig. 2) etc. The richness of species decreased with an increasing altitude.

Structural Pattern of the identified communities: Total trees density was ranged from 40.0-800.0 Ind ha^{-1} (Fig. 3) and Total Basal Area (TBA) was 0.08-126.29 m^2 ha^{-1} (Fig. 4). Maximum total trees density was recorded in *Pinus wallichiana- Pinus roxburghii* mixed (800 Ind ha^{-1}) community, followed by *Quercus floribunda - Abies pindrow* mixed (690 Ind ha^{-1}). Total basal area was recorded maximum in *Aesculus indica- Cedrus deodara* mixed (126.29 m^2 ha^{-1}) community, followed by *Quercus floribunda* (100.13 m^2 ha^{-1}) communities. Shrubs density (3140 Ind ha^{-1}) was found maximum in *Pinus wallichiana - Pinus roxburghii* mixed community (Fig. 5), whereas *Picea smithiana* community (13.73 Ind m^{-2}) showed maximum herb density (Fig. 6). Seedlings and saplings density was found maximum in *Populus ciliata* (1290 Ind ha^{-1}) and *Quercus floribunda* community (810.0 Ind ha^{-1}), respectively (Fig. 7-8).

Species diversity and Concentration of dominance of the identified communities

The species diversity (H') ranged from 0.01 - 1.90 in the identified communities. Highest Species diversity (H') was found in *Picea smithiana - Pinus wallichiana - Populus ciliata* mixed community (1.90), followed by *Salix daphnoides-Acer cappadocicum* mixed (1.69), *Aesculus indica - Cedrus deodara* mixed (1.68), *Pinus roxburghii - Toona serrata* mixed (1.48), *Cedrus deodara-Picea smithiana* mixed (1.46), *Picea smithiana-Acer acuminatum* mixed (1.35), *Juglans regia-Ulmus villosa* mixed (1.34), communities (Fig. 9). Concentration of dominance (Cd) ranged from 0.11-0.84. It was highest for *Pinus wallichiana* community and minimum in *Salix daphnoides-Acer cappadocicum* mixed community (Fig. 10). The Total Basal Area (TBA) ranged from 0.08-126.29 m^2 ha^{-1} in the identified communities. Highest Total Basal Area (TBA) was found in *Aesculus indica-Cedrus deodara* mixed community (126.29 m^2 ha^{-1}). Total density ranged from 40-800 Ind ha^{-1} (Table 3). Total tree density was highest for *Pinus wallichiana - Pinus roxburghii* mixed community (800 Ind ha^{-1}), followed by *Quercus floribunda-Abies pindrow* mixed community (700 Ind ha^{-1}).

Area and distribution of forest communities in relation to altitude: Maximum forest area was found in *Picea smithiana community* (42.5 km^2) between 2135-2833m amsl altitudinal range and makes it dominant forest community in the region followed by *Abies pindrow* and *Cedrus deodara* (27.50 km^2 each) between 2651-3340 m and 1551-2342 m amsl respectively, *Pinus wallichiana* (25 km^2) between 1711-3250 m amsl, *Quercus semecarpifolia* (10 km^2) between 2608-3137 m amsl, *Betula utilis, Hippophae salicifolia, Quercus floribunda* and *Pinus wallichiana-Cedrus deodara* mixed (07.25 km^2) between 2651-3340 m, 2408-2493 m, 2062-2222 m and 1666-2261 m amsl, respectively, etc (Table 2/Fig. 11).

Impact of Climate change in the forest communities: Climate change is now recognized as one of the most serious challenges facing the world, its people, the environment and its economies (Lindner et al 2010). Over geologic time, changes in disturbance regimes are a natural part of all ecosystems. Even so, as a consequence of climate change, forests may soon face rapid alterations in the timing, intensity, frequency, and extent of disturbances (Dale et al 2001). Change in climatic patterns throughout this belt is affecting forest ecosystem and the wealthy forest ecosystem. The present study shows that these forest communities are sensitive to climatic change. The information obtained through such studies would be useful in predicting the future directions of vegetation changes at the climate sensitive upper elevations. There is a considerable gap in theory and practice was observed while understanding the changing climatic conditions. More importantly, understanding of adaptive capacity and regional vulnerability to climate change in these area is not well developed and requires more focused research efforts. The timberline species are at the threshold of their climatic limits. Any change in climate, which perturbs the vegetation and climate equilibrium, will lead to significant changes in the demographic patterns of these species of the communities. The role of anthropogenic activities on climate change has emerged as a much debated issue globally. Although the climate has always been changing, and species and ecosystems have responded to these changes, it is the rapidly increasing rate of climate change which has been of concern to the global community of late (Loarie et al 2009). Already there are evidences to indicate that the Himalayan region is warming at a higher rate than the global average rate (Jianchu et al 2007). As a consequence, many important forest species are likely to fail to regenerate if the synchrony between their seed ripening and commencement of monsoon rains is broken due to climate change (Rawat 2011). Studies have suggested that changes in plant phenology (like advancement of flowering in *Rhododendron arboreum*) and movement of species (like *Tagetes minuta*, *Lantana camara* and *Ageratina adenophora*) to higher ridges may be the earliest responses to modest climate change. Altitudinal shift of many species clearly indicates that the forest communities are facing high pressure of climate change. Climate change has also influenced the germination, regeneration, fruiting and flowering of many ecologically and economically important plants. Some species are trying to adjust this climatic uncertainties by occupying more suitable habitats in the upper elevation and retreating themselves from the disturbed areas. The continued trend of warming and

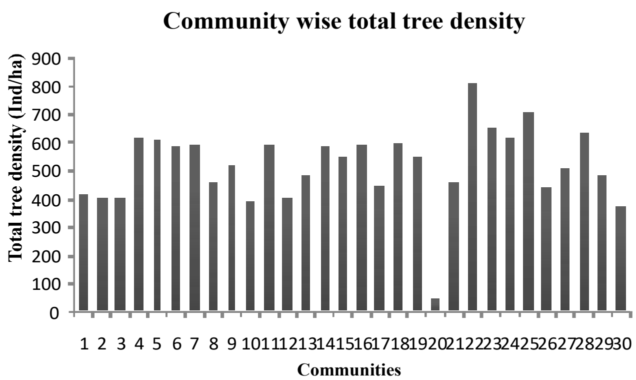


Fig. 3. Total tree density in the identified forest communities

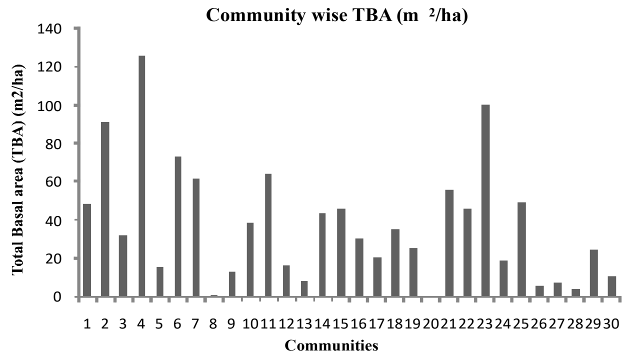


Fig. 4. Total basal area in the identified forest communities

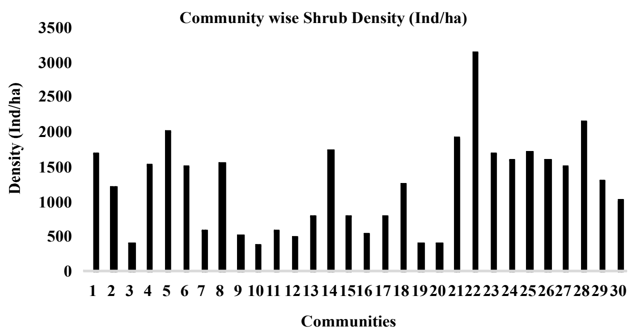


Fig. 5. Density of shrubs in the identified forest communities

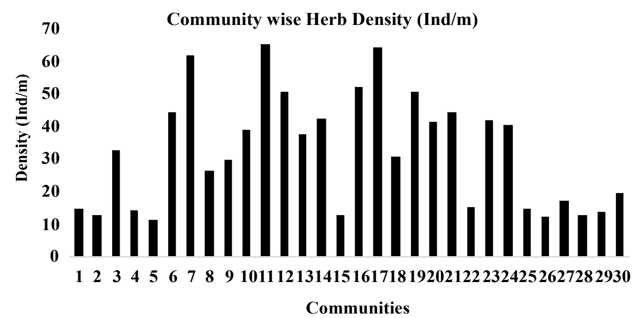


Fig. 6. Density of herbs in the identified forest communities

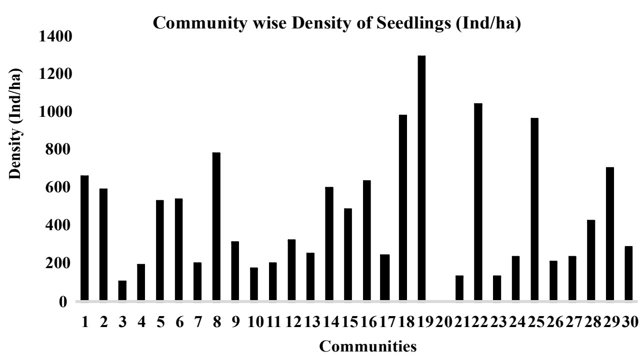


Fig. 7. Density of seedlings in the identified forest communities

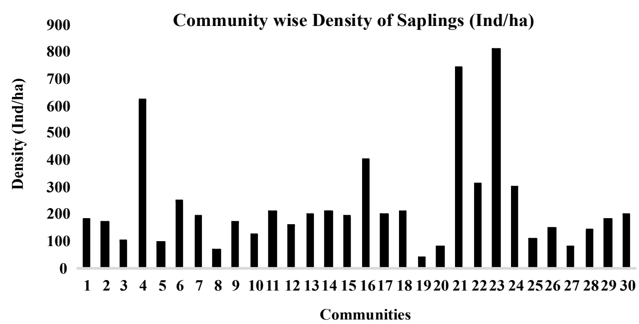


Fig. 8. Density of saplings in the identified forest communities

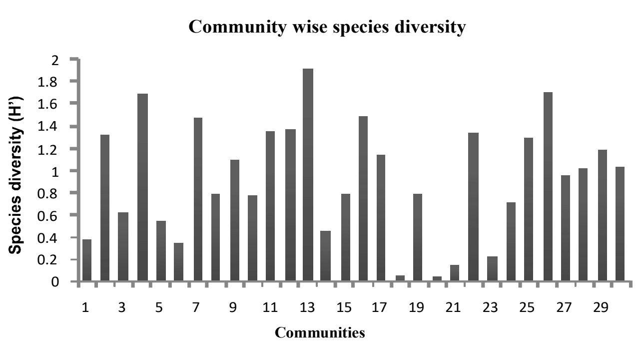


Fig. 9. Species diversity in the identified forest communities

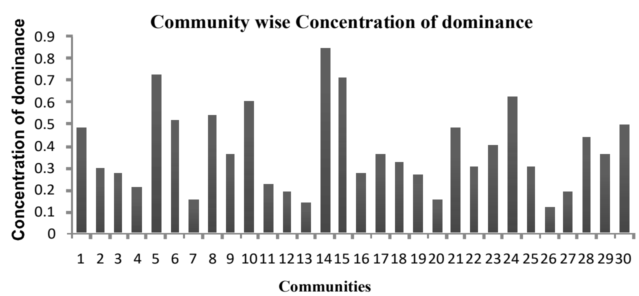


Fig. 10. Concentration of dominance in the identified forest communities

Abbreviations used: 1=*Abies pindrow*, 2=*Abies pindrow- Aesculus indica* mixed, 3=*Aesculus indica*, 4=*Aesculus indica - Cedrus deodara* mixed, 5=*Betula utilis*, 6=*Cedrus deodara*, 7=*Cedrus deodara-Picea smithiana* mixed, 8=*Corylus jacquemontii*, 9=*Cornus macrophylla-Ulmus villosa* mixed, 10=*Hippophae salicifolia*, 11=*Juglans regia-Ulmus villosa* mixed, 12=*Picea smithiana-Acer acuminatum* mixed, 13=*Picea smithiana-Pinus wallichiana-Populus ciliata* mixed, 14=*Pinus wallichiana*, 15=*Pinus roxburghii*, 16=*Pinus roxburghii - Toona serrata* mixed, 17=*Picea smithiana-Taxus baccata ssp. wallichiana* mixed, 18=*Pinus wallichiana - Cedrus deodara* mixed, 19=*Populus ciliate*, 20=*Pyrus pashia*, 21=*Picea smithiana*, 22=*Pinus wallichiana - Pinus roxburghii* mixed, 23=*Quercus floribunda*, 24=*Quercus semecarpifolia*, 25=*Quercus floribunda - Abies pindrow* mixed, 26=*Salix daphnoides-Acer cappadocicum* mixed, 27=*Salix acutifolia*, 28=*Taxus baccata ssp.wallichiana*, 29=*Taxus baccata ssp .wallichiana - Abies pindrow* mixed and 30=*Ulmus vilosa* community altitudinal shift are likely to result in species extinctions, particularly at mountaintops in near future. Four tree species namely, *Abies pindrow*, *Cedrus deodara*, *Picea smithiana* and *Pinus wallichiana* amongst the total species distributed within the tree communities showed altitudinal shift in the higher elevation based on the expansion of seedlings and saplings (Fig. 12 a-d) possibly due to the severe and serious climatic threats.

Abies pindrow: Eleven plots of 27.5 km^2 total area were laid in different habitats and aspects to understand the pattern of the altitudinal shift of the species (Fig. 12a). In the plots, mature individuals density ranged from 27-412 ha^{-1}; saplings

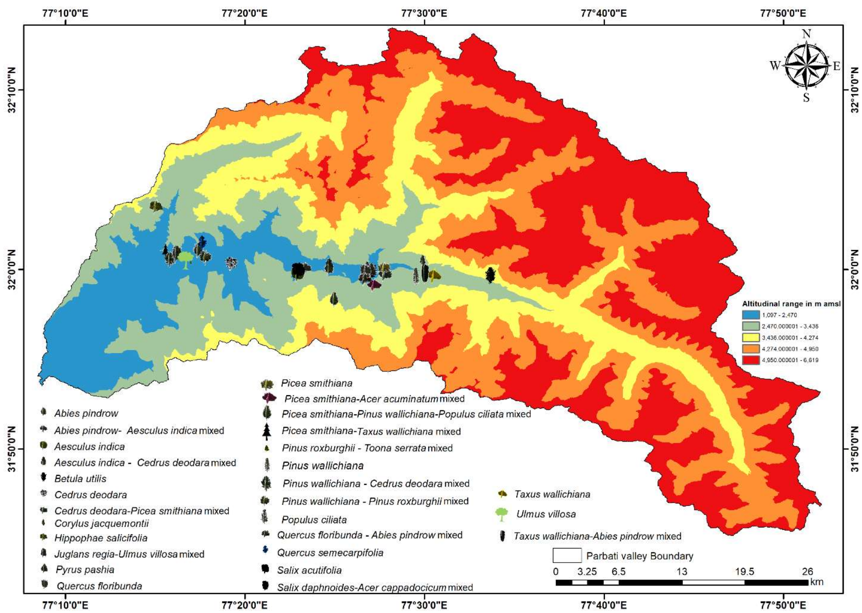


Fig. 11. Altitude wise distribution of forest communities in Parbati valley

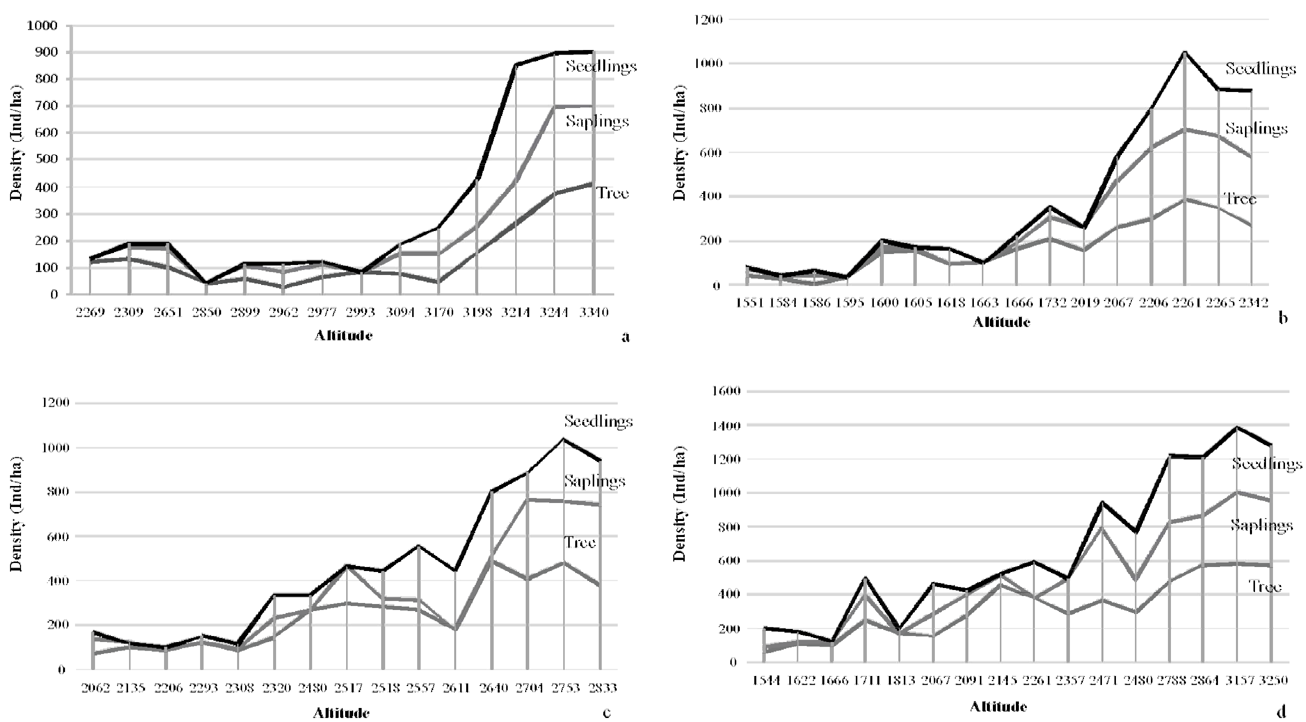


Fig. 12 (a-d). Density of trees, saplings and seedlings of species along an altitudinal gradient

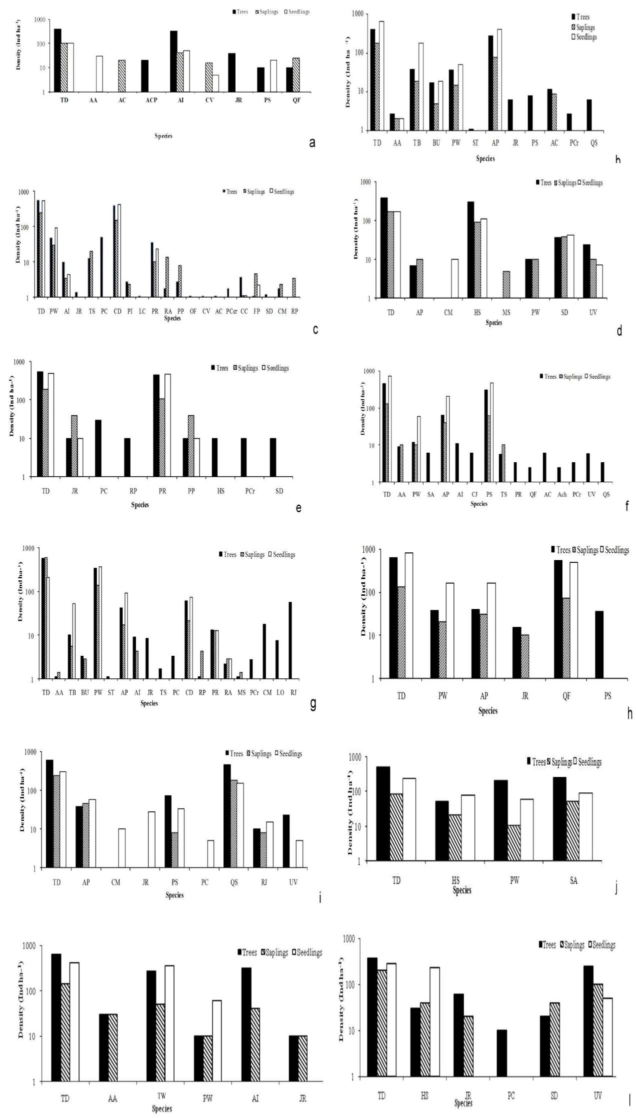
11-321 ha^{-1} and seedlings 09-429 ha^{-1}. Maximum density of mature individuals has been recorded between 3198-3340m amsl and recruits between 3000-3340m amsl. Approximately below 2700m amsl, the density of mature trees, saplings and seedlings was low as compared to altitudinal zone above 3000m amsl. Increasing density of seedlings and saplings towards high altitude simply indicates the gradual shift in the altitude of the species.

Cedrus deodara: Eleven plots of 27.50 Km^2 total area were laid in different habitats and aspects to study the altitudinal shift of the species (Fig. 12b). In the plots, tree density ranged from 10-386 ha^{-1}; saplings 12-328 ha^{-1} and seedlings 10-349 ha^{-1}. Maximum density of mature individuals has been recorded between 2206-2342m amsl and recruits between 3000-3340m amsl. Increasing density of mature trees, saplings and seedlings was observed above 2000m amsl compared to altitudinal zone below 1500m amsl denoting the altitudinal shift of the species towards climate vulnerable higher elevation.

Picea smithiana: Seventeen plots of 42.5 km^2 total area were laid in different habitats and aspects to study the altitudinal shift of the species (Fig. 12c). In the plots, density of the mature individuals ranged from 18-489 ha^{-1}; saplings 10-367 ha^{-1} and seedlings 13-290 ha^{-1}. Maximum density of mature individuals has been recorded between 2600-2800m amsl and recruits between 3600-2833m amsl. Increasing density of mature trees, saplings and seedlings was observed above 2500m amsl compared to altitudinal zone below 2000m amsl simply denoting the altitudinal shift of the species towards climate vulnerable higher elevation.

Pinus wallichiana: Ten plots of 25 km^2 total area were laid in different habitats and aspects to understand the pattern of the altitudinal shift of the species (Fig. 12d). In the plots, mature individuals density ranged from 10-580 ha^{-1}; saplings 15-426 ha^{-1} and seedlings 11-388 ha^{-1}. Maximum density of mature individuals has been recorded between 2400-3250m amsl and recruits between 2800-3250m amsl. Approximately below 2300m amsl, the density of mature trees, saplings and seedlings was low as compared to altitudinal zone above 2600m amsl. Increasing density of seedlings and saplings towards high altitude simply indicates the gradual shift in the altitude of the species.

Himalayan ecosystem is unique and supports a large number of forest ecosystem due to its diverse topogeographical gradients. Total tree density ranged from 40.0-800.0 Ind ha^{-1} and total basal area (TBA) from 0.08-126.29 m^2 ha^{-1} which is higher to the values reported earlier from North West Himalaya (Rana and Samant 2010, Pant and Samant 2012, Sharma and Samant 2013, Sharma et al



Abbreviations used: TD=Total density, AA=*Acer acuminatum*, AC=*Acercaesium*, *Ach=Alangium chinense*, ACP=*Acer cappadocicum*, AI=*Aesculus indica*, AP=*Abies pindrow*, BU=*Betula utilis,* CD=*Cedrus deodara*, CJ=*Corylus jackmontii*, CM=*Cornus macrophylla*, *CC=Cornus capitata*, CV= *Carpinus viminea*, *FP=Ficus palmata*, HS=*Hippophae salicifolia*, JR=*Juglans regia*, *LC=Ligustrum compactum*, LO= *Lyonia ovalifolia*, MS=*Morus serrate, OF=Olea ferruginea*, PP=*Pyrus pashia,* PC/Pcr=*Prunus cornuta*, *PI=Pistacia Integerrima*, Pcer=*Prunus ceresoides*, PR=*Pinus roxburghii*, PS=*Picea smithiana*, PW=*Pinus wallichiana*, QF=*Quercus floribunda*, QS=*Quercus semecarpifolia*, RA=*Rhododendron arboreum*, *RP=Robinia pseudoacacia*, RJ=*Rhus javanica*, *SA=Salix acutifolia*, SD=*Salix daphnoides*, ST=*Salix tetrasperma*, TW=*Taxus wallichiana*, TS= *Toona serrata* and UV=*Ulmus violosa*

Fig. 13 (a-l). Communities having highest regeneration of the dominant species (a= *Aesculus indica* community, b= *Abies pindrow* community, c= *Cedrus deodara* community, d= *Hippophae salicifolia* community,e= *Pinus roxburghii* community, f= *Picea smithiana* community, g= *Pinus wallichiana* community, h= *Qerecus floribunda* community, i= *Querecus semecarpifolia* community, j= *Salix acutifolia* community, k= *Taxus walllichiana* community and l= *Ulmus villosa* community)

2014, Thakur et al 2015). Tree diversity and richness is comparable to the values reported by Joshi and Samant (2004), Pant and Samant (2012) and Sharma and Samant (2013). The regeneration pattern of different forests varied from community to community. Total 30 forest communities had been identified and most of the species present in these communities are used for fuel, fodder, making agricultural tools, house building and miscellaneous purposes. During the surveys, it has been observed that massive pressure on species is responsible for habitat degradation, poor regeneration and population depletion of the tree species. Regeneration status of tree species of any forest is determined by recruitment of saplings and seedlings (Dhar et al 1997, Samant et al 2002, Singh and Singh 1992). Based on the density of seedlings and saplings, the identified communities in Parbati Valley has been categorized in to the following four categories.

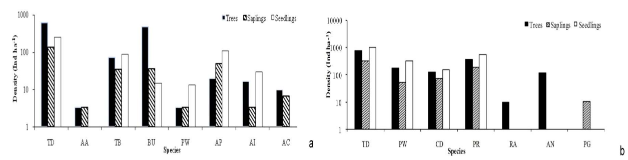
Communities having highest regeneration of the dominant species: Twelve communities *i.e. Aesculus indica, Abies pindrow, Cedrus deodara, Hippophae salicifolia, Pinus roxburghii, Picea smithiana, Pinus wallichiana, Qerecus floribunda, Querecus semecarpifolia, Salix acutifolia, Taxus baccata* ssp. *walllichiana, Ulmus villosa* (Fig. 13 a-l) communities showed highest regeneration of dominant species. This indicates that these communities will continue their dominance in near future too.

Communities with highest regeneration of co-dominant species: Two communities *i.e., Betula utilis* and *Pinus wallichiana- Pinus roxburghii* (Fig. 14 a-b)) mixed community showed highest regeneration of co-dominant species indicating that these communities will be replaced by the co-dominant species in near future.

Communities having poor or no regeneration of dominant and co-dominant species: Six communities *i.e., Salix daphnoides- Acer cappadocicum* mixed community, *Quercus floribunda- Abies pindrow* mixed community, *Picea smithiana- Acer acuminatum* mixed community, *Pyrus pashia, Populus ciliata, Corylus jacquemontii* community (Fig. 15 a-f) does not show regeneration of the dominant species.

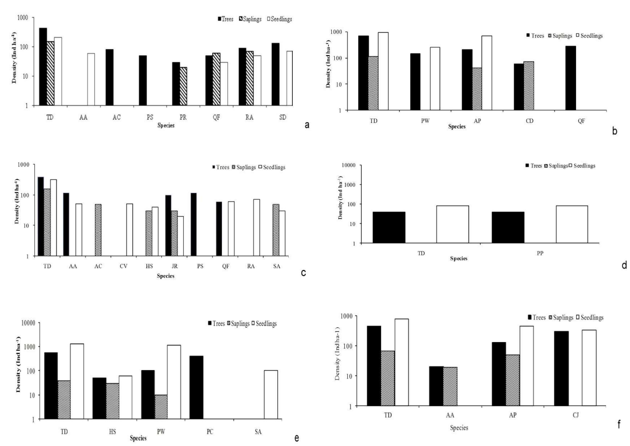
Mixed tree communities with highest regeneration of one of the dominant species: Ten communities *i.e.*, *Aesculus indica-Cedrus deodara* mixed community, *Abies pindrow-Aesculus indica* mixed community, *Cedrus deodara-Picea smithiana* mixed community, *Cornus macrophylla- Ulmus villosa* mixed community, *Juglans regia-Ulmus villosa* mixed community, *Pinus roxburghii- Toona serrata* mixed community, *Picea smithiana- Pinus wallichiana- Populus ciliata* mixed community, *Picea smithiana- Taxus baccata* ssp. *walllichiana* mixed community, *Pinus wallichiana- Cedrus deodara* mixed community and *Taxus baccata* ssp. *walllichiana- Abies pindrow* mixed community (Fig. 16 a-j) showed higher regeneration of dominant species than the other species indicating that these communities will shift from mixed type to dominant types in near future.

Based on the present results, it can be concluded that the Parbati Valley supports a high diversity of forest trees and communities. But, unfortunately rapid depletion of population



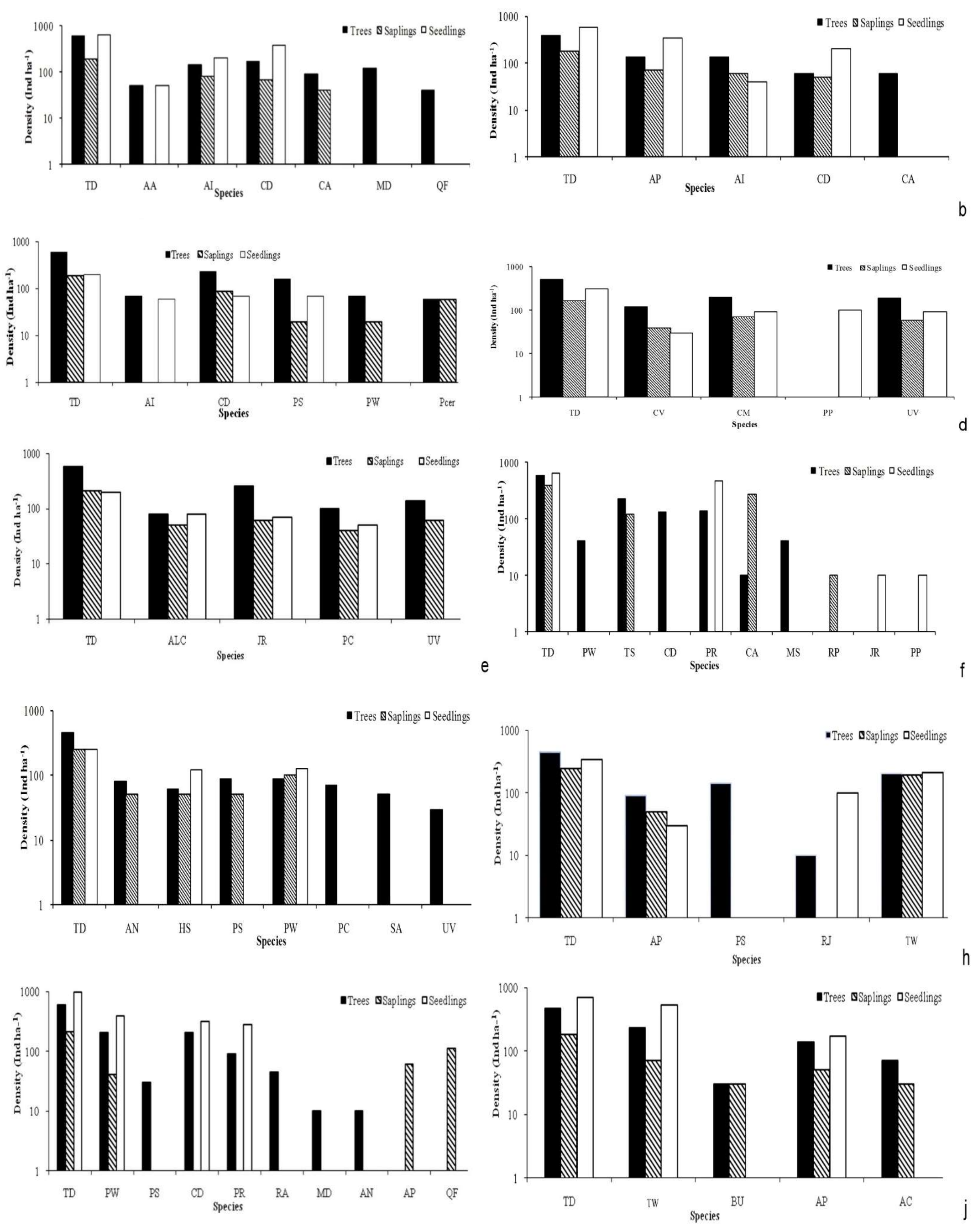
Abbreviations used: TD=Total density, AA=*Acer acuminatum*, AC=*Acercaesium*, AI=*Aesculus indica*, AP=*Abies pindrow*, AN= *Alnus nitida,* BU=*Betula utilis,* CD=*Cedrus deodara*, PG=*Punica granatum,* PR=*Pinus roxburghii*, PW=*Pinus wallichiana*, and RA=*Rhododendron arboretum*

Fig. 14 (a-b). Communities with highest regeneration of co-dominant species (a= *Betula utilis* community and b= *Pinus wallichiana- Pinus roxburghii* mixed community)



Abbreviations used: TD=Total density, AA=*Acer acuminatum*, AC=*Acercaesium*, AP=*Abies pindrow*, CD=*Cedrus deodara*, CJ=*Corylus jackmontii*, CV= *Carpinus viminea*, HS=*Hippophae salicifolia*, JR=*Juglans regia*, PP=*Pyrus pashia*, PR=*Pinus roxburghii*, PS=*Picea smithiana*, PW=*Pinus wallichiana*, QF=*Quercus floribunda*, RA=*Rhododendron arboreum*, *SA*=*Salix acutifolia* and SD=*Salix daphnoides*

Fig. 15 (a-f). Communities having poor or no regeneration of dominant and co-dominant species (a= *Salix daphnoides- Acer cappadocicum* mixedcommunity, b= *Quercus floribunda- Abies pindrow* mixed community, c= *Picea smithiana- Acer acuminatum* mixedcommunity, d= *Pyrus pashia* community, e= *Populus ciliata* community and f=*Corylus jacquemontii* community)



Abbreviations used:TD=Total density, AA=*Acer acuminatum*, AC=*Acercaesium*, ALC=*Alangium chinense* AI=*Aesculus indica*, AN= *Alnus nitida*, AP=*Abies pindrow*, BU=*Betula utilis,* CA= *Celtis australis*, CD=*Cedrus deodara*, CM=*Cornus macrophylla*, CV= *Carpinus viminea*, HS=*Hippophae salicifolia*, JR=*Juglans regia*, MD=*Meliosma dillenifolia*, MS=*Morus serrata,* PP=*Pyrus pashia,* PC/Pcr=*Prunus cornuta*, Pcer=*Prunus ceresoides*, PS=*Picea smithiana*, PW=*Pinus wallichiana*, QF=*Quercus floribunda*, *RP=Robinia pseudoacacia*, *SA=Salix acutifolia*, TB=*Taxus baccata* ssp. *wallichiana*, TS= *Toona serrata* and UV=*Ulmus violosa*

Fig. 16 (a-j). Mixed tree communities with highest regeneration of one of the dominant species
(a= *Aesculus indica-Cedrus deodara* mixed community*,* b= *Abies pindrow-Aesculus indica* mixed community,c= *Cedrus deodara-Picea smithiana* mixed community*,*d= *Cornus macrophylla- Ulmus villosa* mixedcommunity*,* e= *Juglans regia- Ulmus villosa* mixedcommunity, f= *Pinus roxburghii- Toona serrata* mixed community, g= *Picea smithiana- Pinus wallichiana- Populus ciliata* mixedcommunity,h= *Picea smithiana- Taxus baccata* ssp. *walllichiana* mixed community, i= *Pinus wallichiana- Cedrus deodara* mixed community and j= *Taxus baccata* ssp*. walllichiana-Abies pindrow* mixed community)

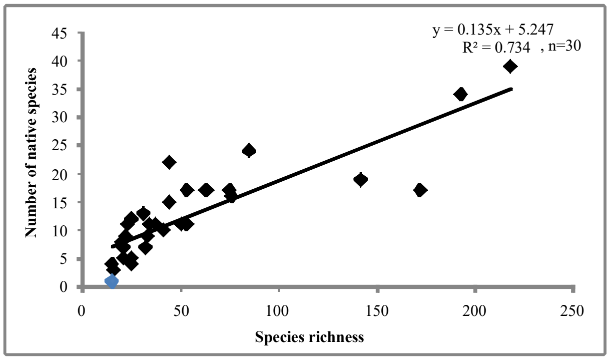


Fig. 17. Correlation between species richness and native species

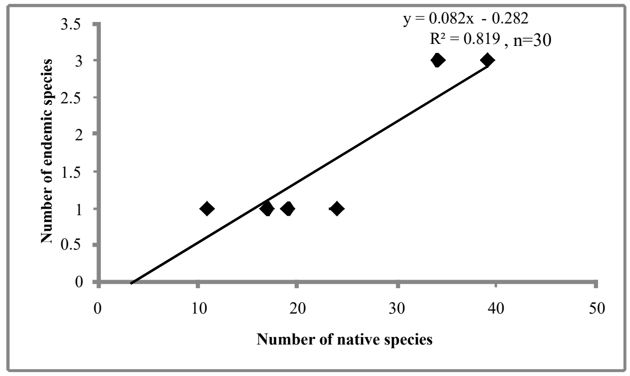


Fig. 18. Correlation between native and endemic species

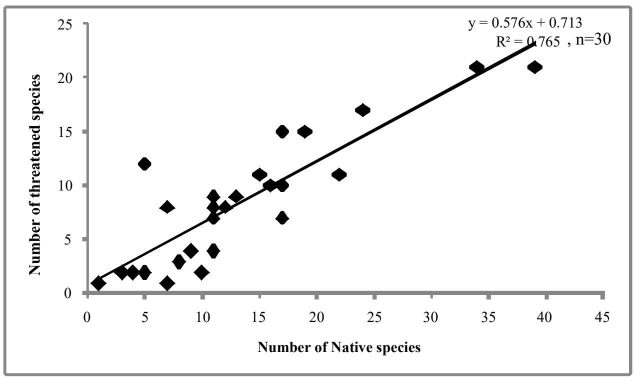


Fig. 19. Correlation between native and threatened species

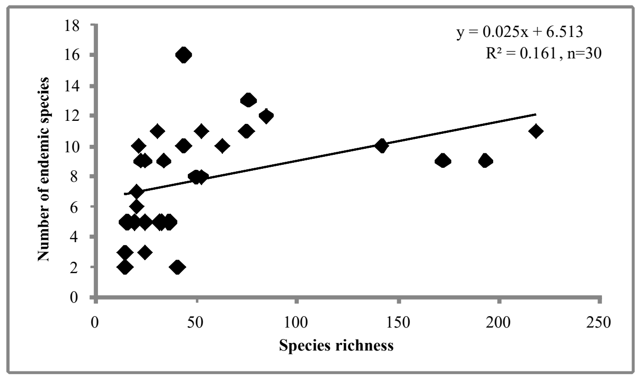


Fig. 20. Correlation between species richness and endemic species

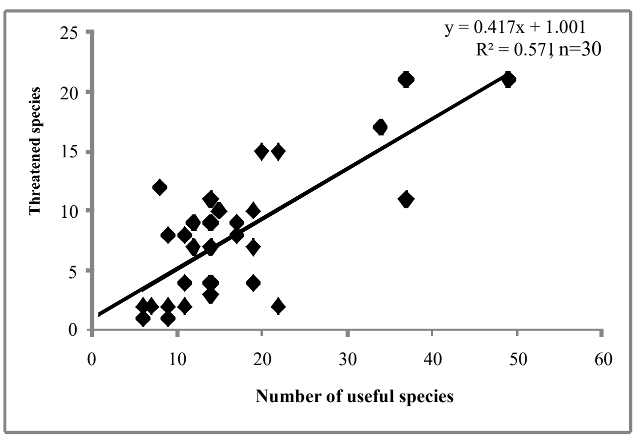


Fig. 21. Correlation between useful species and threatened species

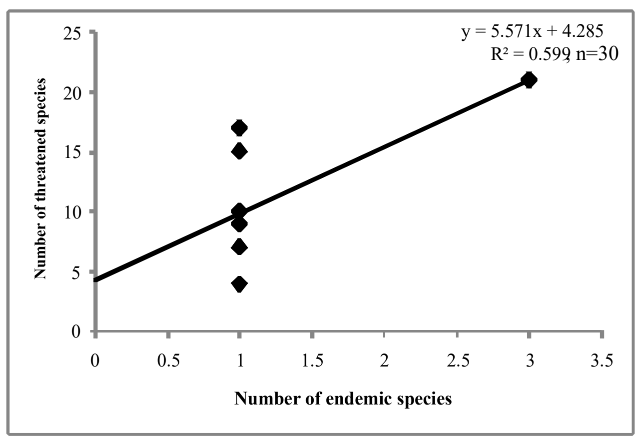


Fig. 22. Correlation between endemic and threatened species

will replace the tree species with some other species with no or very little economic value (Samant et al 2000, 2006) in near future.

Analysis of Correlation

Significant positive correlations between species richness and native species (r = 0.85, p< 0.01, n = 30) (Fig. 17); native and endemic species (r = 0.90, p < 0.01, n =30) (Fig. 18); number of threatened species with native species (r = 0.874, p< 0.01, n = 30) (Fig. 19); and endemic and threatened species (r = 0.773, p< 0.01, n = 30) (Figure 22) within the identified communities were found and indicating that the native and endemic species were severely affected due to anthropogenic and environmental stresses while relatively low positive correlations found between species richness and endemic species (r = 0.40, p < 0.01, n =30) (Figure 20). Positive correlation was found between the

Table 2. Community diversity, distribution pattern and major associates in the Parbati Valley

Community types	SR	Habitat	Altitudinal range (m)	Slope (°)	Aspect	Major associates
Abies pindrow	11	SM, Dg, D	2651-3340	20-60	NE,N,SW,SE,NW	*Taxus walllichiana, Acer acuminatum, Pinus wallichiana, Betula utilis,Picea smithiana, Quercus semecarpifolia & Acer cappadocicum*
Abies pindrow- Aesculus indica mixed	1	D,SM,R	2269	45	N	*Cedrus deodara*
Aesculus indica	2	D,B	2057-2226	45-50	W, NE	*Acer cappadocicum, Picea smithiana, Juglans regia & Quercus floribunda*
Aesculus indica - Cedrus deodara mixed	1	SM	1595	54	NE	*Celtis australis*
Betula utilis	3	SM,R	2980-3407	42-49	NW,N	*Taxus wallichiana Acer cappadocicum, Abies pindrow*
Cedrus deodara	11	SM, R,D,R,	1551-2342	10-60	NW, W, E,N, NE,W	*Picea smithiana, Pinus wallichiana, Toona serrata,Pinus roxburghii & Rhododendron arboreum*
Cedrus deodara-Picea smithiana mixed	1	SM	2206	20	NW	*Pinus wallichiana, Aesculus indica & Prunus cornuta*
Corylus jacquemontii	1	R	2552	48	NE	*Abies pindrow*
Cornus macrophylla-Ulmus villosa mixed	1	D	2556	45	SW	*Carpinus viminea*
Hippophae salicifolia	3	SM, Dg, R	2408-2493	25-75	E, W	*Salix daphnoides, Ulmus villosa, Pinus wallichiana & Abies pindrow*
Juglans regia-Ulmus villosa mixed	2	B,D	2262-2411	30-45	NW,W	*Prunus cornuta, Alangium chinense, Cedrus deodara, Picea smithiana & Pinus wallichiana*
Picea smithiana-Acer acuminatum mixed	1	R	2062	15	SE	*Juglans regia & Quercus floribunda*
Picea smithiana-Pinus wallichiana-Populus ciliata mixed	1	R	2480	45	W	*Alnus nitida, Hippophae salicifolia & Salix acutifolia*
Pinus wallichiana	10	D, R, SM	1711-3250	15-70	E, W ,S, NW, NE, SE, N	*Prunus cornuta,Picea smithiana, Cedrus deodara, Lyonia ovalifolia, Rhododendron arboreum, Abies pindrow & Aesculus indica*
Pinus roxburghii	1	R	1715	38	E	*Prunus cornuta*
Pinus roxburghii - Toona serrata mixed	1	R	1524	18	N	*Cedrus deodara*
Picea smithiana-Taxus wallichiana mixed	1	SM	2753	40	N	*Abies pindrow*
Pinus wallichiana - Cedrus deodara mixed	3	D, SM	1666-2261	35-60	SE, NW, N	*Pinus roxburghii, Rhododendron arboreum & Picea smithiana*
Populus ciliata	1	R	2142	50	SW	*Hippophae salicifolia & Pinus wallichiana*
Pyrus pashia	1	D	2225	30	S	-
Picea smithiana	17	R, SM D	2135-2833	20-70	NE, N, NW,W, E,SW,S	*Corylus jacquemontii, Abies pindrow, Acer acuminatum, Acer cappadocicum, Quercus floribunda, Aesculus indica, Juglans regia, Aesculus indica, Pinus wallichiana*
Pinus wallichiana - Pinus roxburghii mixed	1	Rr	1544	14	SE	*Cedrus deodara*
Quercus floribunda	3	SM, D	2062-2222	25-55	N, SW	*Picea smithiana* and *Abies Pindrow*
Quercus semecarpifolia	4	D, SM	2608-3137	35-60	SE, NE, E	*Picea smithiana, Abies pindrow* & *Ulmus villosa*
Quercus floribunda - Abies pindrow mixed	1	SM	2309	24	N	*Pinus wallichiana*
Salix daphnoides-Acer cappadocicum mixed	1	D	2240	30	N	*Picea smithiana, Rhododendron arboreum & Quercus floribunda*
Salix acutifolia	1	Dg	2165	25	SE	*Pinus wallichiana & Hippophae salicifolia*
Taxus wallichiana	1	SM	2910	42	NW	*Acer cappadocicum*
Taxus wallichiana - Abies pindrow mixed	1	R	2977	40	NE	*Acer acuminatum*
Ulmus villosa	1	D	2590	50	SE	*Juglans regia* & *Hippophae salicifolia*

Abbreviations used**:** SR=Site representation, B=Bouldery, D=Dry, Dg=Degraded, R=Rocky, Rr=Riverine, SM=Shady Moist, E=East, N=North, NE=North East, NW=North West, S=South, SE=South East, SW=South West, and W=West

Table 3. Total density, species diversity (H'), concentration of dominance (Cd) and total basal area (TBA) of tree communities in Parvati valley

Community type	TD (Ind ha^{-1})	H'	Cd	TBA m^2 ha^{-1}
Abies pindrow	411.80	0.36	0.47	48.10
Abies pindrow- Aesculus indica mixed	400.00	1.30	0.29	91.61
Aesculus indica	400.00	0.60	0.27	32.06
Aesculus indica - Cedrus deodara mixed	610.00	1.68	0.20	126.29
Betula utilis	603.30	0.52	0.72	15.14
Cedrus deodara	578.50	0.33	0.51	73.28
Cedrus deodara-Picea smithiana mixed	590.00	1.46	0.15	46.16
Corylus jacquemontii	450.00	0.77	0.53	0.58
Cornus macrophylla-Ulmus villosa mixed	510.00	1.08	0.35	12.38
Hippophae salicifolia	403.40	0.75	0.60	38.39
Juglans regia-Ulmus villosa mixed	500.00	1.34	0.22	37.71
Picea smithiana-Acer acuminatum mixed	400.00	1.35	0.18	16.42
Picea smithiana-Pinus wallichiana-Populus ciliata mixed	470.00	1.90	0.13	8.46
Pinus wallichiana	577.20	0.43	0.84	43.72
Pinus roxburghii	540.00	0.76	0.70	46.15
Pinus roxburghii - Toona serrata mixed	590.00	1.48	0.27	30.57
Picea smithiana-Taxus wallichiana mixed	440.00	1.13	0.35	20.17
Pinus wallichiana - Cedrus deodara mixed	595.00	0.04	0.32	35.62
Populus ciliata	540.00	0.77	0.26	25.13
Pyrus pashia	40.00	0.01	0.15	0.08
Picea smithiana	451.00	0.13	0.47	55.23
Pinus wallichiana - Pinus roxburghii mixed	800.00	1.33	0.30	46.33
Quercus floribunda	645.00	0.20	0.40	100.13
Quercus semecarpifolia	610.00	0.69	0.62	18.59
Quercus floribunda - Abies pindrow mixed	700.00	1.27	0.30	49.54
Salix daphnoides-Acer cappadocicum mixed	430.00	1.69	0.11	5.28
Salix acutifolia	500.00	0.94	0.18	7.16
Taxus wallichiana	630.00	0.99	0.43	3.61
Taxus wallichiana - Abies pindrow mixed	470.00	1.17	0.35	24.22
Ulmus villosa	370.50	1.02	0.49	10.56

Abbreviations used: TD=Total Density, H'= Species Diversity, Cd=Concentration of dominance and TBA=Total Basal Area

number of useful species and the number of threatened species ($r = 0.775$, $p< 0.01$, $n = 30$) (Figure 21) indicating that the number of threatened species was higher in communities having anthropogenic pressure. Higher number of useful species will lead to pressure on the selective species, resulting in the threat of extinction.

Implications and strategies for biodiversity conservation: Mountains are known to influence the livelihood of nearly 40% of people globally (Rawat 2011). Mountain ecosystems need proper management against negative climatic and anthropogenic influences for their future sustainability (Kessler 2000, Halloy and Mark 2003, Holzinger et al 2008, Erschbamer et al 2011). In addition to the scientific exploration of biotic and abiotic components of mountain ecosystems, there is also an immediate need for facilitation, social mobilization and education of the indigenous people of these remote regions. Education and awareness about habitat destruction, and decreasing biodiversity with increasing population and climate change are high priorities (Hermy et al 2008, Giam et al 2010). Furthermore, the indigenous people have a great deal of traditional ecological knowledge about vegetation ecosystem services, particularly provisioning services, which, in return, needs to be documented and incorporated into conservation and climate change adaptation strategies (Khan et al 2013). For conserving plant biodiversity, requires consistent and sound qualitative as well as quantitative records of botanical data on a regular basis (Clubbe et al 2010) and robust phytosociological (quantitative ecological) techniques are essential to achieve this. Moreover, the documentation of traditional knowledge aids in the preservation of indigenous culture, identifies threatened species and contributes to the conservation and management of plant diversity (Berkes et al 2000, Watson et al 2003). The conflict between conservation and livelihoods and between larger and local interests has become an integral part of conservation experiences in most parts of the world (Saberwal and Chhatre 2001). The Himalaya is one of the richest and most unusual ecosystems on earth with a variety of forest types due to great altitudinal and climatic variations from foothills to alpine peaks (Shaheen et al 2012). The region has a discrete geographic and ecological entity. Climatic, topographic, geological, and altitudinal variations have generated unique landscapes, ecosystems, and biota in the Himalaya. In view of the rapid loss of biodiversity in the IHR conservation of sensitive biodiversity elements has become essential. For this, the establishment of Protected Area Network which is the basic tenet of in situ conservation (Singh 2002) seems highly significant. It has now been realized that inventorisation of plants occurring in such areas is absolutely necessary and so are the initiatives from the Ministry of Environment, Forest, & Climate Change, Government of India (Subramani et al 2014). Anthropogenic activities and biodiversity are in conflict with each other. People choose species only because of their own needs and hence put pressure on rare species (Ahmad et al 2002). The information generated on these lines will provide a better insight about the present status of floristic diversity and help in developing adequate strategies and action plan for the management of such biodiversity rich areas. Besides, it would also generate baseline information for comparing future changes in regional as well as in global climate that is considered to be significant in changing scenario of the environment (Samant et al 2002). Inventory and monitoring of biodiversity in any area is prerequisite for conservation and management planning (Samant and Joshi 2005). Most of the species present in the study area is of high commercial value. Massive grazing and high extraction trends leads to habitat degradation, poor regeneration and population depletion of these species.

CONCLUSION

Conservation and management of any ecosystem in the Himalaya suffers due to difficult terrain, remoteness, hostile climatic conditions, lack of funds, low manpower, poor infrastructure, and lack of motivation among the management agencies and political will of the governments. Appropriate and suitable strategy should be implemented for the establishment of additional protected areas thorough biogeographic classification. Moreover, declaring protected areas alone would be inadequate to conserve the entire range of an ecosystem thus proper management is also required. In order to conserve ecosystem of the state more effectively the management authorities, ecologists and local communities need to initiate dialogues for (i) better grazing practice and management, (ii) sustainable harvest of high value medicinal and aromatic plants, (iii) improved watershed management and protection of degraded areas, (iv) protection of botanical hotspots and sites of rare endemic plants lying outside the existing protected areas. The research and development agencies need to revamp a well-coordinated long term research and monitoring of fragile alpine landscape.

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Secondary Ecological Succession of Landscapes in Vietnam along Indochina T-Junction

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Abstract: Human activities can influence the transformation rules of natural landscapes. In Vietnam along the Indochina T-junction (in Province Kon Tum), human influences determine the transformation and succession of landscapes, especially their ecological succession. The landscape maps to determine natural components and human factors involved in the transformation and secondary ecological succession in this study area were prepared. Satellite images in different periods, applied rules of formation and development of plant communities in tropical monsoon conditions were used to determine the secondary ecological succession of the landscape in the studied area. The studied area consists of one system, one subsystem, three classes, five subclasses, 11 types and 67 kinds of landscapes. Much of the landscape is under strong human influence, especially herbicides in chemical war, industrial-scale logging, deforestation of indigenous peoples to grow agricultural and technical crops. During 2005 - 2015, 17 different landscape kinds have been lost and 12 have been established. From 1960s, under the influence of chemical war and other anthropogenic impacts, some kinds of landscapes have experienced three to four stages of secondary ecological succession. Human activities continue to be the main factor in the transformation and secondary ecology succession of landscapes in the Indochina T-junction.

Keywords: Anthropogenic factors, Landscape change, Landscape diversity, Secondary ecological succession, Vietnam

As landscapes form, move and transform they undergo various stages of development that constitute a series of successional landscape types (Nguyen et al 2006, 2010, Triskov 2012). As a landscape progresses through successional stages, changes in vegetation, particularly those in forest cover, reflect and contribute to the development of the landscape (Marsinkevic 2005, Krzysztof 2008, Wu 2009, Triskov 2012, Royal Botanic Gardens 2016). Landscapes may also be altered by human use, habitation and natural resource extraction. These human activities can drive trajectories of change within a landscape that are different from those of successional change that occur within unoccupied landscapes (Nguyen et al 2006, Gusev 2012). Human influences often determine the transformation and succession of landscapes in general, and their ecological succession (Nguyen et al 2010, 2016, Marta 2018). The Indochina T-junction lies at the intersection of the borders of Vietnam, Laos and Cambodia. Within Vietnam, the territory that lies along this T-junction is a landscape of interwoven mountains, hills and valleys with a long history of development. Indigenous ethnic groups inhabit the landscape, as do ethnic groups from other places. The characteristics of human use and exploitation of the landscape within this territory are diverse and complex. In this area, the U.S. military sprayed herbicides, heavily affecting the landscape and the regional environment (Phung 1996, Nguyen et al 2006, Kon Tum Statistical Department 2016). In present study changes and secondary ecological succession of landscapes within the Vietnamese territory along the Indochina T-junction during the past half century are presented and the natural components and human factors involved in the transformation and secondary ecological succession of this landscape in the past and present are clarified because they provide insights on the prospect for this landscape's future.

MATERIAL AND METHODS

Data collection*:* The documents collected included the results of the following subject: "Researching structure and function of tropical forest ecosystems for conservation, restoration and sustainable use" of the Vietnam-Russia Tropical Center, materials on chemical war activities, data on population and characteristics of ethnic groups, and data on socio-economic characteristics of the study area. Point and route surveys were conducted in different terrain types to document and characterize both landscape features and human activities for spatial analyses. The boundaries of landscape units, especially the boundaries of different types and kinds of landscapes were verified. Data from these surveys were also used to document chemical war activities and characteristics of landscapes and the regional plant communities before, during and immediately after the war. Residents and local officials of Ngoc Hoi, Sa Thay and Ia H'Drai districts who lived in the area during the war were interviewed. Collect information on the change of vegetations in the changed, destroyed landscapes of war and other human activities over the past 50 years.

Mapping and GIS methods: These methods are widely applied in the fields of geography, ecology, environment, land use and natural resources management, etc. In particular to geoscience, mapping, remote sensing and geographic information systems play an important role. From studies of landslides (Suresh 2018) to studies of changes in land cover – land use or vegetation cover all apply these methods (Polisgowdar et al 2019, Tran et al 2019). Likewise, landscape ecology studies use these methods in the process of overlaying the component map layers. Component and landscape maps of the study area were compiled from SPOT and LANDSAT satellite images, using Computer program MapInfo Pro version 15 and ArcGIS version 10.2. The landscape maps were constructed from the component maps at a scale of 1:50000 by analyzing overlapping composite maps.

The method of overlaying map layers was used with program ArcGIS 10 (License ESU006984479, ArcGIS Desktop Basic); execute the Intersect model. The landscape map (result map) of the study area is made by overlaying the component map layers. According, for every patch includes all attributes of the component map layers (also landscape properties) (Nguyen et al 2019).

Comprehensive landscape assessment*:* A comprehensive landscape assessment was used to determine the status of landscape components, including the identification of plants within forested areas, agricultural areas and grass and shrub landscapes. This method was also used to evaluate ecological succession within the landscape by comparing the comprehensive assessment with data from field surveys. The comprehensive assessment of collected data was conducted with reference to remote sensing data; established origins and development trajectories of forest plant, grass and shrubs communities; and biological and ecological characteristics of crops in tropical monsoon conditions of Vietnam. Based on survey data and satellite images in some periods (Fig. 4 and 6), identify typical landscapes to describe the secondary ecological succession over the past half century.

RESULTS AND DISCUSSION

Characteristics of Landscape Components

Natural components*:* The area of Vietnam that borders the Indochina T-junction comprises three districts, namely, Ngoc Hoi, Sa Thay and Ia H'Drai of Kon Tum province. Its eastern side adjoins the Dak To, Dak Ha district and Kon Tum City. To the north, the territory adjoins the Dak Glei and Tu Mo Rong districts and to the south, it adjoins Ia Grai and Chu Pah, Gia Lai Province. The western portion of the territory adjoins the Attapeu province of Laos and Ratanakiri province of Cambodia. The total natural area of the territory bordering the T-junction is 324 235 hectares, accounting for 33% of the Kon Tum territory. The study area is primarily located on the tectonic unit of Kon Tum. This tectonic unit contains metamorphic formations of the Arctic and Proterozoic ages, sediments of Jurassic and Triassic, granite intrusions form the Ben Giang-Que Son complex, Cenozoic basaltic eruptions and Quaternary sediments (Luu et al 2015). The variety of geological formations found within the territory have led to the formation of diverse terrain types with mountainous terrain over 600 m high, low mountains, high hills and accumulation of eroded sediment in the valley.

The Indochina T-junction is located in the tropical monsoon climate sub region. Conditions are hot and humid all year round, with a short cold season, heavy rainfall and a moderate-length dry season (Nguyen et al 2010). The annual average temperature is 23°C, and the total operating temperature of the year is over 8000°C. Annual rainfall is 2000 mm. The area has two seasons; the rainy season occurs from May to October and the dry season occurs from November to April of the next year. The hydrological network is quite thick and relatively evenly distributed in three main river systems: the Sa Thay, Dak Sia and Dak Poko rivers. The Dak Poko river system has the largest basin area and flows across the entire research area.

There are 14 types of soils (Luu et al 2015). Red-yellow soils derived from acidic igneous rocks are widely distributed and cover an area of 62776 ha, primarily within the Sa Thay district. Red-yellow and yellow-red strongly weathered rocks are concentrated in the Sa Thay river valley. Reddish brown soil on basalt, ancient alluvial soil and new alluvial soil distributed along riverbeds also occur in the study area and are an important component of agricultural landscapes. There are several types of natural and anthropogenic vegetation types in the study area (Nguyen et al 2016). Evergreen broadleaf tropical forests are primarily distributed in the Sa Thay and northern Ngoc Hoi districts in low and medium mountainous terrains. The forest comprises four layers: the emergent layer is quite diverse and includes species such as *Anisoptera costata*, *Bischofia javanica*, *Canarium* sp. and *Dracontmelon* sp.; the canopy layer includes representatives from *Elaeocarpus*, *Endospermum*, *Garcinia* and *Sandoricum* , the understory layer includes species from the Bignoniaceae, Moraceae and Rubiaceae families and the forest floor includes the genera *Areca*, *Aglaonema*, *Bolbitis* and *Diospyros* and representatives of the Arecaceae, Araceae and Poaceae families.Semi-deciduous and deciduous forests primarily comprise species from Dipterocarpaceae, Lythraceae, Combrataceae, Combrataceae and Myrtaceae families. Wood and bamboo mixed forests are scattered throughout the study area. Human-cultivated grasses and shrubs in the area include *Imperata cylindrica, Eriochrysis porphyrocoma*, *Penisetum polystachion* and *Eupatorium odoratum*. Human cultivation has created landscape with a diverse mix of indigenous forest species, harvested plants, agricultural crops and fruit trees.

Anthropogenic factors*:* There are 18 indigenous and migratory ethnic groups that reside within the study area. The indigenous groups include the Gia Rai, Gie Trieng, Xe Dang, H'Lang, Ro Mam and Ro Ngao people (Kon Tum Statistical Department 2016) and the migratory ethnic groups include Kinh, Muong and Thai people. In 2015, the population of the three districts was 100 874. The average population density is 31individuals/km^2. District Ia H'Drai is more densely populated with 11 individuals/km^2, which is still a relatively low-density population compared with that of areas of the Central Highlands and of Vietnam as a whole. The main economic activities of Ngoc Hoi, Sa Thay and Ia H'Drai districts are agricultural production, forestry and biodiversity conservation. The agricultural activities of individuals inhabiting the region have been directly affected by changes in the region's landscapes. The main human activities that cause landscape change include free migration, nomadic migration, deforestation associated with land cultivation, forest exploitation, farming on sloping land and structural changes in crops. Types of forestry activities within the study area include the protection of special-use forests, particularly in Chu Mom Ray National Park, planting of paper-material forests and aromatic plants. The area within the three districts of Ngoc Hoi, Sa Thay and Ia H'Drai is one of the first places where the US military tested the use of herbicides during the war in Vietnam. From 1961 to 1970, more than 40% of the area was repeatedly sprayed with high concentrations of herbicides. The herbicides used were orange, white and blue agents (Arthur 1981, Phung 1996, Nguyen et al 2006). Several areas of the forests have been destroyed and have turned into grasslands and shrubs. Other areas have been restored to forest vegetation, but the quality of these systems has not yet completely recovered, and there are few reserves.

Landscape Characteristics

Taxonomic systems and classification criteria for the landscape*:* In accordance with the type viewpoint, a taxonomic system comprising six ranges (Pham Hoang Hai et al 1997, Nguyen et al 2016), namely, System → Subsystem → Class → Subclass → Type → Kind, was chosen. Using these six ranges, a landscape map of the area bordering the Indochina T-junction was built at the rate of 1/50000. The characteristics of the taxonomic system and classification criteria for the landscape are shown in Table 1.

Landscape diversity in the Indochina T-junction: With a combination of natural components and components either built or transformed by humans, the Indochina T-junction territory is quite diverse and comprises three classes, five subclasses, 11 types and 67 kinds of landscapes (Fig. 1 and 2). The area lies entirely within the highland monsoon tropical landscape subsystem belonging to the monsoon tropical system.

The study area has three landscape classes, namely, mountains, plateaus and valleys, which are valleys between the mountains. The mountainous class is subsequently

Table 1. Taxonomic ranges and classification criteria for the landscape in the Indochina T-junction

Taxonomic range	Classification criteria
System of landscape	The decisive role of the atmospheric circulation regime in the process of climate formation in the belt
Subsystem of landscape	The decisive role of the regime of atmospheric circulation in the process of climate formation and ecological region of the flora
Class of landscape	Relief configuration, which determines the homogeneity of two large processes, namely, erosion and concentration, in the real cycle
Subclass of landscape	The peculiarity of the formation of large relief forms manifests the property of nonzone on the basis of the combination of relief and typical geomorphological processes
Type of landscape	The quantitative peculiarity of bio climate and anthropogenic activities, which determines the formation of vegetation groups (except for the type of reservoir)
Kind of landscape	Differentiation of vegetations on different types of soils (except for the kind of reservoir)

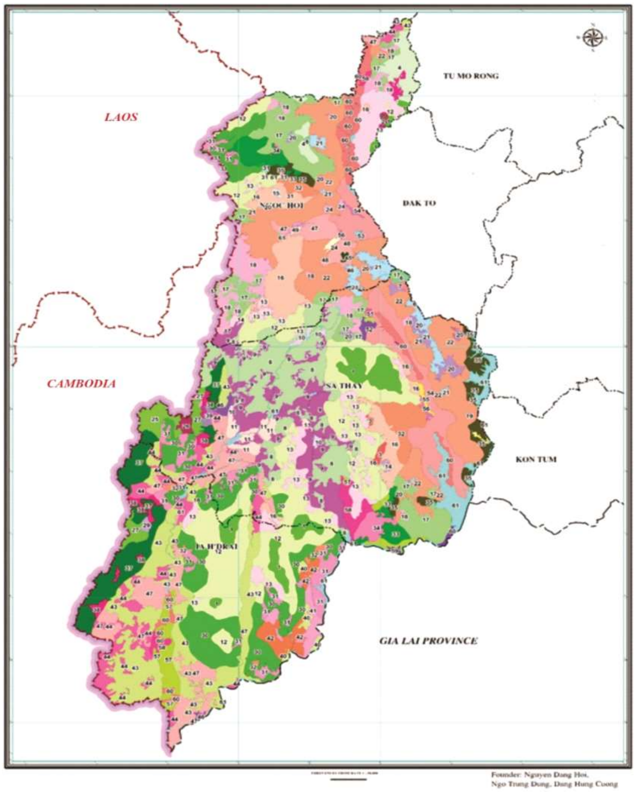

Fig. 1. Landscape map of the Indochina T-junction

divided into three subclasses, namely, medium mountainous subclass with heights over 1000 m, low mountainous subclass with heights 600-1000 m and a low mountain/high hill subclass below 600 m (Fig. 2). The medium mountainous subclass includes areas from 1000 m to 1773 m in height and is further divided into two types and 11 kinds of landscapes (numbers 1–11 on the map). The low mountainous subclass includes areas from 600 m to 1000 m and is further divided into two types and 18 kinds of landscapes (numbers 12–29 on the map).The low mountain/high hill subclass includes areas lower than 600 m and is further divided into two types and 10 kinds of landscapes (numbers 30–39 on the map).The low plateau subclass is divided into two types and 3 kinds of landscapes (numbers 40–42 on the map).The subclass comprising valleys and hollows between the mountains is divided into three types and 18 kinds of landscapes (from number 43 to number 61).

Landscape change in the study area*:* To clarify the characteristics of landscapes under human impact within the Indochina T-junction, a landscape map was established in 2005, which provided a basis for comparisons over the 2005–2015 study period. During this 11-year period, the region's landscapes have considerably changed. The results indicate that 17 kinds of landscape have been lost and 12 new kinds have been established. The lost landscapes include five kinds of grassland-shrubs, five kinds of plantation, five kinds of agricultural crops and two kinds of plants in the residential areas. During this period, 12 new landscapes were established, including seven of mixed wood and bamboo forests, one of grassland-shrub, one of plantation forest and three of industrial crops. Among these, landscapes of mixed wood and bamboo forests have the highest diversity and cover the largest area (18127.02 hectares), accounting for 5.6% of the total study area. Human activities have had strong impacts on regional landscapes, including some positive and negative changes. Figure 3 shows the transformation of landscapes in the Indochina T-junction under human influence, including notably the chemical war period.

Secondary ecological succession of landscapes*:* The landscapes within the research area have developed under the strong influence of humans, which includes chemical war (herbicides used by the US forces) and industrial-scale logging, deforestation of indigenous peoples to grow agricultural and technical crops. Research results show that, under the impact of chemical war and industrial-scale logging, most kinds of tropical forest landscapes turn to landscapes of grasses and shrubs and maintain for decades. In the valleys or areas adjacent to the landscape of natural forests, the succession takes place in the direction of restoring landscape with the dominant of native species and some deciduous species. In areas where people exploit trees to cultivate trees, form landscapes of agricultural and technical crops or landscapes of plantations.

In the west of Ngoc Hoi and Sa Thay districts, results indicate that landscapes of grasses, mixed wood forests and bamboo forests in flat terrain are the result of a post-chemical war succession sequence. Secondary ecological succession within landscapes can follow different trends. The first trend occurs in the valleys, follows stream, after approximately 25-30 years, semi-deciduous tropical vegetation was created with the advantages of dry, drought-resistant plants of Lythraceae, Dipterocarpaceae and Myrtaceae (Fig. 4, Fig. 5a, landscape kind 49). The second trend is the formation of agricultural landscapes, anthropogenic forests that feature a radical change of vegetation by season (annual agricultural crops), cycles of 5-10 years for raw materials and long-term industrial crops (Fig. 4, Fig. 5b, landscape kind 51). The third trend is the continuation of grasslands and shrubs that are often intentionally or unintentionally burned in the dry season (Fig. 5c, landscape kind 30). Landscape kinds formed on the low-medium mountainous terrain Charlie in the north of Sa Thay district (Fig. 6) exhibited very special successions. Landscape kinds of this area also exhibit three main trends, namely, *(i)* after destruction by herbicides and napalm

LANDSCAPES CLASS	LANDSCAPES SUB-CLASS	LANDSCAPES TYPE / LANDSCAPES KIND	Vegetation: Natural vegetation: Evergreen broadleaf tropical forest	Wood and bamboo mixed forest	Semi-deciduous forest (dominance of Dipterocarpaceae and Lythraceae)	Grasslands and shrubs	Anthropogenic vegetation: Plantation forest	Industrial crops	Cereal and other annual crops	Plants in residential areas	Reservoir
		Average temperature is 23°C, total annual temperature (>10°C) is 8000°C. Total annual rainfall is about 2000mm									
Mountain	Average mountain 1000-1773m; Typical process: rapid gravity and erosion	Yellow-red soil on magma acid	1	2				3			
		Yellow-red humus soil	4	5			6	7			
		Yellow-red humus soil on the slate	8	9		10		11			
	Low mountains 600-1000; Typical process: Slow gravity and erosion	Red-yellow soil on magma acid	12	13		14	15	16			
		Red-yellow soil permeable magma rocks	17	18	19	20	21	22	23	24	
		Red-yellow soil on the slate	25	26							
		Yellow soil on the pebbles and sandstone	27	28		29					
	Hills and low mountains below 600 m; Typical process: soil erosion	Red-yellow soil on magma acid	30	31				32			
		Red-yellow soil permeable magma rocks	33	34				35	36		
		Yellow soil on the pebbles and sandstone	37	38		39					
Plateau	Basaltic plateau under 600 m; Typical process: soil erosion	Brown-red soil on basalt	40	41				42			
Valley and hollow between the mountain		Red-yellow soil and Yellow-red soil on different rocks	43	44	45	46		47	48	49	
		Ancient alluvial soil	50	51		52	53	54	55	56	
		New alluvial soil	57	58		59		60			
Reservoir											61

Fig. 2. Legend of landscape map of the Indochina T-junction

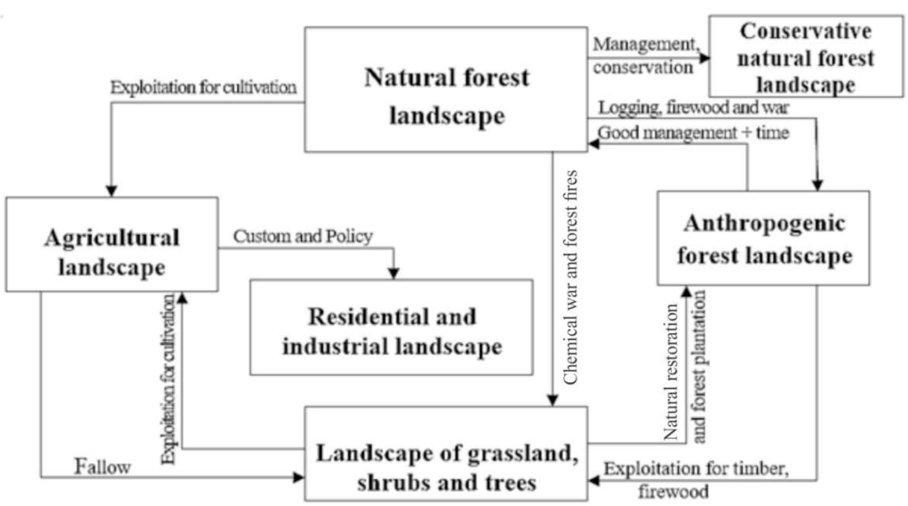

Fig. 3. Diagram of landscape change in the Indochina T-junction (Nguyen et al 2016).

bombs, grassland and shrubs formed and subsequently pine forests formed (*Pinus kesiya*) (Fig. 6; Fig. 7a, landscape kind 59); *(ii)* similar to the first trend, but the dominant plant was *Litseaglutinosa* ((Fig 6; Fig.7b, landscape kind 59) and *(iii)* landscapes that persist as grasslands and shrubs were usually intentionally or unintentionally burned in the dry season by humans (Fig. 6; Fig.7c, landscape kind 10).

The natural forest landscapes in Chu Mom Ray National Park have been under different impacts, being managed and protected. The succession trend here is consistent with the natural law of the tropical and broad-leaved subtropical forests. However, because of management, restoration and conservation activities, the succession of landscape stills exhibits the vestige of human activities against the background of natural successional processes. The process of secondary ecological succession of landscapes in the Indochina T-junction occurs quickly in most transition periods, particularly transitions in the kind of landscape (e.g.

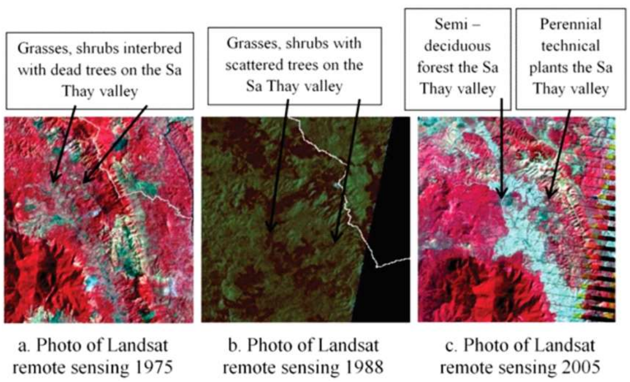

Fig. 4. Image of landscapes on remote sensing photos for some periods (on Sa Thay valley)

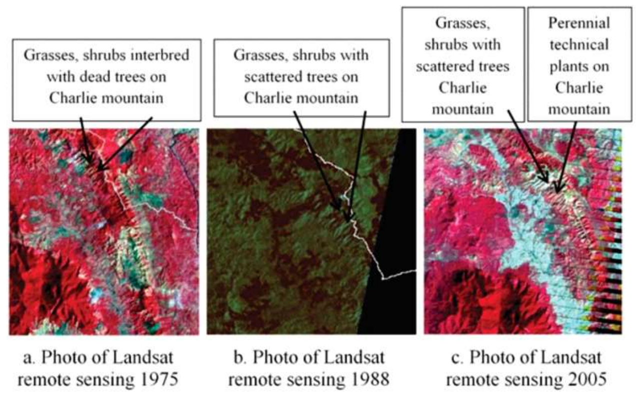

Fig. 6. Image of landscapes on remote sensing photos for some periods (on Charlie mountain)

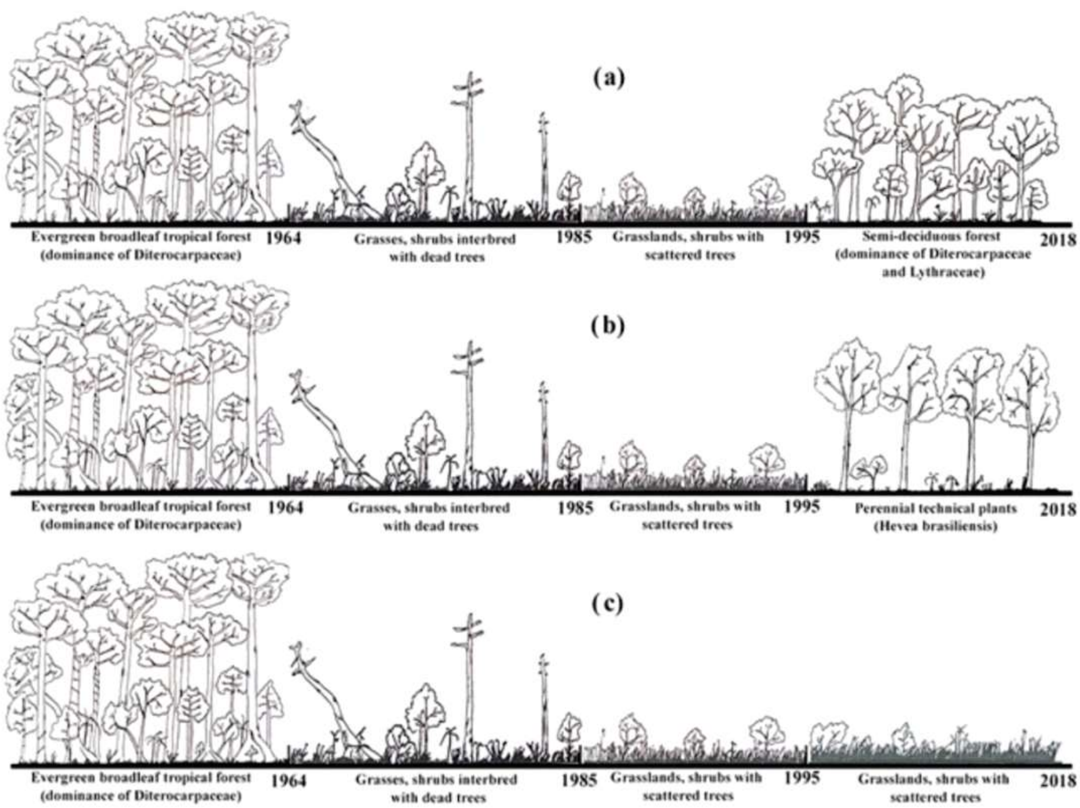

Fig. 5. Successional sequence within the landscapes of the Sa Thay Valley following the chemical war

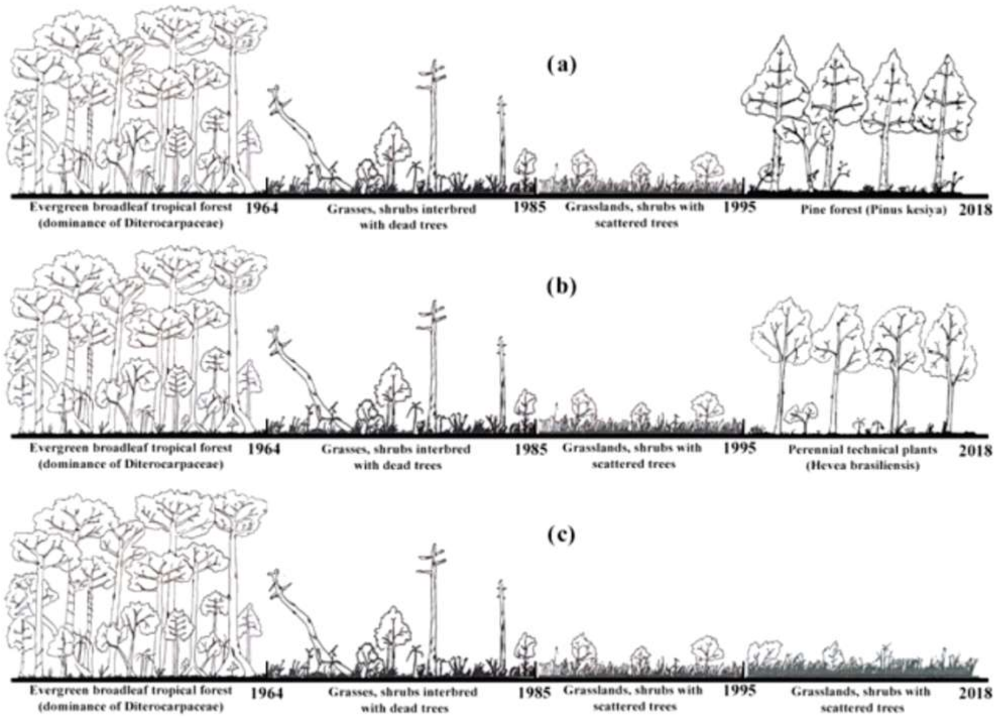

Fig. 7. Successional sequence in the landscapes of Charlie Mountain following the chemical war

a transformation from agricultural to rural residential landscapes or from plantation forests to a landscape of industrial crops).

The process of secondary ecological succession of vegetation in the landscape has changed some types of land use. Our results indicate that from 2005 to 2015, the extent of industrial crops in the landscape has been increasing, which makes the process of secondary ecological succession in the area of the Indochina T-junction increasingly complex. In addition, with the enhancement of territorial management, production of material and commodity trees and establishment of settlement sites, negative impacts such as burning forest, burning grass and shifting cultivation have considerably decreased. The crop conversion process creates a very short period (several years or 5 - 10 years) within the sequence of secondary ecological succession of the landscape in this region.

The differentiation on natural conditions and human activities (including herbicides in chemical war) had contributed to the formation of a diverse landscape system in the study area. The landscapes in the studied territory have been influenced by human activities at different levels. Although there are still landscapes keeping the development under natural rule (for example, in Chumomray National Park), other landscapes changed dramatically and directly depended on human impacts. Especially, the types and kinds of landscapes that have experienced the drastic transformation of the plant component – vegetation and soil. Class of mountain has the highest diverse landscape, with 6 types and 39 kinds, in which, subclass of medium mountain divided into 2 types, 11 kinds and subclass of low mountain - 2 types, 18 kinds. Compare with research in other nearby locations, this class is more diverse than the same class in Konkakinh – Konchurang conservation territory, Gialai province (5 types and 33 kinds), which has the similar latitude (Nguyen et al 2018) and in Daklak province (1 type and 27 kinds) (Phan 2018). This diversity of the studied area is due to three reasons. The first reason is the differentiation of elevation, especially in the Chumomray mountains. The next reason is that the landscape kinds of evergreen broadleaf tropical forest are well preserved in Chumomray National Park. The last is the diversity in agricultural landscapes, which can be referred to the kinds of industrial crops.

The plateau class witnesses the slight differentiation. This class has only 1 subclass (subclass of basaltic plateau under 600 m with predominance of soil erosion process), 2 types and 3 kinds, which means that it is nowhere as many as plateau class in Konkakinh - Konchurang conservation territory with 3 types and 22 kinds (Nguyen et al 2018). The landscapes have been affected by the long-term impact of human activities in different scales and levels, mainly the forest development policies and cultivation habits and chemical war. Anthropogenic impacts are the main cause of dramatic changes at type and kind level. Figure 3 clearly shows the dramatic transformation of the landscape under human activities. Accordingly, natural forest landscapes can be changed to agricultural landscapes due to exploitation for cultivation or transform into grass, shrub and scattered trees landscapes under the impact of chemical warfare, napalm bomb without undergoing any intermediate landscape. Secondary ecological succession is particularity of the type and kinds of landscape in the studied area. Under the natural impact and anthropogenic factors, the landscape succession experienced in different stages and trends. This result is also consistent with the research of Gusev (2012) about landscapes in the southeast Belarus and result of Triskov (2012) about succession of vegetation in zonal ecosystems in Russia. At the same time in another author's own research (Nguyen et al 2018) about landscapes in the Konkakinh – Konchurang conservation territory, Gialai Province, Vietnam also point out similar conclusions. Many kinds of landscape in studied area experienced a process of development with abundant changes caused by living behaviors and livelihood of local residents and chemical war of US forces. Depending on the location and types of human impacts, the successional sequence observed within landscape, particularly within various kinds of landscapes, take on different trends and periodicities. In the western part of studied area, a very special type of secondary ecological succession takes place in the tropical landscape after the impact of chemical war. These dynamics are present not only in the Central Highlands of Vietnam but also globally, where there is a pattern of secondary ecological succession of landscapes in monsoon tropical forests with the dominance of Diterocarpaceae under the influence of chemical war. The herbicide almost destroyed the natural vegetation and results in the dominance of Dipterocarpaceae. After the spraying of herbicides and napalm bombs (which occurred in this region approximately 50 years ago), grassland was established in landscape and was maintained for several decades.

Depending on the location and characteristics of human impacts, the succession of landscape has taken place in different directions and stages, especially at the level of kind. In the last past 55 years, kinds of landscape often experienced through 3 - 4 stages of the succession sequence. This result is similar to the author's own research in many different regions in Vietnam such as Giolinh District, Quangtri Province, Konkakinh – Konchurang Conservation Territory, Gialai Provinces (Nguyen et al 2019). Meanwhile, in the study about the successions of plant in zonal ecosystems in temperate region, from the pioneering stage to the climax stage, Triskov (2012) recorded that vegetation can undergo from two to six stages. The study results of Marilia Cunha-Lignon et al (2009) about the mangrove forest succession in the Cananéia-iguape coastal system, Brazil had made a note of 4 stages, from sediment deposition to the formation of mangroves with the abundance of *Avicennia schaueriana*. Gusev (2015) announced that the recovery succession of the landscape after human impact includes 6 stages. Thus, on a concrete territorial unit, in addition to the natural elements and properties of plants, the rule of ecological succession is also regulated by anthropogenic factors such as policies, cultivation practices and the types of territory exploitation. Each stage of ecological succession has not the same length according to each development direction of the landscape. It depends closely on changing the cultivation practices of indigenous people and the administration policies. For example, on Charlie mountain (a mountain in the studied area), before 1964 was a primeval forest, after that a 21 year of grasses, shrub interbred with dead trees dominated. From 1985 to 1995 grassland and shrubs with scattered regeneration trees appeared and then until now (about 20 years), this area has become plantation forest (Fig.7a). This result is comparable to our research results in Quangtri Province and Konkakinh-Konchurang conservation territory (Nguyen Dang Hoi et al, 2018). Gusev AP (2015) found the lengths of stages are very different. Accordingly, the length of the 6 stages is respectively: 1, 2, 5-6, 8-12, 20-30, 60-80 years. The process of secondary ecological succession of a landscape can be repeated, but there has been changes in properties (e.g. the structure and composition of plants). For instance, the rotation between the rice field landscape and grasslands-shrubs landscape occurs in cycles of 3-7 years as a result of cultivation habits of ethnic minorities, such as Gia Rai, Xe Dang and GieTrieng. Therefore, if the landscapes are not appropriately managed, these landscape kinds will deteriorate (both in terms of environmental health and economic efficiency).

CONCLUSION

The Indochina T-junction area in Ngoc Hoi, Sa Thay and Ia H'Drai districts has a relative strong differentiation, creating a diversity of landscapes. Accordingly, the area has one system, one subsystem, three classes, five subclasses, 11 types and 67 kinds of landscapes. Much of the landscape is under strong human influence, especially herbicides in chemical war, industrial-scale logging, deforestation of indigenous peoples to grow agricultural and technical crops. During 2005-2015, 17 different landscape kinds have been lost and 12 have been established. Several landscape kinds have changed in size and quality. Over the past 50 years, under the influence of chemical war and other anthropogenic impacts, several landscape kinds have experienced three to four stages of secondary ecological succession characterized by different vegetation types. Accordingly, human activities (especially, to grow agricultural and technical crops) continue to be the main factor in the transformation and secondary ecology succession of landscapes in the Indochina T-junction.

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Water Footprint of Crop Production: A Review

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Abstract:Increasing water scarcity means that water footprint may become a valuable tool to manage our water resources better, and focus on water footprint has been increased worldwide—the water footprint with three components blue, green and grey. Blue and green used a significant portion of agricultural water and the least greywater used. The water footprint depends on the consumption and production perspective. In this study, focused was paid on crop water footprint and amount of water used in grown particular crops and subsequent water required to assimilate a load of fertilizer. The literature showed water footprint quantified at regional, national and global level. Most of the author's used the CROPWAT and AquaCrop model for the assessment of water footprint. Eighty-six per cent of studies aimed to quantify water footprint and it's distinguish components, while the remaining 14 per cent water and fertilizer demand comparisons with other footprints. It emerged that most studies that quantified water footprint concerned grain production 53 per cent, including rice and wheat, and the remaining 47 per cent focused on vegetables, fruit production, agricultural products and pulses.

Keywords: Water footprint, Crop production, WFP

Humans have altered the biosphere and the global water cycle significantly by converting natural vegetation into cropland or pasture and extracting water from surface or groundwater bodies to support crop production (Ellis and Ramankutty 2008, Rost et al 2008, Scanlon et al 2007). Freshwater is a renewable but limited resource. About 70% of current water withdrawals are for agricultural production (Molden et al 2007, Fader et al 2011), and population growth, economic development, urbanization, dietary changes and climate change will further increase water demand for food production in the future (Rosegrant and Sombilla 1997, Vorosmarty et al 2000, Steinfeld et al 2006, Liu and Savenije 2008, Liu et al 2008). Producing more food per drop of water is a crucial strategy to address water stress and food insecurity (Brauman et al 2013). Low water use efficiencies have added to the deepening water crisis. It is necessary to calculate the amount of water used in agriculture and measure water consumption directly and indirectly of water consumption in agriculture, which help generate different methods to decrease water consumption per unit of the crop.

Allan (1997) first introduced the concept of the virtual water i.e. the volume of water used to produce a commodity. The concept of water footprint introduced by Hoekstra (2003) and subsequently elaborated by Hoekstra and Chapagain (2008) provides a framework to analyse the link between human consumption and the appropriation of the globe's fresh water. The water footprint is the total fresh water volume used to produce the product (Hoekstra et al 2009). The water footprint (WF) is a measure of a human's appropriation of freshwater resources, considering direct and indirect water use (Hoekstra et al 2011). The WF is a measure of consumptive and degradative freshwater use. The water footprint has divided into three components based on water consumption viz: blue, green and grey. The green WF indicates the volume of rainwater consumed during the crop growth period; the blue WF includes the volume of surface and groundwater consumed. The grey WF measures the volume of freshwater, which is required to assimilate the nutrients and pesticides leaching, running off from crop fields and reaching the groundwater or surface water, based on natural background concentrations and existing ambient water quality standards (Hoekstra et al 2011, Mekonnen and Hoekstra 2014). Crop production needs a large quantity of green and blue water (Siebert and Doll 2010). The WF of a crop offers a calculable indicator to measure the volume of water consumption per unit of crop and the volume of water pollution (Hoekstra and Chapagain 2008, Hoekstra et al 2011). Hoekstra and Hung (2002, 2005) were the first to make a global estimate of water use in wheat production. It is possible to approach water issues by categorizing green, blue and grey water. The global water footprint related to crop production during 1996-2005 (Mekonnen and Hoekstra 2010) was 7404 billion cubic meters per year (78% green, 12% blue, 10% grey).

This article aims to find a literature review on the Water Footprint (WF) of crop production and water required for pullulate assimilation. In the last few years, several researchers published studies on water footprint.

Concept of Water Footprint

The concept of water footprint comes into existence in 2002 by Hoekstra. Mekonnen and several studies focused on developing the concept of water footprint and quantifying the water footprint of a large variety of products from a consumption perspective at either global or national scales (Long et al 2005, Ma et al 2005, Chapagain and Hoekstra 2007, Chapagain and Orr 2009, Bulsink et al 2010, Liu and Yang 2010, Mekonnen and Hoekstra 2011). Hoekstra and Chapagain, 2007 gave global water footprint, and India has the highest water footprint worldwide. Hoekstra (2011) ranked countries according to their WF during the period 1996-2005.

Water Footprint of Crops

Agricultural practice plays a vital role in managing the water footprint for sustainable agriculture. Irrigation is a significant factor resulting in water scarcity (Rosegrant et al 2002, Mekonnen and Hoekstra 2016). Water footprint assessments help find solutions and contribute to better water resources management (Aldaya and Hoekstra 2010). Mekonnen and Hoekstra (2010) analysed crop production global water footprint for ten years. There are three water footprint types (green, blue and grey) in crop production, and the least focused on the grey water footprint. Sun et al (2012) described that crop production's water footprint depends on two factors: total water consumption (green and blue water) and crop yield. Irrigated agriculture gets water from irrigation (blue water) and precipitation (green water), while rainfed agriculture only receives green water. Crop production requires much water and pollutes a large volume of water. Several studies have focused on developing the concept of WF and quantifying the WF of a large variety of products from

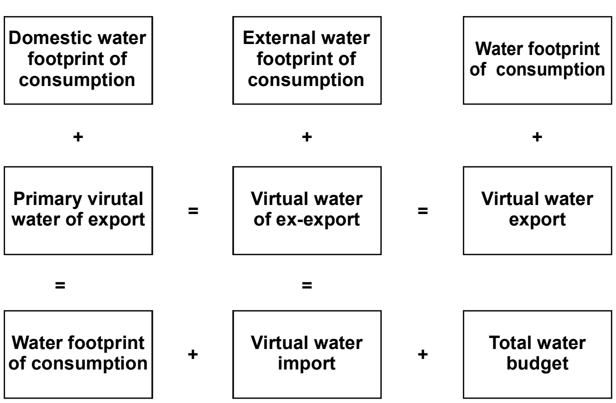

Fig.1. The relation between the water footprints of production and consumption and virtual water trade (Hoekstra et al 2011)

a consumption perspective (Long et al 2005, Hoekstra and Chapagain 2007, Liu and Savenije 2008, Van et al 2009, Bulsink et al 2010, Ge et al 2011). Total global crop water use was 6685 $km^3 year^{-1}$ from 1998 to 2002.

Green water footprint: The green water footprint refers to the consumption of amount total precipitation water used in crop production. Mekonnen and Hoekstra (2010) concluded that the green water footprint represents 80% of the global water footprint. Yoo et al (2013) estimated green water footprint for rice in Korea was 294.5 m^3 ton^{-1}. Zhuo and Hoekstra (2017) studied the effect of varying agricultural management practices on green water footprint. As per the estimate, 72% of the Spanish olive oil production is rainfed, and just 12% is irrigated (Salmoral et al 2011).

Blue water footprint: The blue water footprint refers to the use of surface and groundwater for food products. The global share of blue water footprint is about 10% (Mekonnen and Hoekstra 2010). Currently, four billion people live under severe blue water scarcity for at least one month a year, and 0.9 billion of the four billion live in China (Mekonnen and Hoekstra, 2016). Zhuo and Hoekstra (2017) studied the effect of varying agricultural management practices on blue water footprint.

Grey water footprint: Chapagain et al (2006) introduced the concept of grey component related to freshwater pollution. Most of the studies consider grey water footprint is related to nitrogen use, and Liu et al (2012) also related grey water footprint with phosphorus. The amount of nitrogen that reaches the water bodies is assumed to be 10% of the total fertiliser applied. Grey water footprint is mainly due to the nutrient load of fertilisers used in agriculture, sewage and industrial wastewaters (Liu et al 2012, Mekonnen and Hoekstra 2015). Gil et al (2017) estimated grey water footprint for nitrogen, phosphorus and pesticide of greenhouse cultivated tomato from 2010 to 2013 in Colombia. The polluted water leached into water bodies, Verge et al (2017) examined the effect of time step on the calculation of annual GW footprints by utilizing 30 years of average daily nitrate-nitrogen (NO_3-N) concentrations in drainage water from corn and soybean production systems.

Water Footprint of agricultural productions: The problem of global water accessibility and scarcity considered in various ways includes identifying areas of water availability, water stress, impacts of water use, and projections of future water scarcity (Oki and Kanae 2012, Pfister et al 2009, Wada 2011). Hoekstra and Hung (2002) introduced mapping of the impact of consumption by the people on the global water resources with the help of 'water footprint', and this concept elaborated by Chapagain and Hoekstra (2004). Chapagain and Hoekstra (2010) assessed the green, blue and grey WFs of rice using growing condition data on the actual irrigation of significant producers such as Japan and Korea. Mekonnen and Hoekstra (2010) estimated the green, blue and grey WFs of wheat in a spatially explicit way, both from a production and consumption perspective. Mekonnen and Hoekstra (2011b) quantified the green, blue, and grey WFs of global crop production in a spatially explicit way by taking a high-resolution approach, estimating the WF of 126 crops on a 5 by 5 arc minute grid for the period of 1996-2005. The computation of water pollution levels in river basins based on grey WFs versus assimilation capacity (Liu et al 2012). Zhuo et al (2016a) studied the inter-annual variability and trends in WFs and VWT. Developed water footprint benchmarks for crops (Zhuo et al 2016b), assessed of monthly blue water scarcity at a high spatial resolution based on patterns of blue WFs versus patterns of water availability (Mekonnen and Hoekstra 2016). Reduced the water footprint (WF) of crop production, i.e. the consumption of rainwater (green WF) and irrigation water (blue WF) per unit of crop, is a means of increasing water productivity and reducing water scarcity (Hoekstra 2017).

Chapagain et al (2006) estimated the water footprint of cotton products consumption and assessed major cotton-productive countries from 1997 to 2001. The result showed that 256 Gm^3 per year water required worldwide, out of which 42% was blue water, 39% green water and 19% greywater. A study was conducted in Beijing in North China to evaluate the sustainability of water utilization by calculating the water footprint in 2007 and 2010, based on actual and virtual water consumption (Ma et al 2015). Chapagain and Hoekstra (2007) assessed the water footprint of coffee and tea consumption and processing and estimated 140 billion cubic meters of water required for worldwide coffee and tea consumption. The total water footprint of Dutch coffee and tea consumption amounts to 2.7 billion cubic metres of water per year. Every nation has a different water footprint, and consumption of water depends upon their inhabitants. Hoekstra and Chapagain (2007) calculated the water footprint for each nation of the world for 1997–2001. The estimated average value of water footprint of USA 2480 m^3 cap^{-1} $year^{-1}$, china 700 $m^3 cap^{-1}$ $year^{-1}$ and global 1240 $m^3 cap^{-1}$ $year^{-1}$.

Global water withdrawals increased double in the last four decades (Gleick 2003a). Several researchers conducted studies to quantify the water footprint of a large variety of different crop products (Chapagain and Hoekstra 2003, 2004, 2007, Oki and Kanae 2004, Hoekstra and Hung 2005, Chapagain 2006, Hoekstra and Chapagain 2008). Ming and Chen (2013) calculated the water footprints of 112 countries and significant sources of water consumers were analysed. Less than 35% of the global virtual water consumed by agricultural products. Liu et al 2003 estimated both the blue and green water components of consumptive water use (CWU) for various crops. According to Hoekstra and Mekonnen (2012), 92% of water footprint due to agricultural production and a nearby one-fifth of water footprint related to export.

Yoo et al (2009) quantified the amount of water required to produce 1 ton of rice in Korea. Chapagain and Hoekstra (2011) quantify globally freshwater used in rice production and water footprint components and collected higher spatial resolution and local data on actual irrigation. The global water footprint of rice production was 784 $km^3 year^{-1}$ with an average of 1325 $m^3 t^{-1}$, 48% green, 44% blue, and 8% grey. The annual evaporation and polluted waters were 2279 Mm^3 and 178 $Mm^{3,}$ respectively. Salmoral et al (2011) evaluated the water footprint of Spanish olives and olive oil over 1997-2008. The water footprint for the region determined as volume per unit of product. The result showed that 99.5 % water footprint related to 1 litre of olive oil production and the remaining 0.5 % due to bottle, cap and label. The green, blue and grey water footprint was 84%, 6% and 10%, respectively. Yoo et al (2013) calculated the green, blue and grey water footprint of rice in Korea. The maize water footprint was assessed by Sun et al (2013) in Beijing from 1978 to 2008, and the result showed that the multi-year average WF of maize was 1,031 m^3 ton^{-1} which was 56% green, 25% blue, and 19% grey.

Several studies reported the growing freshwater scarcity in different parts of the world (Gleick 1993, Hoekstra et al 2012, Oki and Kanae 2006, Postel 2000, Vörösmarty et al 2010, Wada et al 2011) Domestic water consumption effect the need of irrigation water and Duarte et al (2014) examined water consumption in the production of vegetable and animal products for five different years: 1860, 1900, 1930, 1962 and 2010. Crop requires a huge quantity of green and blue water for its growth and product. It also stated one of the largest water depleting countries was Spain. Donoso et al (2014) estimated the green, blue and grey water footprint of agricultural production in Chile based on the Agricultural Census of 2007. The mainly cultivated area was under 30% forages, 28% Cereal, 19% fruits, 7% vineyards, and 4% legumes and tubers. A study found that 80 % water footprint from the agricultural sector and the current water footprint was 9,508.73 $Mm^3 year^{-1}$.

Mekonnen and Hoekstra (2014) studied distinguishes between benchmarks for the green-blue WF and the grey WF. The study period was from 1995 to 2005 for a total of 124 crops. The approach has been to analyse the spatial distribution of the green-blue and grey WFs of different crops as calculated at a spatial resolution of 5 by 50 with a dynamic water balance and crop yield model. The developed benchmark has provided an incentive for farmers to reduce the WF of their crops and thus use water more efficiently. The benchmark values can measure performance, set WF reduction targets, and monitor progress in achieving these targets. Nyambo and Wakindiki (2015) estimated the water footprint of vegetables in South Africa from 2000 to 2013. The CROPWAT model was used to calculate crop evapotranspiration, differentiating green and blue water in Zanyokwe (ZIS), Thabina (TIS) and Tugela Ferry (TFIS) Irrigation Schemes. Green beans had the highest grey water footprint, i.e.,373 m^3t^{-1}, and the lowest was cabbage with 37 m^3t^{-1}. Potato, spinach and tomatoes had footprints of 156 m^3t^{-1}, 214 m^3t^{-1} and 132 m^3t^{-1}, respectively. The change in place of crop production helps efficient water utilization.

According to Hoekstra et al (2011), water footprint explored at three global, national/regional and local and corporate levels. Wheat one of the most widely cultivated cereal grains globally, and Hoekstra and Hung (2002, 2005) were the first to make a global estimate of the water use in wheat production. Mekonnen and Hoekstra (2010) estimated the global and high-resolution green, blue and grey water footprint of wheat from a production and consumption perspective. A grid-based water calculated approach was used dependent upon daily soil water balance and climatic conditions. The global water footprint of wheat production in 1996-2005 about 108 billion cubic meters per year. A significant portion of this water (70%) comes from green water, about 19% comes from blue water, and the remaining 11% is greywater. The water footprint (Ababaei and Etedali, 2014) of wheat production estimated at the national level in Iran, and added one more component, the white water footprint that proposed to account for the irrigation losses. Ababaei and Etedali (2016) applied the first-time concept of the water footprint in Iran, at the regional scale. The mainly grown crops were wheat, barley and maize, and estimated water footprint given by Hoekstra and Chapagain (2008) and Hoekstra et al (2009), and modifications proposed by Ababaei and Etedali (2014). The shares of wheat, barley and maize were 76%, 16% and 8%, with average national green+blue WFs were 24,628, 5,123 and 1,604 Mm^3 per year, respectively. The grey and white prints were 33%, 36%, and 57% for wheat, barley, and maize. The result showed a need to reduce the grey and white water share and develop a better irrigation strategy.

The significant portion of freshwater consumed in green and blue water, Rost et al (2008) studied the global consumption of both blue and green water-based on spatially explicitly. For every nation, water footprint assessed based on consumption and production perspective and Hoekstra and Mekonnen (2012) quantified and mapped the water footprint (WF) of humanity at a high spatial resolution. The global annual average WF in the period 1996–2005 was 9,087 Gm^3 $year^{-1}$ (74% green, 11% blue, 15% grey). The national water policy considered human water footprint within a country and assessed virtual water entering and leaving a country. A study conducted in Morocco for assessing water footprint at river basin monthly estimated the green, blue and grey water footprint and virtual water flows derived mainly from a previous grid-based (5 x 5 arc minute) global study for 1996-2005 (Schyns and Hoekstra 2014). Field-scale water footprint could help optimize sustainable water management strategies. Qin et al (2016) explore field-scale variation in the water footprint of growing sunflowers in the western Jilin Province, China, during a 3-year field experiment. The green, blue, and grey water footprints accounted for 93.7-94.7%, 0.4-0.5%, and 4.9-5.8%, respectively, of growing sunflowers' water footprint. The green water footprint for adequate precipitation during the growing season accounted for 58.8% in a typical drought year but 48.2% in an extreme drought year.

The water and carbon footprint were investigated by Casolani et al (2016) in Italian *durum* wheat production from 2011 to 2015. Zhuo et al (2016) conducted study for assessing green and blue water footprints (WFs) and virtual water (VW) trade in China under alternative scenarios for 2030 and 2050. They considered five driving factors of change: climate, harvested crop area, diet, technology and population. The WF of producing a tonne of crop decreases due to the combined effect of climate change and technology improvements on yield increase.

Dourte et al (2014) developed a dynamic web-resources tool for analysed seasonal water footprints of agricultural production in U.S. Developed system respond to changes in location, time, soil, and management. Several researchers developed different water balance models for different time series and input data (Xu and Singh 1998) and Miguel et al 2015. CWUModel was used to evaluate green and blue water consumed by crops and water required to assimilate the nitrogen leaching resulting from fertilizer application. The total WF of crops in the Spanish Duero river basin was simulated as 59% green, 20% blue and 21% grey. Cabello et al (2017) determined the water footprint for potato crop using the CROPWAT model. The study conducted from 2009 to 2012 observed that the water footprint of potatoes in Cuba is less than that in countries like Costa Rica and the Dominican Republic. Although other components of WF*s* were similar, the grey water footprint was much smaller, achieving more efficiency in fertilizer use. The water footprint from potato crops is also compared with other crops in Cuba, finding that potatoes represent the fourth largest water demand.

The water footprint of a nation depends on the crop production, Phalow et al (2015) used water footprint as a tool for water management and policy-making in South Africa and mainly grown crop was maize, fodder crops, sugarcane, wheat and sunflower seed. The average water footprint of a South African consumer is 1255 m^3 $year^{-1}$, below the world average of 1385 m^3 $year^{-1}$. Thaler et al (2017) simulated the green and primary blue WF of selected main crops for Austrian conditions. The (green and blue) WF of growing a crop equals the total actual ET over the cropping period divided by the crop yield (Y) and used the AquaCrop model for simulating yield in kg ha^{-1} of dry matter. The mainly growing crops were grain maize, potatoes, spring barley, sugar beet, sunflower and winter wheat, and observed that sunflower, winter wheat and grain maize showed the highest WF in the semi-arid study regions, especially on soils with low water capacity. Zhuo and Hoekstra (2017) explored the effect of various agricultural management practices on different water efficiency indicators: irrigation efficiency (IE), crop water use efficiency (WUE), and green and blue water footprint (WF).

Reducing water footprint in the water-scarce region is a big challenge for researchers, and Chukalla et al (2017) developed a marginal cost curve for the irrigated region to decreased water footprint. An AquaCrop model was used to study the effect of management practice on crop evapotranspiration and crop yield and another water footprint of a crop. Figure 2 and 3 showed a study based on water footprint components and crop production.

Overdraft of groundwater problem has been increased globally in last few decades and facing the challenges of freshwater scarcity. Chu et al (2017) analysed crop water footprint and its annual variation from 2000 to 2013 in Hebei southern plain, North China. The total water footprint was 604.8 km^3, out of which 288.5, 141.3 and 175.0 km^3 were blue, green and grey.

Despite the growing enthusiasm for the development and use of water footprints, several researchers have raised significant concerns concerning the concept and its usefulness, both as a policy tool, as it does not provide sufficient information on the opportunity cost of water, and as an indicator of sustainability and environmental impact (Wichelns 2011a, 2010b, Gawel and Bernsen 2011b, a, Perry 2014). The cut flower demand increased worldwide in recent years. Mekonnen et al (2012) quantified the water footprint used in cut flower in Lake Naivasha Basin and try to find out a possible way to mitigate it. The estimated water footprint of one rose flower was 7-13 litre.

Criticism of Water Footprint Concept

Several researchers stated that water footprint provides insufficient information for the decision-making process. The water footprint considers only one input and neglects other input sources (Wichelns 2015), so the water footprint is not helpful in the policy-making process. The role of water footprint increased in recent years due to increasing water scarcity, but the information provided is insufficient. In the eastern rural areas, rainfall exceeded 1100 mm per year, but rainfall was not self-sufficient for the produced crop. The criticism of the water footprint concept is made in two ways i.e. economic perspective, which finds no value in WF calculations in defining trade and production policies and a hydrological perspective analysed based upon the oversimplification of the hydrological cycle (Haie et al 2018). Gawel and Bernsen (2011b) stated that water footprint should be used at the regional or national level, not globally, because some regions with abundant water resources and

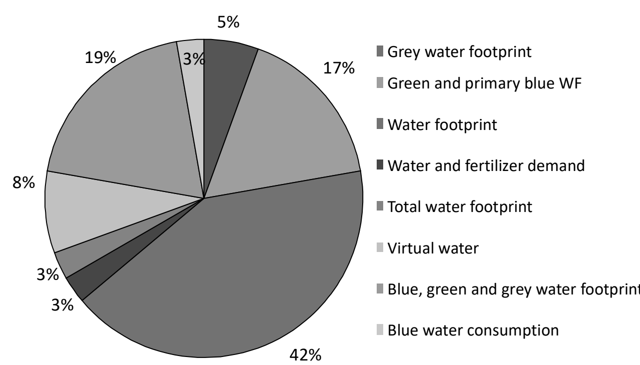

Fig. 2. The literature studied on the water footprint and distinguish components studied

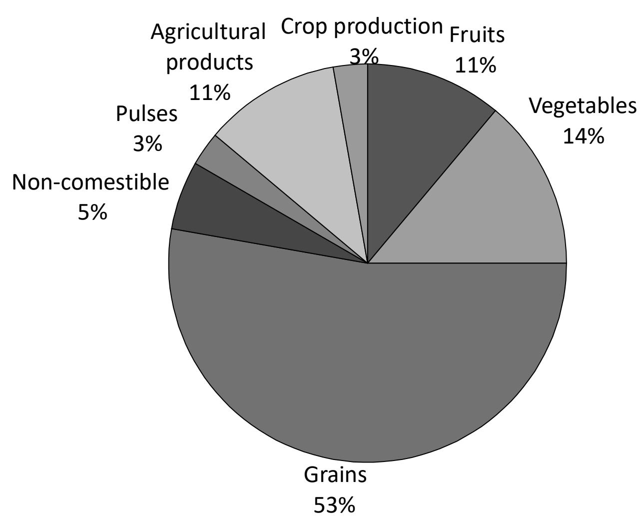

Fig. 3. The water footprint based on the crop studied

Table 1. Summary of the studies on the water footprint of crop production

Products	Area	Period	Functional unit	Phase accessed	Component	Author's
Tomato production	Colombia	2010-2013	Year	N, P and pesticide	Grey water footprint	Gil et al (2017)
Grain maize potatoes spring barley sugar beet sunflower winter wheat)	Austria				Green and primary blue WF	Thaler et al (2017)
Corn and soybean production	Canada	1971-2000	Year	Nitrate-nitrogen (NO_3-N) concentrations in drainage water	Grey water footprint	Verge et al (2017)
Tomato	Greece	2013-2015	Year	Cultivation	Water footprint	Evangelou et al (2016)
Vegetables crops			Year	Cultivation	Water footprint	Roux et al (2016)
Sunflower	China	2006-2008	Year	Cultivation	Water footprint	Qin et al (2016)
Rice production	Sri Lanka	1979-2013	Year	Cultivation	Water and fertilizer demand	Davis et al (2015)
Crop production (maize, fodder crops, sugarcane, wheat and sunflower seed	South Africa	1996-2005	Year		Total water footprint	Pahlow et al (2015)
Agricultural production	U.S.	2007-2008	Year	Changes in location, time, soil, and management.	Green and blue	Dourte et al (2014)
Export Cut Flowers	Kenya	1996-2005	Year	Cultivation and export	Water footprint	Mekonnen et al (2012)
Almonds, barley, grapes, maize, olives, oranges, sugar beets, sugar cane, mandarins, tomatoes, wheat	Morocco	1996-2005	Year	Cultivation	Green, blue and grey WF's	Schyns and Hoakestra (2014)
Grain production	China	2010	Year		Virtual water	Wang et al (2014)
Grain production	China	1998, 2005, 2010	Year	Cultivation	Water footprint	Cao et al (2014)
Cereals	Iran	2006-2012	Year	Cereals	Water footprint	Ababaei and Etedali (2016)
Wheat prdouction		2010-2015	$m^3\ ha^{-1}$	Cultivation	Water footprint	Casolani et al (2016)
Crop production	China	2005	Year	Cultivation	green and blue water footprints and virtual water	Zhuo et al (2016)
Potato	Cuba	2009-2012	Year	Cultivation	Water footprint	Cabello et al (2015)
Paddy rice system	Argentina	2009-2013	Year	Cultivation	Water footprint	Marano and Filippi (2015)
Rice	The Netherlands	2000-2004	m^3/Year	Cultivation	blue, green and grey water footprint	Chapagain and Hoekstra (2011)
olives and olive oil	Spain	1997-2008	Mm^3	Production	Blue, green and grey water footprint	Salmoral et al (2011)
Vegetables	South Africa	2000-2013	m^3/t	Cultivation	Water footprint	Nyambo and Wakindiki (2015)
Agricultural production	Chile	2007	Year	Cultivation	Green, blue and grey WF	Donoso et al (2014)
Colombian cocoa	Colombia	2000 - 2012	Year	Cultivation	water footprint	Ortiz-Rodriguez et al (2015)
Wheat production	Iran	2006-2012	Year	Cultivation	Green, blue, gray and white	Ababaei and Etedali (2014)
Maize	Beijing	1978-2008	Year	Production	Green, blue and grey water footprint	Sun et al (2013)

Cont...

Table 1. Summary of the studies on the water footprint of crop production

Products	Area	Period	Functional unit	Phase accessed	Component	Author's
Pasta production	Barilla	2006-2010	Kg, l	Sustainable production process	Water footprint	Ruini et al (2013)
Rice production	Korea	2004–2009	$M^3 ton^{-1}$	Cultivation, import and export of rice product	Green, blue and grey water footprint	Yoo et al (2013)
Grain production	Korea	2003-2007	T, Mm^3	Cultivation	virtual water	Yoo et al (2012)
spring wheat production	China	1989-2009	Year, m^3	cultivation	Water footprint	Sun et al (2012)
agricultural	Iran	2005-2006	Year	cultivation	Blue water consumption	Arabi et al (2012)
Wheat production	The Netherlands	1996–2005	Year	cultivation	Green, blue and grey water footprint	Mekonnen and Hoekstra (2010)
Rice production	Worldwide	2000-2004	Year	Cultivation and consumption	Green, blue and grey water footprint	Chapagain and Hoekstra (2011)
Crop production	Germany	1998–2002	Year	production	Blue and green virtual water	Siebert and Petra (2010)
Grain prodution	China	2010	Year	cultivation	Virtual water flow	Wang et al (2010)
Coffee and Tea consumption	The Netherlands	1995-1999	Year	Consumption and processing	Water footprint	Chapagain and Hoekstra (2007)
Cotton products	Worldwide	1997-2001	Gm^3	Impact of cotton on water resources	Green, blue and grey	Chapagain et al (2006)

others facing water scarcity. Several authors stated that water division into colours (blue, green and grey) does not reveal the complexity of the hydrological cycle. Witmer and Cleij (2012) questioned the water footprint concept and not provide sufficient information on greywater pollutant because it does not represent actual water volumes, as for the blue and green WFs.

CONCLUSION

This article reviewed the literature on water footprint indicators focussing crop water footprint and its components. The review divided into green, blue and grey water footprint and crops studied. The paper considered water footprint of several crops at the global, national and regional level. 86 per cent of studies aimed to quantify Water Footprint and its distinguished components, while the remaining 14 per cent compared the water and fertilizer demand with other footprints. It emerged that most studies that quantified water footprint covered grain production 53 per cent, including rice and wheat, and the remaining 47 per cent focused on vegetables, fruit production, agricultural products and pulses. Forty-two per cent of studies showed no division in water footprint (blue, green and grey).

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MaxEnt Modeling for Predicting the Potential Distribution of *Valeriana jatamansi* Jones. in Chakrata Forest Division of Garhwal Himalaya

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Abstract: *Valeriana jatamansi* is distributed in subtropical to the temperate regions between 1000 to 3000m in Himalayas. Its' population is decreasing at an alarming rate to meet the demand of pharmaceutical industries and is placed under endangered categories. The present study was attained to depict its potential distribution in Chakrata forest division. For modeling procedure, Worldclim bioclimatic variables along with slope, aspect, elevation, forest types (based on Sentinel-2) data and 50 spatially well-dispersed species occurrence points were used to predict the potential distribution in the 1164.23 km^2 study area. The suitable habitat for *V. jatamansi* was recorded 207 km^2. The temperature (31%) and precipitation (15%) where is the key influential factors that affects its distribution. Jacknife test was used to evaluate the importance of the environmental variables for predictive modelling. Maxent model was highly accurate with a statistically significant AUC value of 0.89. The findings can be applied in various ways such as species restoration and conservation planning, identification of additional localities where *V. jatamansi* may already exist but has not yet been detected. This approach could be promising in predicting the potential distribution of medicinal plant species.

***Keywords*:** *Valeriana jatamansi*, MaxEnt, Species distribution, Conservation

Indian Himalayan Region (IHR) is considered a biodiversity hotspot with over 8000 species of vascular plants (Singh and Hazra 1996). Out of the total species of vascular plant, 1740 species of medicinal and aromatic plants (MAPs) fall under various traditional and modern therapeutic uses (Negi et al 2018). Uttarakhand endows with a high diversity of MAPs. A total 964 species of medicinal plants are known to occur in this small Himalayan state of India (Kala 2010). *Valeriana jatamansi* Jones is a medicinally important herb growing wildly in the temperate Himalayan region between 1000 and 3000 m asl. The plant is dioecious, perennial, tetraploid, polygamous or occasionally polygamo-monoecious (Rajkumar et al 2011). Being well known for its medicinal and other ethnobotanical properties, it is used in several Ayurvedic, Unani and modern medicines (Bhatt et al 2012). Rhizome/roots of the species are known to cure obesity, skin diseases, epilepsy, insanity and snake poisoning. It generally prefers to grow on sloppy, moist places, damp woods, ditches, and streams. In the Himalayan region, the species is found to grow particularly in the understory of *Qurecus leucotricophora–Pinus roxburghii* mixed forests and on grassy habitats. In India, the species is included in the list of 178 medicinal plants with high volume trade/consumption between 100 and 200 metric tons. Further, the estimated annual consumption of the species in India is 123 MT with a price range of Rs. 95-100 kg^{-1} rhizomes with root (Ved and Goraya 2008). Over 90% of the market demand for this species is met from the wild. To induce 1 kg of the dry weight of *V. jatamansi* plant, as many as 400 to 500 individual plants are uprooted. Due to the narrow distribution range, small population size, high use value and increasing demand, the species figured among the 58 identified as top priority species for conservation and cultivation in Doon Valley. Indiscriminate and unscientific harvesting and lack of organized cultivation leads to threatened status in wild and listed as endangered (Ved et al 2003). Habitat degradation, fragmentation, invasion of alien species, over-exploitation and an ever-increasing human population are a number of the critical factors accountable for the species loss at some stage in the planet (Barnosky et al 2012), bringing about one-5th of the plant species on the threat of extinction (Brummitt and Bachman 2010). Species habitat recovery is one of all the successful ecological engineering measures for species rehabilitation and habitat conservation (Polak and Saltz 2011). Detailed knowledge of the current distribution of species is often a pre-requisite to rehabilitate the species in any ecosystem (Adhikari et al 2012). Yet studies on the geospatial extent of the species across the landscape has hardly been conducted. Hence the present study is intended for predicting its spatial extent and most suitable areas for *V. jatamansi* in Chakrata forest division of Doon valley. It is, therefore, of considerable interest if the information on the potential habitats of this medicinally important plant is known for reintroduction and restoration.

MATERIAL AND METHODS

Study area: The study area, Chakrata lies in the Jaunsar-Bawar region occurring at 30°70'16" N latitude and 77°86'96" E longitude along an altitudinal gradient of 1500 m to 2400 m asl. The total area of the division is 36168 hectares. It is bounded by tons forest division in the north, Yamuna forest division in the east, Yamuna river in the south and Tons river in the west. It receives a mean annual rainfall of 1734 mm. The temperature ranges from 4°C in winter to 42°C in summer in the lower valley. Geographically, it has rich vegetation and mostly covered by coniferous and broad leaves forest. Pine forest has maximum contribution (24%). The region is well known for the medicinal plant diversity which includes many threatened plants. Principal forest types are Lower Himalayan Moist Temperate Forest, Himalayan Subtropical Pine Forest and Northern Dry Mixed Deciduous Forest.

Species occurrence data collection: The occurrence data of *V. jatamansi* in the Chakrata hills (Doon Valley) were collected during field survey conducted in the month of November- December 2019-20. A total of 50 well dispersed primary and secondary ground truth points of *V. jatamansi* were retrieved using global Positioning device (Garmin Oregon 550). Besides this, Forest Research Institute (FRI, DD herbarium), Dehradun was also consulted (Fig. 1). The population of *V. jatamansi* was represented by hill slopes, moist places, damp woods and along the streams.

Environmental variables: Nineteen bioclimatic variables (Hijmans et al 2005) with 30 seconds (1 km) spatial resolution, downloaded from WorldClim datasets (www.worldclim.org), were used to find the most influential variables associated with *V. jatamansi* distribution. Digital Elevation Modal (DEM) with 30 m resolution, was used to generate the slope, aspect and elevation data layers. Besides this, forest type was also considered. Erdas 11 and ArcGIS 10.3 were used to create the spatial data layers. The categorical data were re-sampled to 1 km spatial resolution using the nearest neighbor re-sample technique. The multicollinearity test was conducted using the Pearson Correlation Coefficient (r) to examine the cross-correlation. The variables with a cross-correlation coefficient value greater than ±0.80 were excluded. Twelve of the 23 environmental variables remained for use after 11 were removed based on collinearity analysis using the Variance Inflation Factor, implemented (Table 1).

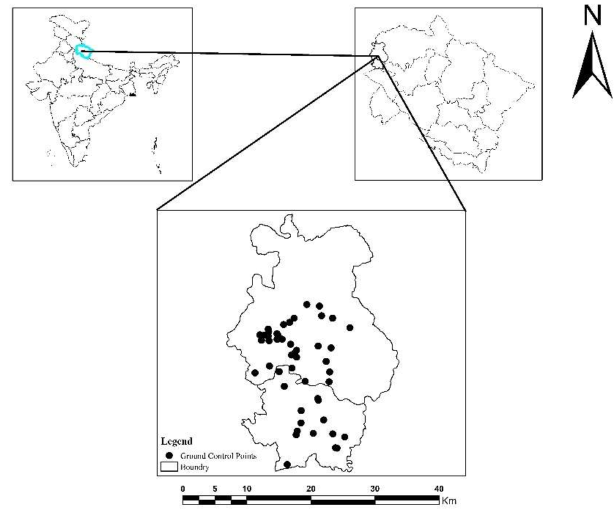

Fig. 1. Intensive study area

Species distribution modeling: The maximum entropy model (Maxent version 3.3.3) (Phillips et al 2006) was applied in this study because it has been shown to perform better with small sample sizes relative to other modeling methods (Pearson et al 2007, Kumar and Stohlgren 2009). Maxent (Phillips et al 2006) uses presence-only data to predict the distribution of a species based on the theory of maximum entropy (Fig. 2). It also facilitates replicated runs to allow cross-validation, bootstrapping and repeated subsampling in order to test model robustness. The maximum number of background points was 10000. Linear or quadratic or product, categorical threshold and hinge features were used with the values 0.050, 0.250, 1.000 and 0.500, respectively. To reduce model over fitting and over-prediction, regularization multiplier value was set to 0.1 (Philips et al 2005) with 5000 iterations and the rest of the values were kept as default (Yang et al 2013). In our models, selected 75% geocoordinate for model training and 25% for model testing (Phillips and Dudik 2008) keeping other values as default. To validate the model robustness, executed 20 replicated model runs for the species with a threshold rule of 10 percentile training presence. Jackknife analyses were performed to determine variables that reduce the model reliability when omitted. Jackknife test to examine the importance of individual environmental variables for prediction. The Jacknife test gives training, test and AUC gains of three scenarios (without the variable, with only one variable and with all the variables) for different environmental variables used in prediction. The area under the Receiving Operator Curve (AUC) was used to evaluate model performance. The value of AUC ranges from 0 to 1. An AUC value of 0.5 indicates that model did not perform better than random, whereas a value of 1.0 indicates perfect discrimination (Singh et al 2020). The AUC provides a single measure of model performance independent of any particular choice of threshold. The model with the highest AUC value was considered the best performer. For display and further analysis, imported the results of the Maxent models predicting the presence of *V. jatamansi* (0-1 range) into ArcGIS 10.3.

Assessment of habitat status and identification of areas for reintroduction: Assessment of the actual habitat type of the species in the localities of occurrence as well as in the entire predicted potential area was done through repeated field surveys. The predicted suitability maps were exported in KMZ format using Arc GIS 10.3. KMZs are zipped Keyhole Markup Language (KML) files which specify a set of features such as place marks, images, polygons, 3D models or textual descriptions for display in Google Earth. The exported KMZ files were overlaid on satellite imageries in Google Earth to ascertain the actual habitat condition prevailing in the areas of occurrence.

RESULT AND DISCUSSION

Model performance and variables contribution: The total of 50 distribution points of *V. jatamansi* were used to build the model. Maxent's model statistically demonstrated highly significant performance and evaluation of the model indicated that the model provided useful information. The area under curve (AUC) for training and test was 0.89 and 0.82, respectively indicating high accuracy (Fig. 3). The jackknife test showed a mean temperature of the coldest quarter (Bio 11) as the environmental variable with the highest training gain in the model, which indicated that it had the most predictive ability of any variable (Fig. 4). The variable, which decreased the gain most when excluded from

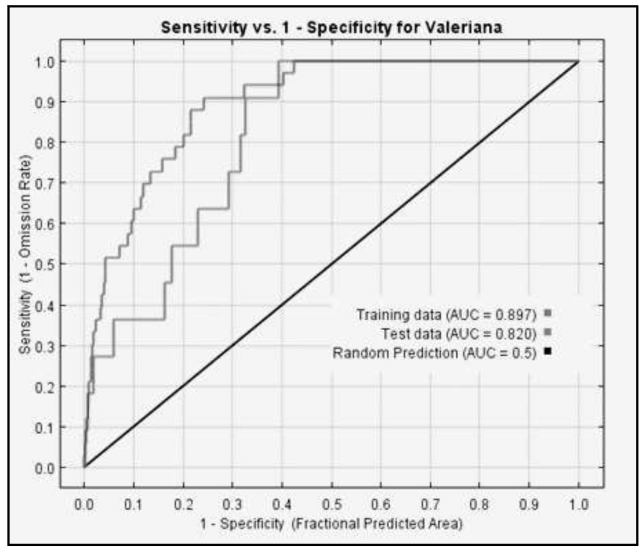

Fig. 3. Area under curve for *V. jatamansi*

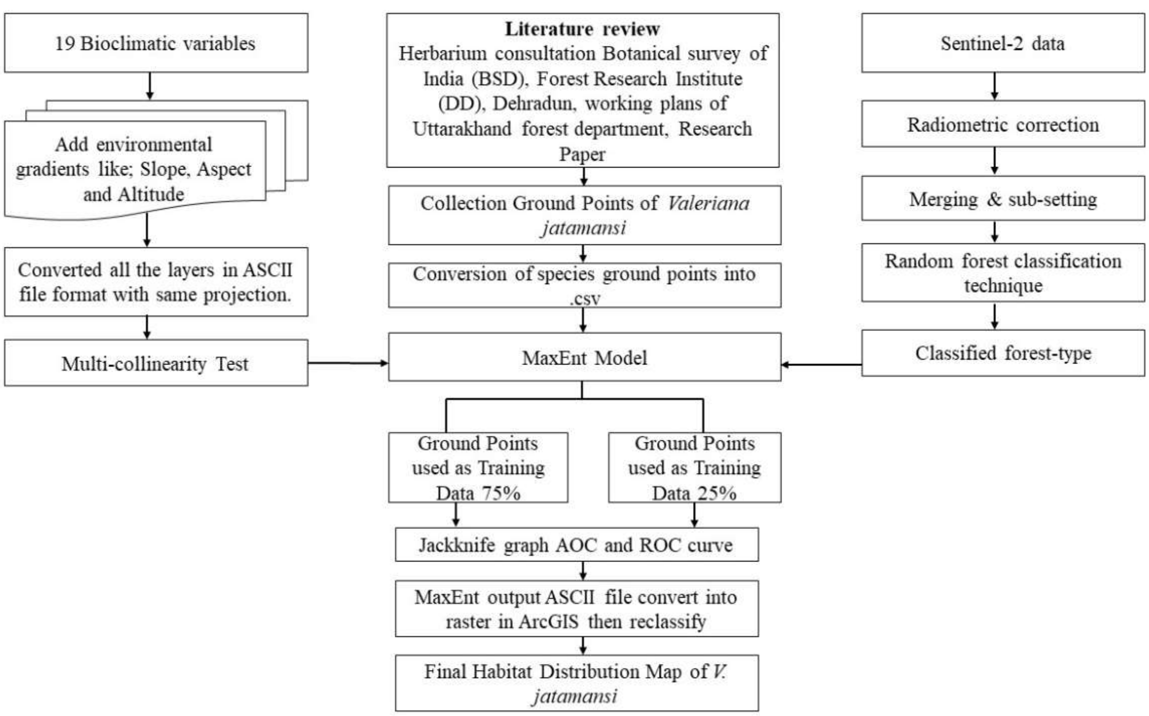

Fig. 2. Methodology for habitat distribution modelling through MaxEnt model

the model, was Mean Diurnal Range (Bio 2), indicating that it had the most unique contribution to the model. Amongst the predictor bioclimatic variables, Mean Temperature of Coldest Quarter (Bio11), Precipitation of Coldest Quarter (Bio19), Precipitation of Wettest Month. (Bio13) and Mean Diurnal Range (Bio2) was the most influential and contributed 64.5, 19.1, 6.8 and 5.9%, respectively to the MaxEnt Model (Table 1). Considering the permutation importance, mean temperature of the coldest quarter had the maximum influence on the habitat suitability model and contributed to 48.5%, while precipitation of the warmest quarter (Bio 18) and temperature annual range (BIO 7) contributed to 22.2 and 20.0%, respectively.

Potential habitat distribution area: Potential habitats with high suitability thresholds were distributed in the hill slopes, moist places and along the streams and higher elevations of Chakrata forest division. Primary field surveys revealed that the predicted potential habitats were mostly located along the streams from the subtropical to temperate region of Doon valley. Areas with low to very low habitat suitability were away from the water channels. The areas in red in Figure 4 depict localities with the highest probability of harbouring *Valeriana*,

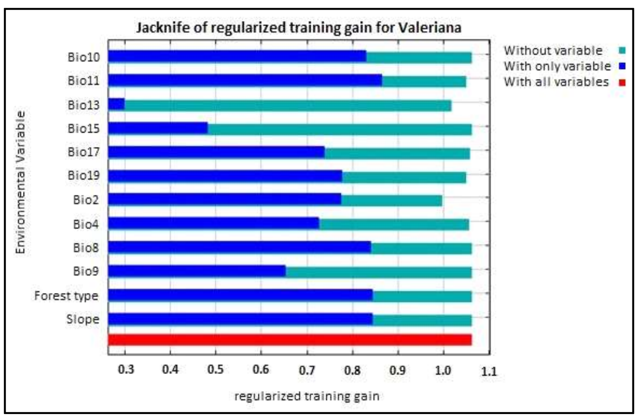

Fig. 4. Jacknife graph of *V. jatamansi*

while those in white represent fewer probability areas. Moderate probability areas are designated with green. Out of the 1164.23 km^2 of the study area, a total 207 km^2 (very high and high suitable class) in Shivalik foothills was predicted to be highly suitable for *V. jatamansi* (Fig. 5). Area of medium suitability was restricted only to about 471.0 km^2. The 10-percentile training presence logistic threshold was applied. To set the 10% minimum threshold, first maxent results.csv file in the results section was navigated. The column titled "10 percentile training presence logistic threshold" was opened. The value in the last row of this column, which represents the average of all runs performed along with the averaged model results was used to reclassify the averaged model results to match the selected threshold in ArcGIS. The final map thus obtained had three classifications.

Habitat status assessment and identification of areas for reintroduction: Field surveys for assessing the habitat types of *V. jatamansi* in the predicted potential areas revealed that the species occurred in the Subtropical broad leaves forest, mixed forest (*Quercus leucotrichophora*, *Q.floribanda*), pine forest and grassland ditch and moist shady places. The species was mostly present in mixed forest types (45%) followed by oak forest (26%), pine forest (19%) and grassland (10%). The species was more frequent in areas having >25° slopes and North, North-East aspects. The areas with high to very high habitat suitability for the species were continuous patches of subtropical broad-leaved forests, mixed forest, along the stream, moist places. The areas with medium to low habitat suitability were pine forest areas, grassy slopes, damp wood, dry slope, rocky and scree and ditch. The areas with very low habitat suitability were cultivation lands and human settlements. Such areas and could also be used for re-introduction/recovery and commercial cultivation of the species. Superimposing the predicted potential habitat map of the species on Google Earth satellite imageries revealed a mosaic of habitats to be

Table 1. Environmental variables used in the study and their percentage contribution

Variables	Percent contribution	Permutation importance
Mean temperature of coldest quarter (Bio11)	30.9	64.5
Precipitation of coldest quarter (Bio19)	14.2	19.1
Mean temperature of wettest quarter (Bio8)	11.8	0
Annual mean diurnal range (Bio2)	10.4	5.9
Precipitation of wettest month (Bio13)	8.8	6.8
Slope	8.2	0
Forest type	5.5	0
Mean temperature of warmest quarter (Bio10)	4.4	0
Mean temperature of driest quarter (Bio9)	3.4	0
Precipitation of driest quarter (Bio17)	2.2	2.4
Temperature seasonality (Bio4)	0.2	1.3
Precipitation seasonality (Bio15)	0	0

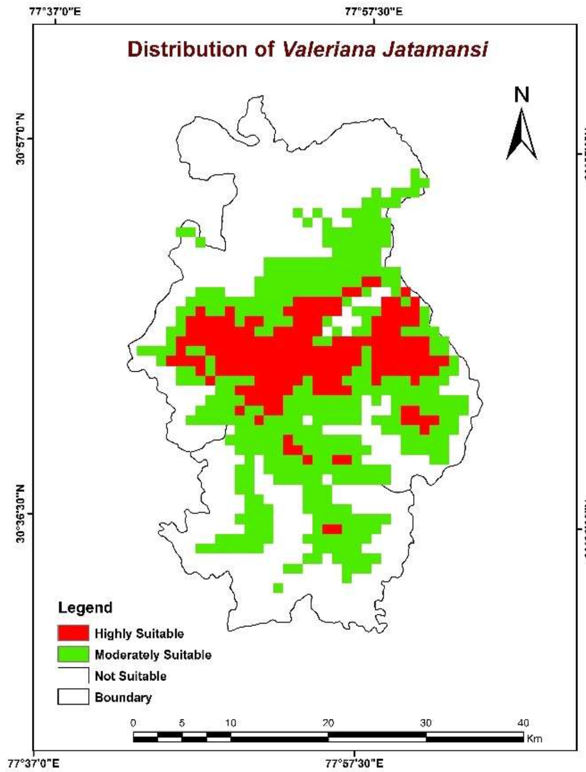

Fig. 5. Habitat distribution modelling of *V. jatamansi*

suitable for the species persistence. These forest areas would act as in situ conservation area for the species and could also be used for reintroduction/ recovery of the species in the wild.

The present study provides the first eco-distribution map of *V. jatamansi* in Uttarakhand using Sentinel-2 satellite imagery data. Out of the total geographical area (1164 km^2) of the study area, 207 km^2 was estimated under *V. jatamansi* by Maxent model. The areas with high to very high habitat suitability for the species were continuous patches of subtropical broad-leaved forests, mixed forest, along the stream, moist places. Highest areas were recorded near subtropical broad leaves forest dominated by *Quercus leucotrichophora* and *Q. floribanda* at an elevation range from 1800-2500 m asl. In the pine forest, the carpet of needles on the ground makes the condition unsuitable for the regeneration of other species; and the situation becomes worse due to the repeated incidence of forest fire (Gupta et al 2009), which led to the scattered distribution of the understory species. Overall, the results of actual habitat assessment through Google Earth superimposition and field surveys were identical. Through both the methods, the prevalence of *V. jatamansi* was in similar land use and landcover types. This analysis confirms the application of Google Earth superimposition along with limited field survey as a powerful tool for habitat assessment of the species and could be a substitute for an extensive field survey (Benham et al 2011).

Through geographical data, a species distribution, threat and habitat requirement could be interpreted. Also, the conservation status of a species could be developed by synthesizing information on each of its known populations. Mapping by such intrinsic features of the land as natural regions and physiographic areas is the best way of presenting plant distribution data. Species and habitat relationship modelling with precise locality data on microclimate, topography and soil in association with site-specific location data of concerned taxa help in understanding the interrelationships and controls of biotic and abiotic factors on species distribution pattern. The over-exploitation of *V. jatamansi* roots and rhizomes for medicinal purposes and the biotic interferences in its distribution range have caused habitat degradation thus creating a nearly extinct conditions for the herb. Thus, a convention on international trade of endangered species notified *V. jatamansi* enlisted an endangered species in the list of National Medicinal Plant Board, New Delhi, India (Nawchoo et al 2012). Hence, it is of immediate concern that different conservation measures and strategies should be adopted to stop further depletion of the herb from its natural habitat. Conventionally the herb is propagated through seeds. Despite being the common method of its propagation, it is not an attractive practice, since the seeds germinate slowly and remain dormant for long time. Therefore, the establishment of an efficient protocol and propagation system is necessary for large-scale production and plantation of *V. jatamansi* which would also help in developing new varieties with high levels of important compounds via biotechnology. The results support the statement that the predicted potential distribution areas through Maxent modeling almost always appear as over-estimated compared to a realized niche of the species, i.e., the habitat (Mishra et al 2020). Since Maxent model considers only niche-based presence data, it predicts the species fundamental niche rather than realized niche (Pearson 2007).

CONCLUSION

The potential habitat distribution map can help in knowing the potential distribution region, especially the high probability areas and can help in planning the land use management in and around the existing population of *V. jatamansi*. The areas predicted suitable, but currently not occupied by the species are the candidate areas to be considered for conservation prioritization and propagation of this species and would help in discovering the new populations, identification of priority survey sites and in designing the conservation priority zone/resource management zone with an emphasis on species ecological boundary. The method is certainly promising in predicting the potential distribution of other medicinal plant species and can be a valuable tool in species conservation planning and climate change-species distribution studies. The areas identified in the present study for the reintroduction of *V. jatamansi* would not only help in the Eco-restoration of degraded forests and habitats where the species had existed before, but also in rehabilitating the species population and improving its conservation status. Therefore, the results would be quite useful for natural resource managers in the management of this species and conserving overall biological diversity in the region.

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Oxygen Productivity in Different Tree Species

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Abstract: The assessment of biomass production, carbon sequestration and oxygen production was assessed in selected nine multipurpose tree species planted on degraded land of Dharwad, Karnataka. The species were planted at 4 x 4 m spacing in randomized block design with three replications. The carbon sequestration was worked out to the total biomass and net oxygen production by trees was calculated based on the amount of oxygen produced during photosynthesis minus the amount of oxygen consumed during plant respiration. Among the tree species evaluated, the biomass, carbon sequestration and oxygen production were significantly higher in *Eucalyptus tereticornis* followed by *Albizia lebbeck* and *Anogeissus latifolia* when compared to other tree species.

***Keywords*:** Environmental stability, Human health, Oxygen production, Carbon sequestration

Trees provide improvements in air and water quality, building energy conservation, cooler air temperatures, reductions in ultraviolet radiation, and many other environmental and social benefits (Nowak and Dwyer 2007). Planting of multipurpose tree species in non-forest land categories serves a dual purpose, i.e. promotion of biodiversity and carbon sequestration. Trees serve as additional source of income at the time of crop failures and also provide economic rewards from the non carbon benefits (Shepherd and Montagnini 2001). A tree planting design with a combination of fast and slow growing species is useful, for different rotation rates of the two species render valuable wood that is economically beneficial, as well as wood for use as fuel and for construction purposes (Ong and Swallow 2003). The higher biomass of ecosystems is associated with higher species diversity leads to greater carbon sequestration. The management of agricultural lands will therefore play an important role in enhancing carbon sinks and in turn reducing emissions. Tree cultivation on agricultural land improves biomass productivity per unit area and also uses nutrients from different soil layers. Further, land such as bund and avenues that are hitherto not cultivated would increase the tree cover of the landscape (MoEF 2010). The Greening India mission under the National Climate Change Action Plan targets 1.5 Mha of degraded agricultural lands and fallows are to be brought under agroforestry; about 0.8 Mha under improved agroforestry practices on existing lands and 0.7 Mha of additional lands under agroforestry (Puri and Nair 2004). The purpose of this article is to estimate the oxygen production by trees, compare it with estimated oxygen consumption by the local population, illustrate why oxygen production by urban trees is a relatively unimportant benefit, and compare this benefit with other environmental benefits provided by urban trees and forests. Thus, it is an effort to understand the amount of oxygen production from different fast growing tree species under low land conditions which help in selection of trees for plantation around village/urban or nearby cities.

MATERIAL AND METHODS

A trial consisted of nine tree species *viz., Eucalyptus tereticronis, Tectona grandis, Dalbegia sissoo, Anogesis latifolia, Albizzia lebbeck, Grevellea robusta, Hardwickia binata, Acacia nilotica and Azadirachta indica* were planted on degraded site of Main Agricultural Research Station, University of Agricultural Sciences, Dharwad. The experimental site was degraded red gravelly soil with 15-20 cm depth (Class V) with a pH of 6.4 and with soil nitrogen, phosphorous and potassium of 172:18.6:164.7 kg ha^{-1}, respectively. The seedlings were planted at 4 x 4 m spacing in randomized block design with three replications. The average rainfall of the location is 800 mm received in 75 rainy days. The mean annual maximum temperature ranged from 37°C to 28°C and mean minimum temperature ranged from 21°C to 13.6°C. The sample trees were felled to assess biomass distribution and productivity. The carbon sequestration was worked out to the total biomass and oxygen productivity was calculated and presented in the Tables.

Oxygen production by trees: Net oxygen production by trees is based on the amount of oxygen produced during photosynthesis minus the amount of oxygen consumed during plant respiration (Salisbury and Ross 1978):

Photosynthesis: $n(CO_2) + n(H_2O) + \text{light} \rightarrow (CH_2O)n + nO_2$

Respiration: $(CH_2O)n + nO_2 \rightarrow n(CO_2) + n(H_2O) + \text{energy}$

If carbon dioxide uptake during photosynthesis exceeds carbon dioxide release by respiration during the year, the tree will accumulate carbon (carbon sequestration). Thus, a tree that has a net accumulation of carbon during a year (tree growth) also has a net production of oxygen. The amount of oxygen produced is estimated from carbon sequestration based on atomic weights:

Net O_2 release (kg yr^{-1}) = net C sequestration (kg yr^{-1}) × 32 /12

RESULTS AND DISCUSSION

Growth of tree species: Growth of *Eucalyptus tereticornis* (17.23 m) was significantly superior as compared to other tree species whereas least height was observed in *Azadirachta indica* (9.75 m). Diameter at Breast Height was significantly higher in *Albizzia lebbeck* (27.17 cm) and *Eucalyptus tereticornis* (27.06 cm) followed by *Hardwickia binata*. Crown area was significantly higher in *Albizzia lebbeck* (16.85 $m^2 plant^{-1}$) followed by *Acacia nilotica* whereas least crown area was observed in *Dalbergia sissoo*. Growth of *Eucalyptus tereticornis* and *Albizzia lebbeck* were fast growing tree species.

Ideotype characteristics: *Azadirachta indica* is found to be having lowest branching angle (48.5°) and *Eucalyptus tereticornis* had the lanceolate type of leaf whereas leaves of *Tectona grandis* were ovate elliptic. *Acacia nilotica* has the maximum leaf shedding period of 48 days followed by *Tectona grandis* (45 days). Among the nine multipurpose tree species evaluated, *Eucalyptus tereticornis* is having good coppice and *Tectona grandis, Dalbergia sissoo, Hardwickia binata* and *Acacia nilotica* had moderate coppice. It is also recorded that, *Eucalyptus tereticornis* is having maximum crown depth (7.2 m).

Biomass distribution: The total biomass was significantly higher in *Eucalyptus tereticornis* (323.6 ton/ha) followed by *Albezzia lebbeck* (284.8 ton/ha) and *Anogeissus latifolia* (269.6 ton ha^{-1}) as compared to other tree species and lowest was in *Azadirachta indica* (141.6 ton ha^{-1}). The biomass in pole was lowest in *Azadirachta indica* (40.6 kg $tree^{-1}$) and *Acacia nilotica* (45.8 kg/tree). Similarly carbon sequestration was significantly higher in *Eucalyptus tereticornis* (161.8 ton ha^{-1}) followed by *Albezzia lebbeck* (142.4 ton ha^{-1}) when compared to other multipurpose tree species. Open-grown, maintained trees tend to have less aboveground biomass than predicted by forest-derived biomass equations for trees of the same diameter at breast height. To adjust for this difference, biomass results for open-grown urban trees were multiplied by a factor of 0.8 (Nowak 1994). No adjustment was made for trees found in more natural stand conditions (e.g., vacant lands, forest preserves). Because deciduous trees drop their leaves annually, only carbon stored in woody biomass was calculated for these trees. Total tree dry weight

Table 1. Growth parameters of multipurpose tree species

Tree species	Height (m)	DBH (cm)	Crown area (m^2/pl)
Eucalyptus tereticornis	17.23	27.06	8.87
Tectona grandis	15.16	17.49	8.57
Dalbergia sissoo	11.87	16.22	7.94
Anogeissus latifolia	12.11	17.10	8.28
Albizia lebbeck	11.15	27.17	16.85
Grevillea robusta	14.25	21.19	8.67
Hardwickia binata	13.85	22.08	8.22
Acacia nilotica	11.42	18.62	13.54
Azadirachta indica	9.75	18.15	8.36
CD (p = 0.05)	1.10	2.59	1.62

Table 2. Ideo type characteristics of multipurpose tree species

Treatments	Nature of stem	Branch angle (degrees)	Number of branches	Type of leaf	Nature of tree	Crown shape	Crown depth (m)
Eucalyptus tereticornis	Straight	60.0	8.5	Lanceolate	Evergreen	Round	7.2
Tectona grandis	Straight	58.6	16.5	Ovate elliptic	Deciduous	Round	6.5
Dalbergia sissoo	Medium	80.8	12.5	Pinnate	Semi Evergreen	Spread	4.8
Anogeissus latifolia	Straight	52.4	9.8	Opposite Simple	Deciduous	Round	5.8
Albizia lebbeck	Medium	60.0	14.6	Alternate pinnate compound	Deciduous	Spread	3.4
Grevillea robusta	Straight	70.8	12.8	Pinnately compound	Evergreen	Round	6.1
Hardwickia binata	Straight	78.0	10.8	Alternate pinnate compound	Semi Evergreen	Round	5.2
Acacia nilotica	Medium	85.0	7.8	Bipinnate	Deciduous	Spread	4.6
Azadirachta indica	Straight	48.5	7.0	Pinnate Opposite	Evergreen	Round	4.6

Table 3. Biomass distribution, carbon sequestration and oxygen production by different multipurpose tree species

Treatments	Timber/ Pole (kg $tree^{-1}$)	Small branches (kg $tree^{-1}$)	Leaf & twigs (kg $tree^{-1}$)	Total biomass (kg $tree^{-1}$)	Total biomass (ton ha^{-1})	Carbon sequestration (ton ha^{-1})	Net oxygen produced (ton ha^{-1} yr^{-1})
Eucalyptus tereticornis	132.6	16.9	12.4	161.8	323.6	161.8	431.47
Tectona grandis	66.8	23.3	10.2	100.3	200.6	100.3	267.47
Dalbergia sissoo	76.0	32.2	15.3	123.5	246.9	123.4	329.07
Anogeissus latifolia	96.8	20.6	17.4	134.8	269.6	134.5	358.67
Albizia lebbeck	92.0	34.8	15.6	142.4	284.8	142.4	379.73
Grevillea robusta	90.0	18.2	11.6	119.8	239.6	118.4	315.73
Hardwickia binata	92.6	21.6	13.4	127.6	255.2	127.6	340.27
Acacia nilotica	45.8	28.6	10.4	84.8	169.6	134.8	359.47
Azadirachta indica	40.6	20.6	9.6	70.8	141.6	70.8	188.80
CD (p=0.05)	6.68	4.19	2.19	9.57	42.00	26.05	69.47

biomass (above- and belowground) was converted to total stored carbon by multiplying by 0.5. The biomass distribution in poles was maximum in *Eucalyptus tereticornis* (132.6 kg $tree^{-1}$) followed by *Anogeissus latifolia* (96.8 kg $tree^{-1}$). Small branches biomass was higher in *Albizia lebbeck* (34.8 kg $tree^{-1}$) followed by *Dalbergia sissoo* as compared to other tree species. The lowest was in *Grevillea robusta* (18.2 kg $tree^{-1}$). Similarly higher biomass in leaves and twigs were noticed in *Anogeissus latifolia* (17.4 kg $tree^{-1}$) followed by *Albizia lebbeck* as compared to other tree species. The leaf and twigs biomass was lowest in *Azadirachta indica* (9.6 kg $tree^{-1}$) and *Tectona grandis* (10.2 kg $tree^{-1}$) as compared to other tree species. This may be due to genetic variation to growth of tree species and their response to site conditions. Similarly variation in growth of multipurpose trees was reported by Mishra and Bhatt (2003) and Chauhan et al (2009, 2019).

Oxygen production by the tree species: Net oxygen release was significantly higher in *Eucalyptus tereticornis, Anogeissus latifolia, Albizia lebbeck* and *Hardwickia binata* and lower in *Azadirachta indica*. Oxygen production is one of many environmental benefits that tree can produce a significant amount of oxygen. Oxygen productivity varies by tree size and type of species.

CONCLUSION

Among the nine multipurpose tree species evaluated, the growth of *Eucalyptus tereticornis* was significantly superior when compared to other tree species. The carbon sequestration, total biomass and the biomass distribution in poles were significantly higher in *Eucalyptus tereticornis, Anogeissus latifolia* and *Albezzia lebbeck.* The net oxygen released awas significantly higher in *Eucalyptus tereticornis, Anogeissus latifolia, Albizia lebbeck* and *Hardwickia binata* as compared to other species evaluated.

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Effect of Forest Fire on Ammonification and Nitrification: A Study under Chir Pine (*Pinus roxburghii*) Forest Areas of Himachal Pradesh

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Abstract: The present study was conducted to evaluate the effect of fires on the ammonification and nitrification rates under different land uses based soil under chir pine forest areas. Ammonification and nitrification rates as influenced by fire under different land use patterns soils were studied in Solan district, Himachal Pradesh. The study revealed that ammonification and nitrification rates varied between the different land uses and seasons. The higher amount of ammonification and nitrification were recorded during rainy period. Ammonification rates were favored more over nitrification in all land uses which would be useful for safeguarding the soil nitrogen for longer periods.

Keywords: Ecosystem, Ammonification, Nitrification, Nutrient management, Immobilization

Forest fire is regarded as major feature of forest disruption as it do not pose a threat only to the forest wealth but also to the entire regime of the fauna and flora by interrupting their bio-diversity and ecology. Fire disturbance controls plant community succession and competition, native species genetics and ecophysiology, soils, nutrients, and erosion; and pest behavior (Brown and Smith 2000). Soil temperature higher than 50°C resulted in death of heat sensitive microflora and further higher around 70°C directly affects the vegetation of the region. The effects of fire on forest landscape are dependent on the duration of fire (Shakesby and Doerr 2006). High severity fires can be lethal to many trees within the entire stand, and tend to effectively influence forest structure (Rosemary and Veblen 2006). Disturbances caused by fire controls the plant community succession, competition, eco physiology, soil nutrients and erosion. Sub surface soil mass contains appreciable amounts of heavy fuels and combustion of which can increase the temperature around 500-700°C (Neary et al 2005). Fire act as vigorous mineralizing agent, causing the rapid transformation of organic nitrogen to inorganic forms which can be easily available to plants and microflora. Fires consume nitrogen from the plants and surface soil layer, resulting in reduction of N pool in a burned forest (Hyodo et al 2013). The global carbon and nitrogen emissions from fires have been estimated to be 3.53 Pg year^{-1} (van der Werf et al 2004) and 8 Tg N year^{-1} (Crutzen and Lelieveld 2001), respectively.

Biomass burning in the sub-tropical regions of Himachal Pradesh, especially in the chir pine forests is a common phenomenon which occurs regularly each year. In these regions, prescribed fires are common in the dry season and have been occurring from many years. Prescribed burning of naturally accumulated forest floor is a standard practice to reduce fuel levels, improving stand quality, nutrient concentrations in eco systems with the intention of minimizing the extent and severity of wildfires or facilitating germination and growth of desired forest species In order to avoid the risk of wildfires, prescribed fire is frequently performed during the moist seasons. Fire result in reduction of microbial abundance by an average of 33.2% and fungal abundance by an average of 47.6% (Dooley and Treseder 2012). Direct transformation of elements during fire combustion can affect the cycling and availability of nutrients. The combustion of organic matter releases significant quantities of available nutrients and can be an important source of nutrients for plant re-growth. The mineral ash can also influence the soil pH and microbial activities related to decomposition and nutrient turnover (Deluca et al 2002). The N cycle is particularly sensitive to changes induced by frequent fires due to substantial loss of this element through volatilization. This short duration of the fire effect is followed by a period in which the rate of net mineralization returns to pre-fire levels, and, in many cases, turns to net N immobilization six months to two years after the fire event. Effect of fire on nitrogen mineralization in different land uses based soils have received a very limited scientific attention till now. So for a better understanding effect of forest fires on nitrogen mineralization, ammonification and nitrification has been studied in the chir pine (*Pinus roxburghii*) forest areas of Himachal Pradesh, India

MATERIAL AND METHODS

The study was conducted in Solan region, falls in sub-temperate climatic zone of Himachal Pradesh (Zone 2). The mean annual temperature of 17.4°C with annual rainfall of 1100 mm was recorded during study period. The climatic conditions in the district vary from place to place due to mountainous topography. Winter rains were meagre and received during the months of January to March. Four land use sites viz. forest area, grassland area, agricultural land area and non-fire site taken as control were selected. All of the selected experimental sites were located on elevation of 1275 amsl (average). Plot size of 200 m x 500 m has been selected for the sampling sites with a distance of 2 km separating the forest fire areas to non- fire areas. PVC cores of dimension of 5 cm diameter and 10 cm long were perforated by four holes had been driven into the soil to the 5 cm mark and capped on top. Ten PVC cores were arranged in three parallel lines 15 m apart from each other with cores positioned every 5 m. Soil samples were collected on monthly basis from the ten places of the respective study sites from depth (0-10 cm) in replicates. Initial soil samples were collected near the core and the successive monthly samples were collected from the core with minimal disturbance. The one set of soil samples were collected from the different selected sites that has been burned by prescribed fire. Whereas, the second set of soils were collected from the neighbouring sites taken as control. Changes in ammonium and nitrate concentrations were obtained by subtracting the initial concentrations from final concentrations, and the resultant values were referred to as ammonification and nitrification rates, respectively.

RESULTS AND DISCUSSION

Soil characteristics: The soils of the area were found Typic Eutrochrept at sub group level according to soil taxonomy of USDA. The soil texture was sandy loam and sandy clay loam in nature among the different selected land uses (Table 1). Bulk density of the soils varied between 2.32 to 2.35 g cm^{-3}. Higher values of porosity were recorded which could be due to presence of organic matter and higher amounts of fine fractions present in soil having higher surface area. Available soil nitrogen was in the range of 173.18 in forest land to 390.28 kg ha^{-1} in the agricultural land use. Soil available K content ranges from 272.68 in forest land to 431.88 kg ha^{-1} in agricultural site (Table 1). Higher concentration of available potassium in agricultural based ecosystems could be attributed to additional doses of inorganic fertilizers applied for crop production. As a result good amount of potassium has been conserved in the soil through the crop residues. Uses of farm yard manure (FYM) along with inorganic sources might have also improved the potassium content in the soil.

Ammonification (μg g^{-1} $month^{-1}$): In forest land, pooled data showed that higher ammonification rates of 12.05 μg g^{-1} $month^{-1}$ were in October while the minimum (7.04 μg g^{-1} $month^{-1}$) in April (Table 2). Similar trend has been observed in grassland and agricultural land (Fig. 1). In grassland, maximum ammonification (10.37 μg g^{-1} $month^{-1}$) was associated October and minimum (6.30 μg g^{-1} $month^{-1}$) in April whereas, agricultural based sites brought highest ammonification rate of 9.85 μg g^{-1} $month^{-1}$ with minimum (8.15 μg g^{-1} $month^{-1}$) in March. The ammonification rates varied differently in non-fire sites as it was maximum in January and least rates were in November. Overall ammonification rates were higher than nitrification in all the selected land uses. Higher rates of ammonification in October could be attributed to the reason that the soil microbial population was greatly affected by the inclusion of fire and thus minimal activities were observed. Higher rate of ammonification in non-fire sites during January could be due to lower soil temperature which severely affected microbial populations and nutrient transformations as they are temperature dependent.

Nitrification(μg g^{-1} $month^{-1}$): Pooled analysis of two fire season reported that under forest land, maximum nitrification rate was recorded in the September (6.81 μg g^{-1}

Table 1. Soil initial physico-chemical properties under selected land use patterns

Land use	Initial physical and chemical properties							
	Particle density (g cm^{-3})	Bulk density (g cm^{-3})	Porosity (%)	pH (1:2)	Electrical conductivity (ds m^{-1})	Organic carbon (%)	Available N (kg ha^{-1})	Available K (kg ha^{-1})
Forest land	2.32	1.33	42.70	5.93	0.22	1.18	173.18	272.68
Grass land	2.33	1.34	42.48	6.05	0.24	1.31	179.54	319.54
Agricultural land	2.35	1.36	42.12	6.44	0.27	1.22	390.28	431.88
Control (Non-fire site)	2.32	1.33	42.67	6.57	0.25	1.17	291.29	339.52

Table 2. Effect of forest fires on monthly variations in the soil ammonical and nitrate (µg g^{-1} $month^{-1}$) under different land uses

Month	Year	NH_4-N				NO_3 – N			
		Forest land	Grass land	Inorganic land	Control (Non-fire)	Forest land	Grass land	Inorganic land	Control (Non-fire)
June	2018	7.52	6.96	8.86	7.46	3.41	2.81	2.74	2.18
	2019	8.14	7.22	9.04	7.22	3.67	2.88	3.18	2.44
	Pooled	7.83	7.09	8.95	7.34	3.54	2.85	2.96	2.31
July	2018	8.34	7.86	8.14	6.54	2.94	2.63	4.89	1.81
	2019	9.52	7.46	8.16	6.9	3.12	2.76	4.66	2.09
	Pooled	8.93	7.66	8.15	6.72	3.03	2.70	4.78	1.95
August	2018	10.68	9.72	9.64	7.16	5.58	3.97	3.86	3.54
	2019	9.88	8.84	9.82	7.24	6.74	3.84	3.69	3.23
	Pooled	10.28	9.28	9.73	7.20	6.16	3.91	3.78	3.39
September	2018	9.98	9.87	9.36	8.34	6.64	4.35	3.72	3.2
	2019	10.16	9.52	10.02	7.97	6.98	4.65	3.04	2.99
	Pooled	10.07	9.70	9.69	8.16	6.81	4.50	3.38	3.10
October	2018	11.64	10.66	8.92	9.94	4.19	3.05	2.9	2.01
	2019	12.46	10.08	10.78	8.66	5.14	4.22	2.71	2.58
	Pooled	12.05	10.37	9.85	9.30	4.67	3.64	2.81	2.30
November	2018	9.22	8.08	7.24	5.88	3.66	2.69	2.34	1.99
	2019	10.45	9.96	11.53	6.22	4.81	3.95	2.56	2.14
	Pooled	9.84	9.02	9.39	6.05	4.24	3.32	2.45	2.07
December	2018	7.44	7.98	7.94	6.78	3.82	2.9	2.12	1.74
	2019	8.54	8.54	8.62	6.88	3.62	3.02	1.19	1.88
	Pooled	7.99	8.26	8.28	6.83	3.72	2.96	1.66	1.81
January	2018	10.12	9.28	9.08	9.86	4.98	3.29	4.64	2.66
	2019	9.72	10.46	9.23	8.98	5.56	3.16	3.9	2.94
	Pooled	9.92	9.87	9.16	9.42	5.27	3.23	4.27	2.80
February	2018	8.84	9.06	10.24	8.9	3.52	2.69	5.88	3.15
	2019	7.56	8.02	8.99	9.76	3.41	2.25	5.12	3.19
	Pooled	8.20	8.54	9.62	9.33	3.47	2.47	5.50	3.17
March	2018	7.42	8.82	8.42	8.46	3.06	1.64	3.22	1.21
	2019	7.48	7.47	8.04	8.02	3.25	2.19	3.9	2.02
	Pooled	7.45	8.15	8.23	8.24	3.16	1.92	3.56	1.62
April	2018	6.96	5.42	8.34	7.04	3.21	2.28	2.97	1.56
	2019	7.12	7.17	8.82	7.64	3.64	1.9	2.2	1.71
	Pooled	7.04	6.30	8.58	7.34	3.43	2.09	2.59	1.64
May	2018	7.74	6.18	8.67	7.36	3.38	2.45	2.41	1.44
	2019	8.33	7.08	8.66	6.92	3.88	2.34	2.72	2.23
	Pooled	8.04	6.63	8.67	7.14	3.63	2.40	2.57	1.84
CD (p=0.05)	2018	1.28				1.01			
	2019	1.36				1.24			

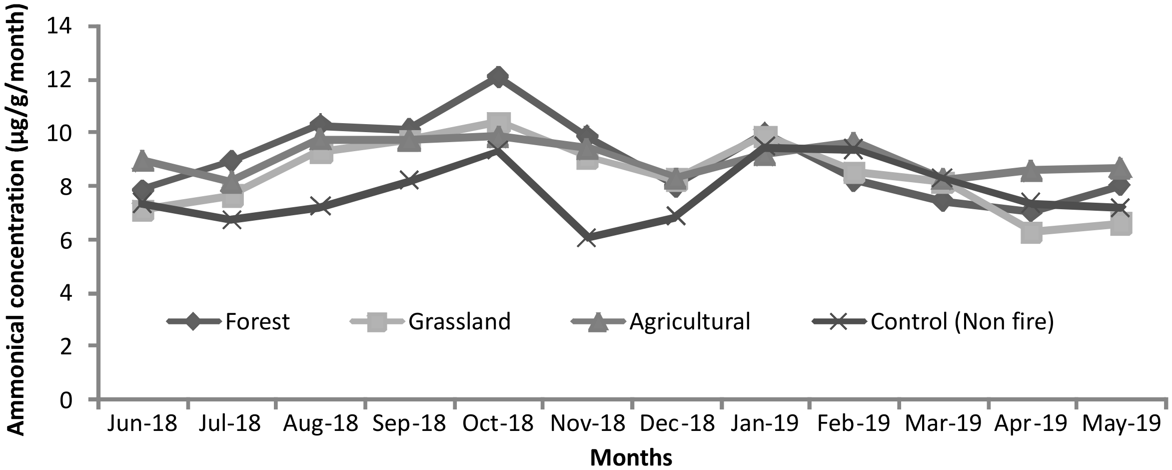

Fig. 1. Effect of forest fire on monthly ammonical (µg g^{-1} $month^{-1}$) concentrations under different land uses

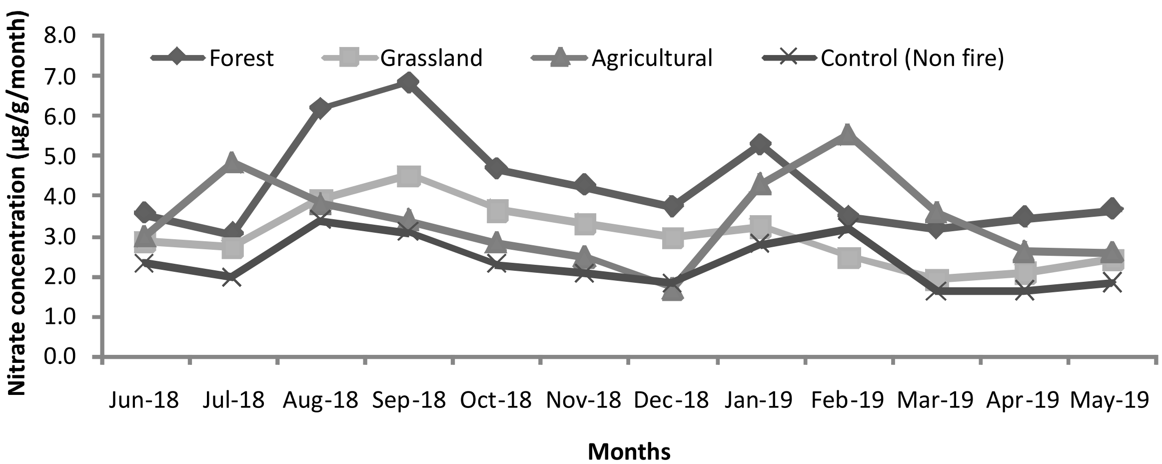

Fig. 2. Effect of forest fire on monthly nitrate (µg g^{-1} $month^{-1}$) concentrations under different land uses

$month^{-1}$) with minimum of 3.03 µg g^{-1} in July (Table 2). Similar results were observed in grass land with maximum of 4.50 µg g^{-1} $month^{-1}$ while the least (1.92 µg g^{-1} $month^{-1}$) was attained in March. Agricultural based site brought maximum nitrate accumulation of 5.50 µg g^{-1} $month^{-1}$ in February and minimum (1.66 µg g^{-1} $month^{-1}$) in December. Nitrification rate were greatly affected by the soil moisture and environmental conditions. Non-fire sites showed maximum nitrification in the rainy season i.e. August and minimum 1.62 µg g^{-1} $month^{-1}$ in March. It was observed that nitrification rates did not show any seasonal variations in either of the selected land uses. In the burned sites, highest nitrate accumulation was linked to forest land with higher nitrification rate (6.81 µg g^{-1} $month^{-1}$), which was quite higher than to grass land and agricultural land areas (Fig. 2). The highest rates during the rainy period and lowest rates in the dry season indicated that soil moisture was the control factor of N mineralization in these land uses. Lower concentration of nitrate in the soil could be a consequence of lower mineral N availability during the incubation period. Although presence of plants might cause an intense competition between microbes and plants for NH_4-N. Lower nitrification rates could also be attributed to lower population of nitrifiers as the fire might have drastically reduced their count and hence the period of incubation was insufficient for their significant expansions.

CONCLUSIONS

Fire resulted in increase in ammonification and nitrification rates but was found to return to pre-fire levels with the passage of time. Rates of ammonification were favoured more over the nitrification rates with inclusion of fire. Rainy period brought higher levels of ammonical and nitrate content accumulation in the soil. The effect of fire on nitrogen mineralization was highly dependent on the type, intensity of the fire on the experimental site.

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Assessment of Soil Seed Bank on Three Different Vegetation Types in Kumaun Central Himalayan Forest

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Abstract: The present study was conducted to assess the soil seed bank in *Shorea robusta, Pinus roxburghii* and *Quercus leucotrichophora* dominant forest. The study was carried out between 439 and 2145 m in Kumaun Himalayan region. A monolith of 25x25x15 cm^3 was used to extract the soil sample from the study sites. The soil samples were divided into 03 depth classes 0-5cm, 5-10 cm and 10-15 cm. ANOVA showed that number of viable seeds varied significantly across sites and depths ($p<0.05$) but not with species. The soil seed bank density at 0-5 cm depths was 3.2±0.05 and 10.1±0.08 m^{-2} in *S. robusta*, 4.5±0.08 and 12.4±1.07 m^{-2} on *P. roxburghii* and 2.3±0.06 and 5.4±0.3 m^{-2} on *Q. leucotrichophora*. In oak dominated forest the total tree forest emergent varied from 3.2±1.89 to 18.4±2.01m^{-2}, shrubs forest emergent varied from 8.3±1.21 to 64.4±2.97 m^{-2} and herb emergent varied from 20.3±0.6 to 164.3±0.62m^{-2}. A significant positive co-relation was found between tree and shrubs emergent ($r=0.228$, $p<0.01$) and shrubs and herbs forest emergents ($r=0.573$, $p<0.01$). Litter abundance increases in areas of high pine density, which may decrease seed banks. The highest emergent in *Q. leucotrichophora* dominant sites could be due to the high moisture present in oak forest soil and favorable climatic conditions as compare to *S. robusta* and *P. roxburghii* dominated forests. Rise in temperature and resultant enhanced evapo-transpiration which desiccates seeds more rapidly in soil.

Keywords: Himalaya, *P. roxburghii, Q. leucotrichophora, S. robusta*, Soil seed bank

Himalayan forest has been under severe anthropogenic pressure and highly fragmented and degraded due to changing climatic patterns over the several years, with its closed canopy cover declining gradually (Mitchell 2004). Fire incidence, severe drought and overgrazing as well as overdependence of the adjacent local communities on these Himalayan forests are common. Several factors can delay or stop regeneration in degraded sites such as; low soil fertility, soil compaction, lack of seeds (Mukhongo et al 2011), depleted seed banks (Uhl and Jordan, 1984), unfavorable microclimatic conditions (Guarigata et al 1995), emergence of aggressive herbaceous growth and high seed and seedling predation (Nepstad et al 1991). Climate change may affect seed production and reproduction biology of Himalayan tree species, especially those which have short seed viability and synchronizes their regeneration with the commencement of monsoon. Early maturation of seeds due to warming and stress may break this synchronization. Regeneration status of a species is one of the most important phenomena for maintaining the forest cover. *S. robusta, P. roxburghii* and *Q. leucotrichophora* are the main forest forming tree species from tropical to temperate region of Himalaya. These are the economically and ecologically important species in Himalayan region and provide many tangible and intangible benefits to human. Due to many climatic and anthropogenic disturbances, these species facing regeneration and seedling survival problems. In such disturbances condition the soil seed bank study of these important Himalayan species are much needed for future prospectus.

Soil seed bank is an important component in plant community dynamics and enable plant populations to maintain their genetic variability and to withstand periods of adverse conditions and persist over time (Templeton and Levin 1979). It is also an important component of ecosystem resilience and represents a stock of regeneration potential in many plant assemblages (Wang et al 2013) and restoration of species-rich vegetation. High seed density and a large number of species in the seed bank contribute to a potential role of the seed banks in vegetation development during restoration of degraded sites (Thompson et al 1997, Grime 2001). The strong mechanistic relationship between climate variables and seed dormancy and germination indicates that forecast climatic changes will inevitably affect seed ecology. The soil seed banks of above ground vegetation would be depleted by changing climate effecting the future regeneration of several species (Naylor 1984). Due to prolonged viability of seeds stored in the soil and their ability to germinate over time, the risk associated with their germination under unfavorable conditions may be reduced (Venable and Brown 1988). Subsequently, this will have an impact on seed banks, which are important for ensuring population persistence, particularly in habitats subjected to variable or stochastic disturbance regimes (Fenner and Thompson 2005). The objective of the present study to assess the composition and diversity of soil seed bank in sal, pine and oak dominated forests and impact of climatic was irregularities on regeneration status in Kumaun central Himalayan region.

MATERIAL AND METHODS

Study sites: The study sites situated at 29°18'-29°24' N and 79°19'-79°30' E, occurs between are an altitudinal transect 439 and 2145 m in sal, chir-pine and banj oak dominated forests in Kumaun Himalaya. At each site one dominant and one under canopy species was selected for the study. In the sal dominated forest *Shorea robusta* (Roxb.) and *Mallotus philippnensis* (Arg), in chir pine dominated forest *Pinus roxburghii* (Sarg.) and *Myrica esculenta* (Thumb), and in banj oak dominated forest *Quercus leucotrichophora* (A. Campus) and *Rhododendron arboreum* (Wall) were selected for detailed study of soil seed bank.

Climate: Average annual precipitation for oak and pine dominated forests site was 2258 mm of which two third occurred during rainy season and 1201 mm for sal dominated forest sites across the years. Mean annual temperature for oak and pine dominated forests sites was 15.2°C and 23.4°C for sal dominated forest sites during the study period.

Methodology: To assess the soil seed bank, two parallel transect of 5x5m were established 10m apart in the site and each transect were divided into 5 quadrats of 5x5m with a sub-plot of 1m^2 located in the middle of each quadrate. Five soil sample from each 1m^2 plot in each transect samples were extracted of 25x25x15 cm^3 depth from study site and brought back to a laboratory. The soil samples were divided into 03 depth classes 0-5cm, 5-10cm and 10-15cm. To assess the seed density m^{-2} seed germination experiment was conducted. The procedure given by Grine (1989) was following for germination. Large sized seeds could be separated by passing through a 2mm sieve. The seeds of other un-identified species were manually separated, counted and kept in separate petridishes and placed in a seed germinator at 20°C on the top of germination paper and watered as per requirement. Newly germinated seedlings were identified and removed from the seed trays every 2-3 days. The germination experiment was continued until no new seedling emerged for 6 weeks (Wang et al 2009). To assess the variation in tree, shrubs and herbs emergent, the soil sample were collected in autumn, winter, spring, summer and rainy season from each dominant forest sites.

Data analysis: SPSS (2007) version 16 for windows was used for all statistical analysis. The data was statically analyzed using Analysis of variance (ANOVA) yearly, seasonally and for site wise variations. Two-tailed Pearson Correlation was performed between different parameter.

RESULTS AND DISCUSSION

Across all sites and years, the mean number of viable seeds of all studied species declined with increasing soil depths. The maximum numbers of viable seeds were in top soil layer (0-5cm) and minimum in deeper soil layer (10-15cm). ANOVA showed that number of viable seeds varied significantly across sites and depths ($p<0.05$) but not with species. All the interactions showed non-significant variation ($p<0.05$). A significant positive co-relation was found between tree and shrubs emergent ($r=0.228$), shrubs and herbs emergent ($r=0.573$) while a negative co-relation was found between tree and forbs emergent ($r=-0.047$) at 0.01% significant level ($p<0.01$).

Sal dominated forest: The soil seed bank density of *S. robusta* across all the sites varied between 3.2±0.05 and 10.1±0.08m^{-2} at 0-5cm, 5.1±0.02 and 10.5±0.1m^{-2} at 5-10cm and no viable seeds were present at 10-15cm depths (Fig. 1a) and in *M. philippnensis* it was 4.5±0.08 and 8.6±0.06m^{-2} at 0-5cm, 1.1±0.02 and 3.9±0.03m^{-2} at 5-10cm and only 1.0±0.0 viable seeds were present at 10-15cm depths (Fig. 1a). In *S. robusta* dominated forest, the total emergent of tree varied from 7.6±0.12 to 16.3±0.17m^{-2} at site I, 4.8±0.09 to 14.2±0.21m^{-2} at site II and 0±0.0 to 8.1±0.31m^{-2} at site III. The emergent was maximum in rainy season and minimum in winter season (Fig. 1b). The emergent of shrubs varied from 12.3±0.14 to 32.5±0.23m^{-2} at site I, 8.2±0.32 to 24.8±0.43m^{-2} at site II and 4.2±0.87 to 12.4±0.81m^{-2} at site III. It was maximum in summer season and minimum in winter season (Fig. 1b). Similarly, the number of herbs emergent varied from 16.1±0.61 to 60.3±1.21m^{-2} at site I, 28.0±1.67 to 56.1±2.76m^{-2} at site II and 24.3±1.72 to 68.3±1.38m^{-2} at site III. Herbs emergents were maximum in autumn season and minimum in spring season (Fig. 1b).

Pine dominated forest: The soil seed bank density of *P. roxburghii* across all the sites varied between 4.5±0.08 and 12.4±1.07m^{-2} at 0-5cm, 1.0±0.08 and 3.1±0.09m^{-2} at 5-10cm and 1.1±0.7m^{-2} at 10-15cm depths (Fig. 2a) and in *M. esculenta,* it varied between 4.9±0.9 and 12.0±1.7m^{-2} at 0-5cm, 1.0±0.8 and 3.1±0.4m^{-2} at 5-10cm and only 1.0±0.0 viable seeds were present at 10-15cm depths (Fig. 2a). In *P. roxburghii* dominated forest, the total emergent of tree varied from 6.1±1.1 to 22.1±1.4m^{-2} at site I, 2.3±1.01 to 14.4±2.11m^{-2}

at site II and 0±0.0 to 10.5±0.8m^{-2} at site III. The tree emergent was maximum in summer season and minimum in winter season (Fig. 2b). The emergent of shrubs varied from 4.6±0.8 to 24.3±2.11m^{-2} at site I, 16.2±1.54 to 24.0±1.90m^{-2} at site II and 4.0±0.6 to 36.2±2.12m^{-2} at site III. It was maximum in summer season and minimum in winter and spring season (Fig. 2b). Similarly, the number of herbs emergent varied from 36.3±1.65 to 128.4±2.09m^{-2} at site I, 44.0±1.78 to 124.2±2.00m^{-2} at site II and 56.4±1.04 to 200.2±1.78m^{-2} at site III. It was maximum in autumn season and minimum in winter season (Fig. 2b).

Oak dominated forest: The soil seed bank density of *Q. leucotrichophora* across all the sites varied between 2.3±0.06 and 5.4±0.3m^{-2} at 0-5cm, 1.0±0.05 and 2.2±0.7m^{-2} at 5-10cm and no viable seeds were present at 10-15cm depths (Fig. 3a) and in *R. arboreum* it varied between 2.1±0.8 and 5.2±0.5m^{-2} at 0-5cm, 1.0±0.3 and 2.1±0.4m^{-2} at 5-10cm and no viable seeds were present at 10-15cm depths (Fig. 3a). In *Q. leucotrichophora* dominated forest, the total emergent of tree varied from 3.2±1.89 to 10.1±1.90m^{-2} at site I, 6.5±0.9 to 16.3±1.06m^{-2} at site II and 7.8±1.83 to 18.4±2.01m^{-2} at site III. The tree emergent was maximum in rainy season and minimum in winter season (Fig. 3b). The emergent of shrubs varied from 16.4±1.89 to 64.4±2.97m^{-2} at site I, 16.2±0.98 to 48.7±1.86m^{-2} at site II and 8.3±1.21 to 36.4±2.1m^{-2} at site III. It was maximum in summer season and minimum in spring season (Fig. 3b). The herbs emergent varied from 64.4±1.65 to 164.3±0.62m^{-2} at site I, 20.3±0.6 to 112.4±1.51m^{-2} at site II and 52.2±1.02 to 132.1±1.32m^{-2} at site III. The herbs emergent was maximum in autumn season and minimum in spring season (Fig. 3b).

In Himalayan areas, the soil seed bank plays a crucial role in the patterns of vegetation (Hirsch et al 2012). A soil seed bank is a major initiator of regeneration in a natural forest (Mukhongo et al 2011). With increasing temperature due to global warming and irregularity of climatic events, frequency of good seed years in the Himalayan species had decline (Joshi and Tewari 2009). The present observation showed that the mean number of viable seeds of all studied species declined with depth across all the sites and species

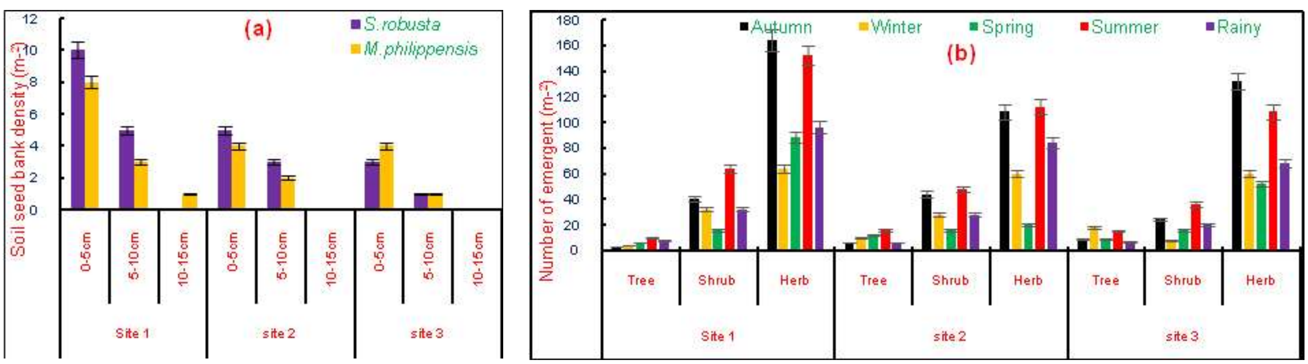

Fig. 1. (a-b) Mean soil seedling bank density (m^{-2}) of *S. robusta* and *M. philippnensis* and number of emergent of trees, shrubs and herbs in sal dominated forests across sites and seasons

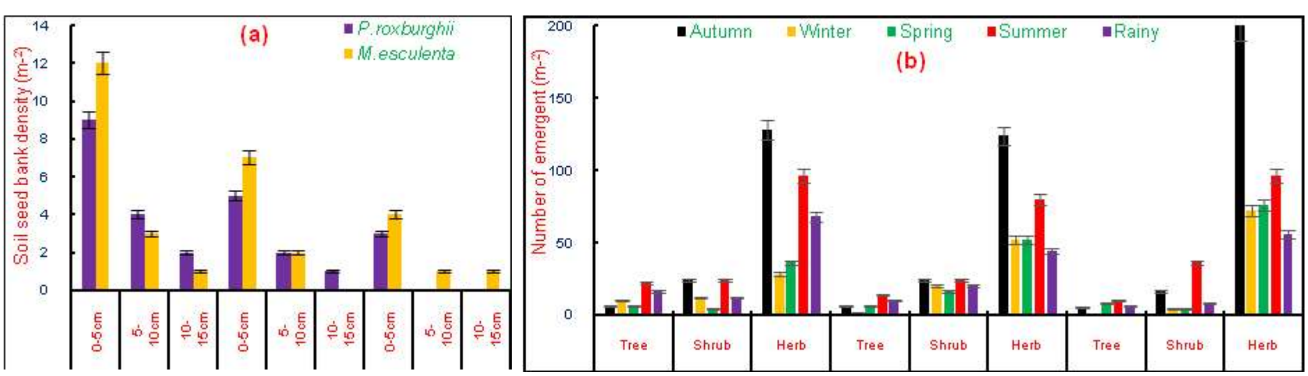

Fig. 2. (a-b) Mean soil seedling bank density (m^{-2}) of *P. roxburghii* and *M. esculenta* and number of emergent of trees, shrubs and herbs in chir-pine dominated forests across sites and seasons

and the pattern of species representation differed from one site to another. The maximum numbers of viable seeds of all species were in the top soil layer. Tiebel et al (2018) in a study on soil seed bank of pioneer tree species birch, alder and willow have also reported that with increasing soil depth seed density decline and maximum number of viable seed of all species were present upto 10cm soil. Sullivan and Ellison (2006) have also reported that tree seeds in general and black birch seed at particular were uncommon at soil below 8cm. Wang et al (2015) in three evergreen broad-leafed forest in south China have reported soil seed bank abundant for trees 1.9±0.05 to 11.4±3.3. In the present study the total seed density across all depths and sites varied between 4 to 15 m^{-2} in *S. robusta*, 5 to 12 m^{-2} in *M. philippnensis*, 3 to 15 m^{-2} in *P. roxburghii*, 6 to 16 m^{-2} in *M. esculenta*, 4 to 7 m^{-2} in *Q. leucotrichophora* and 3 to 7 m^{-2} in *R. arboreum*. Singh (2019) reported that the mean number of viable seed varied between 2.00 and 2.67 m^{-1} in *A. spectabilis*, 1.0 and 1.67 m^{-2} in *Q. semecarpifolia* 3.67 to 4.33 m^{-2} in *R. arboreum* and *R. campanulatum* and 4.33 to 6.33 m^{-2} in *B. utilis* in treeline areas of Uttarakhand Himalaya. Savadogo et al (2017) studied that no tree species seeds were encountered in the soil seed banks, even the understory species component of the vegetation was not closely related to the soil seed bank. Much of the recent evidence from forest seed bank studies suggests that the flora of soil seed banks is not closely associated with the standing vegetation (Mukhongo et al 2011). Tessema et al (2012) observed that the disturbed habitats generally have less relation between the species present in the seed bank and the vegetation. Abella and Springer (2008) suggested several factors could cause minimum number of soil seed banks to be smaller in areas with thick and heavy litter. Seeds may become trapped in litter so that fewer reach mineral soil (Korb et al 2005) or retain viability. Litter abundance increases in areas of high pine density, which may decrease seed banks by decreasing aboveground vegetation that provides seed inputs (Abella and Springer 2008).

The results from the soil monoliths collected from different sites and seasons indicates that there were large quantities of seeds of herbaceous species, and very few of woody species were detected in the germination experiment of soil seed bank. At top soil layer, 0-5cm depth, 70% of the emergent were herbs, 20% were shrubs and 8-10% trees. This is consistent with findings in several studies (Lemenih et al 2005, Wassie and Teketay 2006) of high proportions of viable seeds of herbaceous species and low proportions of woody species in the soil seed bank. Savadogo et al (2015) reported that the former is probably due to the ability of grasses, sedges and herbaceous plants to produce numerous small, persistent seeds, while the lack of woody species is due to the relatively short residence time of seeds of most woody species. According to Wang et al (2013), 63% of the species that were in the seed bank were absent from the vegetation, and these species were mostly annual forbs. In addition, 49% of the species that occurred in the standing vegetation were not found in the seed bank, and these species were perennial forbs and sub-shrub/shrubs (Elizabeth 2006). The total number of herbs, shrubs and trees emergent varied from 296 to 357 individuals in the *S. robusta* dominated forest, 492 to 597 individuals in *P. roxburghii* dominated forest and 582 to 779 individuals in *Q. leucotrichophora* dominated forest at 0-5cm soil layer across all the seasons. According to Teketay (1996), most of the tree species produce seeds that germinate within a few days or weeks after dispersal and do not form large soil seed banks. Other factors that probably contribute to the difference in composition of seed banks are that the seeds of large woody species are heavily predated and decompose rapidly (Teketay 1996). Moreover, because of their large size they

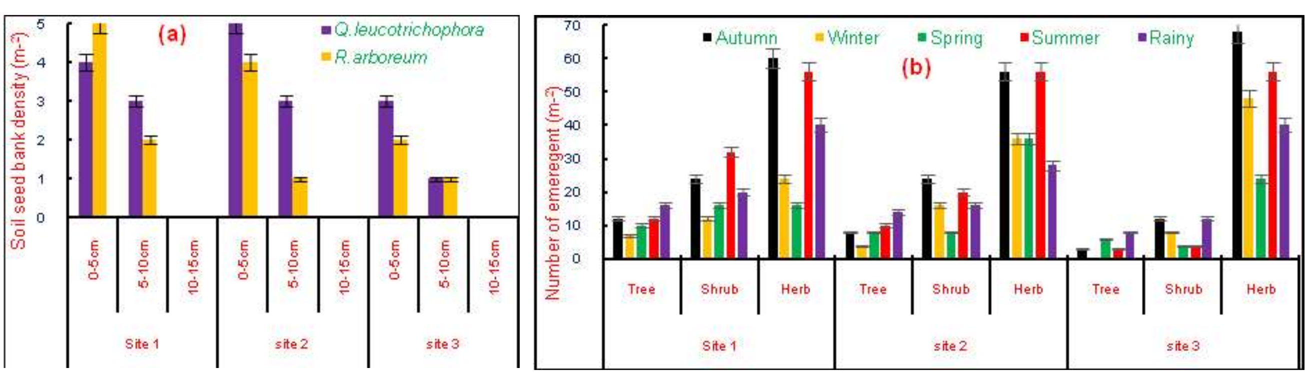

Fig. 3. (a-b) Mean soil seedling bank density (m^{-2}) of *Q. leucotrichophora* and *R. arboreum* and number of emergent of trees, shrubs and herbs in oak dominated forests across sites and seasons

cannot be easily incorporated into the soil seed bank and thus remain on the surface. Thus, they will be affected by surface fire set by the local people to create space for grazingland. They are therefore also exposed to other severe stresses. Furthermore, due to their fruiting behavior some tree species produce seed infrequently (Savadogo et al 2015).

In the present study, the emergent species were maximum in soil of autumn season followed by rainy seasons. Yu et al (2008) observed that the aboveground vegetation and the soil seed bank in a Mediterranean coastal sand dune were found to be seasonally dynamic with highest similarity value occurring during May to September and the lowest value at about the end of April when no new seedlings were emerging. Either excess rainfall affects the regeneration and growth of vegetation whereas during dry season insufficient rainfall limits the production. Maximum number of grasses emerged in *P. roxburghii* forests and least were in *S. robusta* forest soils whereas maximum forbs emerged that in *Q. leucotrichophora* forest soils. According to Andersen et al (2012), the number of weed plants decreased with increasing distance to the hedgerow. From the study, it is evident that the viable soil seed bank increased with altitude being minimal at the foothill in *S. robusta* dominant site and maximum between 1800-2100 m in *Q. leucotrichophora* dominant sites. The highest numbers of emergent were found in *Q. leucotrichophora* dominant forest this could be due to the high moisture present in oak forest soil, which helpful for plants regeneration, growth, and favorable climatic conditions as compare to *S. robusta* and *P. roxburghii* dominated forests. Augusto et al (2003) have reported that seed bank under *Pinus sylvestris* was poor when compared to the other plantation types as confers species are more acidic and have higher concentration of aluminum than soil under hardwood. Determining the plant species composition and food resources is an important tool to examine the habitat suitability and productivity of a forest ecosystem (Rajpar et al 2020). These results suggest that the species composition of the soil seed bank can be predicted with extant vegetation to some degree, and the recovery of soil seed bank and vegetation needs a relatively long period. To conclude that the studied species had vary less number of seedlings and saplings due to low soil seed bank across the depth in its natural stands. Rising temperature and resultant enhanced evapo-transpiration desiccates seeds more rapidly in soil seed banks. Such conditions are likely to be more pronounced in the coming future due to atmospheric temperature rise brought about climate change and many other factors such as water stress, rainfall pattern, soil moisture, wind speed, nutrients and oxygen levels that would be useful to better understanding spatial patterns of soil seed bank. Hence, more detailed investigation is required to examine the influence of these events in future studies.

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Allometric Models for Predicting Above-Ground Biomass and Carbon Stock of Fodder Tree Species in Northwestern Himalayas

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Abstract: Five important fodder species of mid-hill zone of North-Western (NW) Himalayas *viz. Grewia optiva, Celtis australis, Bauhinia variegata, Leucaena leucocephala,* and *Morus serrata* were selected for the study. Whole tree biomass, biomass partioning, the carbon content of each part, was determined. Five models *viz,* linear, quadratic, cubic, power and compound were tried and tested with the data of biomass and carbon of fodder trees. Test statistics *viz*. T-test, R^2, adjusted $R^{2,}$ and Standard Error (SE) were applied to arrive at the best fit model for each parameter. It was found that for leaf estimation of *B. variegata* and *G. optiva* compound model, for *L. leucocephala* and *M. serrata* power model and for *C. australis* Quadratic model is the best fit. Similarly, for other parameters like branch biomass, above-ground biomass, rate of carbon sequestration, and above ground carbon stock best fit models have been derived. The models developed had high significance as tested with different statistics and thus can be applied for NW Indian Himalayas.

Keywords: Allometric equations, Carbon sequestration, Carbon stock, Fodder tree

Forest ecosystems can act as both sources and sinks of carbon (Watson et al 2000). Deforestation results in a high level of carbon dioxide and greenhouse gas emissions. Carbon dioxide emissions associated with land-use change were about 1.6 Gt per annum over the 1990s (IPCC 2007). The forest ecosystem efficiently converts CO_2 into biomass, decreasing carbon in the atmosphere and sequestering in the plant above and below-ground biomass (Chauhan et al 2009), resulting in the growth of different parts (Chavan and Rasal 2010). Allometry is used to relate some non-easy to measure tree characteristics from easily measurable traits, diameter at breast height (dbh), height, or tree age and provides relatively precise estimates. The allometric models are based on correlations between biomass and morphological features, such as basal area/diameter, height, canopy diameter/ volume, *etc.* (Kuyah et al 2016). It is essential to provide precise tree allometric estimates to understand the relationship between carbon sinks and the global carbon cycle (Henry et al 2013).

Tree growth parameters vary considerably with tree species, site characteristics, climatic conditions, topographic features, *etc.* Accordingly, allometric biomass models are of different types, such as regional, site-specific, species-specific, *etc.* (Mahmood et al 2019). The accuracy of these biomass models is highly variable (Sileshi 2014). The choice of the most appropriate allometric model is the most crucial step for minimizing the errors of above-ground biomass and carbon estimates (Molto et al 2013). *Grewia optiva, Celtis australis, Bauhinia variegata, Leucaena leucocephala* and *Morus serrata* are the most important agroforestry tree species of the mid-hill zone of Himachal Pradesh. These species are highly valuable for their nutritious fodder, fuel, and small timber needs. So far, no comprehensive study has been carried out to develop an allometric equation for predicting the biomass, carbon stock, and carbon sequestration potential of these tree species in this region. Development of allometric equations will be helpful in farm management, decision making, regulating the supply of resources from them, and calculating and offering carbon credit to the farmers who intend to raise these species under the carbon project. The present study was undertaken with the objectives to develop an allometric equation for estimating biomass and carbon stock of important fodder tree species, and test the accuracy of the equation for estimating biomass and carbon stock.

MATERIAL AND METHODS

Study area: The study site is located at an elevation of 1250 m above mean sea level that lies between 30°51”N latitude and 76°11”E. The area falls in the mid-hill zones of Himachal Pradesh. The soil is well-drained silt loam type, and the terrain is undulating, hilly, marked with elevation and depressions. Climatically, the site lies in transition zone between the sub-tropical and the temperate climate. There is a considerable variation in seasonal and diurnal temperature with a minimum of 1°C in winters to a maximum of 37°C during hot summer. The mean annual temperature is 19.8°C. May and June are the hottest months, whereas December and January are the coldest months. Winters are accompanied by a fair amount of frost, which kills a large amount of regeneration in the area. The area receives an annual rainfall of 110-115 cm with maximum downpour during the monsoon season (July and August).

Estimating biomass and carbon stock: Naturally growing scattered trees of *Bauhinia variegata, Celtis australis, Grewia optiva, Morus serrata, Leucaena leucocephala* were selected for the study. Fifty trees of each species were chosen covering all possible diameter ranges of tree species. The entire stem was divided into sections, and then the volume was calculated using quarter girth formula (Chaturvedi and Khanna 1982 a). In the case of tall trees, Spiegel Relaskop was used to measure the growth variables like tree height, diameter at specific height intervals, form factor, *etc.* The basal area was calculated for all the estimated trees of each species. The volume of each tree calculated was then multiplied with specific gravity to estimate the biomass of the main stem. Above-ground biomass of each tree was estimated by adding the stem biomass, branch biomass, and leaf biomass to calculate biomass per tree of each of the selected species. Biomass was multiplied with carbon content to calculate the carbon stock of each tree. Various forms of linear and non-linear equations were used to find the best fit regression equation.

Rate of carbon sequestration: Fifty Trees of selected species were cross- marked using white paint at diameter at breast height (dbh) (at 1.37m above the ground level). dbh was measured successively for two years *i.e.,* 2017 and 2018, using tree caliper and expressed in centimeters and to the nearest of two millimeters to calculate the diameter increment. Increment in diameter was used for calculating stem volume increment, which was multiplied with respective specific gravity to estimate the rate of biomass increment of each selected tree. To estimate rate of carbon sequestration, biomass increment was multiplied with their respective carbon content. Various regression equations were tried to find the best-fit regression equation by putting the rate of carbon sequestration against DBH.

Total height (H): It is the height from base to top of standing tree measured using Ravi Multimeter and expressed in meters. Crown height (CH): It is height from ground to the height of the first crown origination point measured using Ravi Multimeter and expressed in meters. Crown width (CW): It was measured in two directions, *i.e.*, north-south and east-west using a measuring tape. It is calculated using formula (Chaturvedi and Khanna 1982b).

$$CW= D_1 + D_2/2$$

Where, CW= crown width in meters; D_1= crown width in north-south direction; D_2= crown width in east-west direction

Crown depth (Cdp): It was calculated by deducting crown height from the total height of the tree (Baleghan et al 2012); Crown area (CA): CA is assumed to be a circle and was calculated using the formula given by Chaturvedi and Khanna (1982a) and expressed in meter square.

$$CA= \pi \div 4\, D^2$$

Where,

CA= crown area in square meters; D= crown diameter in meters

Form factor: The formula given by Pressler calculates form factor:

$$f = 2h_1/3h$$

Where, f = form factor; h_1= height at which diameter is half of dbh; h = total height

Specific gravity: Specific gravity was calculated following Negi and Chauhan (2002), Mani and Parthasarathy (2007), Jana et al (2009).

Specific gravity = oven-dry weight of wood sample ÷ green volume of that sample.

Crown volume (CV): It is assumed to be a sphere because the crown structure resembled a sphere better than any other three-dimensional structure and was calculated following Baleghan et al (2012) equation:

$$CV = 4\pi \div 3 + (CW \div 2 + CD_p \div 2)^3$$

Where; CV= crown volume in cubic meters; CW= crown diameter in meters; CDp= crown depth in meters

Branch biomass: Total number of branches on the tree were counted and grouped based on basal diameter into different classes. The fresh weight of two sampled branches from each group, were recorded separately. The formula by (Chidumaya 1990) is used to determine the dry weight of branches and expressed in kg tree^{-1}.

$$B_{dwi}= B_{twi}/1 + M_{cbdi}$$

Where; B_{dwi}- oven-dry branch weight; B_{twi}- fresh branch weight; M_{cbdi}- moisture content of branch on a dry weight basis; Total branch biomass (fresh/dry) per sample tree is determined by the given formula: $Bbt = n_1bw_1 + n_2 bw_2 + n_3 bw_3 + ... + n_ibw_i$; Bbt – branch biomass per tree n_i– number of branches in i^{th} branch group, bw – average weight of branch of i^{th} group, I = 1, 2, 3, 4..........................

Leaf biomass (Lbt): Leaves from sampled branches were removed, weighed, and oven-dried separately to a constant weight at 80±5°C. Leaf biomass is estimated by formula (Chidumaya, 1990) expressed in kg tree^{-1}.

$$Lbt = n_1lw_1 + n_2lw_2 + n_3lw_3 .... + nilwi$$

Where; Lbt is leaf biomass per tree; ni is the number of branches in the i^{th} branch group

Iw is the average weight of leaf in i^{th} group; i= 1,2, 3,4…………………

Total biomass: It is calculated by the addition of stem, leaf, and branch biomass and expressed in kg per tree.

Carbon percent: Carbon content in leaves and branch was determined by loss of ignition method (Kalra and Maynard 1991). Oven-dried samples were grinded in Wiley Mill; 5g of powdered leaf samples were taken in silica crucible with constant weight. The combustion process of the material, was carried out in a muffle furnace at 550°C for 6-7 hours till the constant weight of the crucible is obtained. Carbon percent so calculated was converted into a per gram of sample. The calculated leaf, branch, and total carbon (leaf+ branch) values were then multiplied with their respective biomass to obtain carbon content in kilogram per tree.

Carbon stock: Carbon stock was calculated by multiplying the biomass of each tree species with their respective carbon content.

Biomass increment: Volume increment for each tree species was multiplied with their respective specific gravity to calculate biomass increment.

Carbon sequestration: The rate of carbon sequestration was calculated by multiplying leaf, branch, and stem biomass increment with respective carbon content.

Best fit equations were derived for different parameters of tree species by taking respective parameters as dependent variables with a diameter at breast height as an independent variable. The models used are given in Table 1.

RESULTS AND DISCUSSION

Total above-ground biomass: Total above-ground biomass (TAGB) estimation based on dbh is a convenient way of knowing the biomass of trees. The relationship between dbh with total biomass may vary with species and region and this relationship can be ascertained and described as best fit model. Five different equations were applied for five fodder yielding tree species to find out the best fit equation for TAGB estimation. The best fit model for *B. variegata* was Quadratic with R^2 0.93, Adjusted R^2 0.92, and SE 7.8 (Table 2). The best fit model for *C. australis* and *G. optiva* was Power. The R^2 for both the species was 0.93. Adjusted R^2 was also above 0.9, and SE for *C. australis* was 0.228, and for *G. optiva* it was 0.054. The best fit model for *L. leucocephala* and *M. serrata* was Linear with R^2 and Adjusted R^2 above 0.8. The SE was 1.72 for *L. leucocephala* and 17.4 for *M serrata*.

Tree biomass is a function of DBH that is well supported by Navar (2009) and Segura and Kanninen (2015). Singh et al (2011) also derived allometric equations to estimate biomass using DBH, for *Dalbergia sissoo, Acacia catechu* and *Albizia lebbeck*. The observed data from the field and the predicted data from the developed best-fit equations for a particular species were validated using a t-test and $p < 0.05$ level of significance (Table 3). It was found that the paired t-test was non-significant. Except for *B. variegata* rest all species showed statistically significant results for best fit models with values more than 0.86 at $p < 0.05$ level of significance, which means that above-ground biomass equations developed based on DBH predicts biomass near equal to the actually observed biomass.

Branch and leaf biomass: The best fit branch biomass equations for different agroforestry tree species (Table 4)

Table 1. Models used for biomass and carbon estimation

Model types	Equations
Linear Model	$Y = \alpha + \beta X$
Quadratic Model	$Y = \alpha + \beta_1 X + \beta_2 X^2$ ∞, β_1 and β_2 are regression coefficients
Cubic Model	$Y = \alpha + \beta_1 X + \beta_2 X^2 + \beta_3 X^3$ Y= dependent variable; X = independent variable; ∞, β_1 and β_2 are regression coefficients
Power Model	$Y = \alpha X^{\beta}$
Compound Model	$Y = \alpha \beta^{x}$

Table 3. Validation of best-fit equations for TAGB of the agroforestry tree species

Species	Paired t-test value for predicted versus observed variable	p-value (<0.05)
B. variegata	-3.34	0.55
C. australis	-0.39	0.95
G. optiva	-1.16	0.86
L. leucocephala	-0.5	0.99
M. serrata	0.001	0.99

Table 2. Best fit equations for TAGB (stem+branch+leaf) based on DBH

Species	Model type	Equation	R^2	Adj R^2	S.E.
B. variegata	Quadratic	$-1.182+2.956\times DBH+.018\times DBH^2$	0.93	0.92	7.8
C. australis	Power	$.075\times DBH^{2.175}$	0.93	0.92	0.228
G. optiva	Power	$12.931\times DBH^{0.736}$	0.93	0.93	0.054
L. leucocephala	Linear	$-5.187+6.187\times DBH$	0.84	0.84	12.72
M. serrata	Linear	$-15.806+5.420\times DBH$	0.87	0.86	17.4

show that the R^2 varied from 0.81-0.99, and adjusted R^2 ranged from 0.80-0.98. This indicates that branch biomass production can be predicted with a good degree of accuracy. The best fit model for *B. variegata* and *M. serrata* was compound function, whereas, for *C. australis*, *G. optiva* and *L. leucocephala* the best fitted model is linear, quadratic, and power, respectively.

In fodder species, leaf biomass is an important variable. The best fit equation for the leaf biomass production as the dependent variable and diameter as the independent variable are given in Table 5. It was found that leaf biomass production can be predicted with a confidence interval ranging from 81 to 99% level under a different model for different species. The degree of accuracy in leaf biomass production in *B. variegata* (R^2 = 0.97), *G. optiva* (R^2 = 0.97), *L. leucocephala* (R^2 = 0.99) and *M. serrata* (R^2 = 0.95) is very high.

Carbon sequestration: Carbon content in different parts of fodder species was determined and is presented in Table 6. Carbon per cent in the stem was highest in *L. leucocephala* (56.67%) and lowest for *C. australis* (54.91). *B. variegata* recorded the highest branch (55.66%) and leaf carbon (53.65%).

The best fit non-linear equation for predicting the rate of carbon sequestration (kg $tree^{-1}yr^{-1}$) based on diameter as an independent variable is presented in Table 7. The confidence level for predicting the rate of carbon sequestration varies from 80%-99%. The best-fit Model for predicting the rate of carbon sequestration for *Bauhinia variegata* is compound function, whereas for *Celtis australis* and *Grewia optiva* quadratic model was found to be the best predictor, *L. leucocephala* and *M. serrata* can be predicted with high accuracy (R^2 = 0.99) using a power function.

The paired t-test between the observed and predicted rate of carbon sequestration was found to be non-significant in all the species (Table 8) along with high p-value range from

Table 6. Carbon in stem, branch and leaf of the agroforestry tree species

Species	Stem C%	Branch C%	Leaf C%
B. variegata	56.08	55.66	53.65
C. australis	54.91	53.10	47.86
G. optiva	55.01	52.46	51.24
L. leucocephala	56.67	54.45	52.45
M. serrata	55.66	54.91	49.12

Table 4. Best fit equations for branch biomass production (g $tree^{-1}$ yr^{-1}) based on DBH

Species	Model type	Equation	R^2	Adj R^2	S.E.
B. variegate	Compound	$2357.054 \times 1.076^{DBH}$	0.99	0.98	0.063
C. australis	Linear	$-5440.185+871.382 \times DBH$	0.81	0.80	5384.057
G. optiva	Quadratic	$36038.407-2724.504 \times DBH+75.060 \times DBH^2$	0.81	0.80	1599.461
L. leucocephala	Power	$268.677 \times DBH^{1.238}$	0.9	0.98	0.028
M. serrata	Compound	$7070.538 \times 1.046^{DBH}$	0.96	0.95	0.072

Table 5. Best fit equations for leaf biomass production (g $tree^{-1}$ yr^{-1}) based on DBH

Species	Model type	Equation	R^2	Adjusted R^2	SE
B. variegata	Compound	$726.183 \times 1.110^{DBH}$	0.97	0.97	0.139
C. australis	Quadratic	$2164.978-11.761 \times DBH+4.886 \times DBH^2$	0.81	0.80	2127.875
G. optiva	Compound	$3476.530 \times 1.029^{DBH}$	0.97	0.97	0.024
L. leucocephala	Power	$268.677 \times DBH^{1.238}$	0.99	0.99	0.028
M. serrata	Power	$642.459 \times DBH^{.797}$	0.95	0.95	0.079

Table 7. Best fit equations for rate of carbon sequestration (kg $tree^{-1}yr^{-1}$) based on DBH

Species	Model type	Equation	R^2	Adj R^2	S.E.
B. variegata	Compound	1.692×1.075^{DBH}	0.99	0.98	0.053
C. australis	Quadratic	$-6.820+.824 \times DBH-.004 \times DBH^2$	0.81	0.80	3.355
G. optiva	Quadratic	$20.594-1.374 \times DBH+.048 \times DBH^2$	0.85	0.84	0.833
L. leucocephala	Power	$.294 \times DBH^{1.166}$	0.99	0.99	0.025
M. serrata	Power	$1.089 \times DBH^{.849}$	0.99	0.99	0.20

0.90 for *C. australis* to 0.98 for *L. leucocephala*. This shows that all the values predicted through developed equations for predicting the rate of carbon sequestration had no significant difference with the observed values.

The results are in line with the findings of Singh et al (2011), Gera et al (2011) and Jana et al (2009). Similarly, Adam and Jusoh (2018) developed allometric equations to estimate annual carbon sequestration for *Acacia mangium*.

AGC stock of *B. variegata* and *M. serrata* was best predicted with a linear model having R^2 value of 0.91 and 0.86, respectively (Table 9). In *C. australis* the best fit model (R^2= 0.97) was the quadratic model, whereas, in *G. optiva* (R^2=0.93) and *L. leucocephala* (R^2= 0.80) power model was the best fit.

CONCLUSION

The availability of appropriate biomass models for fodder tree species, is a major constraint in north-western Himalaya. The present study concluded that stem volume, rate of volume increment, above-ground biomass, stem biomass increment, branch biomass production (yr^{-1}), leaf biomass production (yr^{-1}) of the agroforestry tree species viz., *B. variegata*, *C. australis*, *G. optiva*, *L. leucocephala* and *M. serrata* can be predicted with good degree of accuracy (confidence level greater than 80%) using diameter as independent variable. The rate of carbon sequestration of *B. variegata, L. leucocephala* and *M. serrata* can be predicted with a high degree of accuracy (0.98-0.99). The confidence level of predicting the rate of carbon sequestration of *C. australis* and *G. optiva* was 81% and 85%, respectively. The finding of the present study can be used in deciding the optimum number of trees which farmer have to maintain at his farmland for fulfilling the fodder needs of the dairy cattle and energy requirement of the farmers. The findings of the present study can also be used by environmental scientists in estimating the CO_2 mitigation potential of the selected agroforestry tree species. The models developed in the present study can be applied for multi-species evaluation of above-ground biomass and carbon assessment at a local and regional scale. The models developed under this study are the best available for the species studied and provides a good estimation of biomass with a relatively smaller data set.

Table 8. Validation of best-fit equations for the rate of carbon sequestration

Species	Paired t-test value for predicted versus observed variable	p-value
B. variegata	-0.47	0.97
C. australis	0.36	0.90
G. optiva	0.60	0.94
L. leucocephala	0.28	0.98
M. serrata	0.62	0.96

Table 9. Best fit equations for Above ground biomass (AGC) stock (kg $tree^{-1}$) based on DBH

Species	Model type	Equation	R^2	Adj R^2	S.E.
B. variegata	Linear	-.528+1.692×DBH	0.91	0.90	4.325
C. australis	Quadratic	-46.512+ 3.373 ×DBH +.021×DBH^2	0.97	0.97	10.42
G. optiva	Power	6.46×$DBH^{.736}$	0.93	0.90	0.054
L. leucocephala	Power	1.460×$DBH^{1.252}$	0.80	0.80	0.215
M. serrata	Linear	-8.715+2.967×DBH	0.86	0.86	9.57

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Remote Sensing Techniques and Geographic Information Systems to Study Soil Characteristics in Baquba Governorate

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Abstract: This study was conducted in the district of Baquba in the province of Diyala in central Iraq between latitudes 44 ° 24 '03.306'- "41 44º '36.564, and latitudes 33º 47'13.824" -33º 58'27.108 "and the area of 527,820 km^2. For the purpose of studying the soil characteristics (texture, virtual density, pH and EC), the field survey was based on the selection of 30 random samples with a depth of 0-30 cm for each sample using GPS and the use of a satellite image of Landsat 8 satellite for the purpose of preparing maps of the studied soil characteristics. Soil texture was soft to medium and pH values ranged from 7.27 to 7.88, which were neutral soils to moderate alkaline soils. EC for the study area ranged from 0.54 to 7.91 ds m^{-1}. This study aims to identify some of the soil characteristics in Baquba and map them for assessment and management of these soils, which makes it easier for researchers to obtain the require information.

Keywords: Remote sensing, GIS, Soil texture, Soil salinity

The soil plays an important role in the life of plants and in their geographical distribution, and is the cradle and medium of plant growth and provides water and nutrients for the physiological processes of its growth (Ghauee 2009, Ali et al 2015). The reflective properties of soil are the result of the relationship between the spectral behavior within the wavelength use in which interference and interaction with the falling rays occurs. Because the soil represents a heterogeneous mix of different characteristics such as soil salinity and organic matter, iron oxides, soil minerals and soil texture that affect the surface reflective properties and soil color, which are one of the most important visual properties of soil (Dulaimi 2007, Muhammad et al 2017).

The use of remote sensing techniques is one of the most effective methods of studying natural resources (soil, water and vegetation), identifying their properties and places of residence, monitoring and developing plans for their exploitation, as well as their applications in monitoring and tracking environmental phenomena that affect agricultural development processes such as drought, soil degradation, desertification and erosion and analyze data, information and maps to draw conclusions and indicators that are useful for forecasting and the management their resources (Omar and Abdul Samad 2016, Ismail et al 2017). Sunita (2016) observed most important soil characteristics that can be studied using remote sensing applications are texture, soil minerals, moisture, salinity and carbonate content at the local and regional levels, and the various analyses of satellite images through the available software. Asnake et al (2017) pointed out that the use of spatial data for the management and sustainability of natural resources is of great importance, especially in the preparation of maps and study the structure or construction of these resources, soil, water and vegetation. The use of remote sensing techniques and geographic information systems have become important factors encouraging in the study of natural resources. Nabal et al (2015) used remote sensing and geographic information systems for the study of some soil characteristics in the Suweida area in Syria, The soil texture ranged from clay to clay to loam and by 36.84 to 63.14%, respectively. Engin and Mehmet (2017) determined the change in soil characteristics using GIS in the Iznik region in Turkey, by adopting software in GIS, especially ARC GIS, and observed that there was a change in the percentage of sand, clay and salts by depth, as well as the difference in density from one depth to another. This study aims to identify some of the soil characteristics in Baquba and map them for the purpose of benefiting from them in the processes of assessment and management of these soils, which makes it easier for researchers to obtain the require information.

MATERIAL AND METHODS

Study area: The study area was determined by means of field visits using the Global Positioning System (GPS). Samples of the studied sites were taken with the help of the ouker drill at the selected depths. The study area is located within the administrative boundaries of Diyala Governorate in Baquba district. The coordinates are between latitudes 44 ° 24 '03.306'- "41 44º '36.564, and latitudes 33º 47'13.824" - 33º 58'27.108 and the area of 527,820 km^2. The satellite data of the Landsat 8 satellite OLI_TIRS (row 37 and path 168), was recoded on December 23, 2015. Using the Erdas imagine V.2014 program, the study area was cut from the original satellite image and then a shapefile point layer was created for the 30 sample sites using ArcGIS 10.3.1 and UTM (Fig. 1, Table 1).

Study samples: Soil samples were taken from the depth 0-30 cm from different locations were well mixed to their homogeneous and passed from a 2 mm diameter sieve, from which a composite sample was taken for the purpose of conducting chemical and physical analysis. The volumetric distribution of the soil, compost was estimated in a condensed manner according to(Day 1965, Black ,1965). The soil pH was measured using a pH- electrical conductivity EC was estimated in the suspended leaky soil: water 1: 1 using a Conductivity Bridge device was done (Page et al 1982).The carbonate minerals were determined by using Calcemitr and acid HCl-3N (Al-azzawi et al 2018).

RESULTS AND DISCUSSION

Soil texture: Using ArcMap, The kriging / cokriging analysis was perofmed to obtain a texture distribution map for Baquba

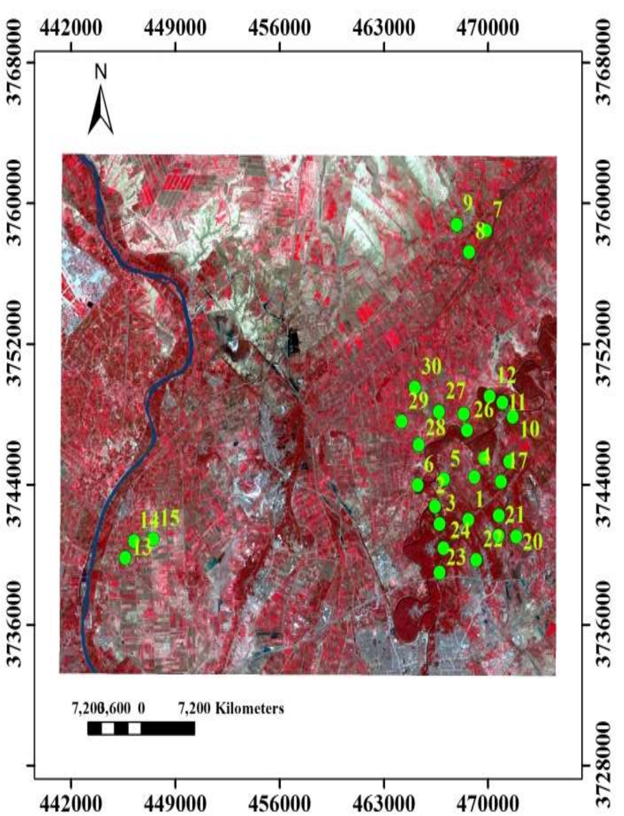

Fig. 1. Site map of the study area showing the satellite Image and sample sites

(Fig. 2). The Figure 2 shows a difference in soil, texture between the sites in the study area, namely clay, sand (10.519 km^2 and 1.99%), loamy (33.742 km^2 and 6.39%), loamy clay (with an area of 42.413 km^2 and 8.04%) clay (with an area of 55,721 km^2 and 10.56%), loamy clay, clay (27.683 km^2 and 5,24%) clay sand loamy (193.256 km^2 and 36.61% (45.486 km^2 and 8.62%) and sand loamy (17.326 km^2 and 3.28%). Thus, the soil of the region is generally located within sedimentary soils, Contains soft and medium soft textures (Al-Badiri 2018).

EC: EC ranged from 0.54 to 7.91 ds m^{-1}. These results confirm the role of physical properties affecting the movement of water within the body of the soil and the

Table 1. Samples names and geographical coordinates

Region name	UTM coordinates	
	X	Y
Alabara	468183	3742080
Alabara	467046	3742860
Alabara	467335	3741690
Khreisan	468614	3744500
Khreisan	467507	3744420
Khreisan	465847	3744080
Sheikh River	469408	3758530
Sheikh River	468202	3757410
Sheikh River	468466	3758770
Great Zaganeh	472172	3748110
Great Zaganeh	471297	3749170
Great Zaganeh	469867	3749560
Alsada	445190	3739840
Alsada	445750	3741010
Alsada	447052	3740930
Alhadagder	470862	3745350
Alhadagder	471379	3744210
Alhadagder	470015	3745040
Abdul Hamid	471276	3742420
Abdul Hamid	472379	3741250
Abdul Hamid	471240	3741170
Alhakem	468663	3739700
Alhake	467294	3739040
Alhakem	467461	3740480
Alsawaed	468400	3748630
Alsawaed	469078	3747190
Alsawaed	467227	3748170
Haadmakser	465888	3746490
Haadmakser	464689	3747790
Haadmakser	465246	3749030

accompanying movement of soluble salts. The state of deterioration in saline soils and its negative impact on porosity of the soil and its direct impact on soil permeability and its reflection on the amount of salts accumulated in the soil. Using ArcMap, a kriging / Cokriging analysis was done to obtain the EC soil distribution (Fig. 3). The highest percentage was for the category 3.76-4.55 ds.m-1 (78.5%) with an area of 414,204 km^2 and the smallest area is 3.286 km^2 for category 6.33-7.91 ds.m^{-1} (0.62%).

pH: The soil pH ranged between 7.27 – 7.88, which is a neutral soils to moderate base alkaline soils based on NRCS (2005). Increasing the soil content of calcium carbonate minerals has its significant influence on soil chemical and physical properties and nutrient readiness. However, the range in the study areas is the ideal range for most crops and elements so its effect is limited. Using ArcMap, performed a kriging / Cokriging analysis to obtain a pH distribution map for the study (Fig. 4).

pH values were divided into three categories ,2.27-7.49 (122.174 km ^{2}, 23.15%)and 7.50-7.54 (197.481 km^2, 37.41%) and 7.55-7.88, with an area of 208,165 km^2 and 39.44% (Fig. 4).

Calcium carbonate minerals: Calcium carbonate minerals, when present in the soil, help to increase soil granularity and improve its structure. On the other hand, calcium-containing compounds are the best materials for reclamation of acid soils and alkali soils (Khoury and Reem 2014) and also affects soil fertility and nutrient readiness as it stabilizes phosphorus and micro-elements, reduces their plant uptake and also increases soil reaction (Bendawi 2014). Calcium

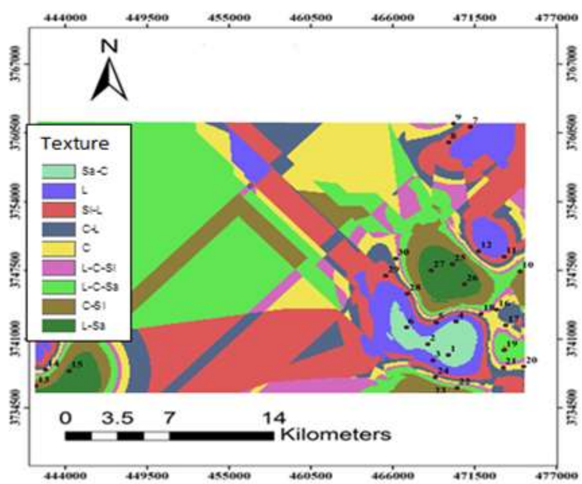

Fig. 2. Distribution of soil texture for the study area in Baquba

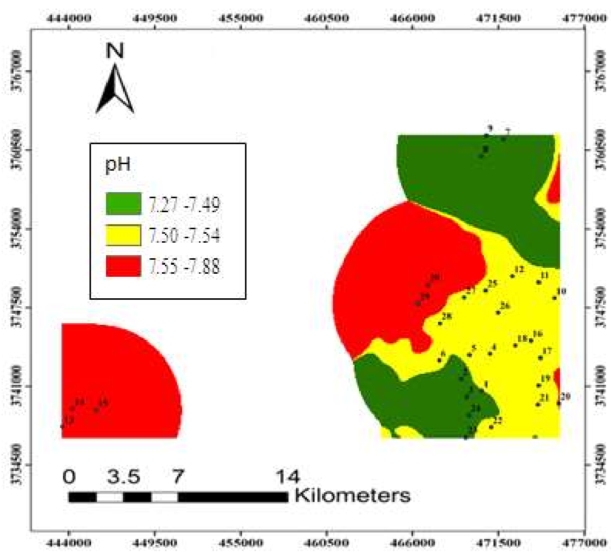

Fig. 4. Distribution of soil pH for the study area in Baquba

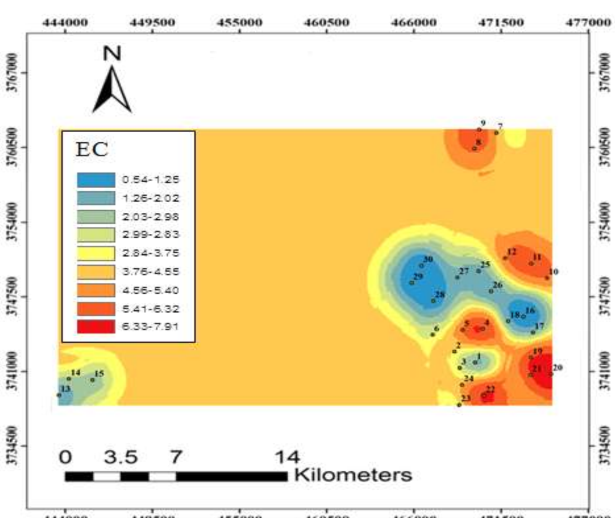

Fig. 3. Distribution of soil salinity EC for the study area in Baquba

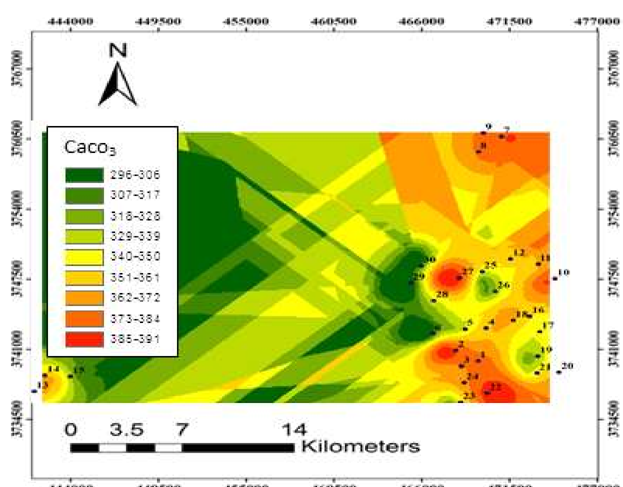

Fig. 5. Distribution of calcium carbonate caco$_3$ for study area in Baquba

Table 2. Characteristics of soil samples in the study area in Baquba

$Caco_3$	EC	pH	Texture	Sand (%)	Silt (%)	Clay (%)
332.307	1.63	7.504	Sand clay	67.2	20.8	12
310.769	3.16	7.486	Loamy	35.2	38.8	26
338.461	2.64	7.798	Silt loamy	17.2	60.8	22
343.076	5.99	7.538	Loamy	39.2	34.8	26
361.538	4.67	7.489	Clay loamy	38	35	27
384.615	2.69	7.272	Loamy	38	36	26
323.076	3.82	7.635	Clay loamy	35.2	36.8	28
329.230	5.01	7.421	Clay loamy	24	41	35
336.921	5.36	7.423	Clay	28	31.4	40.6
323.076	4.61	7.495	Clay loamy silt	19.2	48.4	32.4
347.692	5.39	7.563	Clay loamy	29	40.4	30.6
350.769	4.51	7.475	Clay loamy	29.2	38.4	32.4
341.538	1.21	7.685	Clay loamy sand	59.2	20.4	20.4
343.384	2.09	7.602	Clay	25.2	28.4	46.4
369.230	1.92	7.589	Clay silt	14	44.4	41.6
353.846	0.61	7.877	Clay	8	36	56
356.923	1.69	7.622	Clay	9.2	28.4	62.4
338.461	1.41	7.268	Clay	6.2	29.4	64.4
367.692	5.71	7.659	Clay loamy silt	15	42.4	42.6
344.615	7.91	7.482	Clay	14	34	52
356.923	5.93	7.590	Clay	12	38.4	49.6
303.076	6.22	7.417	Clay loamy silt	20	43	37
366.153	3.16	7.544	Clay silt	17	40.4	42.6
343.076	3.72	7.417	Clay	14	34	52
367.692	1.32	7.454	Sand loamy	56	30.4	13.6
367.692	1.20	7.525	Sand loamy	53.2	30.4	16.4
296.923	1.34	7.717	Sand loamy	66	20.4	13.6
366.153	0.72	7.667	Clay loamy	20	40	40
390.769	0.56	7.718	Clay loamy	30	33	37
380.000	0.54	7.700	Clay	16	34.4	49.6

carbonate values ranged from 296.923-390.769, using ArcMap, performed a kriging / Cokriging analysis to obtain a calcium carbonate distribution map for the study area in Baquba (Fig. 5). The calcium carbonate was divided into 9 categories and that the highest area was in the fourth category (329-339 g.kg^{-1}), with an area of 98,854 km2 and by 18.73% and the lowest area of the ninth category (385-391 g.kg^{-1}) with an area of 4,871 km^{2} and a rate of 0.923% (Fig. 5).

CONCLUSION

There were differences in soil characteristics of the study areas based on mechanical and chemical analyzes of soil samples. Soil texture was soft to medium softness in most study samples and pH values ranged from 7.27 to 7.88, which were neutral soils to moderate alkaline soils. EC values ranged from 0.54 to 7.91 ds m^{-1}. The use of remote sensing techniques and geographic information systems have been instrumental in the preparation of maps of the studied characteristics and how they are distributed spatially.

CONTRIBUTION OF AUTHORS

Basem R B: designed Research Methodology and Data collection, Data Interpretation, Manuscript Writing and Manuscript final Writing and approval and Ahmed B K : interpreted the data and prepare maps.

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Capsule Ripening and Seed Germination in *Rhododendron campanulatum* (D. Don) in Aali Treeline Area of Western Himalaya, India

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Abstract: *R. campanulatum* is found at the treeline, timberline and subalpine forests between 3000-4200msl across the Himalaya. The present study documents the capsule maturation time and seed germination status of *R. campanulatum* in recent warming scenario at Aali treeline area. The different physical parameters like, capsule size, number of capsule/100g, weight and mass of 100 capsule were taken and germination was carried out in a dual chamber seed germinator for each collection date. The tree density of *R. campanulatum* was 190 ha^{-1}. The mean capsule size during collection ranged from 63.71 to 246.14mm^2, the change in capsule weight was 46.67 to 48.66 g across the collection period. The mass of 100 capsule during study varied between 19.13 and 79.43g. Seed germination was low and maximum germination 39.57 occurred at 29.00 per cent moisture content. The change in capsule colour from light green to dark green and decline in moisture content of capsules appear to be good indicators of seed maturity in *R. campanulatum*.

Keywords: *R. campanulatum,* Maturity, Moisture Content, Germination, Treeline

Rhododendrons are among the most popular flowering plants that adorn the mountains with fantastic and ineffable flowers of different shades (Bhattacharyya and Sanjappa 2008). It belongs to the family, Ericaceae which is primarily a Northern Hemisphere genus, extending from North America across Europe and Asia to Japan and from the extreme north to the Equator (Singh et al 2015). The genus consists of 1000 species divided into 8 subgenera (Chamberlain et al 1996) out of this about 80 species with 10 subspecies and 14 varieties found in India (Bhattacharyya 2005) and 21 species can be considered as rare. Understanding the ecological needs of keystone species, such as *Rhododendrons* (Singh et al 2009) in the Himalayas, is of critical importance for ecosystem conservation.

R. campanulatum D. Don is found at the treeline ecotone, timberline and subalpine forest at an elevational range from 3000-4200m across the Himalaya (Rana et al 2016). It occurs in krummholtz form in treeline areas (Singh et al 2019). The species generally grows in high rainfall, humid temperate regions of highly organic well-drained acidic soils and mountains that have dry, cool summer and long winters (Milleville 2002). It produces very minute seed, small-seed species usually present high mortality in the transition between seed germination and seedling emergence and tend to exhibit lower values of survival (Singh 2019). Climate has a large influence on plant recruitment, regeneration and survival.

In life cycle of forest trees fruit/seed ripening is an important part. Knowledge of the maturation process contributes to the establishment of the ideal time to harvest when seeds have a better physiological quality and a recommended way to study the effect of climatic variations on forest tree species (Tamta and Singh 2018). Change in seed maturity timing can influence regeneration, development and hence impact stand composition and structure (Tewari et al 2017). Capsule maturation affects the timing of seed dispersal, and in turn, germination. Capsule size and mass, reflects potential food reserves for seedling growth and are considered as important traits determining the successful establishment of individual plants (Tewari et al 2016).

Limited studies have been carried and there is lack of baseline data regarding the seed maturity and germination in treeline areas especially of *R. campanulatum*. Some seed characteristic and germination related studied have been carried out by Dhiman et al (2015) for *Wendlandia exserta*, Bhardwaj and Sood (2016) for *Rheum australe*, Punia et al (2016) for *Vigna radiata*, chauhan and Verma (1995), Tewari et al (2017) for *Quercus leucotrichophora*, Kumar et al (2018) for *Celtis australis*, Mohammed and Mohamed (2019) for *Anacyclus pyrethrum* and Singh et al (2020) for *Betula utilis* in different parts on India. The present study reports the capsule maturation time and seed germination status of *R.*

campanulatum in recent warming scenario in treeline areas of Indian Himalayan regions.

MATERIAL AND METHODS

Study site: The studied treeline site (Aali) situated at 30°11´02˝N and 79°39´28˝E and occurs between 3233 and 3446msl in the sub-alpine zone. Soil is sandy loam in texture and generally acidic with pH value 4 to 5 (Singh et al 2019). The climate of the study area is characterized by short cool summers and long severe winters. The mean annual temperature of the sites varied from -8.0 and 24.8°C. Anthropogenic disturbance in treeline sites mainly occurs in the form of migratory grazing and tourist activities (Singh et al 2019).

Phytosociological analysis: *R. campanulatum,* which is a small tree/ sub tree/ shrubs species is found at treeline areas. In the present study it was considered as a tree species following Singh et al (2019). The phytosociological analysis of treeline tree species was done by placing 40 quadrats of 10 x 10m in the study site. The size and number of the samples were determined following Saxena and Singh (1982) and Singh et al (2014). The importance value index was determined as the sum of the relative frequency, relative density and relative dominance (Ambasht and Ambasht 2002).

Maturity indices: Twenty five individuals were selected which had a well-developed crown with sufficient number of capsule and free from any disease in 1.0 ha area. Capsule collection of *R. campanulatum* was started from Ist week of June up to the availability of capsule till IVth week of November. The capsule collection was made directly from the tree and seeds germinated in the laboratory. For capsule physical parameters three replicate of 100 capsule each were taken and the different parameters capsule size (mm^2) (length ×width), number of capsule per 100g and weight and mass of 100 capsule were measured. For calculating moisture content of capsule three replicates of 25 capsule were taken for each collection date. The moisture content was expressed on fresh weight basis in which capsule were dried at 103±2°C for 16±1 hour and then reweighed following (ISTA 1981).

Seeds were extracted from the capsule at each collection date. Germination was carried out in a dual chamber seed germinator for each collection date. The petridishes and germination paper was sterilized at high temperature (130ºC) for 4 hours to make it free from fungal infection. For germination 4 replicates of 1gm (approx. 5500 seed per gram) seeds each were used following Tewari and Tewari (2019). The germination of seeds was carried out at 25±1ºC on top of the paper in seed germinator under dark condition. Daily observation was taken and germination was counted when visible protrusion of radical (1mm) occurred. Water was added as required during the experiment. After completion of experiment germination percent was calculated (Paul 1972).The data were subjected to analysis of variance with a 95% confidence level using SPSS version 2016.

RESULTS AND DISCUSSION

Tree layer analysis: At studied treeline site the total tree density was 710 ha^{-1} and total basal area 75.42 m^2 ha^{-1}. The tree density of *R. campanulatum* was 190 ha^{-1}, sapling density was 290 ha^{-1} and seedlings density was 310 ha^{-1}. The total basal area of *R. campanulatum* was 1.94 m^2 ha^{-1} and the IVI was 45.87. The tree density of associated species *Abies spectabilis, Betula utilis, Quercus semecarpifolia* and *Rhododendron arboreum* was between 50 and 160 ha^{-1} and total basal area ranged from 1.88 to 27.98 m^2 ha^{-1}.

Capsule colour: The capsule colour of *R. campanulatum* during first collection was light green and at final collection it changed to dark green in both the years (Table 1).

Capsule characteristics: The mean capsule size during first collection was 68.53mm^2 in Yr1 and 63.71mm^2 in Yr2 which gradually increased with each collection date. The maximum capsule size was 242.26mm^2 in Yr1 and 246.14mm^2 in Yr2 during the eleventh collection, after that the capsule size started declining and reached to 230.34 and 235.00mm^2 in Yr1 and Yr2 at final collection (Table 1). The mean weight of 100 capsules during first collection was 28.6 and 27.33g in first and second year which gradually increased with each collection date. The maximum weight of 100 capsules was 88.00 and 86.33g during the eighth collection, after that the capsule weight started declining and reached 77.33g in Yr1 and 74.00g in Yr2 at final collection (Table 1). During the first collection the number of capsules per 100 g was 370.00 in Yr1 and 375.00 in Yr2 which gradually decreased with each collection date. The minimum number of capsules per 100 g was 119.67 in Yr1 during eighth collection and 142.33 in Yr2 during the tenth collection, after that the capsules number per 100 g started increasing and reached to 147.33 and 153.67 both two year. The mass of 100 capsules during first collection was 20.07g in Yr1 and 19.13g in Yr2 which gradually increased up to the 79.43g in Yr1 and 78.65g in Yr2 during the ninth collection, after that the capsule mass started declining and at final collection was 71.15g in Yr1 and 68.08g in Yr2 (Table 1).

The Δ change (change between initial and final collection) of capsule size was 161.81mm^2 in Yr1 and 171.29 mm^2. The Δ change of weight of 100 capsules was 48.66g in Yr2 and 46.67g in Yr2 and Δ change number of capsules/100g was

222.67 in Yr1 and 221.33 in Yr2. Similarly the Δ change in mass of 100 capsules was 51.08g and 48.95g in Yr 1and 2.

Germination: The seeds of *R. campanulatum* failed to germinate for first seven collections in both the years. The germination started from eighth collection and was 10.67% in Yr1 and 11.33% in Yr2 which gradually increased with each collection date. The maximum was 39.57 and 38.83 in two years at the final collection. The moisture content across all collection dates varied from 29.00 to 70.63% in Yr1 and 28.95 to 72.08% in Yr2. The maximum germination occurred when the moisture was 29.00% in Yr1 and 28.95% in Yr2 (Fig. 1). *R. campanulatum* seeds attained maturity in the fourth week of November. The capsule size, weight of 100 capsules, number of capsules per 100g, mass of 100 capsules, capsules moisture content and germination varied significantly across the dates ($p<0.05$), but not across two year of study. The interactions between years × dates varied significantly with number of capsules per 100g and moisture content ($p<0.05$) (Table 2).

A significant positive correlation was observed between capsule size and weight of 100 capsules, capsule size and mass of 100 capsules, capsule size and germination, weight of 100 capsules and mass of 100 capsules, weight of 100 capsules and germination, number of capsules per 100 g and moisture content and mass of 100 capsules and germination at 0.05% significant level (Table 3). A significant negative correlation was observed between capsule size and number of capsules per 100g, capsule size and moisture content, weight of 100 capsules and number of capsules per 100g, weight of 100 capsules and moisture content, number of capsules per 100g and mass of 100 capsules, number of capsules per 100g and germination, mass of 100 capsules and moisture content and moisture content and germination at 0.05% significant level (Table 3).

Table 1. Variation in physical attributes of *R. campanulatum* capsules over the collection period in Yr1 and Yr2

Collection number	Collection date	Capsule colour	Capsule size (mm^2)	Weight of 100 capsules (g)	Number of capsules/ 100 (g)	Mass of 100 capsules (g)
Yr1						
I st	I st week of June	G	68.53±5.79	28.67±2.67	370.00±5.77	20.07±1.87
II nd	III rd week of June	G	85.92±5.89	33.67±0.88	313.33±3.33	23.57±0.62
III rd	I st week of July	BG	100.81±2.39	48.33±2.03	219.33±2.96	33.83±1.42
IV th	III rd week of July	BG	111.17±2.40	49.67±1.20	207.33±1.20	36.75±0.89
V th	I st week of August	BG	123.67±3.12	58.33±0.88	198.00±1.15	43.17±0.65
VI th	III rd week of August	BG	129.16±3.75	60.33±0.88	170.00±1.15	47.06±0.69
VII th	II nd week of September	BG	168.79±2.28	72.67±0.88	152.67±1.20	56.68±0.69
VIII th	IV th week of September	BG	209.16±7.86	88.00±1.73	119.67±1.20	73.04±1.44
IX th	II nd week of October	BG	215.62±9.04	86.33±2.33	122.67±1.20	79.43±2.15
X th	IV th week of October	BG	225.00±9.23	84.33±2.33	142.00±2.31	77.59±2.15
XI th	II nd week of November	DG	242.26±1.23	84.00±1.15	140.67±1.33	77.28±1.06
XII th	IV th week of November	DG	230.34±0.93	77.33±1.20	147.33±1.20	71.15±1.11
Yr2						
I st	I st week of June	G	63.71±2.92	27.33±1.20	375.00±2.89	19.13±0.84
II nd	III rd week of June	G	83.62±2.52	29.33±0.88	322.67±1.45	20.53±0.62
III rd	I st week of July	BG	99.08±1.18	46.19±0.50	227.67±1.45	32.33±0.35
IV th	III rd week of July	BG	107.57±1.72	47.89±0.56	208.00±3.06	35.44±0.41
V th	I st week of August	BG	124.76±2.42	59.33±3.84	158.00±1.15	43.91±2.84
VI th	III rd week of August	BG	142.87±1.35	66.00±1.15	146.00±0.58	51.48±0.90
VII th	II nd week of September	BG	170.88±3.21	74.67±2.40	145.90±1.15	58.24±1.87
VIII th	IV th week of September	BG	204.11±4.22	86.33±3.48	145.67±1.86	71.66±2.89
IX th	II nd week of October	BG	218.33±0.88	85.49±0.64	144.00±0.58	78.65±0.59
X th	IV th week of October	BG	228.51±3.32	84.00±2.08	142.33±1.45	77.28±1.92
XI th	II nd week of November	DG	246.14±1.97	83.00±0.58	146.00±0.58	76.36±0.53
XII th	IV th week of November	DG	235.00±1.53	74.00±0.58	153.67±1.20	68.08±0.53

Note: G = Green, BG = Brownish Green and DG = Dark Green

Seed development and maturation, which are temperature and moisture dependent processes, affect seed quality (Copeland and McDonald 2001). The stage and time of maturity of capsules/seeds is essential for collection of abundant quantity of healthy and vigorous seeds. The physical characters of fruits/seeds play a significant role in maturity indices. The physical parameters such as moisture content and specific gravity are interrelated and more objective. Both have been reported as reliable maturity indices by numerous researchers (Tewari and Tewari 2019).

The change in capsule colour from light green to dark green and decline in moisture content from 72 to 29% appear to be good indicators of seed maturity in *R. campanulatum*. Initially the moisture content of capsule was very high as the capsule matured it declined continuously. Change in fruit colour and decline in fresh capsule moisture content from maturing is closely related to seed maturity. The maximum seed germination of *R. campanulatum* was at 29.15% moisture content of capsule. Similar study have also done by Tewari and Tewari (2019) and Mittal (2018) in *R. arboreum*

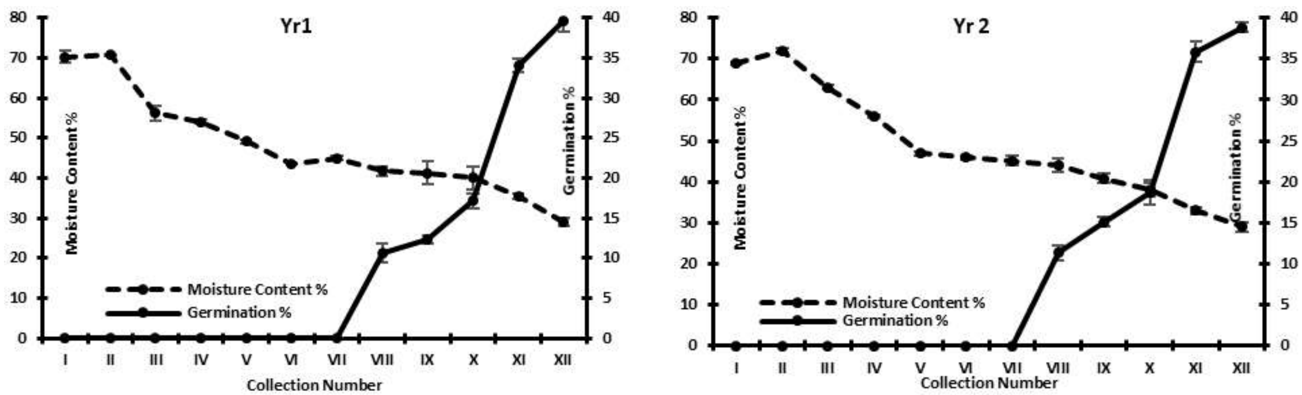

Fig. 1. Relationship between moisture content and germination of *R. campanulatum* seeds over the collection dates in Yr1 and Yr2

Table 2. Analysis of variance (ANOVA) for different capsules attributes of *R. campanulatum* across collection dates and years

Parameter	Source of variation	DF	Mean square	F-value
ANOVA				
Capsule size	Years	1	25.04	0.359^{NS}
	Dates	11	24460.17	350.59**
	Years × Dates	11	41.36	0.593^{NS}
Weight of 100 capsules	Years	1	8.20	0.879^{NS}
	Dates	11	2686.28	287.22**
	Years × Dates	11	10.31	1.106^{NS}
Number of capsules/100 (g)	Years	1	4.50	0.350^{NS}
	Dates	11	36364.00	2.830**
	Years × Dates	11	506.62	39.43**
Mass of 100 capsules	Years	1	5.30	0.87^{NS}
	Dates	11	2930.20	484.30**
	Years × Dates	11	6.25	1.03^{NS}
Moisture content	Years	1	4.42	0.955^{NS}
	Dates	11	1047.11	226.23**
	Years × Dates	11	10.14	2.19**
Germination	Years	1	4.64	3.731^{NS}
	Dates	11	1228.32	987.37**
	Years × Dates	11	1.57	1.265^{NS}

NS = Non-Significant, ** = Significant at 5% (p<0.05)

Table 3. Correlations between different capsule parameters and seed germination of *R. campanulatum*

Parameters	Capsule size	Weight of 100 capsules	Number of capsules/ 100 (g)	Mass of 100 capsules	Moisture content	Germination
Capsule size	1	0.933**	-0.809**	0.918**	-0.899**	0.820**
Weight of 100 capsules		1	-0.918**	0.959**	-0.899**	0.611**
Number of capsules/100 (g)			1	-0.856**	0.883**	-0.459**
Mass of 100 capsules				1	-0.869**	0.637**
Moisture content					1	-0.743**
Germination						1

**Correlation is significant at the 0.01 level (p<0.01) (2-tailed)

and maximum germination observed between 30.11 and 37% moisture content of capsule in Central Himalayan region.

Various physical parameter such as, size, weight, number and mass of fruit have been associated with maturation time. Generally the fruit/seed attain maximum weight or mass at the time of maturation. In the present study at the time of maximum germination the weight of 100 capsule was 74 to 77 g and size was 230 to 235 mm^2. Mittal (2018) reported the weight of 100 capsule was 33 to 40 and size was 208 to 240 mm^2 and Singh (2019) reported the weight of 100 capsule 31 to 32 g and size 199 to 208 mm^2 in *R. arboreum*. Warming increased seed mass in plants and higher mass increased the seedling survival. The capsule mass was 68 to 71 g at the time of maximum germination.

CONCLUSION

Present study shows that the colour change of capsule from light green to dark green and change in physical parameters such as capsule size, weight and mass of capsule and number of capsule per 100 gm is a reliable indicator of maturity in *R. campanulatum*. Besides this capsule moisture content also appear as useful indicator of maturity. *R. campanulatum* capsules attain maturity when the capsules moisture content ranged between 28 and 30%. The capsule moisture content coincided with maximum germination. Thus, the knowledge of seed maturation of this important treeline species can be helpful in promoting this poorly regenerating species.

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Gnomonia leptostyla Causer of Walnut Anthracnose in Iraq and Its Biochemical Resistance

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Abstract: *Gnomonia leptostyla* (Fr.) Ces. et de Not. (*Marssonina juglandis* (Lib.) Magn, has been detected as the fungus that causes walnut anthracnose in Iraq, dependence on the presence of a cervuli on the dead tissue of leaves and the morphology of the fungal colony and microconidia. The brown spotting disease (anthracnose) causes weakness of walnut trees falling leaves and the lack of and poor fruits. Symptoms revealed that in early May on the lower surface of the leaves in the form of small necrotic spots surrounded by a yellow halo, then the necrotic spots increased and spread and began to merge with each other to cover most of the leaf surface, and the leaves began to fall due to the dryness of the stems. The optimum temperature for fungus growth was 22°C. The best medium used was a sabouraud agar. The alcoholic extract of sage and the fungicide (fberusat) were able to inhibit the growth of *G. leptostyla* by 100%. The alcoholic extract of clove inhibited the growth of the fungus 100% at the concentrations (30 and 40 mg ml^{-1}).

***Keywords*:** *Gnomonia leptostyla*, Anthracnose, Walnut, Cloves, Sage, Fberusat

Walnut (*Juglans regia* L.) is an economically important crop and belongs to the Juglandaceae family. Iran is the main habitat of the walnut, from which spread to the rest of the world. Its cultivation extended from the Americas to Europe to Asia (Marrano et al 2019). Anthracnose is one of the most deadly diseases around the world of walnut trees (Lamsal et al 2011, Ridzuan et al 2018) caused by the fungus *Gnomonia leptostyla* (Fr.) Ces. et de Not. (anamorph *Marssonina juglandis* (Lib.) Magn. (Karov et al 2014). Symptoms appear on leaves, stems and fruits in the form of irregular necrotic spots of a diameter of less than 5 mm, surrounded by yellow halos (Woeste and Beineke 2001).The spots that appear on the scales of the fruits, will die less than 2 mm in diameter (Wang et al 2020). Buds and branches are attacked, and the circular spots are dark brown-black, and in severe cases these spots merge to form necrotic areas in the form of lesions late in the season (Belisario et al 2008) and cause the leaves to fall prematurely and the fruits fall off before ripening, or produce bad taste fruits, and the injury leads to a reduction in the amount of processed food, which leads to poor tree (Hasan 2010, Kalkisım 2012) The disease becomes severe in the rainy spring, which leads to weak trees and sometimes plant deaths (Karov et al 2014). Pathogenic fungi spend the winter in the form of ascospores in fruiting bodies called perithecial and conidia spores within acervuli in the leaves and fruits of the nut. Initial infections appear in May, when the wet spring provides optimal conditions for the production of ascospors, which are transferred in the presence of rain and wind to new green leaves where infection occurs (Hashemi 2005). The number of infected leaves increases in the early summer, when a small black acervuli appears on the affected leaves and is responsible for transmitting the infection by forming conidia spores that can survive on the leaf litter when insufficient moisture is available for their germination for at least two weeks (Hasan 2010). The current study aimed to isolate and detect the fungus that causes anthracnose nut in Iraq while describing the symptoms of infection, and the use of some plant extracts and the fungicide fberusat to combat the pathogen fungus.

MATERIAL AND METHODS

Brown spotting disease on walnuts was observed on a number of trees of the local walnut variety: Amadiyah, Aqrah, Dohuk, and Mosul, where observations were recorded of the occurrence and development of the disease. Leaves, twigs, and fruits were collected for the purpose of detecting the pathogen, and were sterilized surface with a solution of sodium hypochlorite at a concentration of 1% for a period of 3-5 minutes. After drying it was placed in the Petri dishes on the PDA medium and left in the incubator at 25°C (Mohammed et al 2018, Suryavamshi and Shivanna 2020). Detection was made based on phenotypic properties such as colony shape and growth rate, as well as the shape of conidia and the ascospores (Sogonov et al 2008). The production of ascospores was tested by taking several tablets with a diameter of 7 mm from a colony at the age of 21 days and placing them in a test tube containing a container of 5 ml of sterile distilled water, put in the vortex to release the spores. Then the centrifugation was performed, a drop of precipitate was taken and examined under a microscope (Matteoni and Neely 1979). A microscopic examination of the presence of acervuli in the affected leaves was also carried out, as well as the observation of the spread of fungal hyphae between the leaf cells.

Effect of temperature on growth of *G. leptostyla*: The fungus were grown with temperatures 5, 10, 15, 20, 22, 25, 30°C. The 5 mm disk taken from a growing fungal colony were cultured on the PDA medium. The growth rate was calculated based on the difference between the colony diameter after 21 days incubation and the first disc diameter.

Effect of culture medium type on growth of *G. leptostyla*: The fungus was grown in different cultivation media: walnut medium (2%), Czapek-Dox agar medium, PDA medium, and sabouraud agar medium. Place a tablet with a diameter of 5 mm from the fungal culture of *G. leptostyla* in the center of the Petri dish containing the culture medium and leave it in the incubator at 22°C for 21 days. The growth rate of the fungus was then calculated for each culture medium.

Evaluation of plant extracts and fungicide (fberusat) : Alcoholic extracts of Sage (*Salvia officinalis*) and Clove (*Syzygium aromaticum*) were prepared using the soxhlate apparatus and evaluated at 10, 20, 30, 40 mg ml^{-1}. Concentrations were distributed to petri dishes with 3 replicates for each concentration. The medium was used without addition as control. After that all the dishes were inoculated by transferring the 5 mm diameter tablets from the fungal colony and placing them in the center of the plates. The plates were left in the incubator at 22°C for 21 days. The inhibition rate was calculated by using the following equation (Alinizy 2010).

$$\text{Percent inhibition} = \frac{\text{Mean of control diameter} - \text{Mean of treatment colony diameter}}{\text{Mean of control colony diameter}} \times 100$$

RESULTS AND DISCUSSION

Initial infections were observed on the lower surface of the leaves, and later appeared on the rest of the plant parts (buds and fruits). The symptoms began on the leaves in the form of chlorotic lighting turned into brown spots small to medium in size (2-5 mm) surrounded by a yellow halo, then the necrotic spots increased by spreading and began to merge with each other, thus covering most of the surface of the leaf (Fig. 1), and this is consistent with earlier studies (Arnaudov et al 2014, Karov et al 2014). The infections occurred on the lower surface more than on the upper surface, and that the dense areas of the tree are more susceptible to disease. Hasan (2010) also observed similar trend. The high humidity in these parts played major role on the occurrence of the disease and its development. The leaves begin to fall due to the dryness of their stems. On the branches, the symptoms started in the form of necrotic oval lesions, while the disease on the fruits in the form of dark, slightly sunken spots (Fig. 2). Usually the fruits fall off before they reach maturity and have a bad taste and little nutritional value (Arnaudov et al 2014, Hassan and Ahmad 2017). The development of the disease continued in the following months, when the affected leaves were dehydrated and fall by the end of July and the beginning of August. (Hasan 2010) mentioned that the apparent symptoms of brown spotted disease on the nuts in Syria appeared at the end of April and the beginning of May 2019 and the rate of infection increased with time and reached its climax at the end of the growing season in November. The leaves of nuts, as they contain the source of the primary infection, which is ascospores.

Microscopic navigation: The examining the dead tissue in the leaves indicate the black-brown acervuli near the veins of the leaf (Fig. 3) around the dead tissue, as well as scattered near the veins of the leaf. The fungal culture of *G. leptostyla*, it was obtained 21 days after incubation (Fig. 4). Its diameter ranged between 6-8 cm. The bacilli microconidia was obtained in a transparent single-cell form (Fig. 5). Belisario et al (2008) also observed that all of the colonies of *G. leptostyla* produced conidiomata on the PDA medium after incubation of 21 days at a temperature of 22°C as arranged as concentric rings on the edge of imaginary circles in two months, a single, transparent, *Bacillus* microconidia was produced.

Effect of temperature on growth rate of *G. leptostyla*: The best temperature for growth was 22°C as the colony diameter reached 7.5 cm while growth was low at the lower temperature and growth was almost non-existent with high temperatures reaching 30°C (Fig. 6). These results are consistent with the findings of Belisario et al (2008) and Hasan (2010).

Effect of the medium on growth rate of *G. leptostyla*: The sabouraud agar (SDA) medium was the best medium and gave the highest growth rate for the *G. leptostyla* fungus after 21 days of incubation, while the effect of the walnut medium was equal to Potata Dextrose Agar (PDA) on the growth rate of fungus (Fig. 7). Hasan (2010) has shown that conidia spores of the fungus causing brown spotted disease in walnuts grow well in normal and distilled water and best growth occurred in the medium of walnut leaves.

Evaluation of plant extracts and fungicide (fberusat) against *G. leptostyla*: Growth of the fungus *G. leptostyla* showed a high degree of inhibition of 100% with all plant extracts concentrations used for the Sage (*Salvia officinalis*) and fungicide fberusat at concentration (30 and 40 mg ml^{-1})

Fig. 1. Shape of spots caused by *G. leptostyla* on leaves

Fig. 2. The shape of spots caused by *G. leptostyla* on fruit

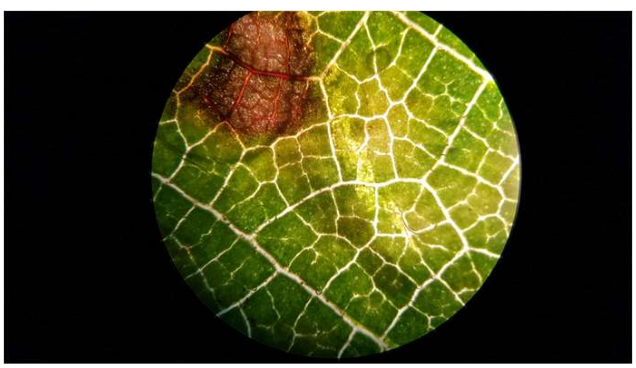
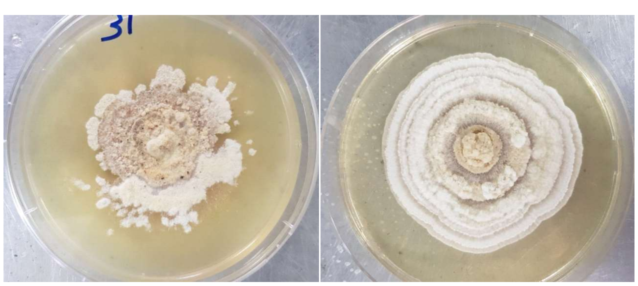


Fig. 3. Presence of acervuli on the leaf tissue



1 2

Fig. 4. Colony morphology 1- on PDA with presence of black acervuli, 2- on sabouraud agar

for Cloves (*Syzygium aromaticam*) (Table 1). Medicinal plants are widely used as a medicine and antibiotic (Debnath and Das 2019, Negi et al 2020). *Salvia officinalis* possess many active compounds in their leaves such as cineole, phenol, thujoun and terpenoid (Pierozan et al 2009). These compounds are effective in inhibiting the growth of fungi (Pinto et al 2007). The ability of aqueous and alcoholic extract of sagebrush to inhibit the growth of *Fusarium solani* and *Rhizoctonia solani* (Shawkat et al 2012). The aqueous and alcoholic extract of sagebrush was able to inhibit the growth of yeast *Saccharomyces crevasse* and fungi *Microsporum*

Fig. 5. Microconidia of *G. leptostyla*

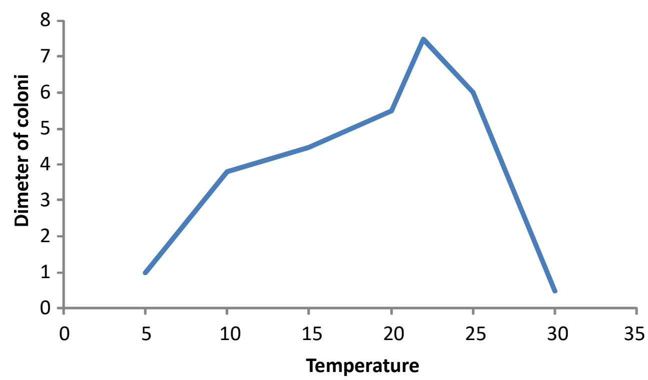


Fig. 6. Effect of temperature on the growth rate of *G. leptostyla*

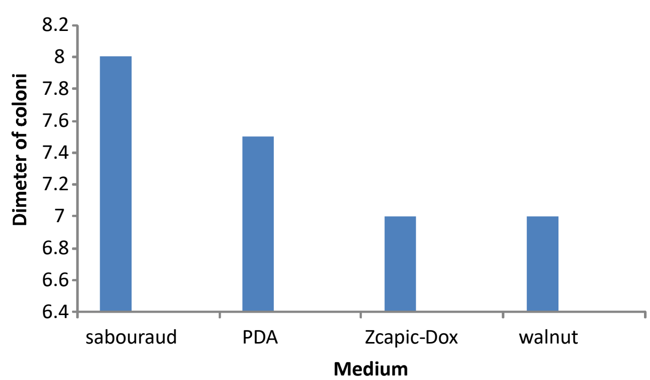


Fig. 7. Effect the type of medium on the growth rate of *G. leptostyla*

Table 1. Evaluation of plant extracts and fungicide (fberusat) against *G. leptostyla*

Plant extract and fungicide	Per cent inhibition at different concentrations (mg ml^{-1})			
	10	20	30	40
Sage	100	100	100	100
Cloves	79	86	100	100
Fberusat	100	100	100	100

canis and *Trichophyton violaceum* (El Astal et al 2005). Alinizy (2010) also observed that clove oil is the most effective oil used to inhibit the growth of the fungus *Rhizoctonia solani*. The fungicide fberusat is an effective in the elimination of pathogenic fungi of the plant because it contains copper ions that have the ability to bind with many chemical groups inside the fungal cell such as carboxyl and amine groups and SH groups that lead to the death of pathogenic fungi. The growth inhibition of *Alternaria solani* and its formation of spores, occur at a concentration of 200 mg active ingredient liter^{-1} (Al-khafagi 2019). Al-Asadi et al (2006) used the fungicide fberusat against *Alternaria alternate*, the causing the date rot fruit disease.

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Effect of Osmotic Agents on the Quality Characteristics of Osmo-dried Plum

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Abstract: The present investigation was carried in Division of Food Science and Technology, SKUAST Jammu during the year 2018-2019. The objective of this study was to develop osmo-dried plum by different osmotic agents and their shelf stability. Plums were dipped in different osmotic agents (40, 50, 60 and 70 °Brix) of sugar and honey for the preparation of osmo-dried plum followed by packing in LDPE bags and storage in ambient conditions subjected to physico-chemical and microbial characteristics at an interval of one month for a period of three months. Storage studies indicated that there was significant decrease in ash and calcium content. The stored osmo-dried plum was found microbiologically safe. The storability study revealed that osmo-dried plum prepared from dipping in 70 °Brix Honey Syrup have good-shelf life and can be kept for more than three months without affecting the quality attributes.

***Keywords*:** Plum, Osmo-dried, Sugar, Honey

Plums are one of the most important stone fruits crops of the world. Prunes also include several familiar stone fruits-apricot, cherry and peach. There are more than 2000 varieties of plums, among which relatively few are of commercial importance (Somogai 2005). Plums are rich in sugars and carotenes. Plum fruits can be used as fresh dessert fruit, dried or cooked. Dried plums are rich in minerals and vitamins, and are mildly laxative. The dried plum is often added to cathartic decoctions to improve their flavour. Plums have attractive colour, flavour, taste and particularly rich in carbohydrates and minerals. Plums, which contain high moisture (86-90%, wet basis), are highly perishable and hence drying and storage are considered important. Traditionally fruits and vegetables are dried in open sunlight, which is weather dependable and also prone to microbial and other contamination. Osmotic dehydration is a useful technique that involves product immersion in a hypertonic aqueous solution leading to loss of water through the cell membranes of the product and subsequent flow along the inter-cellular space before diffusing into the solution (Sereno et al 2001). It also results in increased shelf-life, little bit loss of aroma in dried and semi-dried food stuffs, lessening the load of freezing and to freeze the food without causing unnecessary changes in texture (Petrotos and Lazarides 2001). A loss of water up to 50 per cent of the initial fruit weight is attainable but it mainly depends on several factors like concentration, temperature and type of the osmotic medium. While water diffuses out of the fruit tissue, there is a simultaneous movement of sugar from the solution into the fruit. Due to poor keeping quality of plum and difficulties of transportation, preservation and marketing facilities, a huge quantity of these valuable fruits are being damaged and spoiled. To reduce the wastage of this fruit and to get a reasonable price by the producer of this fruit, preservation is necessary.

MATERIAL AND METHODS

Fresh plums (*cv*. *Santa rosa*) with uniform size and shape, free from transportation injuries, bruises, insect damages were purchased from fruit Mandi Narwal and diseases were selected for making the nutritionally rich osmo-dried plum. Fully matured fruits were washed thoroughly with clean water and wiped properly. The fruits were pierced gently with the help of fork. The sugar and honey syrup of different concentrations *viz* 40, 50, 60 and 70 °Brix were prepared and plums were dipped in different concentrations of sugar and honey for 24 h. In control, dipping treatment was not applied. After completion of dipping time, sugar and honey syrups were drained and the osmo-dried plums were spread on trays. The plums were dried for two days at 55-60°C. After drying, the plums were collected and packed in LDPE bags and stored at room temperature for a period of 3 months. The osmo-dried plums were analyzed at an interval of 0, 1, 2 and 3 months of storage for physico-chemical and microbiological characteristics. Ash was estimated as per the procedure (AOAC 2007). Calcium content was estimated as per the procedure of Verma et al (2015). Total plate count of micro-organism was estimated as per the procedure of Pelczar and Chan (1997).

RESULTS AND DISCUSSION

Physico-chemical characteristics of fresh plum fruit: The fresh plum having average fruit weight, length, width and pulp stone ratio 38.15 g, 40.05 mm, 40.18 mm and 16.18, respectively (Table 1), whereas moisture content, TSS, acidity, reducing and total sugars were 84.35 per cent, 13.60 °Brix, 1.63, 5.75 and 7.06 per cent, respectively. These values are in accordance with findings of Singh (2014) and Kumar et al (2018) while working on storage of pulp and value added products of plum (*Prunus salicina* L.) and studies to evaluate the morphological and horticultural diversity among 15 plum varieties under Kashmir conditions, respectively. The ascorbic acid and ash content of the fresh plum were as 6.32 mg/100 g and 0.38 per cent and the value for calcium was 20 mg/100 g which coincides with the result of Sharma et al (2011) while working on instant value added products from peach, plum and apricot fruits. Further the anthocyanin and total phenols values of fresh plum were 40.10 and 221 mg/100 g, which were supported by the findings of Walkowaik- Tomczak (2008), Kumar (2013), Singh (2014) and Moustafa et al (2016) while working on characteristics of plums as a raw material with valuable nutritive and dietary properties, the optimization of method for the preparation of osmo-dried plum (*Prunus salicina* L.), storage studies of pulp and value added products of plum *(Prunus salicina* L.*)* and osmotic dehydration of fig and plum, respectively.

Table 1. Physico-chemical composition of fresh plum fruit

Attributes	Quantity
Physical parameters	
Weight of fruit (g)	38.15
Length of fruit (mm)	40.05
Width of fruit(mm)	40.18
Pulp stone ratio	16.18
Chemical parameters	
Moisture (%)	84.35
Total soluble solids (%)	13.60
Titratable acidity (%)	1.63
Ascorbic acid (mg 100 g^{-1})	6.32
Reducing sugar (%)	5.75
Total sugar (%)	7.06
Anthocyanin (mg 100 g^{-1})	40.10
Total phenols (mg 100 g^{-1})	221
Ash content (%)	0.38
Calcium content (mg 100 g^{-1})	20

Ash content: The perusal of data regarding the ash content of osmo-dried plum revealed that storage mean values decreased from the initial level of 1.35 to 1.15 during three months of storage (Table 2). Initially among different osmotic treatments, the maximum value of 1.45 per cent was recorded in T_6(40 °Brix honey syrup) whereas the minimum of 1.10 per cent was in control which decreased to 1.26 and 1.05 per cent, respectively after three months of storage. Maximum ash content value of 1.34 per cent was in T_6 (40 °Brix honey syrup) while the lowest value of 1.07 per cent was in control. Moreover the interaction between the treatment and storage period was also found significant. The decrease in ash content due to microbial activities utilizing the minerals for growth. The rate of decrease of ash content was more pronounced at ambient temperatures. The findings are in conformity with Muzaffar et al (2016) in pumpkin candy and Munaza (2018) also reported decline in ash content during storage while working on value added products from quince.

Calcium content (mg/100 g): During three months of storage, the decrease in calcium content was in osmo-dried plum from initial value of 40.80 to 40.24 mg/100 g. Initially maximum value of 48.15 mg/100 g was recorded in T_9 (70

Table 2. Effect of treatments and storage period on ash content (per cent) and calcium content (mg/100 g)* of osmo-dried plum

Treatments	Storage period (months)				
	0	1	2	3	Mean
T_1: Control	1.10 (30.16)	1.08 (29.90)	1.07 (29.65)	1.05 (29.15)	1.07 (29.71)
T_2: Dipping in 40 °Brix Sugar Syrup	1.40 (35.65)	1.34 (35.40)	1.28 (35.12)	1.24 (34.85)	1.31 (35.25)
T_3: Dipping in 50 °Brix Sugar Syrup	1.37 (38.05)	1.29 (37.91)	1.23 (37.75)	1.13 (37.40)	1.25 (37.78)
T_4 : Dipping in 60 °Brix Sugar Syrup	1.35 (43.15)	1.27 (43.00)	1.19 (42.90)	1.10 (42.78)	1.23 (42.96)
T_5: Dipping in 70 °Brix Sugar Syrup	1.32 (46.20)	1.25 (46.05)	1.17 (45.89)	1.10 (45.75)	1.21 (45.97)
T_6:Dipping in 40 °Brix Honey Syrup	1.45 (38.16)	1.36 (38.01)	1.30 (37.92)	1.26 (37.80)	1.34 (37.97)
T_7: Dipping in 50 °Brix Honey Syrup	1.42 (42.30)	1.33 (42.00)	1.25 (41.89)	1.18 (41.76)	1.29 (41.99)
T_8: Dipping in 60 °Brix Honey Syrup	1.39 (45.38)	1.32 (45.13)	1.24 (44.93)	1.16 (44.80)	1.28 (45.06)
T_9: Dipping in 70 °Brix Honey Syrup	1.35 (48.15)	1.27 (48.00)	1.20 (47.92)	1.13 (47.88)	1.24 (47.99)
Mean	1.35 (40.80)	1.28 (40.60)	1.21 (40.44)	1.15 (40.24)	

*in parenthesis CD (P= 0.05) Treatments=0.03, Storage = 0.02, Treatments× Storage=0.06

Table 3. Effect of treatments and storage period on microbial count (cfu x10^4) of osmo-died plum

Treatments	Storage period (months)			
	0	1	2	3
T_1	N.D	N.D	N.D	3.45
T_2	N.D	N.D	N.D	2.65
T_3	N.D	N.D	N.D	2.43
T_4	N.D	N.D	N.D	2.33
T_5	N.D	N.D	N.D	2.15
T_6	N.D	N.D	N.D	1.95
T_7	N.D	N.D	N.D	1.84
T_8	N.D	N.D	N.D	1.65
T_9	N.D	N.D	N.D	1.50

See table 2 for treatment details

°Brix honey syrup) and minimum of 30.16 mg/100 g recorded in control while as in storage period of three months, the maximum and minimum calcium content was in T_9 (70 °Brix honey syrup) and T_1 (control) having values of 47.88 and 29.15 mg/100 g, respectively. Maximum calcium content (47.99 mg/100 g) was recorded in T_9 (70 °Brix honey syrup) followed by T_5, T_8, T_4 and T_7 with values 45.97, 45.06, 42.96 and 41.99 mg/100 g, respectively and lowest was of 29.71 mg/100 g was recorded in control in treatment mean values. The interaction between the treatment and storage period was significant (Table 2). The decrease in calcium content may be due to leaching effects of osmotic dehydration and microbial activity. The highest calcium content was recorded in T_9 and the lowest value was recorded in control. The present findings were also reported by Singh et al (2015) in dehydrated papaya slices using osmotic dehydration, Tripura (2015) in ripe sapota slices and Munaza (2018) while studying value added products from quince.

Microbial studies of osmo-dried plum: Initially, no microbial growth was observed in osmo-dried plum initial, one or two month. After three months of storage, maximum growth of microbial count was observed in control while as minimum was found (70 °Brix honey syrup) having values of 3.45×10^4 and 1.50×10^4, respectively (Table 3). This remained below the range than the limits specified by FDA for such products. An acceptable count of microbes was also observed in intermediate moisture beetroot cubes by Chibber et al (2019) and flavored ladoo by Pandita and Gupta (2019).

CONCLUSION

Osmo-dried plum prepared with 70 °Brix honey syrup have good shelf life and can be kept for more than three months.

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Value Chain Analysis of Tomato in Himachal Pradesh: A Case Study of Kullu District

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Abstract: This paper maps and analyses value chain for tomato in the Himachal Pradesh. Primary data have been collected through survey method by adopting multistage random sampling technique. The value chain highlighted the involvement of diverse actors, who participated directly or indirectly in the value chain. Different actors identified in the study area were input suppliers, farmers, traders/commission agents, wholesalers, retailers and ultimately consumer. Different enablers identified in the study area were district agriculture department and regional horticulture and agriculture research and training stations at Bajaura, Co-operative and Gramin banks, other commercial banks, Agricultural Produce Market Committee (APMC) Kullu and Lahaul Spiti. Four channels were identified in the marketing system of tomato in the study area. Out of the total value added, the wholesalers add 11.39 per cent of value and the retailer creates value to the tune of 11.60 per cent in the domestic value chain by performing functions like place utility, storage utility and possession utility. There is a potential niche for Himachal Pradesh to develop off-season tomato pocket by leveraging the small scale tomato processing units, cooperative societies and self-help groups in the tomato growing temperate region- Naggar, Banjar, Lag valley and Manikaran valley of Kullu block.

Keywords: Tomato, Value chain map, Potential niche, Cost, Markets

Vegetables play a major role in Indian economy by producing higher returns per unit area and time, besides they provide nutritional and economic security. The demand for vegetables is continuously increasing at a faster rate due to increasing population pressure, increasing awareness of nutritional value of vegetables and as a result of the increasing per capita income over time. Vegetables have higher productivity, shorter maturity cycle, high value and provide higher income leading to improved livelihood. The vegetable crops also offer better crop diversification and intensification. The cultivation of better quality vegetable crops have a much higher export potential not only to neighbouring states in the country but have recently found way to the African/South Eastern countries as compared to field crops and thus help to generate a valuable foreign exchange (Arya 2001). India is one of the major vegetable producing countries in the world and ranks second after China with an area 10436 thousand hectares and production 187474 thousand MT during 2018-19.Out of which the total area under tomato is 789.2 thousand hectares and total production is 19759.3 thousand MT during 2018-19 (Anonymous 2019). Agriculture is the mainstay of the economy of Himachal Pradesh contributing around 22 per cent to the state income and engaging 67 per cent of the working population. Because of predominance of hilly terrain, only 11 per cent of total geographical area of 55.7 lakh ha is available for cultivation. Around 86.4 per cent of the land holdings are marginal and small and the average size of holding is around 1.04 ha which is decreasing continuously due to increasing population pressure on limited arable land (Chahal et al 2020). Vegetable production plays important role in poverty alleviation through employment generation, improving the feeding behaviour of the people and creating new opportunities for poor farmers. Since the vegetable products are bulky, perishable and has continuous demand in the market, its production and marketing allows high productive employment. Increasing horticultural production and marketing thus contribute to commercialization of the rural economy and create many off-farm jobs (Weinberger and Lumpkin, 2005). Tomato (*Solanum lycopersicum*) is the major cash generating crops of this area with 4-6 months duration. The cultivation of better quality vegetables have a much higher export potential not only to neighbouring states in the country but have recently found way to the African/South Eastern countries as compared to field crops and thus help to generate a valuable foreign exchange (Arya 2001). The perishable nature of vegetables results in failure with respect to producer to oversee supply in the markets. The overall losses in vegetables can be up to 25 per cent of total production (Verma and Singh 2004). This loss of vegetables at the grower level results from lack of knowledge about proper post-harvest management, improper grading, packing, lack of storage and transportation facilities contribute more to the problem (Ramchandra et al 2015).

The conduit that runs from producer to final user, through which the commodity passes, is conventionally referred to as a “marketing and processing chain”, a “supply chain”, or a “value chain” (FAO 2005). Supply chain activities transform raw materials into a finished product that is delivered to the end customer. In the traditional vegetable supply chains, the post-harvest losses are as high as 35 to 40 per cent (Bhardwaj et al 2011). This is a serious problem with regard to the traditional vegetable supply chains, as a considerable portion of the total harvest is lost and the cost is ultimately borne by the producer and the consumer. Most of the vegetables are perishable in nature. So, efficient supply chain needed to ensure reduction in post-harvest losses and efficient use of produce in one or the other form. In this context, an important area of inquiry is to assess how current marketing arrangements for tomato in Himachal Pradesh are adding value for producers. Therefore, this paper analyse the capacity of tomato producers from one of the largest tomato growing district in the temperate zone of Himachal Pradesh to participate in potential sustainability-oriented market segments through the lens of value chain. This is undertaken by mapping different chain segments and their governance structures. This provides a holistic view of the tomato value chain and potential for upgrading, barriers and challenges as well as policy suggestions.

MATERIAL AND METHODS

Sampling design: Multistage random sampling was adopted in the selection of blocks, villages and the ultimate sample of the respondents who were involved in value chain of vegetables.

Study area: Kullu district of Himachal Pradesh was selected purposively because of its wider adaptability for growing tomato. At first stage, 3 blocks out of 5 blocks in Kullu district were selected on the basis of area under selected vegetable in all the blocks. At second stage, a list of villages growing vegetable from selected blocks was prepared. 5 villages from each selected block were taken randomly. At third stage, list of the households of the selected 5 villages was prepared and a sample of 30 households from each block was selected on the basis of probability proportion to size method and thus a sample is 90 for the present study (Ankita 2017, Ankita et al 2020 and Singh et al 2020).

Selection of market and market intermediaries: Two markets, namely Bhunter and Kullu were purposively selected to collect the information related to markets and marketing. A sample of 5 local traders/commission agents, 5 wholesalers, 5 retailers and 30 consumers were selected randomly for gathering the data of vegetable marketing in Kullu district. Both primary as well as secondary data were collected during the survey investigation. The primary data were collected using pre-tested schedules through personal interview method from the selected households and Traders/Commission agents in the study area and markets. The information regarding value chain aspects like mapping, degree of value addition etc. were collected from other players in the vegetable marketing channel. Secondary data were collected from the Department of Agriculture, Agricultural Produce Market Committee (APMC), traders/commission agents and wholesalers associations of the selected market.

Analytical framework: Costs of cultivation of different vegetable crops were worked out by using the standard method of cultivation i.e. Commission on Agricultural Costs and Prices (CACP) cost concept.

Value chain analysis: Value chain mapping was conducted in two phases.

I. An initial basic map after the collection of initial data illustrating participants and functions.
II. Adjusted mapping, which was conducted by following additional and follow-up interviews.

Market analysis: The total cost incurred on marketing by the producer/ seller and of the various intermediaries, involved was computed. Marketing Margins of middlemen were calculated as the difference between the total payments (marketing cost + purchase price) and receipts (sale price) of the middlemen. The difference between the price paid by consumer and price received by the producers is the marketing margin or price spread. Generally the economic efficiency of marketing system is measured in terms of price spread. Smaller the price spread; greater is the efficiency of the marketing system.

RESULTS AND DISCUSSION

Seasonal calander of tomato crop: In tomato, transplanting starts during March to April. Its harvesting starts onward June-July till August with peak production in June-July as regards the choice of varieties. The sample farmers were growing varieties of tomato like 'Lal Sona', 'Bombay Gola' and 'Red Gold'. Market yard Bhunter, sub-market yard Kullu, Bandrol, Chauribihal, Patlikuhal and Banjar were the major market centres for the transaction of the produce from study area. Annual estimated transactions of tomato recorded in these markets from their production pockets during 2020-21 was 30375 MT.

Mapping of tomato value chain: The tomato season started during January-February and it ended during July-August in different blocks of Kullu district. The proposed mapping methodology drew primarily on secondary data supplemented with field interviews with enterprises through the value chain (Fig. 1). The linkages were drawn between participant blocks with arrow in the direction of the product flow. Market channels were clearly defined in a vertical manner culminating at end markets at the top of the map.

Functionaries/Actors and their role in vegetable value chain: The value chain map highlighted the involvement of diverse actors, who participating directly or indirectly in the value chain. Different actors involved in the value chain are as follow:

Input Suppliers: Agricultural inputs primarily seed, fertilizer and agrochemicals have enormous potential to leverage the efforts of hard-working farmers. Private and government agencies are the main source of input supply in the study area (Fig. 3). Private input supplier includes seed dealers, seed companies, small retail shop that sell small quantities of seed, fertilizers and plant protection chemicals to farmers at the village level while government agencies include HIMFED and state Agriculture Department. Overall expenditure in inputs was Rs. 28834per hectare, out of which 51.15 per cent inputs were purchased from open market and 48.85 per cent from the government agencies. Input use pattern revealed that farmers were using higher doses of Nitrogen and Phosphorus in comparison to recommended doses.

Producers: Vegetable growers are the major actors who perform most of the value chain functions right from farm inputs preparation on their farms or procurement of the inputs from other sources to post harvest handling and marketing.

Cost and return of tomato: The cost of cultivation (based on cost D) per hectare was observed to be Rs.174252. The cost of cultivation was high primarily due to high labour requirements for preparing various farm operations and practices such as irrigation, collection of stakes, staking, hoeing and weeding operations. Further, substantial cost of seed also contributed to the high cost of cultivation in these crops (Table 1). Cost A_1 was highest in medium farms (Rs.95160 ha^{-1}) followed by small farm and marginal farms with overall cost of Rs.82606 per hectare. Cost B was highest on medium farms i.e. Rs.125232 ha^{-1}, while Cost C and D was highest on marginal farms with a magnitude of Rs.167099 and Rs.183809 ha^{-1}, respectively. This was due to more use of family labour in case of marginal farms than other farm categories.

The use of human hired labour was more in medium farm category showing highest cost A_1. Expenditure on plant protection measures was the major contribution in cost A_1. A considerably high jump was observed from cost B to cost C which indicated that tomato production was a labour-

Fig. 1. Pictorial representation of seasonal calendar of tomato production in Kullu district

Block	January	February	March	April	May	June	July	August
Banjar		NP	FP&P		ICO			H&S
Kullu	NP	FP&P		ICO			H&S	
Naggar		NP	FP&P		ICO		H&S	

NP- Nursery Preparation, FP&P- Field Preparation and Planting, ICO- Inter-culture operation and H&S- Harvesting and selling

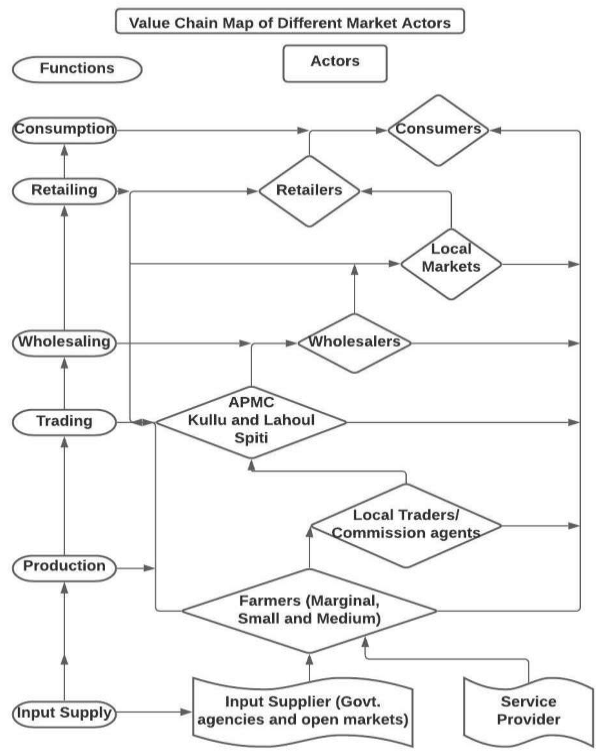

Fig. 2. Value chain map of different market actors of tomato in the Himachal Pradesh

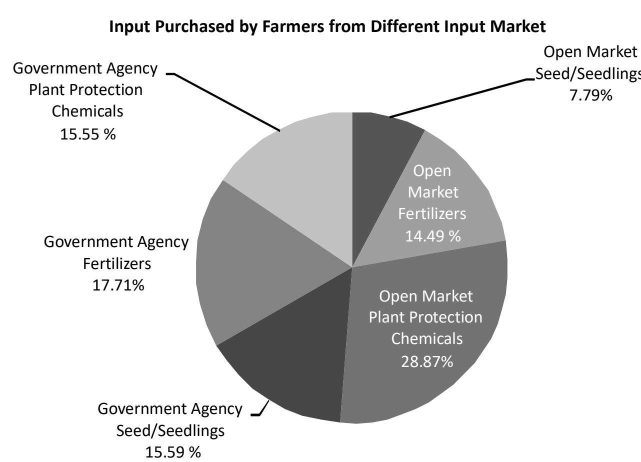

Fig. 3. Input delivery system of sampled farmers

intensive venture. Similar results were shown by Bala et al (2011) in a study conducted in the Kullu district of Himachal Pradesh. Overall gross returns obtained were Rs.368468 per hectare. Net return over cost A_1 wasRs. 285861 and over cost D was Rs. 194216. Based on total cost, the cost of production per quintal of tomato was estimated to be Rs.436. The cost of production per quintal on cost A_1 without family labour amounted to be Rs. 266 and Rs. 351 with family labour.

Overall net farm income earned was Rs.194216 per hectare and maximum was in small farm category i.e., Rs.207878 per hectare. Maximum farm business income and family labour income was earned on marginal farm category i.e. Rs.290803 and Rs.263078 per hectare, respectively while farm investment income was more in small farm category which was Rs.252372 per hectare. Overall break-even point was achieved at Rs.39461 per hectare and break-even output was achieved at 34.25 quintal per hectare. Overall output-input ratio was 2.12 and it was noted to increase as the farm size increases (Table 3).

Table 1. Farm management costs of tomato crop in the temperate zone

(Rs./hectare)

Farm management costs	Marginal	Small	Medium	Overall
Cost A_1	74242	88179	95160	82606
Cost B	101966	117434	125232	111258
Cost C	167099	152392	145800	158410
Cost D	183809	167631	160380	174251

Table 2. Cost of production of tomato in the study area

(Rs./quintal)

Cost of production of tomato	
Based on cost A1 (without family labour)	266
Variable cost (with family labour)	351.41
Total cost (Variable and fixed)	436.05

Table 3. Farm profitability measures of tomato crop in the temperate Zone

(Rs./hectare)

Particulars	Overall
Gross return	368468
Net farm income	194216
Farm business income	285861
Family labour income	257209
Farm investment income	238710
Break- even point	39462
Break- even output (qtl.)	34.25
Output-input ratio	2.12

Market intermediaries: Three types of production system were observed in the study area viz. subsistence production, small scale commercial production and the large scale commercial production. The produce from the first category of farmers generally does not enter the market or enters in a very small quantity especially in the local market. Small and large scale commercial farmers sell most of the produce to various market intermediaries. Due to the existence of various actors working between producer and consumer, there are different marketing channels for the same commodity. The actors involved in the marketing of tomato in the study area are local traders/commission agents, wholesalers and retailers. Thefour marketing channels were patronized for the marketing of tomato the study area (Table 4) (Singh et al 2020).

Trader/commission agent: Traders/Commission agents are the key actors of the tomato value chain who are involved in trading vegetables from production pocket to the wholesale markets. Their trading activities include: buying and assembling, repacking, sorting, selling to middlemen, transporting and selling to wholesale markets.

Wholesalers: Wholesalers are mainly involved in buying vegetables from collectors and producers in larger volume than any other actors and supplying them to retailers and consumers. Survey result indicates that wholesale markets are the main assembly centers for tomato in their respective surrounding areas. They have better storage, transport and communication access than other Traders/Commission agents. In the study area, market yards located in Bhunter, Kullu, Bandrol, Patlikuhl and Banjar.

Retailers: Retailers are the last link between producers and consumers. They mostly buy from wholesalers and sell to urban consumers. Sometimes they could also directly buy from the producers. Consumers usually buy the product from retailers as they offer according to requirement and purchasing power of the buyers.

Consumers: Consumer is an individual who buys products or services for personal use and not for manufacture or resale. It is an end user in the value chain of tomato.

Price spread in marketing of tomato: The producer's price varied from Rs.1110 to Rs.1575 among different channels (Table 5). The price spread was maximum in channel C (49.07%) followed by channel B (46.59%), D (28.88%) and A (2.78%). Marketing margins varied between 14.24 to 20.64 per cent. Marketing cost varied between 2.78 to 29.99 per cent. The highest marketing efficiency was found in channel A (35.01) and lowest in channel C (1.04).

Enablers in production: The service providers in the production of tomato are government agencies and other private agencies. The principle Government agencies supporting the value chain are Agriculture Department, Regional Horticultural and Agricultural Research & Training Stations at Bajaura, IARI, Regional Vegetable Research Station, Katrain which provides extension services and carry out research in vegetable farming. Financial institutions like Cooperative banks, Gramin banks and other Commercial banks provide finance to the farmers and play an important role in financing activities.

Enablers in trading: At trader's level, Agricultural Produce Marketing Committees (APMCs) supported business successively by providing market information. The APMC (Agricultural Produce Market Committee) Kullu and Lahaul Spiti are providing market information and facilitating market linkages in the study area.

Value chain map of tomato: Value chain mapping enables to visualize the flow of the product from conception to end consumer through various actors. It also helps to identify the different actors involved in the vegetable value chain, and to understand their roles and linkages. Value chain map of tomato in which value adds from Rs.90 to Rs.2110 qtl^{-1} among different actors (Fig. 4).

The value was added by different market actors and enablers at different stages in the tomato value chain by creating place utility, time utility and possession utility among the market output channels. Due to these utilities, the value was added 30.25 per cent in the tomato value chain by different market actors and enablers.

Degree of value addition: The degree of value addition varied at each stage or for each sector on the value chain (Table 6). It was observed that degree of value addition in tomato at the trader's stage was 7.26 per cent as they performed the grading and transportation activities due to which the value gets added up. The wholesalers add 11.39 per cent of value and the retailer creates value to the tune of 11.60 per cent by performing the functions like transportation and retailing.

Strategies for up gradation of tomato value chain: Actors within the tomato value chain can undertake a variety of up gradation strategies. The different interventions which are required for the potential growth of tomato in study area were identified where the tomato production have great potential. The different beneficiaries and governing bodies which by

Table 5. Price spread and marketing efficiency of tomato among the different marketing channels

Particulars	A	B	C	D
Producer price (Rs.)	1575	1158	1110	1248
Consumer's price (Rs.)	1620	2169	2179	1755
Gross marketing margin (GMM) (Rs.)	45	1010	1069	506
Marketing cost (Rs.)	45	650	619	256
Marketing margin (Rs.)	-	360	450	250
Total gross marketing margin (TGMM) (%)	2.78	46.59	49.07	28.88
Marketing cost (%)	2.78	29.99	28.42	14.64
Marketing margin (%)	-	16.60	20.64	14.24
Producer's Share (%)	97.22	53.41	50.93	71.12
Marketing efficiency (%)	35.01	1.15	1.04	2.46

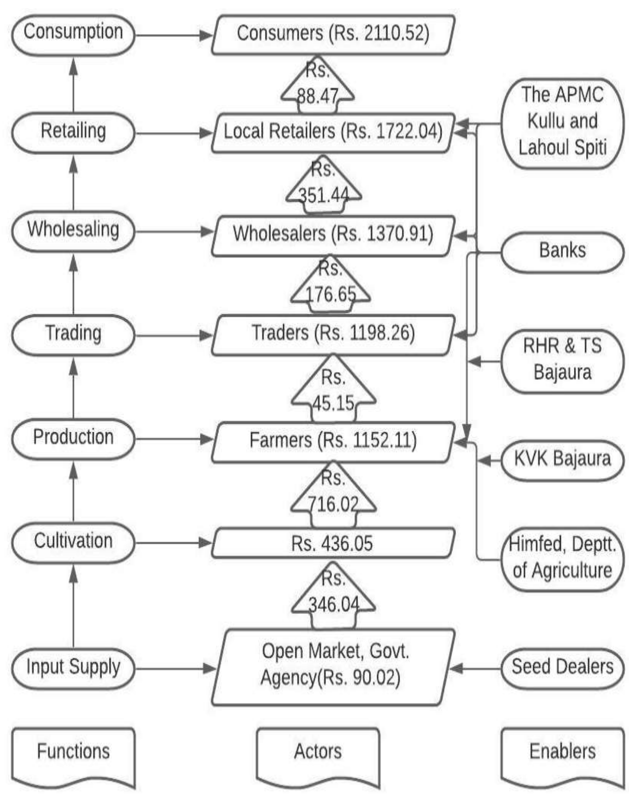

Fig. 4. Value chain map of tomato crop

Table 4. Quantity of tomato marketed through various channels

Marketing channels	Marketing intermediaries	Share in total quantity (%)
Channel-A	Producer-Consumer	3.60
Channel-B	Producer-Wholesaler-Retailer-Consumer	19.91
Channel-C	Producer-Local Trader/Commission agent -Wholesaler-Retailer-Consumer	65.38
Channel-D	Producer-Retailer-Consumer	11.11

use of different means could help in the intervention. Different actors within the tomato value chain currently undertake a variety of upgrading strategies. At the production level, given the pressure for remaining competitive, cost-saving technologies, particularly those involve in mechanization (due to the increasing cost of labour), have been adopted. Further, some processors can increase form utility within the value chain to diversify market outlets. Channel A and D was most efficient channels but Channel A share only 3.60 per cent quantity of produce thus, channel D was found to be most efficient channel. This channel provides an opportunity to sell tomato at competitive prices by reducing intermediaries. The majority of the producers content to produce for the conventional commodity markets. As many smaller farms typically do not have the capital to engage in riskier endeavors such as estate branding or marketing like larger farms.

In term of sustainability conservation, few points have been highlighted to reorient the sustainable tomato segment by addressing local vulnerabilities and challenges embedded within the externally designed standards (Table 7). Specific to the study area, there is potential to explore a segment that could bridge the link between producers and consumers by personalizing the efforts put forth by producers. The dispersed nature of the tomato chain would make such a strategy difficult with significant efforts needed for coordination and building market linkages which adding costs to this type of strategy. This implies market niche is not viable for small producers who like the resources and skill to obtain and sustain the necessary certification, quality standards and bargaining power. Other barriers include, adjacent farm negative externalities and multiple criteria for different international sustainability certification standards i.e. cumbersome. Nonetheless, it is likely to be feasible from individual efforts cited above rather than a sector-wide initiative. A second strategy, and one that is potentially more

Table 6. Degree of value addition at each stage of tomato value chain (Rs./qtl)

Particular	Farmer	Trader/Commission agent	Wholesaler	Retailer	Consumer
Sale price	1239	1405	1774	2127	-
Purchase price	-	1239	1405	1774	2110
Price difference	-	165	369	355	-
Cost	87	117	243	200	-
Margin	-	90	160	20	-
Degree of value addition (%)	-	7.26	11.39	11.60	-

Table 7. Tomato value chain potential scope for the degree of value addition

Interventions	Beneficiaries/activities details		
	Who	Whom	How
Potential of developing off-season vegetable pockets.	Agriculture Developments Officers, Subject Matter Specialists, Krishi Vigyan Kendras, Research Centres.	Commercial farmers.	Training on off -season production of vegetables.
Potential of developing Irrigation technology.	Agriculture Developments Officers, Subject Matter Specialists, Krishi Vigyan Kendras, Research Centres.	Commercial farmers.	Technical and financial support. Replacing conventional methods of irrigation by modern micro-irrigation techniques.
Potential of establishing small scale vegetable processing units.	Private sector, District Agriculture department, HPMC, Himcu.	Commercial farmers.	Technical and financial support. .
Potential of developing roads.	Government Authorities	Commercial farmers, Trader/Commission agent s, Wholesalers.	Technical and financial support.
Provision of crop insurance.	Agriculture department.	Commercial farmers.	Crop insurance and minimum price guarantee.
Potential of minimizing post- harvest losses.	Private sector, District Agriculture department, Krishi Vigyan Kendras, Research Centres.	Commercial farmers, Trader/Commission agent s, Wholesalers.	Technical and financial support. Providing cold storage facilities.
Potential of developing cooperative societies and self-help groups.	District agriculture department, Market committee.	Commercial farmers.	Technical and financial support.

viable is to develop practices on farm that diversify the product offering to include conservation-oriented goods.

CONCLUSIONS

From the study it was concluded that tomato growers needed to diversify their market portfolio to realize better prices. It highlights the need to enhance efficiency of the market channel-B (Producer-W-R-C) and channel-C (Producer-Local Trader/Commission agent -W-R-C) through competition by organized marketing chains and modernizing the vegetable market system in the district, which is largely traditional and lacks modern facilities such as efficient transportation of produce and grading & standardization facilities. The diverse agro-climatic conditions of Kullu have provided nearly unlimited scope for growing vegetable crops like tomato. Thus, exploring market niches and with proper promotion activities, Kullu district can produce potential benefit provided appropriate technology and adequate infrastructure, legal and policy environment for market oriented tomato production. Short term training programmes on pest, diseases management and scientific methods of value addition and grading should be organized in the vegetable producing areas in order to enhance the skill of producers to maximize the net profit and reduce wastage of produce. There is need of producers' groups, marketing cooperatives for proper management and organization within value chain. For better disposal of vegetables, the producer-industry linkages need to be developed as tomato has potential for processing.

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Performance of Knolkhol (*Brassica oleracea* L. Var Gongylodes) under Differential Substitution of Nutrients through Organics in Irrigated Plains of Shiwalik Foothills

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Abstract: An experiment was conducted to evaluate the performance of knolkhol under differential substitution of nutrients through organics. The vegetative growth, yield, quality, total nitrogen uptake and total potassium uptake were significantly influenced by differential Substitution of nutrients through Organics and improvement in all these parameters were observed in *rabi* 2016-17 over *rabi* 2015-16. Significantly highest vegetative growth at all the stages and yield of knolkhol was recorded with recommended dose of fertilizer (100 N: 50 P_20_5: 50 K_20 kg ha^{-1} and FYM @30t ha^{-1}) which was statistically at par with vegetative growth of knolkhol with 75% NPK + 25% N through vermicompost and FYM and 75% NPK+25% N through Vermicompost. Various treatments of differential substitution of nutrients through organics increased the knolkhol growth, yield and quality. Highest knolkhol yield (83.33t ha^{-1} and 86.53t ha^{-1}) were recorded with recommended dose of nutrients. Quality parameters like relative chlorophyll content in leaves and ascorbic acid concentration in knob of knolkhol were influenced considerably by the application of different treatments in which substitution was done through organics and highest quality parameters were recorded with treatment 100% N through FYM. Total N and total K uptake in knolkhol were also significantly influenced with differential substitution of nutrients through Organics.

Keywords: FYM, Growth, Knolkhol, Organics, Quality, Vermicompost, Yield

Cole crops are the important cool season vegetable crops. Among the different cole crops, knolkhol (*Brassica oleracea* var *gongylodes* L.) is the fast growing, short duration crop. Both knob and leaves are edible part of knolkhol. Knolkhol is mainly cultivated in Uttar Pradesh, Himachal Pradesh, Punjab, Haryana, West Bengal and Jammu and Kashmir and demand of knolkhol was increasing. Knolkhol is a heavy feeder crop and shows good response to nutrient application. Furthermore, imbalanced and inappropriate use of inorganic nutrients devoid of requisite quantity of organics has not only worsened the soil resource base by reducing the population of beneficial micro-organisms and the factor productivity of most of the crop lands but also deteriorated the quality of the crops. Increased health consciousness among the masses has augmented the demand for safe and quality foods for which a comprehensive food production technology needs to be developed with emphasises on quality enhancement and yield stability in comparison to the yield and quality aspects realized under conventional practices of crop production. In fact, it is not affordable for an average Indian farmer to jump immediately from inorganic source of nutrients to organics in their crop production programme as it may lead to unbearable drastic reduction in crop yields in the initial years. This may become possible through the progressive substitution of organic sources of nutrients in place of in organics to meet crop nutrient requirement for attaining higher and stable crop yield of better quality with an improvement in soil health. Keeping this in view an investigation was carried out in irrigated plains of Shiwalik foothills to assess the growth, yield, economics, quality and nutrient uptake of knolkhol.

MATERIAL AND METHODS

The experiment was conducted at Sher-e-Kashmir University of Agricultural Sciences &Technology Jammu during *Rabi* 2015-16 and 2016-17. The soil of the experimental site was sandy clay loam in texture with low organic carbon and available nitrogen but medium available phosphorus and potassium. Knolkhol variety G40 was raised as per the recommended agronomic practices (Package and Practice, Rabi, SKUAST-J). The experiment was in Randomized block design with three replication and sixteen treatments (Table 1). The recommended dose of nutrients for the crop were nitrogen (100 kg ha^{-1}), phosphorus (50 kg ha^{-1}), potassium (50 kg ha^{-1}) and FYM @ 30 tonnes ha^{-1}. Application of phosphorus and potassium, and organic manure along with half of the total remaining nitrogen as basal, whereas, remaining nitrogen was applied at 30 days of transplanting. Plant height of five randomly selected knolkhol plants in each net plot was measured from the ground surface to the tip of the uppermost fully opened leaf. The plant frame of knolkhol was measured with the help of meter scale as surrounding area covered by the plants length wise and breadth wise in north-south direction and east–west direction. The knolkhol plants from border row of each plot were taken for dry matter accumulation. All the above ground biomass of five randomly selected plants from border row were chopped, sundried and thereafter shifted in the oven to dry at the temperature of 65$\pm$5°C till constant weight was achieved and the average dry matter accumulation per plant was recorded and averaged to expressed as dry matter accumulation in g/plant of Knolkhol. Total knolkhol weight (leaves along with knob) was recorded from each net plot. Quality parameters viz., relative chlorophyll content in leaves of knolkhol was measured with the help of SPAD (Soil plant analysis development) by simply clamping the device over the leaf tissue at 6 places in each five randomly selected plants and the SPAD value of five plants were averaged to expressed as relative chlorophyll content in leaves of knolkhol. The individual treatment wise five knob samples were subjected to ascorbic acid analysis by using 2, 6 dichlorophenol dye (Ranganna 1986). The ascorbic acid concentration in knob was calculated and expressed as ascorbic acid concentration mg 100 g^{-1}. Total nutrient uptake (kg ha^{-1}) in knolkhol and economics of knolkhol was calculated. The cost of cultivation of knolkhol was calculated on the basis of prevailing market rates of different inputs used. The gross and net returns of knolkhol were worked. The benefit cost ratio of knolkhol was calculated by dividing the net returns with cost of cultivation for different treatments by using the formula.

$$\text{Total Nitrogen uptake (kg/ha)} = \frac{\text{Nitrogen content (\%)} \times \text{dry matter accumulation (kg/ha)}}{100}$$

$$\text{Total Phosphorus uptake (kg/ha)} = \frac{\text{Phosphorus content (\%)} \times \text{dry matter accumulation (kg/ha)}}{100}$$

$$\text{Total potassium uptake (kg/ha)} = \frac{\text{Potassium content (\%)} \times \text{dry matter accumulation (kg/ha)}}{100}$$

Table 1. Growth of knolkhol as influenced by differential substitution of nutrients through organics

Treatment	Plant height (cm)		Number of leaves plant^{-1}		Plant frame (cm)				Dry matter accumulation (g plant^{-1})	
	2015-16	2016-17	2015-16	2016-17	2015-16		2016-17		2015-16	2016-17
					N-S	E-W	N-S	E-W		
T_1	42.15	46.86	17.00	18.00	55.00	45.10	59.63	47.09	49.36	51.43
T_2	38.91	44.36	16.40	17.40	53.00	42.24	57.14	45.76	47.79	49.56
T_3	31.14	35.84	13.80	14.30	46.25	34.00	47.12	37.00	38.49	40.22
T_4	27.67	29.12	11.20	11.40	37.15	27.00	38.17	27.75	31.86	33.67
T_5	26.82	28.13	10.60	10.80	34.21	26.33	37.00	26.78	29.26	31.00
T_6	38.15	43.28	16.10	17.40	52.73	42.00	57.00	45.00	46.75	48.61
T_7	38.00	42.39	16.00	17.20	52.36	41.86	56.65	44.51	46.54	48.33
T_8	30.47	34.73	13.60	14.00	45.29	33.23	46.24	36.27	38.24	40.00
T_9	27.21	28.67	11.00	11.20	36.14	26.86	37.52	27.51	31.60	33.34
T_{10}	26.37	27.40	10.00	10.80	34.00	26.00	36.89	26.34	28.26	30.00
T_{11}	37.85	41.62	16.00	17.20	52.10	40.14	56.42	44.00	45.75	47.46
T_{12}	39.99	46.34	16.80	17.60	54.65	44.86	58.31	46.87	48.71	50.12
T_{13}	32.97	36.00	13.90	14.30	45.71	34.61	48.53	37.49	39.54	41.28
T_{14}	27.85	29.19	11.40	11.80	38.42	27.10	39.39	29.20	31.99	33.81
T_{15}	27.00	28.54	10.80	11.00	35.44	26.47	37.21	26.89	30.45	32.19
T_{16}	39.72	45.21	16.40	17.60	53.15	43.73	58.22	46.54	48.35	49.78
CD (p=0.05)	4.45	5.32	2.08	2.15	6.12	5.32	6.63	6.42	5.38	6.09

T_1-100 % NPK (Recommended dose of fertilizer); T_2-75 % NPK +25 % N through Vermicompost ; T_3-50 % NPK + 50 % N through Vermicompost ; T_4-25 % NPK +75 % N through Vermicompost ; T_5-100 % N through Vermicompost ; T_6-25 % yearly replacement of RDF through Vermicompost; T_7-75 % NPK +25 % N through FYM ; T_8-50 % NPK + 50 % N through FYM ; T_9-25 % NPK +75 % N through FYM ; T_{10}-100 % N through FYM; T_{11}-25 % yearly replacement of RDF through FYM ;T_{12}-75 % NPK +25 % N through Vermicompost and FYM (1:1) ; T_{13}-50 % NPK + 50 % N through Vermicompost and FYM (1:1) ; T_{14}-25 % NPK +75 % N through Vermicompost and FYM (1:1) ; T_{15}-100 % N through Vermicompost and FYM (1:1) ; T_{16}-25 % yearly replacement of RDF through Vermicompost and FYM (1:1)

RESULTS AND DISCUSSION

Growth: Growth characters of knolkhol were significantly influenced by differential substitution of nutrients through organics. The plant height of knolkhol recorded variable trend under different treatments at maturity and plant height of knolkhol in the *rabi* 2016-17 was comparatively higher in all the treatments as compared to *Rabi* 2015-16. Significantly maximum plant height of knolkhol was recorded with treatment 100 % NPK (recommended dose of fertilizer) which was statistically at par with treatment T_{12}, T_{16}, T_2, T_6, T_7 and T_{11} whereas minimum plant height of knolkhol was recorded with treatment T_{10} which was found statistically at par with treatment T_5, T_{15}, T_9, T_4 and T_{14}. Treatment T_{13}, T_3 and T_8 were remained significantly different from all the other treatments in plant height of knolkhol at maturity. Maximum plant height of knolkhol in 100% NPK (recommended dose of fertilizer) was might be due to more availability of nitrogenous fertilizer to the knolkhol plant from inorganic and organic source together ,which increase the foliage of the plant and thereby increase the photosynthesis. The adequate and ready supply of three major nutrients viz., NPK from both inorganic (chemical) and organic source (farmyard manure) are expected to regulate plant physiological functions and morphological responses favourably. Similar, results were also reported by (Shree et al 2014). Significantly maximum number of leaves/plant in knolkhol was recorded with treatment T_1 which was found statistically at par with treatments T_{12}, T_{16}, T_2, T_6, T_7 and T_{11} during *Rabi* 2015-16 and 2016-17, whereas significantly minimum number of leaves/plant were with treatment 100 % N through FYM which was found statistically at par with treatment T_5, T_{15}, T_9, T_4 and T_{14}. Treatments T_{13}, T_3 and T_8 were significantly different from all the treatments in number of leaves/plant of knolkhol during *Rabi* 2015-16 and 2016-17. The 100 % NPK (recommended dose of nutrients) probably provides adequate N in the early growth phase, which is associated with high photosynthetic activity and vigorous growth. The nitrogen might have contributed towards increase in leaf buds and finally increased the number of leaves in the treatment. Similar results were also reported by Azad (2000).

Plant frame of knolkhol was also significantly influenced by differential substitution of nutrients through organics. Further, knol-khol plant in second year i.e *rabi* 2016-17 recorded a slight increase in plant frame in (N-S) (E-W) direction over the first year. Significantly largest plant frame of knolkhol in both (N-S) (E-W) direction was with treatment 100 % NPK, whereas minimum plant frame of knolkhol in both (N-S) (E-W) direction was recorded with treatment 100 % N through FYM. This was might be due to enhanced metabolic activity through the supply of important macro and

Table 2. Yield and quality of knolkhol as influenced by differential substitution of nutrients through organics

Treatment	Knolkhol yield (t ha^{-1})		Relative chlorophyll content		Ascorbic acid (mg 100g^{-1})	
	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17
T_1	83.33	86.53	36.42	36.66	25.44	25.56
T_2	81.00	85.56	37.00	37.32	25.91	26.07
T_3	65.13	70.82	44.74	45.21	32.27	32.50
T_4	51.74	58.52	52.74	53.34	38.29	38.59
T_5	50.55	57.90	53.36	54.01	39.19	39.52
T_6	80.53	85.39	37.05	37.42	26.07	26.25
T_7	79.20	84.00	37.12	37.48	26.14	26.32
T_8	64.70	70.70	44.87	45.36	32.49	32.73
T_9	51.37	58.51	52.81	53.42	38.37	38.68
T_{10}	50.27	57.84	53.47	54.14	40.63	40.96
T_{11}	78.85	83.94	37.18	37.55	26.29	26.48
T_{12}	82.12	86.11	36.63	36.94	25.75	25.91
T_{13}	66.05	71.88	44.63	45.10	31.13	31.37
T_{14}	52.18	59.22	52.46	53.06	37.42	37.72
T_{15}	50.93	58.36	52.92	53.58	39.11	39.44
T_{16}	81.72	85.63	36.81	37.12	25.83	25.98
CD (p=0.05)	11.38	11.18	6.83	7.38	4.59	4.71

See Table 1 for details

micro nutrients in early and late stage of the plant which lead to higher rate of photosynthesis in treatment T_1 which resulted in formation of more photosynthates and in turn leads to the vigorous growth of the plant. Similar results coincided with the research outcomes Abou El-Magad et al (2005). Significantly higher dry matter accumulation of knolkhol was with treatment 100 % NPK (Recommended dose of nutrients) during *rabi* 2015-16 and 2016-17 which might be due to due to highest plant height, more number of leaves and plant frame and also may be due to higher availability of nutrients during early growth stage and at the later stage decomposition of vermicompost and FYM releases macronutrients along with micronutrients which become available to the plant there by resulting enhanced plant growth that culminated into high dry matter accumulation. These findings are in conformity with those of Singh and Pandey (2010).

Yield: Differential substitution of nutrients through organics exerted significant effect on knolkhol yield. The recommended dose of nutrients was statistically at par with treatments T_{12}, T_{16}, T_2, T_6, T_7 and T_{11} in knolkhol yield during *Rabi* 2015-16 and *Rabi* 2016-17, whereas treatment T_{10} was found significantly inferior and statistically at par with treatment T_5, T_{15}, T_9, T_4 and T_{14}. The highest yield in these treatments was might be due to attributed to more carbohydrate accumulation as a result of increased photosynthesis from larger area of the leaves and the translocation of assimilates to the sink which is the knob of knolkhol. The increase in the knob weight along with leaves at harvest of knolkhol was also might be due to the increase in plant spread, plant length and width of leaves. Similar findings were also reported by (Pandey 2008, Kumar et al 2013). The increase of yield in these treatments could be attributed to sufficient amount of plant nutrient supply throughout the crop growth period especially at critical crop growth stages and might also be due to better efficiency of combination of inorganic fertilizers and organic fertilizer because organic manures not only releases essential nutrients but also prevents the losses of chemical fertilizers through denitrification, volatilization and leaching by binding the nutrients and release them with the passage of time. The higher yield in knolkhol in treatments T_{12}, T_{16}, T_2, T_6, T_7 and T_{11} was also due to the reason that organic manures (vermicompost and FYM) would have provided the micronutrients. Vermicompost and FYM activate many species of living organism, which release phyto harmones and may stimulate the knolkhol growth and absorption of essential nutrients. Similar results were also reported by Asghar et al (2006) and Ouda et al (2008).

Among the treatments in which 100% N substituted

Table 3. Total Nutrient uptake (kg ha^{-1}) of knolkhol as influenced by differential substitution of nutrients through organics

Treatment	Total Uptake (Kg ha^{-1})					
	Nitrogen		Phosphorus		Potassium	
	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17
T_1	167.49	182.58	51.66	55.38	239.15	250.07
T_2	183.06	196.79	59.13	65.03	283.50	301.18
T_3	168.69	186.25	54.06	59.49	241.64	264.15
T_4	146.42	169.10	47.08	55.00	195.57	222.93
T_5	148.11	171.96	47.52	56.16	198.15	228.13
T_6	186.84	201.52	59.60	65.75	285.09	303.99
T_7	186.12	200.76	59.40	65.52	284.33	303.24
T_8	170.16	188.76	54.35	60.09	243.27	265.11
T_9	146.41	170.28	47.26	55.59	196.24	224.70
T_{10}	148.81	173.51	47.76	56.68	198.58	229.61
T_{11}	189.23	204.81	59.92	66.31	285.42	295.53
T_{12}	180.66	192.90	58.30	62.86	281.66	297.09
T_{13}	169.09	186.89	54.16	59.66	243.07	264.52
T_{14}	145.58	168.78	46.96	54.48	195.16	222.67
T_{15}	147.18	170.42	47.36	56.03	197.08	227.03
T_{16}	181.42	193.53	58.84	63.37	282.76	298.00
CD (p=0.05)	24.35	25.08	N.S	N.S	32.92	37.02

See Table 1 for details

through organic sources, the highest yield of knolkhol was obtained with vermicompost over FYM contain high proportion of humic substances. humic acids, fulvic acids and humin) which provides numerous sites for chemical reaction and the microbial components of vermicompost enhance the plant growth and disease suppression through the activities of bacteria (*Bacillus*) and Fungi (*Trichoderma*) as well antagonistics such as phenols and amino acids. These results were in close proximity with the findings of Nagavalemma et al (2004) and Chaudhary et al (2018) in cole crops.

See Table 1 for details Quality: The knolkhol fertilized with treatment 100% N through FYM was statistically at par the treatments 100% N through Vermicompost, 100% N through vermicompost and FYM (1:1), 25% NPK+75% N through FYM, 25% NPK+75% N through Vermicompost and 25% NPK +75% N through Vermicompost and FYM (1:1) in quality parameters viz., relative chlorophyll content in leaves and ascorbic acid concentration in knob of knolkhol during *rabi* 2015-16 and 2016-17 (Table 2). Highest chlorophyll content 53.47 and 54.14 in leaves and significantly highest ascorbic acid concentration 40.63 and 40.96 percent in knob of knolkhol with treatment T_{10} at harvest during both the crop growing years. The significant increase in relative chlorophyll content in leaves of knolkhol was might be due to application of organic manures on decomposition added the appreciable quantities of magnesium and nitrogen where nitrogen and magnesium are constituent of chlorophyll molecule. Moreover, nitrogen is the main constituent of all amino acids in proteins and lipids that acting as a structural component of the chloroplast. These results were in agreement with the findings of Nehra et al (2001) and Sanwal et al (2007).

See Table 1 for details Total nutrient uptake: Total nitrogen and total potassium uptake in knolkhol were significantly influenced whereas total phosphorus uptake in knolkhol was non- significantly influenced by differential substitution of nutrients through organics. During 2016-17 knolkhol crop removed large quantity of N, P and K from the soil when compared with first year. The highest total nitrogen uptake, total phosphorus uptake and total potassium uptake in knolkhol was with treatment 25% yearly replacement of RDF with FYM on N-basis. This was due to cumulative effect of nutrient. Similar results were also reported by Harencia et al (2007).

Economics: Highest cost of cultivation of knolkhol was recorded with treatment in which 100% N through vermicompost was due to higher cost of vermicompost. The highest gross returns (Rs 333304 ha^{-1}) of knolkhol during *Rabi* 2015-16 was with 100% recommended dose of fertilizer whereas during *rabi* 2016-17, highest gross returns (Rs1006744 ha^{-1}).

Table 4. Economics of knolkhol as influenced by differential substitution of nutrients through Organics

Treatment	Cost of cultivation (Rs ha^{-1}) (A)		Gross returns (Rs ha^{-1}) (B)		Net returns (Rs ha^{-1}) (C=B-A)		B:C ratio (D = C/A)	
	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17
T_1	82511	82511	333304	995106	250792	912595	3.04	11.06
T_2	93972	93805	324000	983963	230027	890157	2.45	9.49
T_3	105421	105088	260528	814395	155106	709307	1.47	6.75
T_4	116874	116374	206952	672934	90077	556559	0.77	4.78
T_5	126500	125834	303288	998775	176787	872940	1.40	6.94
T_6	93972	105088	322136	981996	228163	876908	2.43	8.34
T_7	85702	84891	316800	966000	231097	881108	2.70	10.38
T_8	88881	87259	258800	813004	169918	725744	1.91	8.32
T_9	92064	89632	205492	672876	113427	583243	1.23	6.51
T_{10}	93420	90177	301644	997671	208223	907493	2.23	10.06
T_{11}	85702	87259	315384	965287	229681	878027	2.68	10.06
T_{12}	89837	89348	328468	990311	238630	900962	2.66	10.08
T_{13}	97151	96174	264204	826631	167052	730457	1.72	7.60
T_{14}	104469	103003	208724	681053	104254	578049	1.00	5.61
T_{15}	109960	108005	305556	1006744	195595	898738	1.78	8.32
T_{16}	89837	96174	326888	984756	237050	888582	2.64	9.24

See table 1 for details

CONCLUSION

Based on two year study it was adjudged that recommended dose of fertilizer and 75% NPK + 25% N through Vermicompost and FYM were adjudged as the best treatments with regard to growth parameters, yield and economics whereas highest crop quality traits where in 100% N was substituted through FYM followed by Vermicompost and Vermicompost and FYM (1:1).

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Assessment of Nutrient Status in Vermicompost Prepared from Fruit Waste

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Abstract: The research work deals with the production of vermicompost from fruit waste by utilising three different species of earthworms, namely *Perionyx excavatus*, *Eudrilus eugeniae* and *Eisenia foetida*. Collected samples were washed with water, air-dried, weighed and mixed with cow dung slurry in the ratio 3:1 and pre composted for three weeks. Four sets of pots in total with three replicates each were taken, of which three sets were used for vermicomposting and the fourth set for composting only. The harvesting of vermicompost and compost were carried out on 60th day. Compound samples of the four sets of pots were processed for analysis of nitrogen, phosphorus, potassium, Iron, Copper, Zinc and Manganese. The macronutrients N,P and K were significantly increased in vermicompost of all the three types of earthworm when compared to the compost without earthworm and substrate. The amount of Copper, Zinc and Manganese decreased in vermicompost. The temperature gradually lowers as the composting process continued and ranged from 25.5 to 23.1°C. The pH gradually increased and value ranged from 6.1 to 7.3. The moisture content ranged from 60.2 to 65.1 per cent. Electric conductivity increases significantly in vermicompost than that of substrate. The growth parameters of the three earthworm species cultured in fruit waste showed that *Eudrilus eugeniae* giving the maximum length and weight followed by *Eisenia foetida* and *Perionyx excavatus*. The number of juveniles and adults increased in *E. foetida* and *P. excavatus*. The total length, weight and biomass of the three earthworm species increased at the end of the experiment. There was increased in growth parameters of the three species. The result indicates that more nutrients were present in vermicompost than the compost and substrate.

***Keywords*:** Fruit waste, Vermicompost, *Eudrilus eugeniae*, *Eisenia foetida, Perionyx excavatus*

Nowadays, organic farming has been opted in every part of the World as people are aware of the health hazards caused by chemical fertiliser, pesticides, insecticides, etc. Bio-fertilizer is the only solution to the above problems, and vermicompost is one of the best organic fertilizers. In the present day agricultural scenario, vermicomposting plays a significant role in organic farming for sustainable agriculture production. The cooperative action of earthworms and microorganisms bring biochemical degradation of organic matter and earthworms drive the process by conditioning the substrate and altering its nutrients (Vig et al 2011, Singh and Kalamdhad 2013c). The nutrients locked up in the organic waste are transformed into simple and absorbable forms such as nitrate or ammonium nitrogen, exchangeable phosphorous, soluble potassium, calcium and magnesium in worm's gut with a significant reduction in the C/N ratio. The final product formed after vermicomposting have rich plant nutrients such as nitrogen phosphorus, potassium, calcium, trace elements, and it can be used as a soil conditioner in agricultural applications (Gabhane et al 2012). By the application of vermin compost the growth of plant increased (Ramadeep et al 2015). The earthworm casts has higher content of nitrogen, phosphorus, potassium and carbon than the soil, so the earthworm castings are valuable nutrient sources for plants and can improve the physical and chemical properties of the soil (Shilpa et al 2017).

In Manipur, Banana is grown widely throughout the plains and hilly region and followed by pineapple plantation. Watermelon is also grown widely and produced in the surplus amount in the market during July-August. Other fruits found in Manipur are musk melon, mango, orange, lemon, papaya, pomelo, peach, pear, passion fruit, avocado, berry, grape, guava, Indian gooseberry, jack fruit, fig, wild apple and silver berry etc. The fruit waste is one of the major constituent of municipal waste in the market area of Imphal city. People are least aware of the effect of fruit waste on the health sector. The present study aims to bring proper management of fruit waste by utilising the three species of earthworms, i.e. the Indian blue (*Perionyx excavatus*), the African nightcrawler (*Eudrilus eugeniae*) and the Tiger worm (*Eisenia foetida*).

MATERIAL AND METHODS

The study area covers the Ima market of Imphal, markets of Bishnupur district. It extends over an area of 29.57 sq km. Geographically, it is situated at 24°48.8'N and 93°57'E and Bishnupur lies in 24° 38' N 93° 46' E, with an area of 496 km^2.

Collection of earthworm species: The species *Eudrilus eugeniae* was sourced from the Institute of Bioresources & Sustainable Development, IBSD Takyelpat, Imphal. The species *E. foetida* was procured from the Directorate of Environment and Climate Change, Porompat, Imphal. The species *Perionyx excavatus* was collected from the local cowshed area of Nambol, Bishnupur District. The identification was done from IBSD Takyelpat, Imphal and Manipur University, Imphal.

Collection of fruit waste: Fruit consumption usually produces two types of waste- the solid waste of peel/skin, seeds, stones etc. the liquid waste of juice and wastewater. The fruit waste of different varieties weighing about 125 kg was collected from various places of the market such as fruit stalls and fruit juice corners, and restaurants etc. in and around Imphal market and some market places of Bishnupur.

Pre-composting: The collected fruit waste was washed and air dried separately, spreading over a polythene sheath. Then it is mixed with cow-dung slurry in the ratio 3:1 and kept for 21 days for pre composting aerobically by the bacteria. The temperature of the pre-composted substrate was brought down to 25°C and was used in the experimental pots.

Experimental design: Five kg of the substrate were added in each pot for vermicomposting and composting. Four sets of experimental pots were taken for the study. One set was used for normal composting without earthworm whereas the remaining three sets were used for vermicomposting by adding the three different species of the earthworm. The number of adult earthworms used is fifty each for the three different varieties of species for vermicomposting. There were three replicates for each experimental set. Each pot was filled with pebbles up to a height of 5cm, and for better drainage and air circulation, small holes were made at the bottom of the pots. The experiment was carried out for a period of 60 days, during which temperature and moisture content were maintained by sprinkling a suitable quantity of water on alternate days. At the end of the experiment, vermicompost and compost were harvested and total earthworm biomass, individual body weight, total numbers of cocoons, juveniles and adults were recorded (Pattnaik and Reddy 2010).

Physical parameters: Weight was taken by using a digital electronic balance. Temperature of the substrate was recorded from day one onwards for 60 days in each replicate pot. Samples of compost and vermicompost were collected on 60th day and pH was measured in a 1:10 suspension. The suspension was prepared by adding 100 ml distilled water to 10 grams of samples in a beaker and stirred for half an hour at regular intervals. The pH was estimated using the pH meter (Hanna model PH-98107), and the values were recorded continuously throughout the experimental period. The electrical conductivity was recorded by using an electrical conductivity meter (Elico model CM180) in the same solution prepared for pH estimation. For estimation of moisture content 10 gm of the sample was taken in a crucible which was kept at 105°C for 16 hrs. The crucible was then cooled in desiccators, and the percentage of moisture content was calculated using the following method.

% moisture content=d/10×100, where, d = reduction of weight after heating (Bhatt and Limaye 2012).

Chemical analysis: From each replicate pot, homogenous samples of each substrate as well as their respective vermicompost and compost (100g dry weight) were collected without damage at the end. Samples of the three replicate pots were processed for analysis of major nutrients—total carbon (C), total nitrogen (N), phosphorus (P), potassium (K), and micronutrients like Iron (Fe), Copper (Cu), Zinc (Zn) and Manganese (Mn). Organic carbon (OC) content was determined by partial oxidation method (Walkey and Black 1934). Total kjeldahl nitrogen was measured by the method as described by Jackson (1958), Determination of P content was done by UV Calorimeter (Anderson and Ingram 1993). Ammonium acetate exchangeable potassium was determined by using flame photometer (Simard 1993).

Trace element analysis: The analysis consists of samples digestion by wet oxidation and determination of heavy metal concentration in the digested samples by using the Association of Analytical Chemists, AOAC (2000) method. In wet oxidation, 5 g of sample is taken, and 2 ml of sulphuric acid, 4 ml of perchloric acid and 20 ml of nitric acid were added. The mixture was heated to boiling on the heating mantle until colourless and then cooled. The mixture is then diluted with distilled water to 100 ml. After sample digestion, an atomic absorption spectrophotometer (Perkin Elmer Model 403, North Chicago USA.) was used to determine the concentration of heavy metals iron (Fe), copper (Cu), zinc (Zn) and manganese (Mn).

Statistical analysis: All the data obtained were subjected to one way analysis of variance () and Tukey test were used for comparing between 0 day and 60 days values. The data analysis was carried out using statistical package, SPSS 21.0 version.

RESULT AND DISCUSSION

Physical characteristics: The physical characteristics of substrate, compost and vermicompost were shown in Table 1. It was found that initial weight of 5 kilograms of the substrate was reduced to 3.3 kilograms of compost. The weight of vermicompost obtained from the pots where *E. eugeniae, E. foetida* and *P. excavatus* were used to feed the substrates was 2.2 kg.

Temperature: The temperature ranged from 23.1ºC to 25.5ºC as compared to the substrate. The temperature lowered gradually at the end of the experiment, when the vermicompost was formed. At the beginning of the experiment, the temperature of the substrate was found to be high. However, it gradually lowered as the composting process continued. Due to intensive microbial activity on the organic matter, the heat was released by oxidative action. This had produced a temperature rise in the first mesophilic phase of composting. Due to the thermophilic phase, the temperature rose up and then followed by cooling phase at the time of compost maturation. So, the temperature decreased with the progress of the composting process. The finding-result is relevant to the findings of Nagavallemma et al (2006). Due to regular sprinkling of water, the temperature also reduced to a little extent.

pH: The pH of the substrate and their respective compost and vermicompost ranged from 6.1 to 7.3. This indicates the pH increased gradually from substrate to compost, then to vermicompost. The value of the pH of vermicompost was very near to neutral because of the secretion of NH_4^+ ions that reduced the pool of H^+ ions and the activity of calciferous glands in earthworms which has carbonic anhydrase catalysing the fixation of CO_2 as $CaCO_3$, thus inhibiting decrease in pH. The increasing trend of pH in the ordinary compost and vermicompost is in consistence with the findings of Tripathi and Bhardwaj (2004). The cation exchange capacity of vermicompost has the potential to correct the acidity and alkalinity of soil as well as improving the physical properties of the soil. Soil chemical properties like soil pH, bulk density, organic carbon, availability of N, P and K in the surface or subsurface soils were significantly affected with the addition of different doses of organic manure (Silpa et al 2017).

Electric conductivity: The electrical conductivity of substrate on day one has lowest value of 1.3 ms/cm while that of 60 days compost had 2. Nevertheless, the highest electric conductivity was on the 60th day vermicompost of the three earthworm species i.e. 3 ms/cm. The electrical conductivity of the vermicompost produced was more than that of the substrate and the control.

Moisture: The moisture content ranged from 60.2to 65.1%. Liang et al. (2003) concluded that maximal microbial activity was in the moisture content of 60-70%, while the minimum moisture content required for the rapid increase of microbial activity was 50%. During the study, it was observed that vermicompost samples showed higher moisture content than the compost and the substrate. This may be because of the microbial population's high absorption capacity and assimilation rate which implies a higher rate of waste degradation by earthworms.

Growth parameters: The growth parameters of the three earthworm species cultured in fruit waste showed that *Eudrilus eugeniae* showed the maximum length of 16.43cm followed by whereas *Eisenia foetida* and *Perionyx excavatus* (Table 2). The maximum increase in weight was in *E. eugeniae* having 2.86g followed by *E. foetida* and *P.excavatus*. The total length, weight and biomass of the three earthworm species was found increased at the end of the experiment. It may be due to the quality of the substrate or could be related to fluctuating environmental conditions. The total biomass gain recorded was maximum in *E. eugeniae* followed by *E. foetida* and *P. excavatus*. The number of worms produced per cocoon was higher in *E. foetida* than in *E. eugeniae* and *P. excavatus*. The number of juveniles collected at the end of the experiment was highest in *E. foetida,* folowed by *P. excavatus* and *E. eugeniae* (168; 162 and 117). The number of cocoons collected at the end of observation was highest in *P.excavatus* followed by *E.foetida* and *E. eugeniae*. The average adult number of *E. foetida* was highest, (393) followed by *P.excavatus* (370) and *E. eugeniae* (312). The higher numbers of juveniles and adults in *E. foetida* showed that it is more adaptable in the fruit waste when compared to the other two species. The overall increase in the above parameters in fruit waste mixed with cowdung could be related to the nutrients present it and the

Table 1. Physical characteristics of the substrate, compost and vermicompost :weight, temperature, pH, electrical conductivity and moisture content

Parameters	0 days	60 days			
	Substrate	Compost	Vermicompost		
			E. eugeniae	*E. foetida*	*P. excavatus*
Weight (kg)	5.0±0.00	3.3±0.06*	2.2±0.06*	2.2±0.06*	2.2±0.04*
Temperature (°c)	25.5±0.04	23.5±0.08	23.1±0.06	23.1±0.17	23.1±0.04
pH	6.1±0.04	6.5±0.06	7.2±0.01	7.3±0.11	7.2±0.004
EC (ms/cm)	1.3±0.06	2.0±0.03	3.0±0.02*	3.0±0.02*	3.0±0.02*
Moisture content (%)	60.6±0.88	60.2±0.06	64.5±0.04	64.8±0.06	65.1±0.22

Table 2. Individual length and live weight, gain in total biomass, the total number of cocoons, juveniles and adults

Earthworm growth parameters	*E. eugeniae*	*E. foetida*	*P. excavatus*
Individual length (cm)			
Initial	13.1±0.06	8.2±0.13	7.3±0.13
Final	16.43±0.11	10.15±0.01	10.1±0.06
Individual weight (g)			
Initial	2.43±0.04	0.56±0.008	0.53±0.01
Final	2.86±0.04	1.6±0.06*	1.02±0.004*
Total biomass (g)			
Initial	120±0.44	28.4±0.4	26.53±0.11
Final	1120±0.66*	809±0.11*	620±0.66*
Average worm no. per cocoon	2.7±0.11	3±0	1.13±0.04
Average cocoon no. at the end	115.66±0.44*	172.33±1.7*	189.13±0.17*
Average juvenile no. at the end	117±0.66	168±0	162±0.66
Average adult no. at the end	312±1.33	393±0	370±1.33

Table 3. Analysis of elements in substrate, compost and vermicompost

Parameters	0 days	60 days			
	Substrate	Compost	Vermicompost		
			E. eugeniae	*E. foetida*	*P. excavatus*
N	0.83±0.011	1.06±0.013	1.86±0.017*	1.90±0.022*	1.92±0.02*
P	0.35±0.01	0.41±0.013*	0.66±0.013*	0.67±0.012*	0.69±0.02*
K	0.19±0.013	0.21±0.011	0.26±0.013*	0.32±0.012*	0.28±0.01*
Total Fe	0.23±0.01	0.24±0.01	0.27±0.02	0.27±0.02	0.27±0.02
Total Mn	0.04±0.02	0.03±0.004*	0.015±0.013*	0.018±0.02*	0.016±0.017*
Total Cu	0.0061±0.0001	0.0052±0.0001*	0.0048±0.0002*	0.0049±0.0001*	0.0049±0.0002*
Total Zn	0.084±0.001	0.083±0.002	0.079±0.003	0.078±0.003	0.079±0.003

finding correlates with the work done on fruit waste by (Dey et al 2018, Hemlatha 2012).

Trace element analysis: The vermicompost of *P. excavatus* has the highest nitrogen content of 1.92% than that of *E. foetida* (1.90%) followed by *E. eugeniae (*1.86%) and compost (1.06%) and the least (0.83%) was recorded in the substrate. The vermicompost of *P. excavatus* has the highest phosphorus content of 0.69%, followed by that of *Eisenia foetida* and *E. eugeniae* and substrate (0.35%).The vermicompost of *E. foetida* has the highest potassium content of 0.32%, followed by that of *P. excavatus* and *E. eugeniae*, compost and the least of 0.19% in the substrate. The vermicompost of all the three species of earthworms have a total iron content of 0.27%, while compost has 0.24% and the least content of 0.23% in the substrate. The iron content slightly increased from substrate to compost and vermicompost. The manganese content significantly reduces in vermicompost from that of compost and substrate. The copper content in the vermicompost of the three earthworms *E. eugeniae*, *E. foetida and P. excavatus* was found significantly reduced from the substrate and compost. The zinc content gradually decreased in the vermicompost of *E. eugeniae, E. foetida* and *P. excavatus* than that of compost and the substrate. Pattnaik and Reddy (2010) also documented the same trend.

CONCLUSION

Eisenia foetida and *P. excavatus* showed better performance in growth and reproduction as compared to *Eudrilus eugeniae*. The ability of reproduction of *Eisenia foetida* and *Perionyx excavatus* was more than *Eudrilus eugeniae*. It may be due to its higher adaptation of the two species of earthworms. The increased amount of nitrogen, phosphorus and potassium in vermicompost showed that it has higher percentage of plant nutrients when compared to the normal compost and substrate. The amount of trace elements decreased from substrate to compost and vermicompost. This is due to bio-accumulation of trace elements in the earthworm tissue during the process of digestion in the alimentary canal. Thus earthworm species *Eisenia foetida* and *Perionyx excavatus* can be utilised in vermicomposting of fruit waste and can produced fertile organic manure called vermicompost.

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Influence of Auxin on Rooting in Hardwood Cuttings of Apple (*Malus × domestica* Borkh.) Clonal Rootstock 'M 116' under Mist Chamber Conditions

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Abstract: The present research work was conducted with an objective to study the influence of auxin on rooting and growth of rooted plants of hardwood cuttings of new apple clonal rootstock M 116. The experiment was laid out in completely randomized design consisting of ten treatments viz., IBA at 1500, 2000, 2500 3000, 3500 and 4000 ppm; NAA 500, 1000, 1500 and (ethanol + water solution). The increased auxin concentration showed a positive correlation with respect to rooting success and growth of rooted plants of 'M 116'. IBA when applied at 3500 ppm recorded the highest rooted cuttings (57.12 %), number of adventitious roots (7.33), total root length (4.16 m), length (97.42 cm) and diameter (5.00 mm), number of leaves per cuttings (51.00) and leaf area (29.22 cm^2), which was statistically at par with hardwood cuttings treated with IBA (3,000 ppm). The propagation through hardwood cuttings with the application of auxin (IBA 3,000 and 3,500 ppm) aids to availability of elite propagation materials of new apple clonal rootstock 'M 116' in order to meet out farmers demand in India.

Keywords: Apple, Auxin, IBA, Rootstock, Rooting

Apple (*Malus × domestica* Borkh.) is the most important cultivated temperate fruit crop of the north-western Indian Himalayan region. In India, apple is commercially grown in an area of 3,01,000 hectare, accounting for an annual production of 23,27,000 MT (Anonymous 2017). Himachal Pradesh shares around about 38 per cent of total area under apple cultivation in India, covering around 1,13,154 hectares, with annual production of 3,68,603 MT (Anonymous 2018). Apple is commercially propagated through grafting and budding on seedling and clonal rootstocks. Although, the seedlings are the most widely and commonly used rootstocks, but the trend is now shifting towards the use of clonal rootstocks for intensive orcharding**.** Rootstock utilization has gained value for solving the limiting factors of production (soil, climate and pest) and productivity, and conditioning of market demands (fresh or processed), short juvenility period and better fruit quality (Demirkeser et al 2009)**.** Rootstocks offer wider adaptability (pH, drought, texture, drainage), tolerance against biotic stress (nematodes, insects and disease) and increasing hardiness to abiotic stresses like low temperature (Dolgov and Hanke 2006). In recent years, especially in modern fruit cultivation, the use of clonal apple rootstocks has been widespread (Dolgun et al 2009). Majority of apple orchards in the state are old and senile, accounting to low production and productivity, which needs to be replace through replantation. But, in recent time, certain biotic and abiotic factors such as specific apple replant disease, collar rot and root rot are causing a major obstacle in replantation of these old and senile orchards. The clonal rootstocks such as M 9, M 7, MM 106, MM 111 and Merton 793 have been evaluated and found promising for commercial use in the agro-climatic conditions of Himachal Pradesh, however, these rootstocks possesses susceptibility to replant problem except Merton793. In the recent years, large number of rootstocks has been developed in which reported tolerant to replant problem, especially by Horticulture Research International (Kent, GB). Among these, 'M 116' (previously AR 86-1-25) is a new rootstock which is a crosses between MM 106 (seed parent) × M 27 (pollen parent) having features like improved resistance to collar rot, mildew and specific apple replant disease, compatible as a rootstock with all apple varieties tested, improved yields over Malling-Merton 106 and semi-vigorous growth (Frank 2008), that offers a great scope in modern cultivation of apple especially in agro-conditions of Himachal Pradesh, India. However, 'M 116' is difficult to propagate and is mainly propagated through layering and cuttings with variable success.

Propagation through cuttings is the most common means of clonal regeneration of number of horticultural crops. Adventitious root formation is pre-requisite to successful propagation through cutting (Hartmann et al 2009). Endogenous factors like growth hormone balance, anatomical structure of cutting and carbohydrate level

(Hartmann et al 2002) and exogenous factors such as humidity, air and light conditions in rooting environment and age of cuttings are pre-requisite for successful results in propagation (Frey et al 2006). Auxin application has been found to enhance the histological features like formation of callus and tissue and differentiation of vascular tissue, resulting in rootings (Satpal et al 2014). Apple clonal rootstock 'M 116' is recently introduced rootstock in India, due to having certain physiological advantages over available clonal rootstocks, this rootstock is in huge demand among farmers. Hence, this rootstock requires standardization of propagation techniques in our agro-climatic conditions with respect to cuttings and plant growth regulator applications for enhancing rooting success. Keeping in view these facts, the present experimental trial was carried out in order to assess the effect of different auxin concentrations on rooting in hardwood cuttings of apple clonal rootstock 'M 116'.

MATERIAL AND METHODS

Plant material and sampling: The trial was carried out at Dr Y S Parmar University of Horticulture and Forestry at Nauni, Solan, Himachal Pradesh, India during the year 2016-2018. The experimental farm is located at 30˚ 51' North latitude and 77 ˚ 88' East longitude at an elevation of 1250 meters above mean sea level. The climate of area is typically sub-temperate. The experiment consist often treatments of auixn viz., T_1 - IBA 1,500 ppm; T_2 - IBA 2,000 ppm; T_3 - IBA 2,500 ppm; T_4 - IBA 3,000 ppm; T_5 - IBA 3,500 ppm; T_6 -IBA 4,000 ppm; T_7 - NAA 500 ppm; T_8 - NAA 1,000 ppm; T_9 -NAA 1,500 ppm and T_{10} - control (Ethanol + water solution). The experiment was laid out in completely randomized design (CRD), with each treatment replicated thrice, consisting of fifty cuttings per replication each. The mother stools of 'M 116' apple clonal rootstock were established under World Bank Funded Himachal Pradesh Horticulture Development Project by planting rootstock at spacing of 90 × 45 cm at the nursery farm area during 2016. The hardwood cuttings ranging from 0.6-0.8 centimeters in diameter and 20 cm in length were taken from mother plants in the month of January, 2017. A slant cut slightly above a node on the apical end and longitudinal wounding cuts of 1.0-2.0 cm were made at basal end of cuttings to facilitate absorption of IBA and NAA. Before planting cuttings in mist chamber for rooting, the basal portion (2 cm length) of the cuttings was dipped for 10-15 seconds in respective IBA and NAA solutions (Quick Dip Method). The treated cuttings were then placed in shade for few seconds to ensure sufficient absorptions of IBA and NAA, and were planted in a mist chamber for rooting at a spacing of 10 cm row to row and 7.5 cm apart in the row.

Evaluations: The cuttings were uprooted from mist chamber in December and number of rooted cuttings out of the total number of cuttings planted per treatment was recorded. The average percentage of rooted cuttings, number of adventitious roots per cuttings, length and diameter of roots was measured (Hartmann et al 2009). The roots were washed with tap water with pressure and then cut into small pieces of each selected individual cutting, separately. The total length of roots was measured with the help of Comair root length scanner and was expressed in meter (m). The roots of each cutting were cut into small pieces and weighed on a top pan electronic balance. To record dry weight of roots, the pieces of entire roots were dried in an oven at a temperature of 65˚C for about 72 hours until the constant weight of sample was obtained. The fresh and dry weight of roots was expressed in grams (g). The length of main shoot was measured in December.

The length of shoot was measured from the point of the emergence on the cutting to the tip of the shoot. The diameter of shoot was measured from the base of main shoot at the point of emergence from the cutting. The entire shoot was cut into small pieces and weighed after removing all the leaves and roots on a top pan electronic balance. To record dry weight of shoot, the pieces of shoot were dried in an oven at a temperature of 65^{O}C for about 48 hours until attaining the constant weight of sample. The fresh and dry weight of shoot was expressed as grams (g). The leaf number was recorded during October before onset of leaf fall. All the leaves, irrespective of their size were counted and average number of leaves per cutting was calculated. The observations on the leaf area were recorded during first week of October. Ten fully expanded leaves were collected at random from the cuttings and area of leaves was measured with the help of "CI-202 Portable Laser Leaf Area Meter. The data on root shoot ratio was recorded at the end of the growing season. Five rooted cuttings were selected and the roots were cut from the shoot with the help of secateur. Both roots and shoots portion were dried in the oven at 65°C for 72 hours till they attained constant weight. The weight of dry roots and shoots were recorded and root shoot ratio was calculated.

Data analysis: The data was analysed by using MS-excel and OPSTAT, The assessment for determining the pearson correlation (Table 3) between different rooting parameters and different auxin concentrations was done with NCSS (2019) statistical software.

RESULTS AND DISCUSSION

The different auxin concentrations significantly influence the rooting and growth of rooted hardwood cuttings of apple clonal rootstock M 116 (Table 1). Simulatonulsy, the rooting and growth parameters also showed a positive correlation with respect to increased auxin concentrations (Table 3).

Rooting parameters: The highest rooted cuttings (57.12 %), length (34.85 cm) and diameter (5.27 mm) of adventitious roots, and total root length (4.16 m) was T_5 (IBA 3,500 ppm), which was statistically at par with cuttings treated with IBA 3,000 ppm (T_4). The maximum number of adventitious roots (7.33), fresh (10.76 g) and dry weight (7.89 g) of roots was also observed in T_5, which was statistically at par with treatments T_4 and T_6. However, the lowest rooted cuttings, number of adventitious roots per cuttings, length and diameter of adventitious roots, total root length, fresh and dry weight of roots was recorded in (control, which was statistically at par with treatment T_7 (NAA 500 ppm) and lower in comparison to all other treatments. Apple clonal rootstock 'M 116' is somewhat difficult to root, which might have accounted for better success in rooting with higher concentrations of auxins. Application of IBA may have triggered the early anticlinal cell division and root primordial formation, enzymes involved in cell enlargement process and considered better than NAA (Ali et al 2009), which might have accounted for better root growth in the 'M 116' clonal rootstock. Auxin application enhance the histological features like formation of callus and tissue and differentiation of vascular tissue (Satpal et al 2014), which results in better rootings. The maximum fresh weight and dry weight of roots was obtained under IBA 3,500 ppm in the cuttings of apple rootstock 'M 116'. These findings are in agreement with the observations of Ray et al (2001) who also reported that litchi cuttings treated with IBA up to 4000 ppm influences the cuttings rooting by increasing the maximum fresh weight. Verma (2019) recorded highest rooting (64.10 %) with better root length and root diameter in difficult to root peach rootstock Rubira with application of IBA 3000 ppm along with

Table 1. Effect of different auxin concentrations on rooting in hardwood cuttings of apple clonal rootstock 'M 116'

Treatments details	Rooted cuttings (%)	No. of adventitious roots per cuttings	Length of adventitious roots (cm)	Diameter of adventitious roots (mm)	Total root length (m)	Fresh weight of roots (g)	Dry weight of roots (g)
T_1 - IBA (1500 ppm)	43.08 (41.01)	4.67	23.66	4.01	2.39	6.91	4.22
T_2 - IBA (2000 ppm)	46.01 (42.69)	5.00	28.77	4.31	2.54	8.35	5.02
T_3 - IBA (2500 ppm)	53.48 (46.98)	5.33	32.12	4.68	3.33	9.41	6.93
T_4 - IBA (3000 ppm)	54.84 (47.76)	6.67	33.90	5.00	3.78	10.40	7.48
T_5 - IBA (3500 ppm)	57.12 (49.07)	7.33	34.85	5.27	4.16	10.76	7.89
T_6 - IBA (4000 ppm)	49.42 (44.65)	6.00	29.71	4.30	3.41	10.36	7.21
T_7 - NAA (500 ppm)	33.59 (35.40)	2.67	19.32	3.13	1.79	3.41	2.45
T_8 - NAA (1000 ppm)	37.68 (37.85)	3.00	22.13	3.33	2.02	4.30	3.03
T_9 - NAA (1500 ppm)	40.76 (39.66)	3.33	23.48	3.70	2.15	4.84	3.25
T_{10} - Control	15.92 (23.46)	2.33	16.80	2.32	1.58	2.64	1.69
CD (p=0.05)	2.90 (1.84)	1.83	4.04	0.52	0.44	1.19	0.88

Table 2. Effect of different auxin concentrations on shoot growth of rooted hardwood cuttings of apple clonal rootstock 'M 116'

Treatments details	Length of main shoot (cm)	Diameter of main shoot (mm)	Fresh weight of shoot (g)	Dry weight of shoot (g)	Number of leaves per cutting	Leaf area (cm^2)	Root: shoot ratio (fresh weight basis)
T_1 - IBA (1500 ppm)	80.08	4.01	30.02	22.59	38.00	23.39	0.23
T_2 - IBA (2000 ppm)	84.09	4.31	31.44	23.21	41.33	25.01	0.26
T_3 - IBA (2500 ppm)	90.14	4.68	32.89	23.75	46.67	26.07	0.29
T_4 - IBA (3000 ppm)	93.11	5.27	34.44	25.04	49.33	28.00	0.30
T_5 - IBA (3500 ppm)	97.42	5.00	35.55	26.68	51.00	29.22	0.30
T_6 - IBA (4000 ppm)	86.31	4.70	34.19	25.68	44.33	25.95	0.29
T_7 - NAA (500 ppm)	66.15	3.13	24.83	17.35	31.67	20.59	0.14
T_8 - NAA (1000 ppm)	68.02	3.33	27.34	19.68	33.33	21.46	0.16
T_9 - NAA (1500 ppm)	71.32	3.70	28.14	20.14	37.67	23.16	0.18
T_{10} - Control	59.39	2.32	22.77	16.11	28.33	17.19	0.12
CD (p=0.05)	4.55	0.50	3.01	2.39	5.55	3.26	0.05

Table 3. Pearson correlation analysis for the effect of different auxin (IBA and NAA) concentrations on rooting and growth of cuttings of apple clonal rootstock 'M 116'

Parameters/ Source of variation	Rooted cuttings (%)	No. of adventitious roots per cuttings	Length of adventitious roots (cm)	Diameter of adventitious roots (mm)	Total root length (m)	Fresh weight of roots (g)	Dry weight of roots (g)	Length of main shoot (cm)	Diameter of main shoot (mm)	Fresh weight of shoot (g)	Dry weight of shoot (g)	Number of leaves per cutting	Leaf area (cm^2)	Root: shoot ratio (fresh weight basis)
Count	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Df	8	8	8	8	8	8	8	8	8	8	8	8	8	8
T-value	5.15	7.09	6.13	5.24	7.23	8.96	9.14	5.94	6.70	9.56	9.39	6.52	6.42	7.17
Standard deviation	12.27	1.75	6.27	0.91	0.89	3.13	2.31	12.77	0.93	4.32	3.57	7.69	3.62	0.07
Pearson Correlation	0.88	0.93	0.91	0.88	0.93	0.95	0.96	0.90	0.92	0.96	0.96	0.92	0.92	0.93
P-value	0.0009*	0.0001*	0.0003*	0.0008*	0.0001*	0.0000*	0.0000*	0.0003*	0.0002*	0.0000*	0.0000*	0.0002*	0.0002*	0.0001*

*indicate significant effect of auxin at $p \leq 0.05$

pre-conditioning treatments with girdling and blanching. Thakur et al (2014) observed higher concentration of auxin at 4000 ppm IBA resulted better rooting in difficult to root olive cuttings. Verma et al (2015) recorded the highest rooting percentage of 65 per cent, and other root parameters with application of IBA 2500 ppm in hardwood cutting of apple clonal rootstock Merton 793. Tauseef et al (2017), also reported maximum rooting percentage, increased number of roots per cutting, number of secondary roots per cutting, average root length) in cuttings of kiwifruit treated with IBA 3,500 ppm.

Shoot parameters: The maximum length of main shoot (97.42 cm) was in cuttings treated with T_5) which was statistically at par with T_4 However, the maximum diameter of main shoot was in T_4which was statistically at par with T_5. The maximum fresh (35.55 g) and dry (26.68 g) weight of shoots was in T_5 which was statistically at par with treatment T_4 and T_6 (IBA 4,000 ppm). The highest number of leaves (51.00) and leaf area (29.22 cm^2) was in T_5 which was significantly at par with treatment T_3 (2,500 ppm) and T_4 (IBA 3,000 ppm). The highest root: shoot ratio (0.30) was recorded in cuttings treated with IBA 3,000 and 3,500 ppm, which was statistically at par with cuttings treated with IBA 2,500 and 4,000 ppm. However, the minimum length and diameter of main shoot, fresh and dry weight of shoot, number of leaves per cuttings, leaf area and root: shoot ratio was in(control, which was significantly lower in comparison to all other treatments. The better rooting and root development in the cuttings treated with 3000 and 3500 ppm might have accounted for higher shoot growth in the present study. As cuttings were grown in mist chamber, the use of intermittent mist on cuttings t reduces the temperature of the leaves, lowers respiration, and increases relative humidity around the leaf surface (Singh 2018), which would have resulted in better shoot growth of rooted cuttings. The higher concentration of IBA (3,000 ppm) influences shoot growth of apple rooted cuttings by increasing shoot length. Similarly, the higher concentrations of auxin also results in better rooting and shoot parameters in difficult to root fruit crops like olive and kiwi (Ahmed et al 2001, Thakur et al 2014, Tauseef et al 2017). The application of IBA at 3000 and 3500 ppm significantly increased the fresh and dry weight of shoots. As the shoot growth in terms of length and diameter increases with the levels of auxin concentrations, as observed in this experiment higher fresh weight of shoot was also noticed. The highest fresh weight might be due to additional weight of cuttings with highest length and diameter in IBA treatment with 3,500 ppm. The maximum number of leaves and leaf area recorded in IBA 3500 ppm. The longer shoots put in more internodes and therefore more number of leaves which emerge from nodes. The leaf area of the rooted cuttings has the direct relation with the number of leaves as well as shoots growth. Agreeing with Taiz and Zeiger (2006), the increased roots in the cuttings due to auxin application may have enhanced the photosynthetic and other activity carried out in leaves which accounted for higher leaf area in the 'M 116' rooted cuttings treated with IBA (3,500 ppm). The higher concentrations of auxin have also resulted in better leaf area and number of leaves in cuttings of kiwi and guava (Alam et al 2007 and Rani et al 2007, respectively). The root: shoot ratio parameter help to assess the overall health of plant. Any change from this normal level would be an indication of a change in the overall health of the plant. Exogenous application of auxin at different concentrations seems to activate sugar metabolism for release of energy and proteins which are necessary for cell division and differentiation during adventitious root primordial initiation or development in the rooting zone of cuttings (Murthy et al 2010). Verma et al

(2015) also recorded better shoot growth with the application of IBA 2500 ppm in hardwood cutting of apple clonal rootstock Merton 793.

CONCLUSION

The results acquire significant importance while considering the present scenario of cultivation of apple varieties on clonal rootstocks in Himachal Pradesh, India, as 'M 116' rootstock offers greater scope being new and possessing diverse feature than other available rootstocks by application of higher concentration of auxin for producing elite propagating material in order to meet for farmers demand.

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Inherent Vulnerability Profiles of Agriculture Sector in Temperate Himalayan Region: A Preliminary Assessment

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Abstract: The economy of J&K is reliant on agriculture, and most of the farmers are smallholders who are highly exposed to the negative impacts of climate change. This study employed nine indicators for measuring the dimensions of vulnerability, i.e., sensitivity and adaptive capacity. Weights were assigned to each indicator according to their importance in determining the vulnerability of the agricultural system. The vulnerability index is highest for Budgam (0.58) and Bandipura (0.57), followed by Baramulla, Ganderbal, Kulgam, Kupwara, Anantnag, Pulwama, and Srinagar. Shopian is the least vulnerable district, with an index of 0.36. The results indicate that the majority of smallholder farmers were highly vulnerable, while four districts were moderately vulnerable in the valley. Several drivers of agricultural vulnerability were also identified.

Keywords: IPCC WG 2014, Vulnerability, Sensitivity, Agriculture, Drivers

Climate change is increasingly becoming the most important global issue and the toughest challenge for humankind in the 21st century (Moser 2016). The impact caused by climate change on earth is unique in that it affects all territories and people alike, without acknowledging political barriers or boundaries of any kind. In the period 2016-2035, relative to 1986-2005, the global mean surface temperature increases for all the four (Representative Concentration Pathways (RCPs) between 0.3 and 0.7°C (Li et al 2016). Climate change will impact agriculture, forests, and water resources (Luo et al 2018). The climate is changing and adversely affecting both biosphere systems (mountains, rivières, forests, wetlands) and socio-economic systems (mountain communities, coastal communities, agriculture, animal breeding), research has produced substantial evidence around the world (Maunder 2012, Tarter et al 2016). However, over time, the impact of climate change is not uniform and is different in the same region because of exposure differences and vulnerabilities between different social groups, economic sectors, and ecosystems (Talhouk et al 2018).

Climate change and variability are sensitive to the Himalayan region (Pandey and Jha 2012, Kumar et al 2019). Over recent decades, the rates of high-temperature events have changed dramatically over the long term, most parts of the world (Hansen et al 2012, Wang et al 2016). The trends are growing in annual intense precipitation days (frequency) and in annual intensity (Westra et al 2013, Zhan et al 2017, Sigdel and Ma 2017, Gujree et al 2017, Iqbal et al 2019). Biodiversity loss and water stress owing to climate change are the most significant challenge for the UT over the coming decades (Myers et al 2017). A significant threat to the ecosystems, biodiversity, forestry, wildlife, fishing, and water supplies of the area is posed by climate change (Beschta et al 2013, Cramer et al 2018). The principal livelihood in the Indian Himalayan Region (IHR) is agriculture-focused, mostly on crop cultivation and tourism activities, both highly climate-sensitive as they are vulnerable to climate change (Singh et al 2019, Sekhri et al 2020). The crop water requirement of different orchard crop has been significantly affected by the change in climatic conditions over a period of time (Sharma 2020).

While Jammu and Kashmir nestle in the fragile Himalayan Ecosystem, there are natural fluctuations in climate, human-induced changes due to large-scale urbanization, driving the warming trend (Rashid et al 2015, Romshoo et al 2020). Agriculture and allied sectors, including horticulture, floriculture, sericulture, remains the mainstay of the UT's economy (Bhat and Lone 2017). Such restrictions are likely to increase the climate vulnerability of Indian Himalayan communities due to climate variabilities (Pandey and Jha 2012, Macchi et al 2015). Furthermore, communities have limited livelihoods and have increased marginalization as they are limited, with greater dependence on natural resources and infrastructure, such as road and transport, markets, power supplied, and communication (Maru et al 2014, Shackleton et al 2015, Heron et al 2016, Meraj and Singh 2021).

Vulnerability assessments have important policy implications for the enhancement of adaptive capacity as well as betterment in the perception of vulnerability reduction measures (Basu 2020). According to IPCC (2014), the first step towards adaptation to future climate change is reducing vulnerability and exposure to present climate variability. Adaptation is not only designed based on climate projections; risk and vulnerability information is also required to assess how the environment interacts with socio-economic issues (Kriegler et al 2012, Berkhout et al 2014). Therefore, it becomes imperative to understand 'who is vulnerable and why?". In order to design adaptation interventions in the area, the identification of current vulnerability drivers can contribute (Hay and Mimura 2013). Vulnerability evaluation in the current climate provides information on current weaknesses, together with drivers of such weaknesses, in the natural or socio-economic system (Van Vuuren et al 2012). This helps the development of techniques to deal with and adapt to perceived program vulnerabilities. The potential roles of adaptation and mitigation strategies and their interactions in response to climate change to improve the agriculture sector in India have been studied as well (Kaur et al 2018). The inherent vulnerability assessment undertaken in this study aims to get insights into ranking the vulnerability of units using an Index, assessing the extent of the vulnerability, and identifying the drivers of vulnerability.

MATERIAL AND METHODS

Study area: The Valley of Kashmir is a longitudinal depression of the Himalayas' broad north-west region (Meraj et al 2018). The latitudinal extent is 32.17^{O}N to 37.6^{O}N, whereas the longitudinal extent is 73.26^{O}E to 80.30^{O}E. At altitude, it ranges from 1,549 m - Wular Lake to a maximum of 5,432 m - Kolahoi Peak. The valley occupies an area of 15,856 km^{2}. The valley is mainly drained by the river Jhelum. It comprises ten districts, namely Anantnag, Kulgam, Pulwama, Shopian, Budgam, Srinagar, Ganderbal, Bandipore, Baramulla, and Kupwara (Fig. 1). The total population of Kashmir Valley is 69,07,623 individuals (Census of India 2011).

The climate of Kashmir falls under Temperate-cum-sub-Mediterranean type of climate. Summer is the period of scarce or null rainfall. The precipitation in the valley is received in the form of snowfall as well as rains, and the average annual precipitation is 660 mm. Summer temperatures are not usually higher than 35°C, and winter temperatures are not usually lower than -5°C. The valley's average annual temperature is 19°C. Kashmir's economy is centered on agriculture, horticulture, and tourism. The primary cultivation in the valley is traditionally rice, which is the people's leading food. Indian maize, wheat, barley, and oats are also cultivated (Kaloo and Choure 2015). Fruit trees are common throughout the valley (pears, apples, and cherries). The total area under agriculture accounts for 34.3% of the total area of Kashmir valley.

Approach to vulnerability assessment: The project used an indicator-based approach to assess the vulnerability of Kashmir Valley. The overall approach and methodology adopted are shown in Figure 2.

Indicators selection: For indicator selection, a list of indicators was prepared based on the vulnerability conceptual framework, which was shared with experts for review and advice. The final selection of indicators was based on expert suggestions and availability of data. All the sensitivity indicators were assumed to have a positive functional relationship with vulnerability whereas, and adaptive capacity indicators were assumed to have a negative relationship with vulnerability. Table 1 shows the list of indicators and the rationale behind selecting the indicators.

Normalization of values: Table 2 presents actual sub-indicator values used and their normalized scores for each of the indicators for all the districts in the valley. Normalization is done depending on the indicators' functional relationship with vulnerability (either positive or negative relationships), and corresponding formulae are used. As sensitivity is positively correlated to vulnerability, therefore, indicators were normalized using equation (1).

$$\text{Normalised value (N)} = \frac{\text{Actual Value} - \text{Minimum value}}{\text{Maximum value} - \text{Minimum value}} \quad (1)$$

While the adaptive capacity is negatively correlated indicators, the indicators were normalized using equation (2)

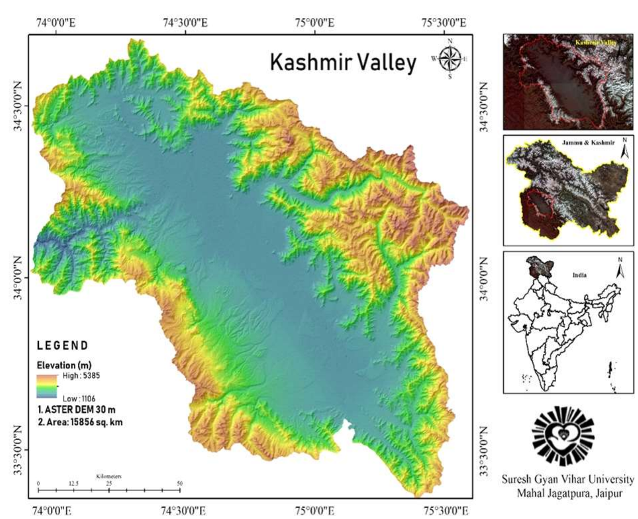

Fig. 1. Study area

$$\text{Category} = \frac{\text{Maximum value} - \text{Minimum value}}{3} \qquad (4)$$

Assigning the weights: In particular, concerning various structures, different metrics have varying degrees of vulnerability effects. Both metrics have been distributed to keep the weights in mind. Mainly secondary stakes consultations-district administrators, academics, and NGOs with significant contributions from experts from different departments of Jammu and Kashmir were part of weight allocation. The indices were measured on a scale between 0 and 100 so that the overall weights were 100. The indicator values and regular ratings are listed in Table 3, and the allocated weights depending on the relative importance of each indicator.

Total vulnerability and categories: Sensitivity and adaptive capacity were recognized as intrinsic attributes of a system, which predispose a community to be adversely affected by any damage.

$$V=S+1-AC \qquad (3)$$

Where S is sensitivity and AC is adaptive capacity.

All districts were categorized according to high, medium, and low vulnerability using the following equation:

$$\text{Normalised value (N)} = \frac{\text{Maximum Value} - \text{Actual value}}{\text{Maximum value} - \text{Minimum value}} \qquad (2)$$

Identifying drivers of vulnerability: By calculating the sum of normalized scores multiplied with weights of indicator, an index value for all the indicators have been derived. This can be used to identify drivers of vulnerability.

RESULTS AND DISCUSSION

Vulnerability indexing: The analysis was performed using the indicators for determining the vulnerability indices across the districts of Kashmir Valley were executed. Out of the eight selected indicators, five were used to access the adaptive capacity, and three indicators were used to determine sensitivity. Results of vulnerability assessments across

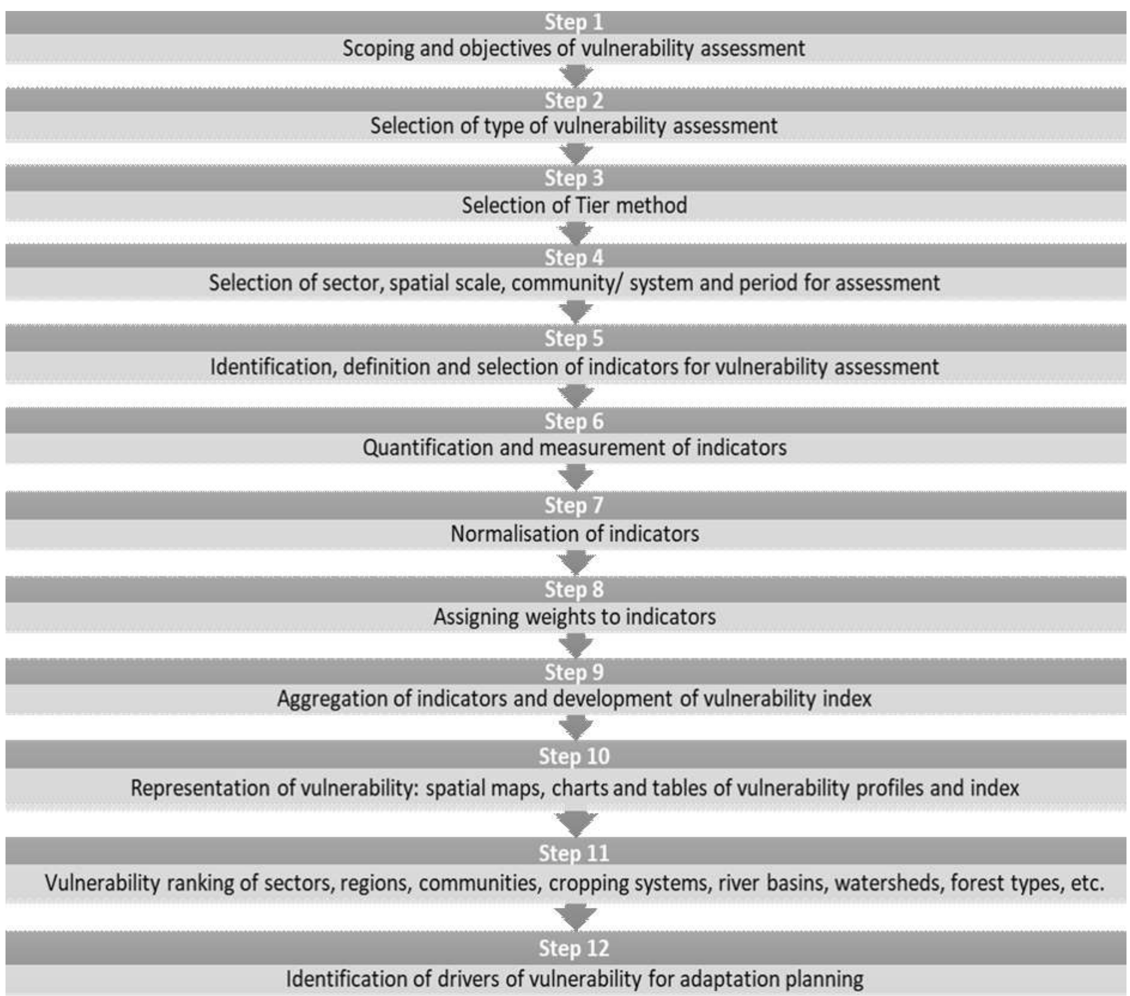

Fig. 2. Approach and methodology adopted to assess the vulnerability of districts in Kashmir valley

districts in Kashmir Valley are spatially represented in Figure 4 below. Figure 5 represents the districts with vulnerability ranking from low to medium to high vulnerability.

Based on this assessment, the vulnerability index ranged from 0.58 to 0.36. Four districts were the highest vulnerability index, viz Budgam (0.58) and Bandipura (0.57), followed by Baramulla (0.54), Ganderbal (0.51). The following four districts were moderately vulnerable; Kulgam (0.49), Kupwara (0.48), Anantnag (0.47), and Pulwama (0.44). Srinagar and Shopian were the least vulnerable

Table 1. List of Tier 1 Vulnerability Assessment Indicators for districts, selection rationale, vulnerability functionality and data sources

Indicators	Rationale for selection	Adaptive capacity or sensitivity	Functional relationship with vulnerability	Source of data
Per cent area under slope 30 degree	More than 30 % of the valley falls under the vulnerable category, young mountains prone to landslides. Steep paths are more vulnerable to soil erosion, impacting the harvest.	Sensitivity	Positive	CARTO DEM 10m NRSC
Per cent area under forest cover	Forest serves as an essential buffer for watershed management hence agriculture sustainability, soil and slope stability, and livelihood. The development of alternative livelihoods through the extraction of forest fodder, fuelwood, and NTFPs improves efficiency. Approximately 10e15 ha of forest land is needed for every hectare of cultivated land to maintain agriculture stability. Therefore, locations with higher forest availability per unit of agriculture area would have better agriculture yields	Adaptive capacity	Negative	Forest Survey of India 2017
Yield variability of foodgrains	High yield variation indicates transitions in agro-climatic conditions over time. For the States within the IHR, the agricultural sector contributes significantly to national domestic products and employment. The loss of adaptive capability represents high yield volatility. The availability of alternate livelihood opportunities improves adaptive capability through timber logging, fuelwood, and NTFPs. In J & K, the Yield variability of food grains has significantly decreased for ten years. Agriculture production is higher on irrigated lands. Higher agriculture productivity further enhances the livelihoods of the agricultural communities.	Adaptive Capacity	Positive	https://data.gov.in 1997-2015
Population density	Pressure on available natural resources The number of people dependent on per unit agriculture area indicates the severity of demographic pressure on limited agriculture land.	Sensitivity	Positive	Census of India, 2011
Female literacy rate	Determines the extent of access to knowledge and information, enabling proactive adaptation to climate variability, as well as a gateway for non-climate sensitive skills and employment for transformational adaptation. Literacy is considered to be an essential factor in determining access to information. Moreover, literacy reduces poverty and provides a more extensive social benefit. The skills required to organize and manage natural resources in the mountains is enhanced through higher literacy, along with the higher capacity for adaptive learning	Adaptive Capacity	Negative	Census of India, 2011
Infant mortality rate	The infant mortality rate is an indicator of the overall state of public health, access to improved water, sanitation, and medical infrastructure.	Sensitivity	Positive	Digest of Statistics, J&K 2014
Per capita income	An overall indicator of the standard of living in J & K GDP dependent on Horticulture and Tourism both are being impacted by climate change, and being a conflict region income from tourism has shown a significant decrease. High income and expenditure, a measure of wealth, provides better access to markets, technology, and other agriculture inputs, increasing the capacity of agricultural communities to cope with any stress.	Adaptive capacity	Negative	Digest of Statistics, J&K 2014
Average man-days under MGNREGA	Under MGNREGA, a non-climatically volatile wage job ensures the protection and adaptability of the households. However, in J&K, limited working season (snowfall), i.e., Nov-March, restricts the average number of man-days.	Adaptive capacity	Negative	www.nrega.nic.in 2008 – 2016

Table 2. Indicator values and normalized scores for the indicator

District	Per cent age of total forest		Per cent age of area > 30% slope		Per capita income		Population density		Female literacy rate		Infant mortality rate		Yield Variability		MGNREGA	
	AV	NV	AV	NV	AV	NV	AV	NV	AV	NV	AV	NV	AV	NV	AV	NV
Anantnag	35.17	0.426	31.66%	0.61	15901	0.49	302	0.26	47.81	0.40	38	0.63	39%	0.59	36	0.59
Kulgam	35.17	0.426	13.04%	0.25	15901	0.49	1035	0.90	51.51	0.31	40	0.68	64%	1.00	34	0.68
Pulwama	34.12	0.444	15.42%	0.29	18027	0.27	516	0.45	48.20	0.39	34	0.53	42%	0.65	27	1.00
Shopian	34.12	0.444	1.38%	0.02	18027	0.27	853	0.74	49.10	0.37	41	0.71	42%	0.65	46	0.14
Srinagar	28.14	0.542	21.17%	0.40	20666	0.00	625	0.54	38.15	0.63	20	0.16	34%	0.51	42	0.32
Ganderbal	28.14	0.542	41.40%	0.80	20666	0.00	1148	1.00	54.29	0.24	39	0.66	53%	0.82	32	0.77
Budgam	18.31	0.703	4.32%	0.08	14921	0.59	554	0.48	55.15	0.22	38	0.63	38%	0.58	32	0.77
Baramulla	24.48	0.602	23.36%	0.45	16196	0.46	238	0.21	47.62	0.41	30	0.42	36%	0.55	30	0.86
Bandipura	24.48	0.602	37.20%	0.71	16196	0.46	1137	0.99	55.66	0.21	52	1.00	47%	0.72	46	0.14
Kupwara	48.34	0.210	33.93%	0.65	11148	0.98	366	0.32	49.05	0.37	38	0.63	39%	0.60	37	0.55

* AV = actual value and NV = normalized value

Table 3. Weights assigned to indicators and the weights to be multiplied with normalized scores

Indicators	Weights (WI)	Multiply weights of uniform values (WI*Wi)
Forest	0.24	0.458×0.24=0.110
Per capita income	0.20	0.484×0.20=0.097
Per cent area under slope >30 degree	0.15	0.469×0.15=0.070
Yield variability of food grain	0.12	0.480×0.12=0.058
MGNREGA	0.10	0.523×0.10=0.052
Population density	0.08	0.369×0.08=0.030
Female literacy rate	0.06	0.438×0.06=0.026
Infant mortality rate	0.05	0.446×0.05=0.022
Total	1.00	0.465

Table 4. Vulnerability indexing and ranking of districts

District	Vulnerability Index	Ranking
Budgam	0.58	1
Bandipura	0.57	2
Baramulla	0.54	3
Ganderbal	0.51	4
Kulgam	0.49	5
Kupwara	0.48	6
Anantnag	0.47	7
Pulwama	0.44	8
Srinagar	0.39	9
Shopian	0.36	10

districts. A composite vulnerability index value was also derived by taking a simple sum of all eight indicators. Centered on composite index values for susceptibility, the districts have been ranked from highest vulnerability to lowest vulnerability (Table 4). A vulnerability ranking and index maps, as shown in Figure 3 and figure respectively, were also prepared in the GIS environment, which help in easily visualizing the most vulnerable districts for effective decision-making. Nonetheless, the fact that vulnerabilities are relatively resilient means that this assessment does not reflect Shopian, Srinagar, and Anantnag as being in a very low sensitiveness in absolute terms is also essential to remember that these regions are vulnerable to climate threats.

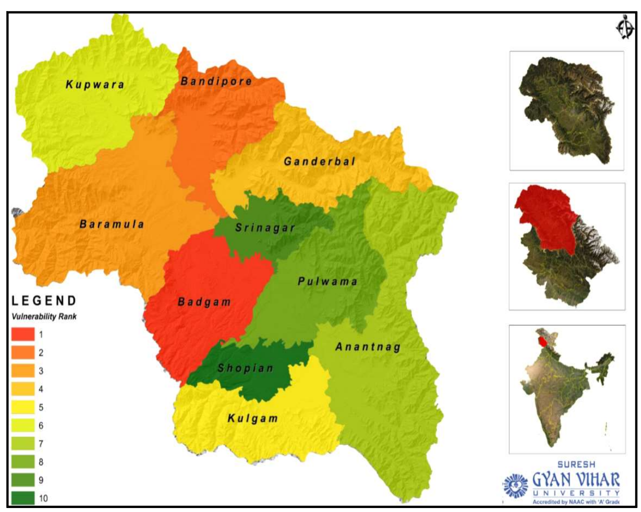

Fig. 3. Map showing Kashmir districts ranked based on vulnerability assessment

Table 5. Drivers of vulnerability (Districts Wise) in Kashmir Valley

District	Drivers of vulnerability
Bandipura	IMR, high population density, maximum yield volatility, and a larger pitch area (slope >30% indicators) are the factors behind this district's susceptibility.
Ganderbal	The Ganderbal displays many drivers of insecurity. These include the highest population density, high yield volatility, higher slope, and the lowest presence of MGNREGA in the order of importance.
Kulgam	The district is extremely vulnerable with growing population densities and inadequate healthcare in the agriculture sector. The district has four primary risk factors- the highest IMR rates, lowest population densities, and weak MGNREGA enrolment.
Kupwara	Among other districts in the region, it has the lowest per capita revenue. The district has three main burdens – more regions in the slope > 30%, high IMR; more considerable yield variation.
Budgam	This district is vulnerable due to a lack of activity in the MGNREGA region and the lower forest.
Baramulla	This district's weakness is also attributed to a lack of MGNREGA participation, reduced forest area, and higher volatility in production.
Anantnag	For the Anantnag District of J&K, many factors of insecurity are evident. Less IMR, higher slope area under >30 percent category, higher yield volatility, decreased attendance of MNGREGA, and less Per-capita income are among these.
Pulwama	Almost at the heart of the list lies Pulwama. As compared with other districts, this district has the lowest enrolment in MGNREGA. With higher per capita production and lower slopes and healthy forests enhances the adaptability comparatively.
Srinagar	Higher population density, high yield variability and reduced forest cover are the three primary reasons that are vulnerable to Srinagar. Nevertheless, the district has the lowest per capita revenue, and its competitive potential is improving.
Shopian	While Shopian's population density, high child mortality, and higher yield rates are high, the Shopian 's area is > 30 degrees lowest, and MGNREGA 's share is higher compared to other districts.

Drivers of vulnerability: Identifying the drivers of vulnerability is crucial for adaptation planning. It enables the authority to chalk out efficient and effective plans to reduce vulnerability. The major drivers of vulnerability in all the districts are presented in Table 5. Figure 5 clearly shows that lack of forest area accounts for 24% of the impact for making the districts vulnerable, followed by low per capita income (16%), yield variability (16%) area having >30% slope (13%), and MGNREGA (11%). This implies that vulnerability assessments can easily help the local governments to find out the indicators where they should focus on channelizing the funding resources to improve these sectors and bring down the vulnerability levels of the area.

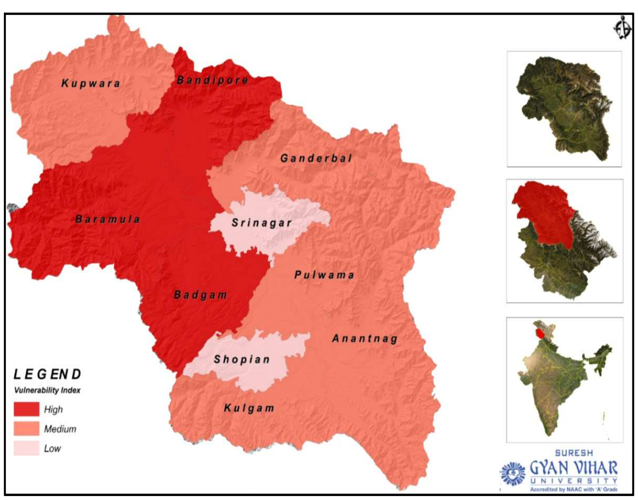

Fig. 4. Distribution of Kashmir districts on a vulnerability scale of low, medium, and high vulnerability

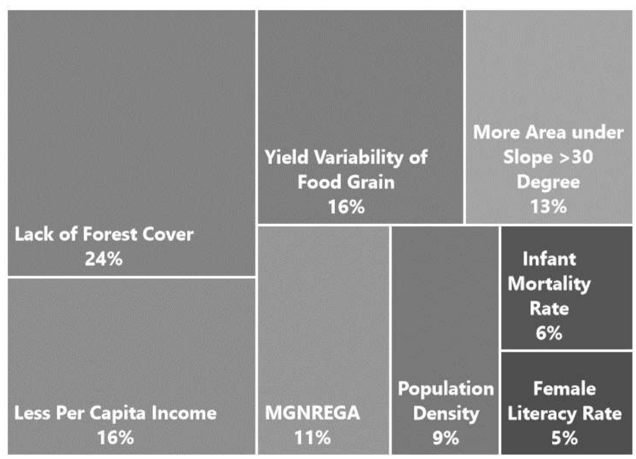

Fig. 5. Per cent share of major drivers of vulnerability in Kashmir Valley

CONCLUSIONS

The study identifies the vulnerability among agriculture communities varies with the common inherent properties of the system. The study focused on the identification of districts having the most venerable characteristics by evaluating their inherent properties. The study also brings out the factors which act as drivers of vulnerability. Increasing the forest cover, providing alternative sources of livelihood, and increasing the per capita income with high-yielding varieties can help in reducing the vulnerabilities of the agricultural communities. The study demonstrates the effectiveness of the methodology for prioritizing the adaptation actions, especially by the policymakers. The study also opens the doors for experimenting with the multiple indicators and weighing them on different parameters for different eco-regions, preferably at Village/Block Level. Besides, the use of statistical techniques like Variable Reduction (PCA/Factor Analysis/Cluster Analysis) can be explored.

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Response of Annual Ryegrass (*Lolium multiflorum* Lam) to Sowing Dates and Nitrogen Fertilization

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Abstract: The effect of planting time and nitrogen fertilization on growth and development, forage yield and economics of annual ryegrass was observed during *Rabi* 2015-16 and 2016-17. Significantly higher plant height, tillers per square metre and dry matter accumulation of annual ryegrass was observed under 2nd fortnight of October sown crop. The application of 160 kg N ha^{-1} resulted in significantly better plant height, tillers per meter square and dry matter accumulation of annual ryegrass. Annual ryegrass produced significantly highest total green, dry forage yields *vis-a-vis* net returns (Rs. 98937.30 ha^{-1}) and BC ratio of 2.97 were obtained under sowing time of 2nd fortnight of October. Application of nitrogen (160 kg N ha^{-1}) resulted in significantly highest total green and dry forage yields, net returns and BC ratio.

Keywords: Ryegrass (annual), Forage yields, Net returns, BC ratio

The success of livestock industry depends on feeding the animals with sufficient quantity of nutritious forage and feed to meet out their requirements for maintenance, growth and production. Annual ryegrass (*Lolium multiflorum* Lam.) is one such cool season fodder crop which is grouped under forages that prefer high soil moisture conditions and is grown throughout the world because of its valuable characteristics including high, excellent quality forage yields, long season production, rapid germination and adaptation to many climatic conditions and can be grown where a minimum of about 500 mm rainfall occurs during the growing season. High palatability and digestibility make this species highly valued for forage/livestock systems (Simic et al 2012). The sowing time is one of the main factors for achieving higher yields as well as a non-monetary input for deciding growth and development and forage yield of grasses. The physiological processes in plants depend on temperature modifications altered by sowing dates which gives an opportunity to the crop of getting optimum temperature for germination and at subsequent growth stages to maximize the production. Nitrogen is the main nutritional determinant of forage yield in grasses. Annual ryegrass is very responsive to nitrogen fertilizer and adequate nitrogen supply in forage crops helps to improve herbage growth rate, tiller density, height and ultimately total herbage production (Lavres and Monteiro 2003). An adequate supply of nitrogen is associated with vigorous vegetative and more efficient use of available inputs finally leading to higher productivity (Fessehazion et al 2011). Keeping in view the above mentioned facts, the proposed study on the effect of sowing dates and nitrogen fertilization on annual ryegrass was planned and therefore, the proper information on sowing time and optimum use of nitrogen could be of great use in getting higher forage yield of this grass.

MATERIAL AND METHODS

The field experiment was conducted at CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur, Himachal Pradesh during *Rabi* 2015-16 and 2016-17. Soil of the experimental field was silty clay loam in texture, moderately acidic in reaction (pH 5.7), medium in organic carbon content (0.68%), available nitrogen (282.2 kg ha^{-1}), available potassium (260.4 kg ha^{-1}) and high in available phosphorus (32.4 kg ha^{-1}). Fifteen treatment combinations having three sowing times *viz*. 2nd fortnight of October, 1st fortnight of November and 2nd fortnight of November and five levels of nitrogen *viz*. control, 40, 80, 120 and 160 kg N ha^{-1} replicated thrice in a factorial randomized block design. Annual ryegrass (variety: *Makkhan grass*) was sown by hand drilling in the rows 30 cm apart using 15 kg seed rate ha^{-1}. The entire quantity of phosphorus (60 kg ha^{-1}) and potash (30 kg ha^{-1}) fertilizers and half dose of nitrogen fertilizer as per treatment were applied at the time of sowing as basal dose. Nitrogen, phosphorous and potassium were applied through urea (46% N), single super phosphate (16% P_2O_5) and muriate of potash (60% K_2O), respectively. Remaining nitrogen dose was applied by top dressing after each cut. The harvested green forage was weighed and cut wise data of both the seasons were pooled, subjected to analysis. The height of five randomly selected plants in each plot was measured in centimetres from the base of the plant to the tip of leaf at each cutting. The mean value of five plants obtained was expressed as mean plant height (cm) in each treatment.

RESULTS AND DISCUSSION

Plant height: Sowing of crop in the 2nd fortnight of October had tallest plants followed by the crop sown in the 1st fortnight of November and shortest plants were observed in the crop sown in 2nd fortnight of November at each cut (Table 1). Likewise, mean plant height also followed the same trend *i.e.* significantly tallest plants (60.4cm) in first date of sowing followed by 2nd date of sowing (50.9cm) and shortest plants (45.2cm) under last date of sowing. The consistent decrease in plant height with delay in sowing may be attributed to delayed germination, poor growth and successive poor regeneration due to comparatively lower temperature on late sowing (Ukai et al 2016). Early sown crop may have enjoyed the ideal environmental conditions especially the temperature and solar radiation which resulted to taller plants (Khurram et al 2002). Plant height at each cut was significantly influenced by the application of nitrogen. At each cut, plant height increased significantly in each successive level of nitrogen (N) from 0 to 160 kg N ha^{-1} and significantly higher plant height was observed with 160 kg N ha^{-1}in all the cuts. Nitrogen being an important constituent of chlorophyll is associated with higher photosynthetic activity and protein synthesis, which promotes cell division and elongation that, in turn, accelerates vegetative growth of the plant (Singh et al 2002). Every increment in nitrogen dose had increased the nitrogen availability in the root zone of the plant, which ultimately might have improved the height of the crop.

Tillers per metre square: Second fortnight of October sown annual ryegrass had significantly higher number of tillers per metre square followed by 1st fortnight of November and 2nd fortnight of November sown crop, however, 2nd fortnight of October was statistically at par with 1st fortnight of November at first, second and third cut (Table 1). The decrease in number of tillers per metre row length with delayed sowing may be due to slow germination, poor growth and environmental stresses particularly low temperature and shorter day length. Similar results were also observed by Pin et al (2011).Application of 160 kg N ha^{-1} resulted in higher number of tillers per metre square over control, 40, 80 and 120 kg N ha^{-1}, but was statistically at par with application of 120 kg N ha^{-1} at cut I, II and III. Nitrogen is the most beneficial element known to increase photosynthetic activity, protein synthesis, cell elongation, cell division and accelerated vegetative growth (Singh et al 2002), which might have favoured the better tiller development of annual ryegrass in the present study. These results are also in conformity with the findings of Chaurasia et al (2006).

Dry matter accumulation: There was significant decrease in dry matter accumulation with the delay in sowing time (Table 1). At all the cuts, dry matter accumulation was significantly highest when annual ryegrass was sown during 2nd fortnight of October followed by 1st fortnight of November sown crop and lowest in the crop sown during 2nd fortnight of November. Similarly, the total dry matter accumulation (sum total of all the cuts) was significantly higher (1104.4 g m^{-2}) in crop sown during 1st fortnight of October followed by in crop sown during the 1st fortnight of November (679.7 g m^{-2}) and lowest (597.4 g m^{-2}) in the crop sown during 2nd fortnight of November. Higher tillers per metre square leading to higher plant population per unit area and taller plants might have led to more light interception resulting in higher photosynthetic activity added to its dry matter value under timely sowing condition. These results are in consonance with Singh et al (2013). Nitrogen application had significant effect on dry matter accumulation at each cut as well as total basis (Table 1). The dry matter accumulation increased with the increase in the doses of nitrogen from no nitrogen to 160 kg N ha^{-1}. However, dry matter accumulation with 160 kg N ha^{-1}and 120 kg Nha^{-1}remained statistically at par under first and third cut. The increase in dry matter accumulation with increased nitrogen application may be attributed to increased plant height and plant vigour. Singh et al (2013) also observed that dry matter accumulation increased significantly with successive level of nitrogen up to 93.75 kg N ha^{-1}. Higher dry matter accumulation with increased nitrogen supply might be due to higher tiller count, plant height, LAI as a result of better plant nutrition. Similar results were also reported by Singh and Singh (2005).

Green and dry forage yields: The total green and dry forage yields (q ha^{-1}) of annual ryegrass were significantly influenced by sowing time and nitrogen levels (Table 2). The forage yields (green and dry) were significantly higher in 2ndfortnight of October sown crop compared to1st fortnight of November and 2nd fortnight of November sown crop. The significant increase in total green forage yield to 59.85 and 87.27 per cent was observed under 2nd fortnight of October sown ryegrass over1st fortnight of November and 2nd fortnight of November sown crop, respectively. Annual ryegrass sown during 2nd fortnight of October produced about 62.11 and 84.65per cent more dry forage yield, respectively than crop sown during 1st fortnight of November and 2nd fortnight of November, respectively. The lower forage yields from late sowing might be related to poor establishment, leading to lower plant densities. Therefore, higher forage yields may be due to their superiority over other dates in respect of various growth attributes such as plant height, tillers per metre square and dry matter accumulation. The total green and dry forage yields of annual ryegrass increased consistently and significantly with increasing levels of nitrogen upto 160 kg N ha^{-1}. Application of 160 kg N ha^{-1} produced 105.72 per cent higher total green forage yield over control. Similarly, application of 160 kg N ha^{-1} recorded significantly higher total dry forage yield with increase of 101.49 per cent over no nitrogen application *i.e.* control. These results are in conformity with the findings of Sharma and Verma (2005), Sheoran and Rana (2006), Soheir El-Sherbenyetal (2012) and Ullah et al (2015). They reported that higher forage yields in plants receiving higher nitrogen may be attributed to the most lucrative consumption of applied nitrogen and other allied environmental resources which resulted in maximum biomass yield and dry matter partitioning.

Economics of production: The effect of different treatments on economic parameters *viz.* gross returns, net returns and benefit cost ratio was significant and the data have been presented in Table 2.The data indicated that significantly highest gross returns (Rs. 131817 ha^{-1}), net returns (Rs. 98937 ha^{-1}) and benefit cost ratio (2.97) were accrued when crop was sown during 2nd fortnight of October compared to its sowing on two later dates. Crop sown under 2nd fortnight of October gave Rs. 49,597 $ha^{-1}$and Rs. 61,704 ha^{-1} more net returns over 1st and 2nd fortnight of November sown crop. The better economics of this treatment could be ascribed to higher forage yield obtained in this treatment. The data further indicated that gross and net returns increased significantly and consistently with increasing graded doses of nitrogen from no nitrogen to 160 kg Nha^{-1}. Application of 160 kg N ha^{-1} resulted in significantly higher gross returns of Rs.118733 ha^{-1}, net returns of Rs.83085 $ha^{-1}$and benefit cost ratio (2.42) followed by 120, 80 and 40 kg N $ha^{-1}$and lowest when no nitrogen was applied *i.e.* control, however, the effect of 120 and 160 kg N ha^{-1} was same in terms of benefit cost ratio. The effect of treatments on economic returns was in accordance with the forage yield of annual ryegrass obtained in respective treatments. The cost of production in all sowing time was similar; however, higher herbage yield made it more profitable. Although the cost of cultivation increased with increasing levels of nitrogen but proportionally better yield improvement make nitrogen application profitable. At higher doses (160 kg N ha^{-1}), the cost of cultivation increased but increase in forage yield was not that much to compensate the

Table 2. Effect of sowing time and nitrogen levels on gross returns (Rs. ha^{-1}), net returns (Rs.ha^{-1}) and benefit cost ratio (Pooled data of two seasons)

Treatment	Gross returns	Net returns	B:C ratio
Sowing time			
2nd fortnight of October	131817	98937	2.97
1st fortnight of November	82220	54489	1.94
2nd fortnight of November	70113	41373	1.41
CD (p=0.05)	1550	1550	0.06
Nitrogen levels (kg ha^{-1})			
No nitrogen	57829	35022.34	1.51
40	84338	57257.14	2.07
80	99858	69618.83	2.25
120	112679	79535.01	2.35
160	118881	83233.19	2.36
CD (p=0.05)	2002	2002	0.08

Table 1. Effect of sowing dates and nitrogen levels on yield attributes and forage yield of annual ryegrass (Pooled data of two seasons)

Treatments	Plant height (cm)	Tillers per m^2	Dry matter accumulation (g/m^2)	Green forage yield (q ha^{-1})	Dry forage yield (q ha^{-1})
Sowing dates					
2nd fortnight of October	60.37	331	1104.45	529.12	111.05
1st fortnight of November	50.88	315	679.75	330.99	68.50
2nd fortnight of November	45.25	300	597.39	282.54	60.14
CD (p=0.05)	1.22	9	18.46	6.16	0.29
Nitrogen levels (kg ha^{-1})					
No nitrogen	26.18	273	490.08	232.49	49.60
40	47.02	295	707.89	339.77	71.32
80	54.61	315	834.39	401.77	83.85
120	62.83	340	943.11	452.12	94.73
160	70.19	353	993.85	478.27	99.99
CD (p=0.05)	1.58	11	23.83	7.95	2.41

increased cost of cultivation; hence, the benefit cost ratio obtained in the treatment was at par with 120 kg N ha^{-1}.

CONCLUSION

Second fortnight of October was adjudged as the best time of sowing for annual ryegrass under mid hill conditions of Himachal Pradesh. Further delay in sowing reduced the yield attributes as well as green and dry forage yields. Application of 160 kg N ha^{-1} to annual rye grass recorded significantly higher forage yields as well as better net returns. However, application of 120 kg N ha^{-1} is considered profitable in terms of benefit cost ratio.

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Analysis of Air Temperature, Relative Humidity and Evaporation over Iraq Using ECMWF Reanalysis

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Abstract: The study was for an examination conducted to analyze air temperature and relative humidity as well as evaporation in selected areas of Iraq. One of the most important ways in which this system can be described and with the development of climatology and its availability by centers and periods that encourage us to conduct a climate study where the European Center data for the time research period (1979-2016). Two different observations, day and night, were used to find the difference in temperature, humidity and evaporation at this time through a comparison between the months of the year, as Man Kendall's results showed that there is an inverse relationship between temperatures and relative. Humidity, in contrast to the relationship between temperature and evaporation, was positive and this is what is observed in all months of the year depending on the nature of the geographical area.

Keywords**:** Air Temperature, Relative Humidity, Evaporation, ECMWF, Iraq

Climate change demonstrates the most pressing issues facing society due to its impact on meteorological. Rising temperatures can directly affect rainfall patterns by increasing the atmospheric moisture holding capacity leading to increased rainfall extremes. Hence, understanding the relationship between temperature and extreme rainfall is a key towards understanding the impacts of climate change on rainfall (Andrew et al 2019). The western wind is moist and the eastern wind dry, thus the change in daily evaporation rate was studied considering the change in relative humidity when other climatic element was stable. Relative humidity is influenced by wind direction blowing on the study. Evaporation has impact on water resources, but it also decreases water available for agricultural region (Nasser, et al. 2018). The most weather elements affecting evapotranspiration are air temperature, humidity, radiation, and wind speed. The reference evapotranspiration is the rate of evapotranspiration from a reference surface, as the water is abundant. (Ali et al 2017). The major subject in hydrology and water balance techniques are the solution of significant theoretical and practical problems. The quantitative evaluation of water resources with their changes can be possibly made relying on the water balance method. In the hydrological cycle, the understanding of water balance is important where the relationship between rainfalls and total loss of water in various forms (Moutaz et al 2017).

Osama et al (2017) analyzed the behavior of monthly and annual temperature data for selected stations from Iraq and observed the relationship between the temperature with period of study from 1982 to 2012 and concluded that that the lowest annual average of temperature was in 1992 and the highest annual average of temperature in 2010 and for all stations. The total annual rainfall was (119.65 mm), while the total annual evaporation was 3201.7 mm, relative humidity is (43.62%), sunshine (8.76 h/day), temperature (23.28 C◦) and wind speed (3.06 m/sec) in Baghdad (Moutaz et al 2017). Ramiz et al (2018) investigated at 24 meteorological stations in Iraq for 30 years. January in winter, July in summer and annual rates of climate indices were analyzed through a factor analysis method. As a result, total rainfall, minimum, maximum and average temperature were found as the strongest indices of the two seasons in Iraq. (Yassen et al 2018) analyzed for temporal trends and spatial variation during 1980-2015. The results of the time analysis showed that during winter, spring, summer and autumn there is a positive trend across Iraq. There was also a trend towards warmer years, with warmer summer and spring seasons and slight warmth in autumn and winter, and the highest increase was (3.5) degrees Celsius in Basra during the summer at 23 stations in Iraq. This research aims to analyze temperature and relative humidity data and find a trend through temporal analysis of selected regions over Iraq.

MATERIAL AND METHODS

The work was carried out using monthly data for air temperature, relative humidity and evaporation, taken from the European Center for Medium-Range Weather Forecast (ECMWF). These data have been converted into annual averages to show the difference in day and night. Data were processed by Mat-lab and drawn by Origin and Surfer 10.

The map of Iraq was drawn using GIS software as shown in Figure 1. Baghdad station was selected at 15z and 03z pm.

Statistical analysis: The data of the European Center, , was used in addition to the agreement of four additional European countries, all of which operate within the World Meteorological Organization. The European Center is known throughout the world for providing accurate, medium-term global weather forecasts for 15 days and seasonal forecasts for 12 months. European national weather service's is as an integral component of short-term and climate activities. Especially giving early warning of can reduce the possible damage in severe weather conditions can be avoided (Person, et al 2005). The data used were the annual and monthly averages of air temperature, relative humidity and evaporation of air temperature, relative humidity and evaporation. The data was by analyzing by using the Man Kendall test. This test has been used in the field of hydrology and climate to test randomness with the direction of the time series, which is a procedure based on ranks, which is strong in influencing extremism and a good test for deviation data and can be expressed in relation (Kendall tau-b correlation):

$$\tau = \frac{\Sigma 1<j \,(\mathrm{Sgn}\,(X_0-X_J)\ \mathrm{Sg}\,(y_i-y_j))}{(T_0-T_1)\,(T_0-T_2)} \quad (1)$$

Where it represents:

$$T_0 = n(n-1)/2 \quad (2)$$

$$T1 = \frac{\Sigma_K\, tk\,(tk-1)}{2} \quad (3)$$

$$T2 = \frac{\Sigma_t\, U\text{-}1\,(U1-1)}{2} \quad (4)$$

RESULTS AND DISCUSSION

The monthly average for the period 1979-2016 (temperature, relative humidity and evaporation) was calculated using the Mann-Kendall direction test for the time series.

Temperature values: There was a significant increase in observation 03 for most of the year except for (January, September, November, and December as compared to Observation 15, The decrease was noticeable in most months of the year except for February, March, September (Table 1).

Relative humidity values: There was significant decrease in the Observation 03z in most months except for March, September as compared to Observation 15Z. The decline was evident in most months of the year except for September (Table 2).

Evaporation values: The increase was observed the Observation 03z for all months except for March, as compared with Observation 15Z where the increase was

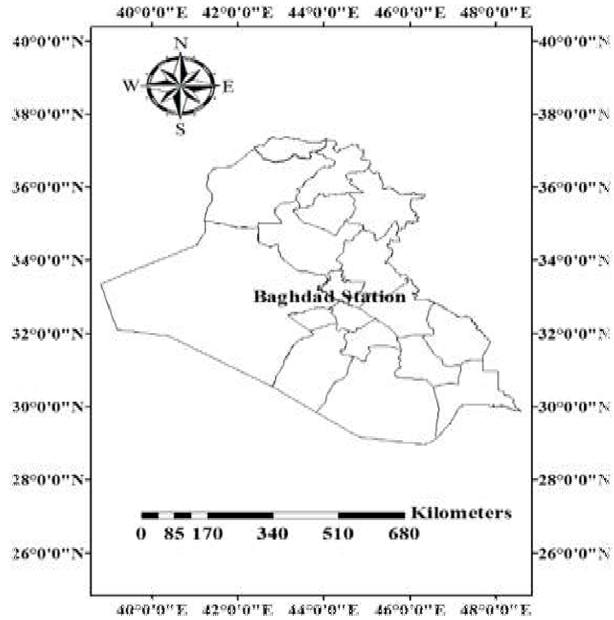

Fig. 1. Baghdad city in Iraq

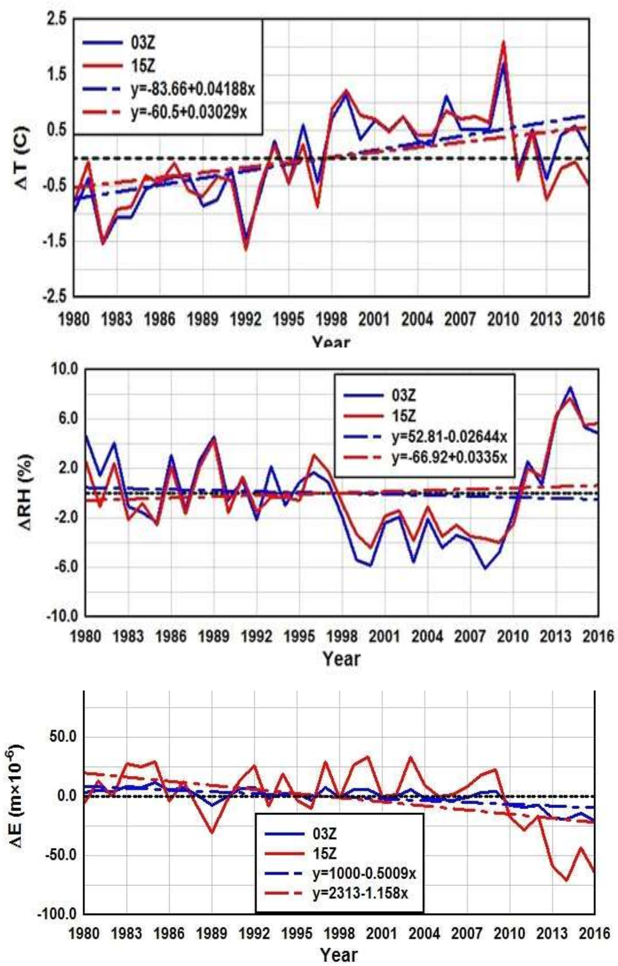

Fig. 2. Anomalies of yearly temperature, relative humidity, and evaporation at 03Z and 15Z for Baghdad (1979 to 2016)

Table 1. Mann Kendall trend test for monthly temperature time series for the period of 1979-2012

Month	03Z				15Z			
	S	Z	p	Trend	S	Z	p	Trend
January	100	1.1971	0.23104	No	102	1.2219	0.22176	No
February	258	3.1091	0.001876	Increasing	236	2.843	0.0044690	Increasing
March	302	3.6414	0.00027113	Increasing	238	2.8672	0.0041416	Increasing
April	210	2.5284	0.011457	Increasing	151	1.8148	0.069555	No
May	190	2.2865	0.022226	Increasing	60	0.71377	0.47537	No
June	264	3.1817	0.0014641	Increasing	124	1.488	0.13674	No
July	194	2.3349	0.01955	Increasing	14	0.15727	0.87503	N0
August	184	2.2139	0.026838	Increasing	177	2.1294	0.033224	Increasing
September	112	1.3429	1.3429	No	-90	1.0767	0.28161	No
October	176	2.1171	0.034251	increasing	87	1.0405	0.29812	No
November	-76	0.90733	0.36423	No	-66	0.78635	0.43166	No
December	56	0.66538	0.50581	No	58	0.7835	0.49046	No

Table 2. Mann Kendall trend test for monthly rel. humidity time series for the period of 1979-2016

Month	03Z				15Z			
	S	Z	p	Trend	S	Z	p	Trend
January	-102	1.2701	0.20406	No	-31	0.3773	0.70595	No
February	-125	1.5589	0.11902	No	-26	0.31432	0.75328	No
March	-204	2.5523	0.010701	Increasing	-137	1.71	0.087257	No
April	-32	0.38982	0.69667	No	9	0.10061	0.91986	No
May	-8	0.088038	0.92985	No	52	0.6421	0.52081	No
June	-21	0.25156	0.80138	No	-64	0.79368	0.42738	No
July	92	1.1445	0.25242	No	99	1.2333	0.21745	No
August	109	1.1445	0.17433	No	57	0.70514	0.48072	N0
September	268	3.358	0.00078501	Increasing	289	3.7353	0.00018747	Increasing
October	57	0.70414	0.48135	No	132	1.6477	0.099423	No
November	48	0.59093	0.55457	No	84	1.0436	0.29669	No
December	-53	0.65384	0.51321	No	21	0.25144	0.80148	No

Table 3. Mann Kendall trend test for monthly Evaporation time series for the period of 1979-2016

Month	03Z				15Z			
	S	Z	p	Trend	S	Z	p	Trend
January		2.1879	0.02868			1.7233	0.084833	No
February		2.5276	0.011486	Increasing		1.3958	0.16277	No
March		1.8734	0.061018	Increasing	138	0.49034	0.62389	Increasing
April		2.5281	0.011469	No	112	0.82957	0.40668	Increasing
May		2.2633	0.023617	Increasing	-40	2.0366	0.041685	Increasing
June	175 202 150 202 181 337 357 366 441 337 221 287	4.2264	2.3747e-05	Increasing Increasing	67	3.6587	0.00025348	Increasing Increasing
July		4.4763	7.5946e-06	Increasing		4.199	2.6808e-05	Increasing
August		4.5901	4.4309e-06	Increasing Increasing	163 292 335 329 397 284 202 112	4.1236	3.7302e-05	Increasing
September		5.5346	3.1202e-08	Increasing		4.9785	6.4087e-07	No
October		4.2248	2.3912e-05	Increasing		3.5581	0.0003735	No
November		2.7663	0.0056704	Increasing		2.5272	0.011499	No
December		3.5961	0.00032298			1.3956	0.16284	

observed in most months of the year except for (December, January, February, March, April.

The changes in the monthly averages of temperature, humidity, and evaporation for Baghdad for 38 years (1979-2016) for observations (03z and 15z) indicate that highest temperature (35°C) was observed in Note 03z and the highest recorded value of monitoring is 15z for observation 47.60. There an increase in temperature in June, July and August) and a minimum temperature was 2.6 ° C in Note 03z. The lowest temperature was 10 ° C in Note 15z and the decrease was evident in December, January, February) There was an increase in temperature from 1996 to 2016, and the hottest year was 2000 (Fig. 1).

In humidity, there is no noticeable increase pattern during the night, but there is some decrease in humidity during the last years of 2012. For evaporation, the behavior contradicts the behavior of humidity. In other words, years when there is little moisture, evaporation is high. The time series of anomalies in temperature, humidity, and evaporation. indicate that the temperature change in the

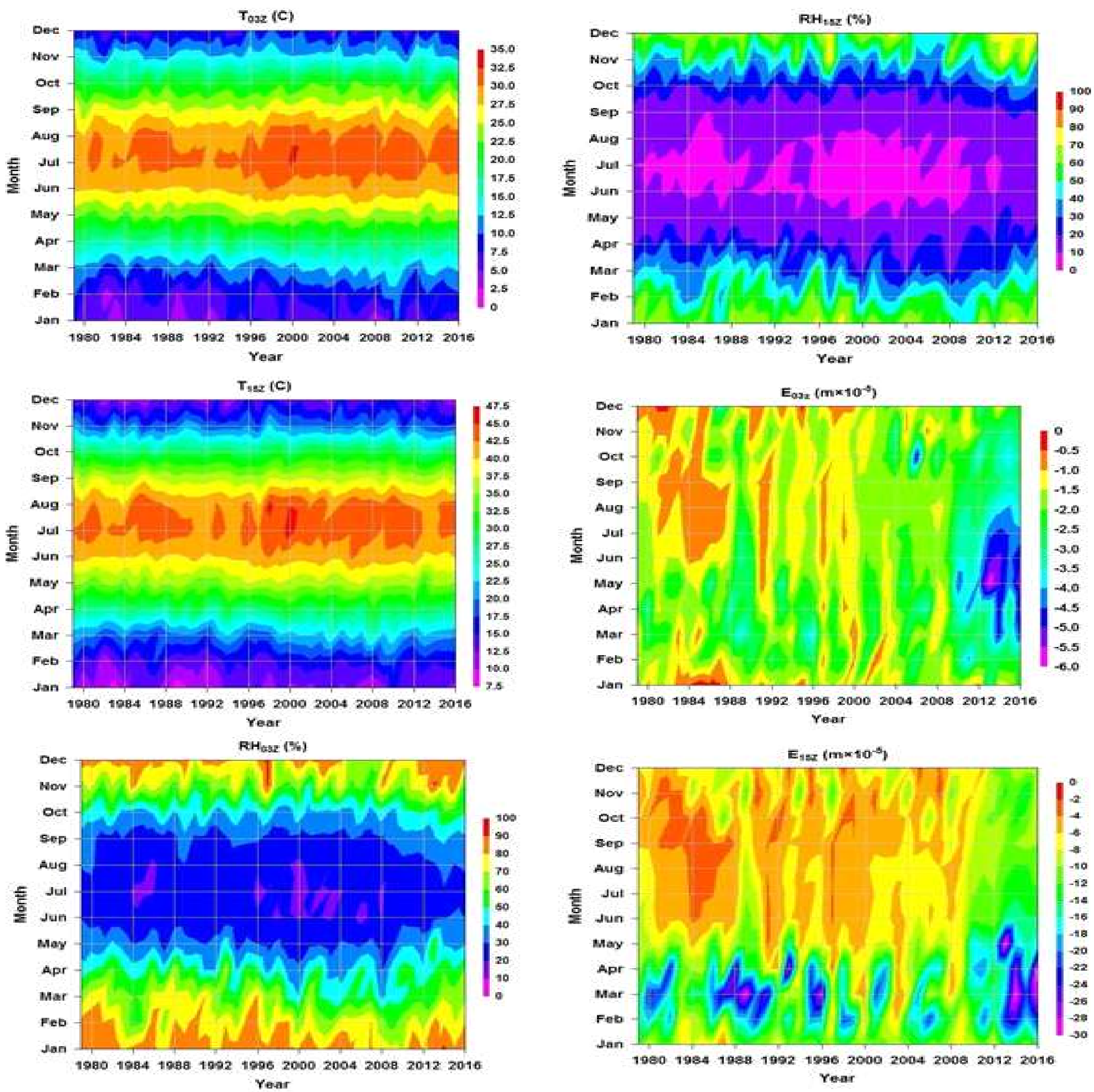

Fig. 1. Variations of monthly means for temperature, relative humidity, and evaporation at 03Z and 15Z for Baghdad during the period of 1979 to 2016

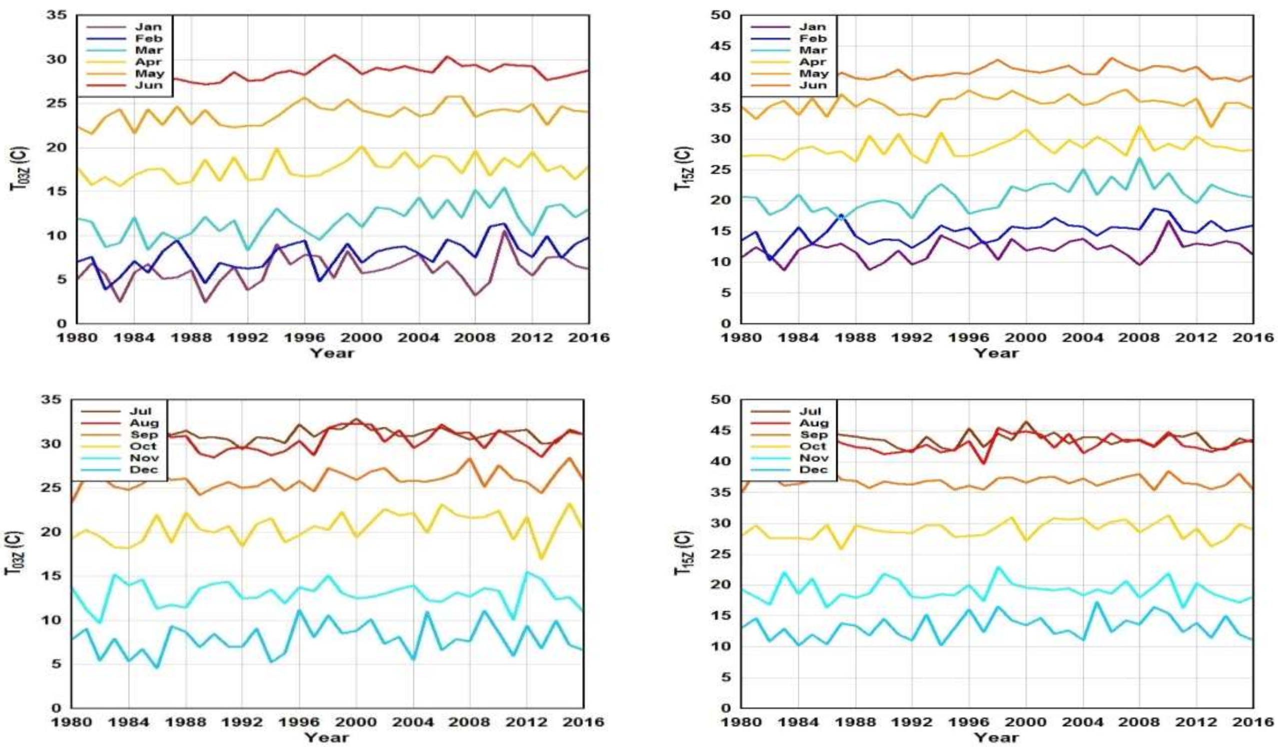

Fig. 3. Time series of monthly temperature, at 03Z and 15Z for Baghdad (1979 to 2016).

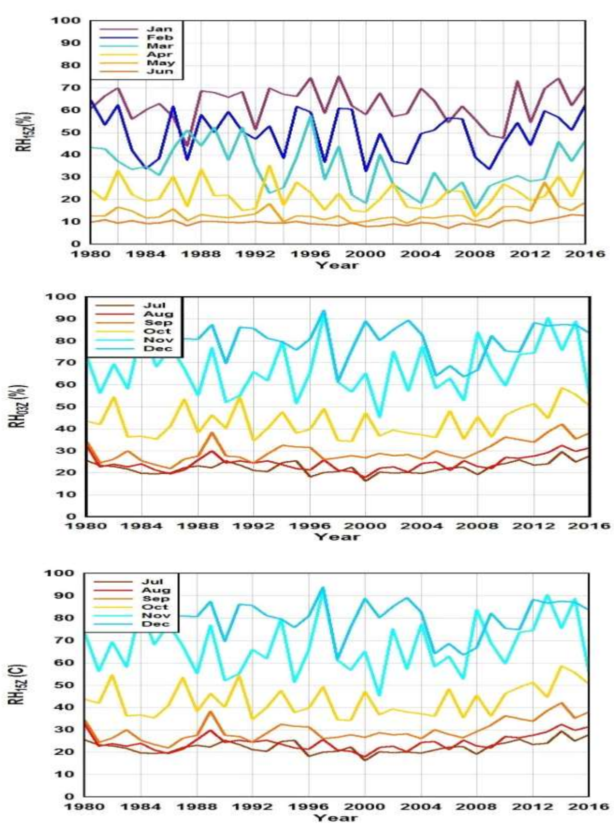

Fig. 4. Time series of monthly relative humidity at 03Z and 15Z for Baghdad (1979 to 2016)

event of a significant increase of 1.7 ° C in observation 03z, but in observation 15z, the increase of 2 ° C in 2010 was accompanied by a decrease in relative humidity (Fig. 2).

The change in relative humidity for 2015 was 8% in observation 03z and 9% in observation 15z. For evaporation, the increase and decrease was observed during the period from 1980 to 2010, but there is a clear decrease in evaporation during the period from 2010 to 2016 accompanying the marked increase in humidity for the same period.

Figure 3: The time series of temperature during two observations (03z and 15z) indicate that during observation (03z), the increase was the largest during July and August (Fig. 3) and the lowest value during January and February. In 5z, the increase in temperature was more during July and August, and the lowest during January and February.

Figure 4: shows the time series of relative humidity during Observations (03z and 15z), where we notice that the increase in relative humidity during observation (03z) is the largest possible percentage during the month (December and January), but the least that can be within months (June and July). Either during observation (15z), the increase in relative humidity during observation (15z) will be the largest during the month of (December and January), while the lowest relative humidity will be during the month of (June and July)Analysis Time series of monthly evaporation at 03Z and

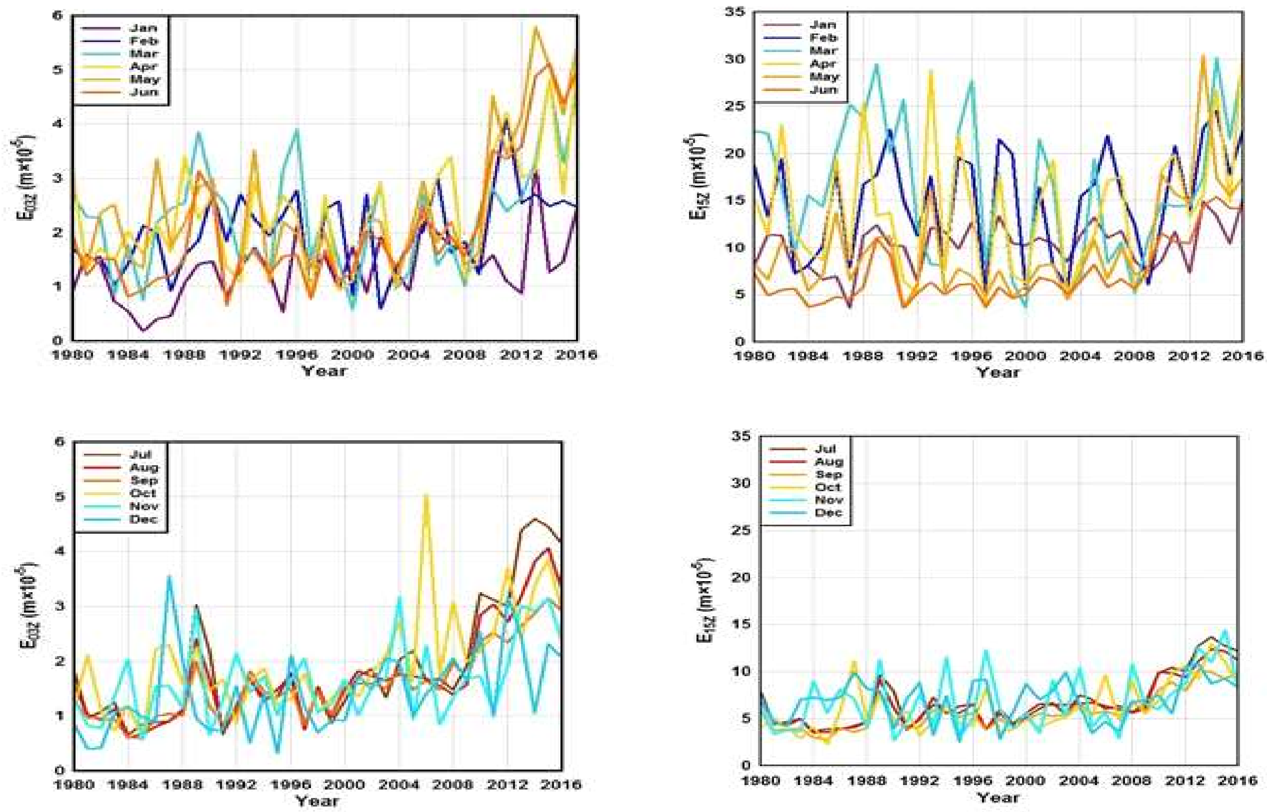

Fig. 5. Time series of monthly evaporation at 03Z and 15Z for Baghdad (1979 to 2016)

15Z

The time series of evaporation during two notes (03z and 15z) indicate that during note (03z) increase in evaporation is the largest possible during the May, June, but the least evaporation was during December and January. As for observation (15z), it appears that the increase in evaporation takes place during March and April. The least amount of evaporation occurs during October and December (Fig. 5).

CONCLUSIONS

In this research the average monthly air temperature, relative humidity, and evaporation values indicate that there was clear increase in temperature in most months of the year at night and less during the day. The night time hypothermia is due to the rapid loss of daytime heat after sunset, the clear skies facilitate heat loss from the surface of the earth and the second factor is the lack of rain. Usually this increase is accompanied by a decrease in the relative humidity of Iraq. As for evaporation, the deficiency is associated with an increase in relative humidity over the same period. The results indicate that the relationship between air temperature and relative humidity is an inverse relationship, while the relationship between air temperature and evaporation is positive.

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Analysis and Interpretation of Rainfall Trend using Mann-Kendall's and Sen's Slope Method

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Abstract: This study aimed at comprehensive framework to investigate the variability and trends in the daily, seasonal and annual precipitation using parametric and non-parametric tests. The daily and seasonal trends of rainfall were analyzed from the IMD data of 1981-2016. The study displays daily, seasonal and annual trend patterns and magnitude of trend slope in precipitation data series for different regions of Andhra Pradesh. The procedures that are adopted to identify the presence of trend are Mann-Kendall and Sen's estimator of slope which are carried out at statistical significance at 95% level of confidence. The month to month precipitation information were utilized to process the yearly and regular time arrangement. The adjustment in extent for a period arrangement is resolved utilizing a nonparametric technique (Sen's estimator) and the factual noteworthiness is breaking down through Mann- Kendall (MK) test.

***Keywords*:** Rainfall variability, Parametric, Non-parametric, Mann- Kendall, Sen's slope

In India due to difference in moisture regions, a large spatial variation is seen from one year to another. In the conditions like arid, humid and per humid a shrinking tendency is seen and spreading tendency in the area under semiarid, dry sub humid and moist sub humid conditions, from 1940. Since the early 1950s, a decreasing trend in winter and monsoon rainfall and an increasing trend in summer post-monsoon is observed. The net effect is a westward shift, more variable and declining rainfall over the country. Out of the total land zone of India, very nearly one-sixth territory with 12% of the populace is dry season which get a yearly precipitation less than or up to 60 cm. The Irrigation Commission (1972) of India recognized 67 regional interstate places of various states which are prone to dry zones which can be considered as a drought. These spread 326 regions situated in 8 states, covering a zone of 49.73 m ha. Along these lines, National Commission on Agriculture perceived more regions which are prone to drought. Progressively, in view of thorough investigations, 74 locales of the nation have been recognized as dry regions.

A period arrangement is characterized as a progression of estimations taken at various occasions (Griffiths 1990, Lavery et al 1992). Time arrangement examination is utilized to discover the example in the given succession of information over some stretch of time (Hirsch et al 1982). During recent decades, analysts have begun utilizing measurable strategies more regularly in hydrological time arrangement investigation (Gajbhiye et al 2016, Kumar et al 2019, Harshavardhan et al 2020). Creating scientific models to make manufactured hydrologic records, gauging hydrologic occasions and recognizing patterns and moves in hydrologic records are different utilizations of the time arrangement. Missing information investigation and augmentation of hydrologic records are other significant applications (Pal and Tabbaa 2009).

Four major suspicions structure the base of hydrologic time arrangement: (I) homogeneity of the arrangement, (ii) non-periodicity with no perseverance, (iii) fixed and (iv) opportunity from patterns or moves. Homogeneity suggests that the information in the arrangement have a place with one populace, and in this way have a period invariant mean (Pattanaik and Rajeevan 2010). Non-homogeneity emerges considering changes in the technique for information assortment and nature in which it is done (Rodrigo et al 2012). A period arrangement is said to be carefully fixed if its measurable properties do not fluctuate with changes of time starting point. In nature, carefully fixed time arrangement does not exist. Periodicities in normal time arrangement are a result of cosmic cycles, for example, earth's pivot around the Sun (Sen 1968). Periodicity impact is not noticeable in yearly time arrangement. Diligence is applicable to hydrologic time arrangement investigation, which is characterized as the inclination for the extent of an occasion to be reliant on the size of past event(s) (Agarwal et al 2019).

A period arrangement is said to have patterns, if there is a noteworthy connection (positive or negative) between the perceptions and time. Patterns and moves in hydrologic time arrangement happen because of common or counterfeit changes. Normal changes in hydrologic factors are generally steady and are brought about by a few reasons. Worldwide or provincial environmental change and urbanization are explanations behind continuous change in hydrologic parameters over the time of study (Roy and Balling 2004). Fake change (step change) in stream example may happen after a significant guideline upstream of the checking site. A watched time arrangement can have three parts: (I) the pattern (long haul heading) (ii) the regular (deliberate schedule related) developments, and (iii) the sporadic (unsystematic present moment) changes. Pattern and regularity are two essential parts of a period arrangement. The previous speaks to a general methodical straight or (frequently) nonlinear segment that changes after some time and does not rehash or possibly does not rehash inside the time run caught by the information. The last may have a comparative nature yet rehashes itself at orderly interims after some time (Subhash and Sikka 2014).

In hydrology, time arrangement investigation is accomplished for accomplishing two significant objectives, to recognize the idea of the hydrologic procedure spoke to by the succession of perceptions, and to figure future estimations of the time arrangement hydrologic variable. For accomplishing these objectives, the example of time arrangement information is to be distinguished and portrayed, which can be deciphered and coordinated with other information. Strategy utilized for time arrangement investigation fall in to two classes: (I) parametric examination, and (ii) non-parametric investigation (Agarwal and Kumar 2019). Parametric and non-parametric are two wide arrangements of factual methodology. Parametric strategies depend on suspicions about the state of the dissemination. On the off chance that the information goes astray firmly from the suspicions of a parametric technique, utilizing the parametric system could prompt mistaken ends (Ahamed and Agarwal 2019).

Non-parametric techniques depend on no or a couple of presumptions about the shape or parameters of the populace conveyance. Even though presumptions about the dispersion of estimations are less in non-parametric tests, they have two principle downsides. (I) They are less factually ground-breaking than the comparative parametric methodology when the information is about ordinary; and (ii) their outcomes are frequently less simple to decipher contrasted with parametric tests (Verma et al 2016). A non-parametric test will require a somewhat bigger example size to have a similar force as the coordinating parametric test. Numerous non-parametric tests use rankings of the qualities in the information instead of utilizing the information. Even though non-parametric systems are helpful by and large and essential in a few, they are not flawless arrangements. Parametric techniques evaluate centrality of pattern by utilizing pre-determined models and related tests. Rank tests are commonly applied in non-parametric techniques (Kumar et al 2020).

The Mann-Kendall test is an ordinarily utilized non-parametric test for pattern identification. It does not consider whether the pattern is direct or nonlinear. Studies show that the viability of the test relies upon the extent of pattern, test size, and the variety inside a period arrangement. Therefore, the greater the outright extent of pattern or bigger the example size, the more impressive are the tests. As the measure of variety in a period arrangement builds, the intensity of the tests diminishes (Zhang 2003). At the 11 point when a pattern is available, the force is likewise reliant on the appropriation type and skewness of the time arrangement. A few investigations on utilization of Mann-Kendall measurements for identifying patterns in hydrologic information are accessible in writing. These examinations show the quality of Mann-Kendall non-parametric pattern test in bringing out patterns in hydrologic information (Agarwal and Kumar 2020). This test is helpful in the investigation of significant stream guidelines, since the supreme greatness of pattern in such cases will be bigger.

MATERIAL AND METHODS

The study area, Andhra Pradesh corresponds to eastern coastal region of India which is the seventh largest state by area (162,975 km^2) and ranks tenth by population (49,386,799). The state is bifurcated into thirteen districts among which nine are in Coastal Andhra while four belongs to Rayalaseema region. The state is widely diverse in Flora and Fauna owing to its varied Topography which lies from Eastern Ghats and Nallamala Hills to Bay of Bengal. Krishna and Godavari are the major rivers which are flowing through the state which provide Irrigation and sustain rich Ecosystem. Some multi-state irrigation projects like Godavari River basin and Nagarjuna Sagar Dam are under development. The economy of the state is enormously dependent on Agriculture and Livestock. The coastal plains are effectively used for intensive agricultural practices. Out of the total population, 60% is mostly involved in Agriculture and related activities throughout the year. Rice is a staple and major food across the state. The whole region is divided into three Agricultural Economic Zones, mainly Chittoor for Vegetables, Krishna for Mangoes and Guntur for Chilies. Besides these crops, Jowar, Bajra, Maize, Millet, Coarse grain, Pulses, Oil seeds, Sugarcane, Cotton, Pepper, Tobacco etc. are also grown by farmers. Livestock and poultry which involves rearing animals in enclosed environment for commercial purposes is also blooming in the region. The geographical condition of the state permits marine and inland fishing in the state. Fisheries contribute 10% of total fish and over 70% of the shrimp production of whole India.

Mann-Kendall test: It is a robust method to analyze trend in time series, which is mainly used to detect monotonic trend. Due to the presence of outliers for extreme rainfall events this test is based on (+ or -) signs, even for random variable it can be used to determine the trends. For detecting the trend in time series, the MK statistic S is given as

$$S = \sum_{i=1}^{n-1} \sum_{j=i+1}^{n} sign\,(x_i - x_j) \qquad (1)$$

Where, 'x_i' and 'x_j' are sequential data for i^{th} and j^{th} terms, 'n' is the sample size and

sign $(x_i - x_j)$ = {+1, if $(x_i - x_j) > 1$} (2a)

sign $(x_i - x_j)$ = {+0, if $(x_i - x_j) = 0$} (2b)

sign $(x_i - x_j)$ = {-1, if $(x_i - x_j) < 1$} (2c)

The statistic S is approximately Gaussian when n=18 with the mean E(s) and variance Var(S) of the statistic S given by the expression

E(S) = 0 (3)

$$Var\ (s) = \frac{N\,(n-1)(2n+5)}{18} \qquad (4)$$

However, if the dataset exists, variance (S) is calculated by the following equation

$$Var\,(S) = \frac{1}{18}\left[\left[n(n-1)(2n+5)\right] - \sum_{p=1}^{n} t_p\,(t_p - 1)\,(2t_p + 5) \right] \qquad (5)$$

The variable 'q' and 't_p' are the tied group numbers and 'p^{th}' group data value numbers, respectively.

The normal Z-statistics is computed as

$$Z = \frac{S-1}{\sqrt{Var\ (S)}} \qquad (6a)$$

Z=0 (6b)

$$Z = \frac{S+1}{\sqrt{Var\ (S)}} \qquad (6c)$$

The trend is said to be decreasing or increasing if 'Z' is negative or positive and the computed Z-statistics is greater or lesser than the z-value corresponding to the 5% level of significance, respectively. If the computed Z-statistics is Zero then, there is no trend.

Sen's slope test: To identify the trend existing in data sets of a particular time series, a slope estimator (m_{ij}) is considered as median for all data sets for various combination. The '+ve' value of (m_{ij}) indicates an upward trend conversely '-ve' value indicates a downward trend. The slope (m_{ij}) is calculated using the following equation

$$m_i = \frac{(Yj - Yi)}{(J-1)} \qquad (7)$$

Where, 'Y_j' and 'Y_i' are the time values at time 'j' and 'I' (j>i).

The Sen's estimator slope is the median of these 'N' values of 'm_{ij}'. The Sen's slope is calculated using the following equation

$$m = m\left[\frac{N+1}{2}\right] \qquad (8)$$

$$m = \frac{1}{2}\left[\frac{^{m}N}{2} + \frac{^{m-}N+1}{2}\right] \qquad (9)$$

Hence, m_{ij} is calculated using two-sided test at 100(1-α) % confidence interval and thus, true slope is given by the non-parametric test.

RESULTS AND DISCUSSION

The Z-Value of Mann-Kendall (MK) test represents significant trend in the rainfall data while the Sen's slope estimator shows a magnitude of decrease or increase trend in the rainfall data. In the analysis Mann-Kendall (Fig. 2) is used for sign test and change in magnitude using Sen's slope estimator (Fig. 3). The test results of the Mann - Kendall (MK) shows that there is a significant positive trend in rainfall distribution during Annual, Summer, Monsoon and Post Monsoon Seasons. In India, monsoon season provides maximum contribution to the annual rainfall, predominantly during the months of June, July, August and September. The daily rainfall events for a period of 36 years (1981 -2016) were analyzed (Table 1). There is a greater variation in CV in

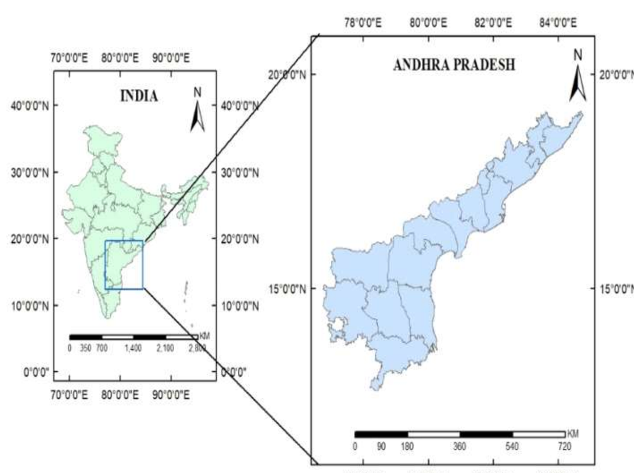

Fig. 1. Study area map of the region

Table 1. Daily rainfall Statistical Indices for different districts of A.P.

District	Annual			Winter			Summer			Monsoon			Post Monsoon		
	Mean	S.D.	C.V.	Mean	S.D.	C.V.	Mean	S.D.	C.V.	Mean	S.D.	C.V.	Mean	S.D.	C.V.
Anantapur	449	204	45	17	11	65	58	39	67	268	148	55	115	70	61
Chittoor	773	309	40	68	55	81	82	52	63	366	145	40	258	162	63
East Godavari	886	416	47	44	34	77	115	98	85	571	263	46	213	153	72
Guntur	627	337	54	14	11	79	58	39	67	268	148	55	115	70	61
Kadapa	551	229	42	16	12	69	58	39	67	268	148	55	115	70	61
Krishna	755	432	57	78	65	83	74	62	84	942	371	39	325	164	50
Kurnool	534	248	46	17	10	59	52	31	60	371	192	52	104	74	72
Nellore	780	434	56	95	84	88	69	61	88	246	145	59	393	260	66
Prakasam	573	318	56	44	38	86	64	52	82	277	167	60	213	141	66
Srikakulam	860	418	49	42	35	83	117	95	81	555	265	48	182	157	86
Visakhapatnam	908	394	43	48	39	81	135	111	82	575	245	43	199	140	70
Vizianagaram	895	327	37	50	39	78	114	101	89	585	216	37	171	117	69
West Godavari	832	430	52	42	32	76	112	95	85	580	305	53	164	121	74

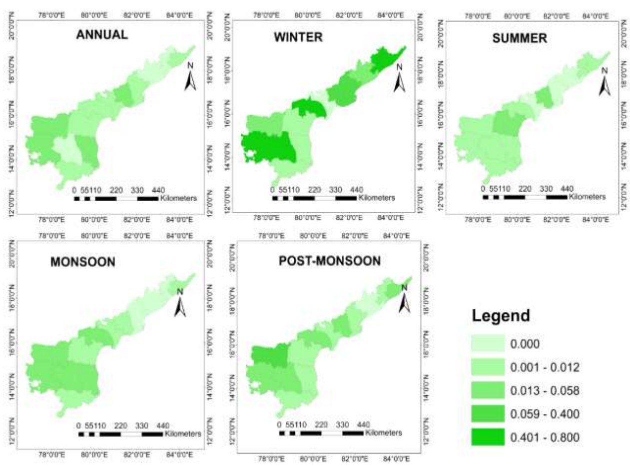

Fig. 2. Spatiotemporal variability of Mann Kendall test Z value

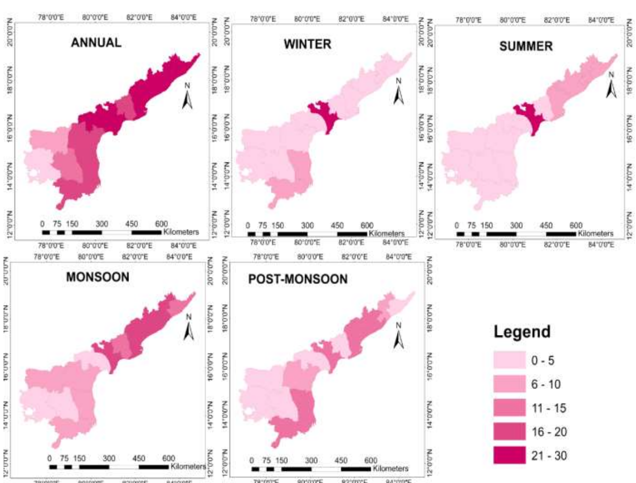

Fig. 3. Spatiotemporal variability of magnitude using Sen's slope estimator

winter season that shows a greater dispersion around the mean.

While analyzing winter, summer and post-monsoon cycles, the change in magnitude for the winter season is nearly equal to zero, which indicates that there is very less change in the magnitude. But in the summer cycle there shows a negative change in magnitude. The annual and monsoon shows a positive and negative change in magnitude for all the regions in a comparative level.

CONCLUSION

The maximum negative magnitude was in the Krishna sub-basin and Tungabhadra sub-basin. The overall analysis using MK sign test demonstrates that there is significant and positive trend in rainfall but a change in the magnitude of the rainfall throughout the region. The magnitude of rainfall is reducing in the upstream compared to downstream sub – basins of the state. The tests also estimate the presence of trend in number of rainy days and number of intensity rainfall events. These rainy-day events and intensity events show a positive and significant trend. Bhima-Upper and Krishna sub-basins shows a negative change in magnitude in the number of rainy days which can impact the amount of rainfall to be received in the sub-basins Bhima- Lower and Krishna middle and Upper sub-basins and Tungabhadra sub-basins shows a negative change in magnitude.

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Property Rights and Technology Adoption for Agricultural Sustainability in Tamil Nadu

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Abstract: The present study examines the interlinkages between property rights, input use, and technology adoption thereby sustainable agriculture. From the results, secure property owners of inheritance, purchase, and trust rental sites have adopted more organic manure and pesticides as compared to private rental tenants. The tenants cultivating long-term trust lease-in land have adopted sustainable practices towards the short-term private contract tenants. Thus, secure property rights allow the farmers and tenants to adopt sustainable agriculture practices.

Keywords: Property rights, Land tenure, Technology adoption, Tenancy, Sustainable agriculture

Sustainable agriculture is acquainted and extensively advocated in government policies and planning. It encompasses land and water use, environmental protection, technology adoption, societal recognition, and economic benefit. A sustainable agricultural operation deeply encourages cohesion between food security, livelihood, agroecological litheness, and productivity (CGIAR 2001). Conceptualizations of international agencies confirm that sustainable agriculture starts from resource use, which is operationalized through technology adoption. In agriculture, resource use solely depends on property rights, which combines the bundles of entitlements regarding exclusivity, security, and transferability. Comprehensive property rights encourage environment-friendly technology adoption, long-term investment, production, and economic efficiency thereby agricultural sustainability. As a result, property right is an important dimension of both the membrane connecting the society with the economy. Adoption of sustainable agriculture technologies namely plough, green inputs, and investment in soil fertility and conservation needs long-term to reap the benefits. Unclear land rights and traditional rental practices reduce opportunities to adopt sustainable agricultural technologies (Arellanes and Lee 2003, Lee 2005). In the Indian context, property rights of the resources differ according to the nature of the land title. The right of inheritance and purchased land differs as the rights of inheritance land acquire equal rights among the household members, whereas the purchased land possesses secure rights to the titleholder (Place and Swallow 2000). Traditionally, the male in the household manages the farm activity and also owns the land rights. At present, the legitimate has provided rights for the female to claim her birthrights (Rao 2007).

In the execution of contract farming, the legislation allows the tenants and landowners to register the agreement of the contract. At the same time, the traditional method of informal agreement (oral) incurs no cost and formalities in collusion. But the traditional method has its limitation. As the future is uncertain, the dominant farmers may threaten the tenants to alter the contract of payment/duration. Therefore, the existing rental markets create insecurity for both tenants and landowners, which affects agricultural sustainability (Holden and Yohannes 2001). Given this backdrop, the paper aims to analyse two important aspects. First, various tenurial system and the farmers/tenant's decision over technology adoption and input intensity is analysed. Next, it probes into the linkages between various tenurial systems and sustainable agricultural practices. Most of the research work in the arena of sustainable agriculture examines input use and productivity. But ill-defined property rights affect the farmer's and tenant's agricultural activity, which is unexplored widely. Thus, the present venture analyses sustainable agriculture from the perspective of property rights, input use, and technology adoption.

MATERIAL AND METHODS

In the Cuddalore district of Tamil Nadu, the farmers, and tenants are involved in agricultural activity. The own lands are inheritance and purchase whereas rental lands are from landowners (short-term lease) and trustees (long-term lease). The trust lands are cultivated by the tenants for generations and ensures long-term cultivable rights. In general, the farmers of the district cultivate inheritance, purchased and private rental lands, whereas trust cultivable lands are few and scattered. According to the information provided by the District Statistical Department, the researcher identified two villages, wherein they cultivate more trust lands. The selected villages represent different types of tenure and technology adoption. The researcher has enumerated the households of the two villages with basic facts for making a sampling design. At the next level, a proportionate stratified random sampling method is employed to identify the sample farmers of different tenurial groups such as inheritance, purchase, private tenants, and trust tenants. During the preliminary investigations, the research has noticed the possession of lands by the households' more than one tenurial system. At this level, the researcher has devised a method following the principle of relatively large holdings of lands of four tenurial groups and given weightage to the large holdings and select sample. It is expected that this process does not disturb the results. The number of households under four tenurial groups and the sample are given in table 1. The issues highlighted have been examined with multivariate techniques and it requires a minimum number of samples to run the analysis. Keeping all those issues, 25 percent of the sample has been identified in each group and the final sample consists of 287. Since the rights differ according to the type of tenure, the researcher has collected data for each site to highlight the influence of property rights on technology adoption and agricultural sustainability. The sample farmers cultivate land under different tenurial systems and the data is collected for each tenure individually. As a result, the data is collected for inheritance (209 sites), purchase (185 sites), private rental (67 sites), and trust rental lands (78 sites). Since paddy is the major crop in the surveyed region, the researcher has examined technology adoption, input intensity, and sustainable agricultural practices.

Description of dependent variables: The dependent variables for the multiple regression model are technology adoption and input intensity (plough, seed, manure, pesticide, weeding, and human energy) are continuous variables. In the Probit model, the dependent variable is the adoption of environment-friendly technologies (animal plough, organic manure, and organic pesticide), which are binary (Table 2).

Description of explanatory variables: All the explanatory variables for the probit and regression models are grouped into three categories. The first group of variables is the type of tenure, where site characteristics and farmers' characteristics are examined in the form of second and third groups respectively. Besides, the type of explanatory variables, expected sign, variable description, and justification and relevance of the variables are discussed (Table 3).

RESULTS AND DISCUSSION

Technology adoption and input intensity: Land tenure influences farm management practices, efficiency, and

Table 2. Dependent variables in regression and probit models

Variable	Cost of different variables (Rs) per hectare
Input Intensity*	
Plough- Animal	Animal traction
Plough-Machine	Machine traction
Seed	Seed
Manure-Inorganic	Inorganic manure
Manure-Organic	Organic manure
Pesticide-Inorganic	Inorganic pesticide
Pesticide-Organic	Organic pesticide
Weeding-Inorganic	Inorganic weeding
Human energy	Human labour
Environment-Friendly technologies**	
Animal plough	Exclusively using the animal plough
Organic manure	Exclusively using organic manure
Organic pesticide	Exclusively using an organic pesticide

**Binary, *Continuous

Table 1. Sampling design

Tenure	Enumerated households			Sample size (25 %)		
	Pannapattu	Kathrimedu	Total	Pannapattu	Kathrimedu	Total
Inheritance	316	212	528	79	53	132
Purchase	221	136	357	55	34	89
Private tenancy	73	51	124	18	13	31
Trust tenancy	89	48	137	23	12	35
Total	699	447	1146	175	112	287

sustainability consequences. It is hypothesized as "the technology adoption and input intensity of organic and inorganic inputs varies significantly among the farmers of different tenurial categories. The per-hectare cost of various agricultural operations for technology adoption and inputs viz., plough, seed, manure, pesticide, weeding, and human labour are the continuous dependent variables representing input intensity (Table 4). The explanatory variables are the types of tenure, site, and farmer characteristics. The fitted nine models of technology adoption and input intensity are found to have a fairly good fit. The adjusted R square values show that the explanatory variables could explain a substantial portion of the intensities of various inputs.

Tenure and input intensity: The input intensity of organic inputs differs significantly among the types of tenure. The input intensity of inheritance, purchase, and trust rental sites are significantly different from private rental sites. The t ratios of regression coefficients for the intensity of manure, pesticide, weeding, and human energy are significant for all the tenure. The inputs such as animal plough, tractor plough, and HYV seed are not significant. In the inheritance sites, the intensity of environment-friendly inputs of organic manure and organic pesticide is significantly greater as compared to the private rental site. That is, the beta value of regression estimates infers per hectare cost of cultivation where the use of organic manure (Rs. 693) and organic pesticide (Rs. 111) is high in the inheritance sies as compared to private rental sites. The intensity of inorganic manure, inorganic pesticides, and inorganic weeding is lower in the inheritance sites as compared to private rental sites. A similar pattern of results was observed in purchase sites and trust rental sites. The input intensity for organic manure and organic pesticide is positively related to tenurial status (inheritance, purchase, and trust) as compared to private rental lands. It further shows a negative relationship between inorganic manure, pesticide, and weeding. As compared to the inheritance plot, the purchased plot is highly secure due to the clearly defined title. But, in the surveyed region both inheritance and purchase are secure due to strong indigenous institutions. Even though trust plots are rental, they are long-term rental

Table 3. Explanatory variables in the probit and regression models

Variable	Type / expected sign	Justification and relevance
Type of tenure		
Inheritance	B / +	Farmers owning inheritance, purchase, and trust rental sites are secured in all aspects and so positive sign is expected towards the adoption of environment-friendly technologies. Private rental sites are highly insecure and short-term lease, which is kept as a reference category for analysing the influence of other types of tenure.
Purchase	B / +	
Trust	B / +	
Site characteristics		
Field size	C / +	The cost of cultivation for the large site involves a lesser amount and thereby higher returns, which is expected to have a positive sign.
Fertile soil	B / +	Sites that have better natural endowments such as fertile soil, loose soil, drainage facility, and groundwater irrigation are expected to have a positive relationship with input use.
Loose soil	B / +	
Drainage facility	B / +	
Ground water irrigation	B / +	
Distance to canal	C / -	Distance from the canal to site and house to the site is expected to have a negative sign. Because lack of irrigation and site faraway from residence may affect the farmers' involvement and management.
Distance to house	C / -	
Farmer's characteristics		
Gender	B / +	Male and aged farmers are expected to have a positive relationship with input use as they may have wider knowledge and experience in cultivation.
Age	C / +	
Education status	C / +	Farmers with higher education may have a positive influence over the adoption of environment-friendly technologies in agriculture.
Household labour size	C / +	Dependence on agriculture would be high in a household with more labour and expected to have positive implications.
Farm size	C / +	The farm size of the site owner is hypothesized to have a positive relationship with rights, adoption, and preservation. Since farmers having more hectares of land may exclusively involve in agricultural management.

Note: B= Binary C = Continuous

lands and as a result, the tenure of the sites has significant influence over sustainable agricultural practices.

Site characteristics and input intensity: The site characteristics such as field size, fertile soil, loose soil, drainage facility, groundwater irrigation, distance to the canal, and distance to the house are expected to influence

Table 4. Determinants of technology adoption and input: Multiple regression estimates

Variable	Plough		Seed	Manure		Pesticide		Weeding	Human energy
	Animal	Tractor	HYV	Inorganic	Organic	Inorganic	Organic	Inorganic	
Type of Tenure									
Inheritance	83.39	-7.73	-78.87	-1304.65**	693.23**	-58.14**	111.98**	-192.89**	402.37**
	(0.70)	(-0.06)	(-0.86)	(-5.88)	(12.52)	(-5.32)	(8.10)	(-9.72)	(1.79)
Purchase	-106.49	47.56	-129.01	-1200.65**	675.58**	-57.36**	118.85**	-157.96**	628.92**
	(-0.89)	(0.34)	(-1.39)	(-5.34)	(12.04)	(-5.18)	(8.48)	(-7.85)	(2.75)
Trust	70.83	-17.39	65.95	-1102.33**	555.77**	-61.84**	69.55**	-196.20**	564.12**
	(0.56)	(-0.12)	(0.67)	(-4.62)	(9.33)	(-5.26)	(4.67)	(-9.18)	(2.33)
Site characteristics									
Field size	-145.64**	146.25**	-40.61	-50.27	25.16	-5.87**	3.38	9.08	-238.81**
	(-4.80)	(4.16)	(-1.72)	(-0.88)	(1.77)	(-2.10)	(0.96)	(1.79)	(-4.13)
Fertile soil	65.94	115.27	42.92	25.60	-28.57	5.24	-28.16**	-9.37	-485.59 *
	(0.70)	(1.05)	(0.59)	(0.14)	(-0.65)	(0.60)	(-2.55)	(-0.59)	(-2.70)
Loose soil	100.11	-143.08	37.02	49.74	-8.87	-0.58	-17.13	-20.52	-119.53
	(1.25)	(-1.54)	(0.60)	(0.33)	(-0.24)	(-0.08)	(-1.83)	(-1.53)	(-0.79)
Drainage facility	-90.65	125.70	-24.06	104.13	-73.49 *	3.85	-6.77	-8.67	56.12
	(-1.20)	(1.43)	(-0.41)	(0.73)	(-2.08)	(0.55)	(-0.77)	(-0.68)	(0.39)
Ground water irrigation	389.99**	-19.97	119.13	439.39	-44.21	20.24	-40.18**	-14.67	860.64**
	(2.54)	(-0.11)	(1.00)	(1.53)	(-0.62)	(1.43)	(-2.24)	(-0.57)	(2.95)
Distance to canal	-60.21	62.43	49.09	207.98	-4.03	22.35 *	-9.62	-62.32**	-103.56
	(-0.55)	(0.49)	(0.58)	(1.01)	(-0.08)	(2.21)	(-0.75)	(-3.39)	(-0.50)
Distance to house	-31.12	60.47**	31.73	91.15	-42.05**	10.99**	4.59	17.18**	241.78**
	(-1.33)	(2.23)	(1.75)	(2.08)	(3.84)	(5.09)	(1.68)	(4.38)	(5.43)
Farmer's characteristics									
Gender	303.75**	-167.35	-181.36**	-250.90	12.82	8.38	47.23**	-29.80	140.61
	(2.50)	(-1.19)	(-1.93)	(-1.10)	(0.23)	(0.75)	(3.33)	(-1.47)	(0.61)
Age	3.53	-7.58	-5.03	-6.72	2.26	0.19	0.58	-1.08	-0.32
	(0.99)	(-1.84)	(-1.82)	(-1.01)	(1.36)	(0.58)	(1.39)	(-1.81)	(-0.05)
Education status	0.85	-29.90	-25.01	80.95	11.69	-0.02	2.32	-0.55	23.58
	(0.03)	(-0.96)	(-1.20)	(1.60)	(0.93)	(-0.01)	(0.74)	(-0.12)	(0.46)
Household labour size	-4.25	-104.05*	28.08	-56.67	-24.05	-8.69**	-7.16	0.31	-134.24
	(-0.11)	(-2.36)	(10.95)	(-0.80)	(-1.35)	(-2.48)	(-1.61)	(0.05)	(-1.86)
Farm size	-97.11**	-335.13**	-140.91**	67.29	46.02**	-3.64	0.95	-8.14	-269.05**
	(-3.01)	(-8.98)	(-5.64)	(1.12)	(3.06)	(-1.22)	(0.25)	(-1.51)	(-4.39)
Constant	365.12	2828.05	3233.96	6636.96	-64.60	434.09	-51.66	298.93	13247.06
	(1.37)	(9.16)	(15.64)	13.29	(-0.52)	(17.64)	(-1.66)	(6.69)	(26.11)
No. of cases	522	522	522	522	522	522	522	522	522
Adjusted R2	0.13	0.21	0.17	0.10	0.39	0.17	0.16	0.29	0.23
F	6.21**	10.40**	8.45**	4.99**	23.97**	8.02**	7.58**	14.93**	11.61**

Figures in parentheses are t ratios* P<0.05**P<0.01

the intensity of various inputs used in cultivation. But all the site characteristics are not consistent in influencing the input intensity. Distance to the house has a significant influence on the intensity of most of the inputs. It has a significant positive influence on the intensity of tractor plough, inorganic pesticides, inorganic weeding, and human labour while having a negative influence on the intensity of organic manure. The input intensity of tractor plough, inorganic pesticide, inorganic weeding, and human energy tends to increase with the increased distance to the house from the site. Land sites situated far away from their living places encourage the farmers to apply more amount of inorganic inputs and reap the benefits quickly. The field size has a significant positive impact on tractor plough while having a significant negative impact on the intensity of animal plough and human energy. From the beta value of regression estimates, as the field size increases by one hectare, the intensity of tractor plough (Rs. 145) increases while animal plough (Rs. 146) and human energy (Rs. 238) tends to decrease. If the farm size increases, the farmers have spent more on mechanization rather than an animal plough and human energy. The sites with groundwater irrigation, distance to the canal, the fertility of the soil, drainage facility have marginally influenced the input intensity.

Farmer's characteristics and input intensity: The demographic and other characteristics of the farmers such as gender, age, educational status, household labour size, and farm size have a significant impact on the intensity of various inputs at the site level. Farm size has a significant impact on most inputs with a significant positive influence on tractor plough and HYV seeds while a negative influence on the animal plough, organic manure, and human energy. Mechanization and inorganic content have been widely adopted by large farmers and thereby the organic and labour usage in agriculture has been reduced drastically. Next to this, gender is yet another farmer characteristic that has a significant impact on the intensity of three of the inputs viz., animal plough, HYV seed, and organic pesticide. It has a positive impact on the intensity of animal plough and organic pesticides. These are environment-friendly inputs and have a negative impact on the intensity of HYV seeds. Male farmers have greater input intensity of animal plough and organic pesticide as compared to the female farmers. Female farmers have greater input intensity of HYV seeds as compared to their male counterparts. The male farmers take more risk in hiring bullock plough from nearby villages where the female farmers are unable to do so. Adoption of organic pesticides requires enough time for managing the same and the male folk alone find enough time for managing the resources. The female farmers do not preserve seeds from their farms; hence, they spend money on purchasing HYV seeds. Household labour size has a significant negative impact on the intensity of tractor plough. This infers that the farmers have used their family labour for the plough in an efficient manner for attaining sustainable agriculture. The age and educational status of the farmers have no significant influence on the intensity of any of these inputs. From the analysis, it could be inferred that property rights of inheritance, purchase, and trust rental plots have a positive marginal impact on the adoption of organic inputs and a negative impact on inorganic inputs. But a similar trend was not obtained from the site and farmers' characteristics. Thus, the nature of property rights influences the input intensity as compared to site and farmers' characteristics.

Adoption of sustainable technologies: The nature of property rights potentially affects sustainable land-use practices wherein owner-operators are more likely than renters to adopt conservation practices. Of the various agricultural activities, plough, manuring, and pesticides have played a major role in attaining the sustainability of agriculture. Use of bullock plough, organic manures (animal waste, green leaves, and dainch-*pasunthalai*), and organic pesticides (neem oil and *Pancha Kavya*) are considered environment-friendly technology and inputs. In the surveyed regions, farmers mostly adopt both organic and inorganic methods in agriculture. Few farmers exclusively adopt environment-friendly technologies in any one of these three activities. Thus, it is hypothesized as "the secure private property holders adopt environment-friendly technologies rather than insecure tenant-right holders in the study villages." The Probit model is adopted to analyse the determinants of environment-friendly technologies (Table 5). Animal plough, organic manure, and organic pesticide are the binary dependent variables. The types of tenure, site, and farmer characteristics are included as explanatory variables in the probit models. The three fitted binomial Probit models are considered to be fairly good. The calculated chi-square values of the models of animal plough (136.37), organic manure (310.17), and organic pesticide (255.75) are significant. The computed McFadden pseudo R square values of these models also show the substantial explanatory power of explanatory variables. The R-square values of animal plough (0.27), organic manure (0.72), and organic pesticide (0.38) are substantial. The percent of cases correctly predicted by the three Probit models also shows similar results. The percent of cases correctly predicted by the models of an animal plough (84%), organic manure (96%), and organic pesticide (83%) are high.

Tenure and sustainable technologies: The secure private property holders adopt environment-friendly technologies rather than insecure tenant-right holders in the study villages and have been accepted given the significance of the Probit coefficients of types of tenure. The t ratios of Probit coefficients of inheritance plots for applying organic manure (6.93), organic pesticide (5.43), and animal plough (1.98) are significant. The t ratios of Probit coefficients of purchase and trust rental sites for animal plough are not but the t ratios of purchase plots for the adoption of organic manure (7.04) and organic pesticide (5.80) are significant at a 1 per cent level.

Table 5. Determinants of exclusive adoption of sustainable technologies: Probit estimates

Variable	Expected sign	Animal plough	Organic manure	Organic pesticide
Type of tenure				
Inheritance	+	0.54* (1.98)	3.72** (6.93)	1.54** (5.43)
Purchase	+	-0.09 (-0.32)	3.66** (7.04)	1.70** (5.80)
Trust	+	0.12 (0.43)	4.21** (7.42)	1.23** (4.24)
Site characteristics				
Field size	+	-1.44** (-7.56)	1.74** (3.93)	1.15** (7.23)
Fertile soil	+	0.18 (0.78)	-0.66 (-1.43)	-0.64** (-2.54)
Loose soil	+	0.04 (0.20)	-0.14 (-0.44)	-0.37** (-1.95)
Drainage facility	+	0.06 (0.27)	-0.54 (-1.52)	-0.34 (-1.72)
Ground water irrigation	+	0.98 (1.61)	4.06 (0.00)	-1.80** (-4.08)
Distance to canal	-	0.06 (0.21)	-0.42 (-0.91)	-0.48 (-1.74)
Distance to house	-	-0.16* (-2.41)	-0.20** (-2.50)	0.00 (0.05)
Farmer's characteristics				
Gender	+	-0.48 (-1.74)	-0.05 (-0.12)	-0.93** (-3.85)
Age	+	0.01 (1.53)	-0.02 (-1.53)	-0.01 (-1.38)
Education status	+	0.04 (0.70)	-0.16 (-1.65)	0.02 (0.39)
Household labour size	+	0.10 (1.00)	-0.21 (-1.23)	-0.26** (-2.81)
Farm size	+	0.19 (1.99)	-0.16 (-0.79)	-0.29** (-3.23)
Number of cases		522	522	522
Log-likelihood function		-185.36	-61.54	-205.75
Restricted Log-likelihood		-253.55	-216.62	-333.63
Chi-squared		136.37**	310.17**	255.75**
McFadden pseudo R^2		0.27	0.72	0.38
Percent of cases correctly predicted		84.10	96.17	82.57

Figures in parentheses are asymptotic t ratios * P<0.05**P<0.01

Likewise, the t ratios of trust rental plots for the adoption of organic manure (7.42) and organic pesticide (4.24) are significant. The inheritance, purchase, and trust sites have a greater likelihood of adoption of organic manure and pesticide as compared to the private rental sites. The secure property rights encourage the farmers towards sustainable agricultural practices as compared to the insecure private tenant holders. Moreover, inheritance land has a greater probability of adopting animal plough technology, which is environment friendly. In a few cases, inheritance landholders have traditional practices in agriculture since they have cultivated lands for generations. This has made them adopt animal plough as compared to other tenurial groups.

Site characteristics and sustainable technologies: The site characteristics such as field size, fertile soil, loose soil, drainage facility, groundwater irrigation, distance to the canal, and distance to the house are expected to influence the adoption of environment-friendly technologies. Of these characteristics, field size, fertile soil, loose soil, drainage facility, groundwater irrigation, and distance to the house have a significant impact on the adoption of at least one environment-friendly technology. The direction and its impact are not consistent across the technologies. The distance to canal and drainage facilities are the site characteristics that have no significant impact on the adoption of any of the environment-friendly technologies. Field size has a significant positive impact on the adoption of organic manure and organic pesticide but has a negative impact on the adoption of the animal plough. But, as the field size increases, the probability of adoption of animal plough decreases, while that of the adoption of organic manure and organic pesticide tends to increase. Rearing bullock has been reduced over the period and the cost of bullock plough is also comparatively high. Because of this, the farmers are unable to adopt bullock plough and particularly for a large site size. However, field size has a positive relationship with the adoption of organic manure (animal waste, leaves, and dainch - *pasunthalai*) and organic pesticide (neem oil and *Panchya Kavya*). Since the farmers possessing a large field size gets interested in managing them sustainably. Distance to the house from the site has a significant negative impact on the adoption of the animal plough and organic manure as expected. As the distance to the house from the site increases, the probability of adoption of environmentally friendly technologies of the animal plough and organic manure tends to decline. Thus, the farmers show lesser involvement in the sites that are distant to the house due to the non-availability of bullock plough and lack of transportation facilities. Fertile soil, loose soil, and groundwater irrigation are the three site characteristics that have a significant negative impact on the adoption of organic pesticides. Distance to canal and drainage facility has no significant impact on any of the environment-friendly technologies studied. To increase productivity and reap the investment, the site owners have adopted modern methods. These practices stand as an impediment in introducing environment-friendly technologies.

Farmer's characteristics and sustainable technologies: The demographic and household characteristics of the farmers such as gender, age, educational status, household labour size, and farm size are expected to make a significant positive impact on the adoption of environment-friendly technologies of the animal plough, organic manure, and organic pesticide. But it has not influenced sustainable agricultural practices and only negatively affected organic pesticide use. Gender, household labour size, and farm size have a negative impact on the adoption of organic pesticides. Interestingly, as compared to male farmers, female farmers have a greater probability of adopting organic pesticides. The preparation of organic pesticides involves huge processes and the female is patient to prepare as towards male farmers. There is an inverse relationship between household labour and farm size and the adoption of organic pesticides. As a greater number of household labourers depend on agriculture, they tend to increase productivity by using chemical pesticides and thus have a negative impact on the adoption of organic pesticides. Similarly, as farm size increases the use of organic pesticides is negative as compared to marginal farmers. The availability of organic pesticides, prepared from animal waste is very poor. The demographic characteristics of the farmers such as age and educational status have no significant impact on the adoption of any environment-friendly technologies.

Tenurial status has a major role in determining environment-friendly technologies. This is proved in the adoption of organic manure and pesticide. In the case of the animal plough, due to an increase in maintenance and rearing cost and further utilizing the same energy throughout the year is difficult. Hence, farmers are reluctant to use the animal plough. On the same line, field size has a positive relationship with the adoption of organic manure and pesticides, but it has a negative relationship with animal plough. Contrary to this, farm size has significantly influenced animal plough and organic pesticide, whereas it has a negative relationship with organic manure. It is reported that the cost of bullock plough is high as compared to other plough technologies. The small farmers adopt tractor plough but large farmers adopt bullock plough. But they do not show similar interest in the adoption of organic manure, which is quite difficult to purchase. The property rights of inheritance, purchase, and trust rental plots have influenced the exclusive adoption of environment-friendly technology and inputs. But, the role of site and farmers' characteristics do not have an impact on sustainable agricultural practices. Thus, the nature of property rights determines the adoption of sustainable agricultural practices.

CONCLUSIONS

Property rights of land influence technology adoption, input intensity, and sustainable agricultural practices. Secure property rights of inheritance, purchase, and trust rental site holders have adopted more organic manure and organic pesticide as compared to private rental tenants. Moreover, few of the inheritance, purchase, and trust site owners have exclusively adopted organic manure and pesticide. The site and farmers' characteristics influenced the technology adoption, input intensity, and sustainable practices at a meagre level and were not consistent. Thus, the nature of property rights significantly influenced agricultural practices as compared to a site or farmers' characteristics. Since the property rights of inheritance and purchase are secure, the adoption of organic materials was high. Even though trust plots are rental, it gives secure cultivable rights for a long tenure, which has motivated them to adopt more organic materials towards the private rental tenants. Thus, the result reveals that the property rights of land have played a major role in determining agricultural activity and sustainable practices.

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Transfer Factor of Radionuclides from Soil to Plant in Natural and Radionuclides Polluted Soils of Iraq

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Abstract: This study was conducted to evaluate accumulation rates of uranium, thorium and potassium as natural radioactive elements in two areas of different human activities and to determine their accumulation in soil and associated crops samples. In the present study, natural radioactivity of U, Th and K in soil and Wheat crops by the Gamma ray spectroscopy and high-purity Ge (HPGe) detector was detected. The samples were collected from two places at Baghdad in Iraq. The overall mean transfer factor (TF) of uranium, thorium and potassium was 0.194, 0.089 and 0.324 respectively, as an average of each element in the six contaminated setting areas Al-Tuwatha. Similarly, the overall mean transfer factors for six selected natural setting areas Al Gherai'at were 0.082, 0.046 and 0.195 respectively. Accordingly, these results the overall mean TF of radionuclides ^{283}U, ^{232}Th and ^{40}K in contaminated soil setting area were 47% higher than that in natural soil sample setting areas. It can be conclude that the activity concentrations of these radionuclides in plants and their plant transfer factors seem to depend on the activity concentrations of the same radionuclides in corresponding soil.

Keywords: Activity Concentrations, ^{238}U, ^{232}Th, ^{40}K, Gamma Spectroscopy, Wheat

The accumulation of radioactive isotopes in soil and air is of global concern because of its association to the public health. It is well known that naturally occurring radionuclides can be released into the soil environment from both nuclear (nuclear power plants-NPPs and waste disposal) and non-nuclear industries (coal-fired power plants and oil and gas processing) (John et al 2003). Utilization of radionuclides in the research field of plant, soil and water studies is also considered as other source for radionuclides to environmental components (Qin-Hong et al 2010). Released radioactive isotopes to the environment are eventually transferred by water and air to the soil and sediment which in turn reacted with soil components to form stable complexes. Radionuclides can transfer from soil to human through several pathways. Soil-plant-man in food chain is one of the major pathways for human to get internal radiation exposure (Chen et al 2005). Radionuclides are incorporated into plants as a result of direct deposition from the atmosphere and resuspension of soil on aerial parts as well as root uptake from contaminated soil and water (Gupta and Walther 2014). Those in soil are then transferred to plants along with the nutrients during mineral uptake, accumulated in various parts and even reach the edible parts. Concentration of radionuclides in soil is a significant factor influencing the concentration in plants. Therefore, it is important to investigate the distribution of radionuclides in soils and plants and their long-term behavior, such as mobility, transfers and translocation (Vera Tome et al 2003).

The uptake of radionuclides in plant from soil is difficult to quantify (Gupta and Walther 2014). Soil-to-plants transfer factor (TF) has been widely used in the estimation of amount of radionuclides expected to enter plant from soil (IAEA 2009) and also in assessment of the contribution to internal radiation dose through ingestion exposure pathway. TF is one of important parameters used in mathematical models for the radiological risk assessment needed for a facility using radioactive material (Gregory and Agbalagba 2014), such as a nuclear power plant. TF is defined as the ratio of the concentration of radioactivity in plants to the radioactivity per unit mass in soil (Aswood et al 2013). Factors such as soil characteristics, climatic conditions, plant type, vegetation period, part of the plants concerned, physicochemical form of radionuclides and the interfering element can all influence the TF (Blanco et al 2002, Vandenhove et al 2009). Transfer factor of radionuclides from soil to plants and crops is reported from different natural and polluted areas regions of the world (Al-Masri et al 2008, Shtangeeva 2010, Nabiha et al 2019). The transfer factor is differ depending on the environments and contaminated sites. Saeed (2012) determined the soil to rice plant transfer factors (TF) of natural radionuclides in the samples were collected from different two places at Kedah in Malaysia where the values of the transfer factor mean (TF) of uranium for rural areas was 0.156 whereas the TF mean values of thorium were 0.062.

For potassium the TFs values were 0.758. Similarly the transfer factor mean for samples selected urban areas were 0.064, 0.066 and 1.13 for uranium, thorium and potassium respectively.

There are very limited databases in natural and radionuclides polluted soils of Iraq and this research has proposed two sites in Baghdad middle Iraq , Al Gherai'at natural district at North part of Baghdad and Al-Tuwatha district south east of Baghdad which was used to the Iraqi nuclear installations. Base line data studies in those areas are in progress. Therefore, it is worthwhile to establish databases on the concentration of ^{238}U and ^{232}Th in soils and plants as well as soil-to-plant TF in these two locations around Baghdad middle Iraq.

MATERIAL AND METHODS

The samples used in this experiment were soil and its associated wheat. The samples were collected from 2 different areas in Baghdad (Iraq) 28 km away from each other. The first site was Al Tuwaitha Nuclear Research Center (33.207471N 44.528679E) at south east of Baghdad which was (A1-A6), contains the remains of nuclear reactors. It was used as a storage facility for spent reactor fuel and industrial and medical wastes. These were the research reactor, the radioisotope production building and the dumping station (waste store), agricultural stations with an area of 600 acres for the implementation of scientific research. The second site was organic agriculture research center with an area of 154 acres located at Al Gherai'at (33.406024N 44.344588E) and is an urban area surrounded by the Tigris River from three sides east, south and west (B1-B6) at North part of Baghdad. It is a peninsula of palm trees that contains nurseries and large areas planted with vegetables, wheat and corn. A total of 6 pairs of topsoil and corresponding wheat plants were collected from selected areas shorty before harvest. Collection sites were mapping using GPS device. For each site, one kg topsoil (depth: 0-20 cm) subsamples were collected from about 3800 m^2 area by using a manual drill trowel. Simultaneously, six corresponding 500 gm wheat plant subsamples were collected and combined into a composite sample. Samples for processing were transported to the laboratory prior to analysis and were dried for 48 hours in oven at 100°C. Grain and straws (wheat plant samples) was oven dried at 65°C for 24 hours. Soil samples collected from the six single subsections were mixed and unwanted materials, such as roots and stone were removed. Sampling was then dried, sieved, and homogenized to obtain a composite of that section. These samples were drying under sunlight for two days to remove the moisture then in an oven at 105°C for 24 hrs until reach the fixed weight to ensure the complete removal of any moisture remaining. Samples were homogenized by grinding and sieving through a 2 mm mesh. Plant samples on other hand were also grinded to pass 100 mesh sieves and homogenized. The sieved soil (1 kg) and grinded wheat plant samples were transferred into Marinellin cylindered plastic containers and then sealed with a plastic tape to prevent airflow from the sample for one month before analysis, thereby allowing the Bismuth ^{21}Bi and the Thallium ^{208}Tl to reach a general equilibrium with Uranium ^{238}U and ^{232}Th and their respective daughters. Further, the containers were preserved airtight by plastic packets to ensure that the radon ^{222}Rn ^{220}Rn is confined within the volume.

A high-resolution measurement system, consisting of a high purity germanium detector coupled with a PC, was used for radioactivity measurement of collected samples. The (HPGe) detector (CANBERA-model 7229N, USA) presented 40% relative efficiency and energy resolution of (2.6 keV) at energy of (1332.6 keV) for ^{60}CO. This system can distinguish radionuclide gamma ray energies of interest. The detector was surrounded by a cylindrical lead shield, gamma spectra were recorded and analyzed with Giene-2000 software. Energy calibration of the detector was performed using standard gamma source (^{152}Eu, ^{60}CO, ^{137}Cs, ^{241}Am and ^{226}Ra) from the international Atomic Energy Agency (Fig. 1.).

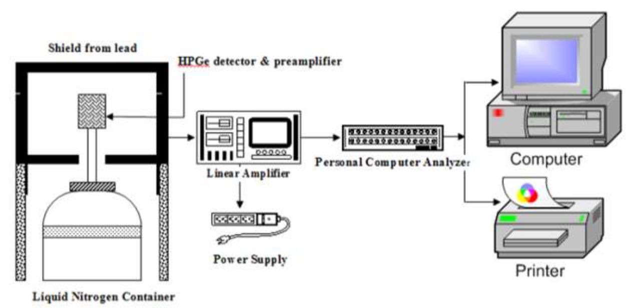

Fig. 1. Gamma spectrum analysis system scheme

Radioactivity measurement of collected samples calculated by using the proposed formula (Amanjeet 2017).

$$A\ (\text{Bq kg}^{-1}) = \frac{N}{M \times I\gamma \times (E\gamma) \times \text{eff} \times T}$$

A: Specific activity concentrations, N: net counts for the sample in the peak range

M: mass of the soil sample (kg), Iγ (Eγ): is the abundance at energy Eγ

T: The time of measurement which was equal to (72000 s.).

Transfer factor TF from soil to wheat yield was calculated according to the following equation suggested by (Asaduzzaman 2015).

$$TF = \frac{\text{Activity concentration of radionuclides in plant (Bq kg}^{-1}\text{ dry weight)}}{\text{Activity concentration of radionuclides in soil (Bq kg}^{-1}\text{ dry weight)}}$$

Statistical software SAS (version 9.3, SAS Institute, Cary, NC) was applied to determine the mean concentration and standard deviation of ^{238}U, ^{232}Th, ^{40}K activity concentration and their transfer factor to wheat. Statistically significant was tested at 95% confidence level. Variations were considered significant at $p<0.05$.

RESULTS AND DISCUSSION

Uranium activity concentrations and plotted as a function of the samples used, in this study were for soil and associated wheat plant (Fig. 2 and 3) which represent uranium ^{238}U radioactivity in the soil and wheat yield at the site of Al-Tuwaitha site (A1-A6) and Al Gherai'at site (B1-B6), respectively. The highest uranium specific radioactivity in soil and wheat plant, at Al-Tuwatha site, was 57.0 Bq kg^{-1} soil and 10.1 Bq kg^{-1} plant dry weight respectively in A4. Uranium specific radioactivity in the soil of the Urban area (Al Gherai'at) on the other hand, was lower than in the soil of the Al-Tuwaitha area. The highest uranium specific radioactivity in the soil of this site was 41.5 Bq kg^{-1} dry soil in B2 and the highest ^{238}U specific radioactivity in the wheat plant had 2.7 Bq kg^{-1} in the same sample.

The results also showed that activity concentrations thorium ^{232}Th (Fig. 4) was the highest in the A1-Tuwiatha soil A6 was 122.3 Bq kg^{-1} soil. The lowest thorium radioactivity was 80.4 Bq kg^{-1} in the A4 location. In terms of wheat yield for the same soil, the highest specific radioactivity of thorium was 10.9 Bq kg^{-1} plant dry weight, while the lowest radioactivity of thorium in the wheat plant was 7.1 Bq kg^{-1} plant dry weight, in the growing wheat plants (A2) at Al-Tuwaitha soil.

For the soil of the Al Gherai'at (Fig. 5) the highest thorium radioactivity was 68.9 Bq kg^{-1} soil in (B4) and 3.80 Bq kg^{-1} plant dry weight for the wheat plant sample (B4) at the same site, respectively. The lowest thorium radioactivity in the Al Gherai'at soil sample (B2) was 36.6 Bq kg^{-1} soil and was 1.42 Bq kg^{-1} plant in (B2). These results are in agreement with the status of these two sites as polluted and not polluted site, where thorium radioactivity in the soil and plant of Al-Tuwaitha (polluted site) were higher than that of Al Gherai'at (Non-polluted site).

The highest specific radioactivity of potassium (Fig. 6 and 7) in Al-Tuwaitha soil was 637 Bq kg^{-1} soil at A3 and the lowest radioactivity was 486 Bq kg^{-1} soil in A5. For the wheat yield grown in the area, the highest Potassium ^{40}K radioactivity at A3 was 257 Bq kg^{-1} plant dry weight and the lowest was 164 Bq kg^{-1} plant dry weight in A4. In the Al Gherai'at soil, the highest of potassium radioactivity was 509 Bq^{-1} kg soil at B5, while B3 sample had lowest potassium radioactivity 385 Bq kg^{-1}soil, and in the wheat yield the highest radioactivity was 106 Bq kg^{-1} plant dry weight at B5 and the lowest was 75 Bq kg^{-1}plant in B3. This may be due to

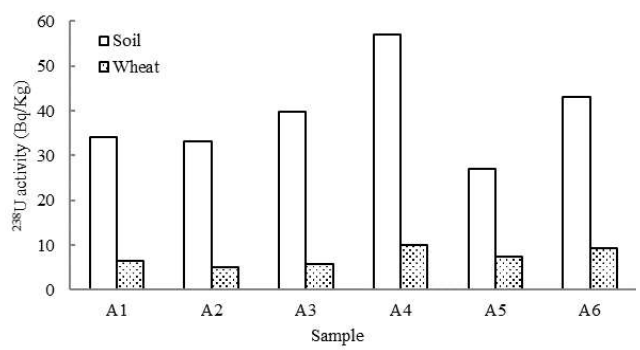

Fig. 2. Concentration of uranium in the Tuwaitha samples

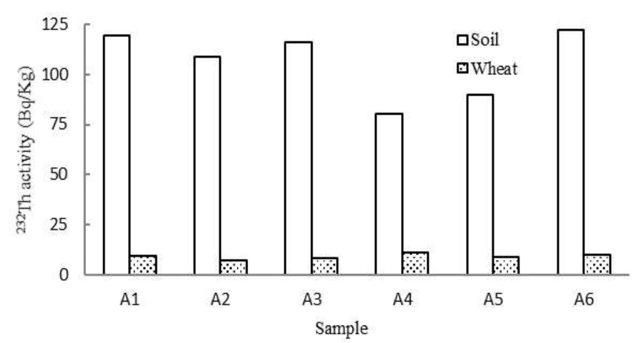

Fig. 4. Thorium concentration of Al-Tawaitha soil

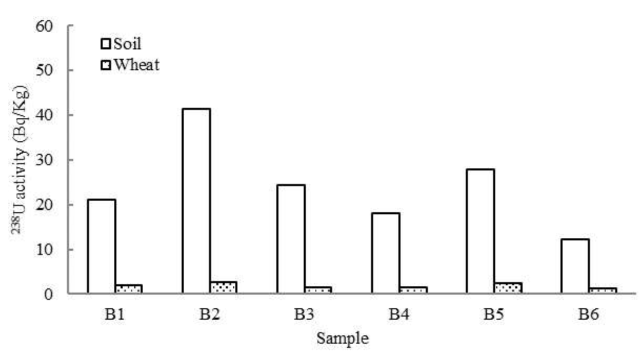

Fig. 3. Concentration of uranium in the Al Gherai'at samples

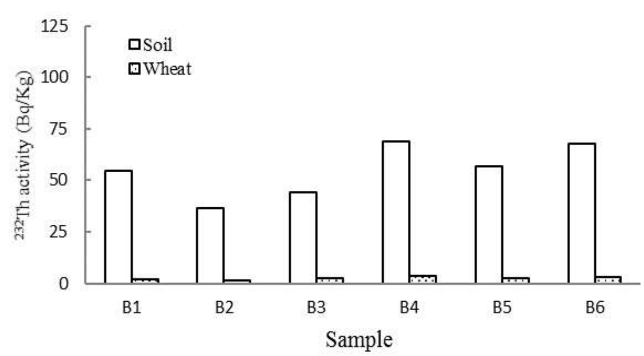

Fig. 5. Thorium concentration of Al Gherai'at soil

differences in human previous activities, chemical and physical soil characteristics. Moreover, the amount of fertilizer or other elements in that soil and yield can also make a difference in all concentrations. Al-Tuwatha location indicated that the highest TF of uranium for wheat crop was 0.278, while TF of thorium and potassium the highest for same crop were 0.098 and 0.403, respectively. In the Al Gherai'at location with natural human activity, the highest values of the transfer factors for uranium, thorium and potassium were 0.060, 0.038 and 0.163, respectively (Table 1).

Uranium and related decay-chain radionuclides remain important subjects of study for a number of reasons. Uranium has the potential to be chemically toxic near mining and processing facilities, and the decay-chain radionuclides can contribute substantially to radiation dose, mobility of U in soil, uptake by plants and ecotoxicity of U near a U refining facility. Because of the presence of co-contaminants, were high enough compared to natural and background sites (Sheppard et al 2005). The present study, indicate that TF of the three radionuclides increase with the increase of radionuclides in soil i.e. TF is function of radionuclide level in

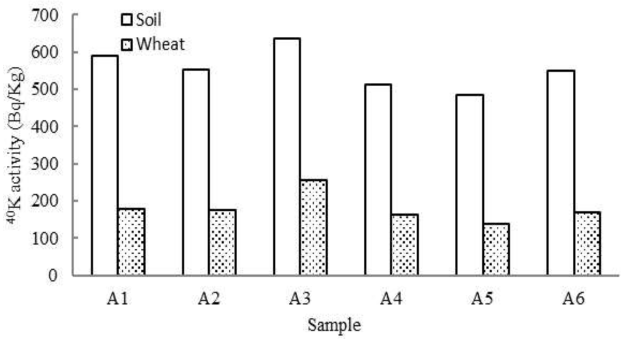

Fig. 6. Potassium concentration of Al-Tawaitha soil

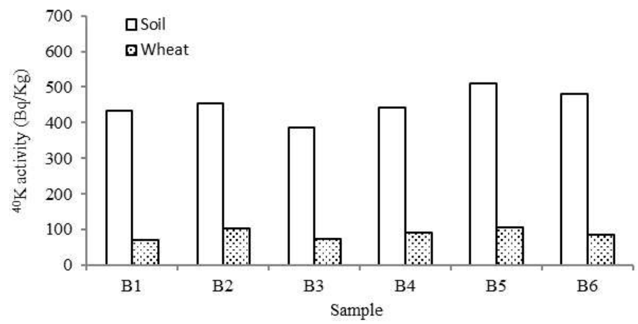

Fig. 7. Potassium concentration of Al Gherai'at soil

Table 1. Transfer factor in the Altuwaitha and Al Gherai'at locations

	Transfer factor (TF) from soil to plant			$Lsd_{0.05}$=0.025 Overall means of elements at each two soils
	Altuwaitha Location			
Samples	Uranium	Thorium	Potassium	
A1	0.188	0.078	0.305	[a]0.202±0.106
A2	0.151	0.065	0.319	
A3	0.148	0.073	0.403	
A4	0.163	0.136	0.320	
A5	0.278	0.098	0.288	
A6	0.235	0.083	0.306	
Means	0.194[a]±0.052	0.089[a]±0.026	0.324[a]±0.041	
	Al Gherai'at location			
B1	0.088	0.038	0.163	[b]0.107±0.067
B2	0.065	0.039	0.225	
B3	0.060	0.052	0.195	
B4	0.088	0.055	0.205	
B5	0.090	0.044	0.208	
B6	0.098	0.046	0.175	
Means	0.082[b]±0.015	0.046[b]±0.007	0.195[b]±0.023	
$LSd_{0.05}$	0.049	0.024	0.041	
Overall means of (TF) for each element at two soils CD (p=0.05) =0.035	0.138[b]±0.069	0.067[c]±0.029	0.259[a]±0.074	

soil. The results showed a significant difference in the natural radionuclides transfer factor ^{238}U, ^{232}Th and ^{40}K between the soil and the yield of the two locations. The average of transfer factor for ^{238}U, ^{232}Th and ^{40}K radionuclides in Al-Tuwaitha location was 0.194, 0.089 and 0.324 respectively, while the value TF in Al Gherai'at for ^{238}U, ^{232}Th and ^{40}K radionuclide was 0.082, 0.046 and 0.195, respectively. The transfer factor of ^{238}U, ^{232}Th, and ^{40}K for wheat crop at Al-Tuwaitha location was 57, 51.6 and 60.2% respectively, higher than that Al Gherai'at location.

There was significant difference in the overall mean of the radionuclide transfer factor in both locations for wheat crop. TF of Potassium is 0.259 which is the higher than the other two radionuclides. Uranium and thorium transport factor for wheat crop were 0.138 and 0.067, respectively. The soil to plant transfer factors for ^{40}K was much higher in plants, which might be due to this element being vital in plants. This study showed that activity concentrations of these radionuclides in plants and their plant transfer factors seem to depend on the activity concentrations of the same radionuclides in soil. The results of this study are consistent with Shanthi et al (2012) and Ibikunle et al (2019). Haque and Ferdous (2017) observed that the plant and corresponding soil samples collected was indicate that activity concentrations of ^{40}K were much higher than those of ^{226}Ra and ^{228}Ra in plants due to higher uptake from soils from samples around the Savar research reactor near Dhaka (Bangladesh). The transfer factors for ^{226}Ra, ^{228}Ra and ^{40}K ranged from 0.04 to 0.10, 0.12 to 0.32, and 0.24 to 0.72, respectively. Kritsananuwat et al (2015) evaluated the concentration of ^{238}U and ^{232}Th in soil and plant as well as soil-to-plant TF in four different provinces (nuclear power plants as well as coal fired power plants) and observed that there was a wide variation of TF for the same plant or same species. The overall TF values ranged from $<4.7 \times 10^{-4}$ to 6.8×10^{-2} with a mean of 1.6×10^{-2} for ^{238}U and $<3.7 \times 10^{-5}$ to 5.9×10^{-2} with a mean of 6.5×10^{-3} for ^{232}Th. TFs of ^{238}U were higher than those of ^{232}Th, even though the concentrations of ^{238}U in soils were lower than ^{232}Th. These could be observed in all plants and their relevant soils. This evidence indicates that the low radionuclide adsorption capacity to soil particles leads to relatively high radionuclides uptake by plants.

CONCLUSIONS

The concentration and transfer factor of some naturally radioactive elements from soil to plant for were experimentally estimated. The two location of different history of previous activity with respect to radioactivity of uranium, thorium and potassium were selected for this study. Among the different outcomes of the research the focused was over the concentration for uranium, thorium and potassium in soil and crop at natural and radionuclides polluted area. Level of specific radioactivity of ^{238}U, ^{232}Th and ^{40}K radionuclide were less than the permissible dose (1 mSv per year) according to the International Atomic Energy Agency (IAEA) standards. In nuclear activity zones (Al-Tuwaitha location) the average of transfer factor for uranium, thorium and potassium was 0.194, 0.089 and 0.324, respectively. In Al Gherai'at location, average TF of the three nuclides for what crop were 0.082, 0.046 and 0.195, respectively. The average transfer factor of all study radionuclide percentage in Al-Tuwaitha location increase 47% than Al Gherai'at location. Specific radioactivity of ^{238}U, ^{232}Th and ^{40}K radionuclides in Al-Tuwatha contaminated area was significantly higher than that of uncontaminated arable land. Specific radioactivity in soils of both locations was higher than that in plant. TF for wheat crop in both locations increased with increase of specific radioactivity in soil and to increase with the plant need of the element.

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Detection of Air Pollution of Road Origin by a Bio-accumulating Plant Species (*Pinus halepensis*) and Evaluation of the Concentrations of Heavy Metals in Western Algeria

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Abstract: The study was conducted to observe air pollution and evaluation of the concentrations of heavy metals by using a bio-accumulating plant species Aleppo pine *(Pinus halepensis*). Analyses of heavy metals in the needles and litter of Aleppo pine, revealed seven heavy metals (Cd, Cr, Cu, Fe, Ni, Pb and Zn) at both study sites (an urban site, Bosquet forest and a rural site located in a Telagh gas station). Each of them is divided into three sampling areas in the Sidi-Bel-Abbès in Algeria. The urban site is less polluted than the rural site. The areas exposed to road traffic in each of the two sites have a higher degree of heavy metal contamination than the other sampling areas. The pine litter accumulates more heavy metals than pine needles. The high concentrations of heavy metals recorded at the two sampling sites show that traffic and road infrastructure is a major source of heavy metals that are toxic to the environment. Lead, iron and zinc, the main metallic pollutants come from exhaust fumes, wear of brake linings, tires and corrosion of guardrails, are present in high concentrations in both sites.

***Keywords*:** Aleppo pine, Bio accumulation, Heavy metals, Road traffic pollution, Western Algeria

Among the main pollutants generated by activities related to car traffic, heavy metals such as Cu, Pb, Cr etc. are of particular concern. Indeed, these elements, by nature non-biodegradable, present a strong ecotoxicity and could be involved in many pathologies. Rapid industrialization and road traffic in urban areas reduce air quality by emitting heavy metals. Human exposures to particulate matter emitted by motor vehicles include complex mixtures of metals. Traffic emits heavy metals in the form of exhaust emissions, but also through releases related to the deterioration of vehicle components such as tires, catalytic converters and brakes (Zereini et al 2012). Air pollution is caused by high density due to road traffic (Gupta et al 2019). Several researchers have shown that sensitive plants react as true bio-indicators of pollution. This bio-monitoring technique uses plant organisms that can store pollutants in their tissues or on their surfaces through fixation and transfer mechanisms. The measurement of pollutant levels in these sensitive plants makes it possible to detect the degradation of air quality before it severely affects the biotope or man. Plants considered sensitive are used as bio-indicators to monitor the stress generated by air pollution (Rupa and Venkatachalam 2018). The evaluation of heavy metal emissions from motor vehicle traffic is the objective of this work. It provides a better understanding of these emissions, whose deposition is harmful to the environment and humans through a plant species used as a bio-accumulator of airborne heavy metal contamination from road traffic. Heavy metal emissions from road traffic are mainly in the form of fine particles that are then collected by leaf surfaces (Sulaiman and Hamzah 2018). Samples of Aleppo pine *(Pinus halepensis*) needles and litter were used for the determination of concentrations of heavy metals such as chromium, nickel, lead, copper, zinc, iron and cadmium at an urban site in Sidi-Bel-Abbès and a rural site in a gas station in Telagh.

MATERIAL AND METHODS

Description of the site: The study area includes the town of Sidi–Bel-Abbes and a service station on the national road linking Sidi-Bel-Abbes to Telagh (Fig. 1). It is located in Western Algeria characterized by a Mediterranean climate of the semi-arid type with an average annual rainfall of 350 mm with a rainfall regime of the HPAE type. The study area is characterized by very dense and elevated road traffic all year round, inducing particles, dust and organic complexes from vehicles. The urban space of study selected is called the Bosquet (Fig. 2), and is a forest that extends over an area of

3.5 ha with a plantation of Aleppo Pines with an average age of 35 years, located along the ring road of the city of Sidi-Bel-Abbes. This area is in contact with a very busy road infrastructure whose average traffic per hour is of the order of 7,000 for light vehicles and 600 for heavy goods vehicles between 8:00 and 10:00 am; between 11:00 and 1:00 pm it is 3,000 light cars and 240 for trucks.

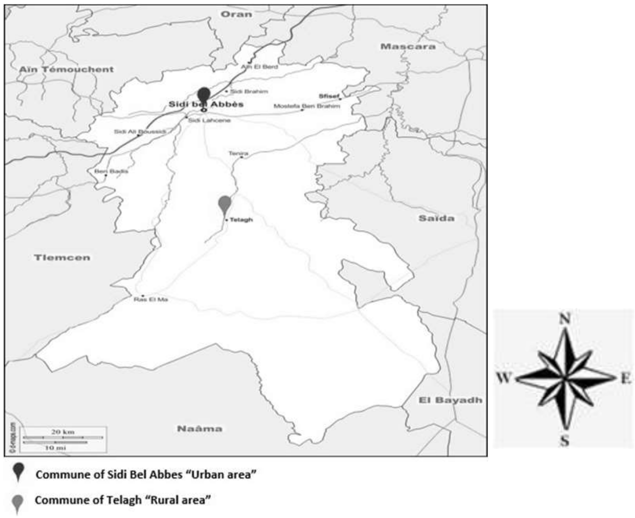
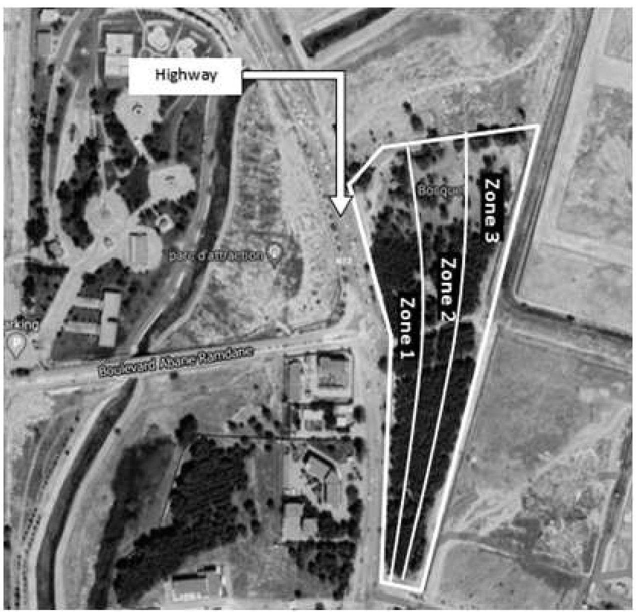


Fig. 1. Experimental sites



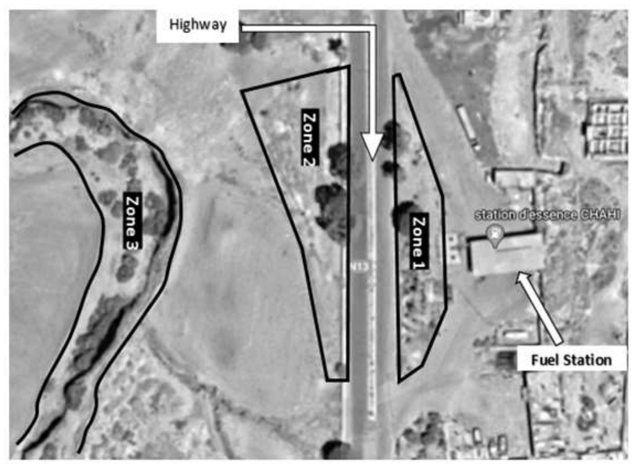
Sites	Sampling zones	Geographic coordinates
Urban area "The Bosquet forest"	Zone 1	Latitude 35.193606° Longitude -0.606898° Elevation. 473 m Altitude 1.07 km
	Zone 2	Latitude 35.193731° Longitude -0.606617° Elevation. 473 m Altitude 1.07 km
	Zone 3	Latitude 35.193773° Longitude -0.606311° Elevation. 473 m Altitude 1.07 km

Fig. 2. Location of the 3 sampling areas at Urban area "The Bosquet forest (Regional Institute of Cartography of Sidi-Bel-Abbès)

For the rural area, they are plants of alignment in Pins d'Alep at the level of the gas station CHAHI (Fig. 3). The latter extends over an area of 5700 m^2 and operates between 5:00 am and 10:00 pm. It is located on the national road linking Sidi-Bel-Abbes to Telagh. The average traffic according to our observations is about 3,000 light vehicles and 500 heavy trucks per hour between 8h00 and 10h00, and about 1,500 light vehicles and 700 heavy trucks per hour between 11h00 and 13h00.

Plant sampling: Needle samples were collected from Aleppo pine trees and samples of litter under the trees at both sites. Each site has been divided into 3 different zones to assess the degree of heavy metal contamination from road traffic. For the chemical analysis, 200 grams of needles and 200 grams of litter were collected for each zone. The 12 samples collected were kept in airtight bags and labeled for analysis.

Extraction method: All media and equipment used for the



Sites	Sampling zones	Geographic coordinates
Rural area "Telagh gaz station"	Zone 1	Latitude 34.795789° Longitude -0.571756° Elevation. 868 m Altitude 1.13 km
	Zone 2	Latitude 34.795793° Longitude -0.572118° Elevation. 865 m Altitude 1.13 km
	Zone 3	Latitude 34.795845° Longitude -0.572876° Elevation. 859 m Altitude 1.13 km

Fig. 3. Location of the 3 sampling areas at the service station in Télagh (Regional Institute of Cartography of Sidi-Bel-Abbès)

analyses were washed with distilled water, then soaked in HNO_3, rinsed with distilled water and dried in an oven. The needles were separated from their supports and dried in a filtered air oven for 4 days at a temperature of 40°C without any treatment and then ground to a powder with an agate mortar. The analytical protocols used are based on ICI (Inter-Institute of Analytical Techniques) methods and dry mineralization was used for Cd, Cu, Fe, Ni, Pb, Cr and Zn. The solution of the metallic elements is carried out on a 1 g ground sample, then the procedure applied: calcination at 420°C for 4 hours in an oven, then recovery of the ashes with 5 ml of HNO3 65%, let evaporate for 3 minutes, then add 10 ml of HNO3 50%. Filtration is then carried out for 24 hours on filter paper (10µm). Six solutions are prepared for each site (3 solutions for the pine needles Zone1, 2, 3and 3 solutions for the litter needles Zone1, 2, 3in total 12 solutions are prepared. A blank control solution of 65% HNO_3 and distilled water was prepared in the same way as the 12 solutions mentioned above.

Elements analyzed: The metals sought in the samples Cd, Cr, Cu, Fe, Ni, Pb and Zn are subjected to analysis by flame atomic absorption spectroscopy (FAAS, Rayleigh WFX-130BAAS). An air/acetylene flame was used for the excitation of the metal atoms and specific lamps for each metal were used for the detection of each element. The limit of quantification of pollutants in plants is, according to the –method used: 0.01, 0.05, 0.13, 0.045, 0.03, 0.1 and 0.007 mg $kg^{-1}$for Cd, Cr, Cu, Fe, Ni, Pb and Zn, respectively.

RESULTS AND DISCUSSION

Concentrations of Zn, Pb, Fe, Cu, Ni, Cr and Cd in Zone 1 are higher in the rural site. Nevertheless, the concentration of lead remains the highest in this zone. Pb and Zn concentrations indicate the presence of contamination from road traffic (Duong and Lee 2011). Belhadj (2009) in the region of Sidi-Bel-Abbes, suggests for Aleppo pine a lead fluctuation between 1.66 and 5.65 ppm due to automobile traffic. For zinc content, it fluctuates between 122 and 266 ppm, for copper between 0.05 and 0.95 ppm. The lead contamination is highest in the zone1 at the rural (462.3 mg kg^{-1}) and urban (398.6 mg kg^{-1}) sites (Tables 2-4). Christoforidis and Stamatis (2009) reported, the primary source of lead is vehicle exhaust emissions, which still use leaded gasoline. That the heavy metal concentrations in zones 1, 2, 3 of the urban site are relatively lower than those observed in zones 1, 2, 3 of the rural site, which is located near the service station (Tables 2-5). Furthermore, when comparing the different sampling zones for pine needles and litter at the urban and rural sites, Zone 1 is the richest in heavy metals, followed by Zone 2 and then Zone 3. The main metallic pollutants emitted, including lead, zinc and iron, are mainly present in exhaust gases and in brake linings (75% of the lead contained in gasoline is emitted in engine exhaust gases), but zinc is also present in tires, lubricants and especially in guardrails (Musilova 2016).The same results are reported by Christoforidis and Stamatis (2009).

A total of 1155.60 mg $kg^{-1}$and 1387.01 mg kg^{-1} were recorded for needles for the urban and rural sites,

Table 1. Distribution of sampling areas in the two study sites

Sampling areas	URBAN Site "Forest of the Bosquet of Sidi-Bel-Abbès " Fig. 2	RURAL Site "Telagh gas station " Fig. 3
Zone 1	Close to the highway	Close to the freeway and in thepetrol station
Zone 2	30m from the highway	Close to the highway At 2 m from the highway 16 m from the gasstation
Zone 3	At 60 m from the highway	At 15 m from the highway 31 m from the gas station

Table 2. Concentrations of heavy metals in the Aleppo pine needles in the Bosquet of Sidi-bel-Abbes (mg kg^{-1})

Metals	Zone 1	Zone 2	Zone 3	Average
Fe	375,00	274,30	232,00	293,77
Cu	146,00	93,60	74,20	104,60
Ni	77,20	32,70	24,20	44,70
Pb	398,10	310,00	267,70	325,27
Zn	362,00	122,10	123,40	202,50
Cd	32,00	25,70	11,00	22,90
Cr	221,80	153,00	110,80	161,87
Total	1612,10	1011,40	843,30	1155,60

Table 3. Concentrations of heavy metals in the Aleppo pine litter in the Bosquet of Sidi-bel-Abbes (mg kg^{-1})

Metals	Zone 1	Zone 2	Zone 3	Average
Fe	385,30	345,50	298,50	343,10
Cu	213,10	200,50	227,20	213,60
Ni	92,30	197,20	197,30	162,27
Pb	405,70	378,70	351,60	378,67
Zn	370,00	310,20	256,00	312,07
Cd	157,00	114,10	111,30	127,47
Cr	244,70	209,40	246,90	233,67
Total	1868,10	1755,60	1688,80	1770,83

respectively. Concentrations in litter were 1770.83 and 2110.40 mg kg^{-1} for the urban and rural sites, respectively indicating that all heavy metals were present in high proportion. The total comparative difference between the needles in the urban and rural site was + 231.40 $mgkg^{-1}$ and for the litter was + 339.57 mg kg^{-1} (Table 6). This increase in concentration at the rural site is justified by the heavy traffic and parking at the service station. The flow of vehicles inducing a disturbance of the fine particles and their uplift as well as the combustion discharges also act on this strong consultation. The litter contains many more heavy metals than the Pine needles at the sites Bosquet Forest and the Telagh gas station.

The classification of heavy metals according to their concentrations in descending order at the two study sites: For the Urban site Pb> Fe> Zn> Cr> Cu> Ni> Cd, and for the Rural site Pb> Fe> Zn> Cu> Cr> Ni> Cd. Cr enriched road dust from our urban site has higher total concentrations than our rural site. Apeagyei et al (2011) observed that urban road dust was significantly enriched in Cr compared to rural road dust**.** Athanasopoulou and Kollaros (2016) observed that total heavy metal concentrations in road dust came mainly from highways**.** With vehicles traveling at 80 km/h, heavy metal levels in road dust were much higher than those emitted by vehicles traveling at 50 km/h (Duong and Lee 2011). The major sources of Ni were determined to be diesel

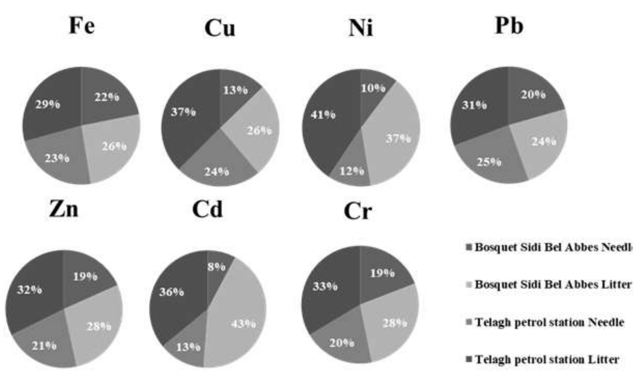


Fig. 4. Percentage representation of each metal in Aleppo pine needles and its litter at the two study site

Table 4. Concentrations of heavy metals in Aleppo pine needles at the Telagh gas station (mg kg^{-1})

Metals	Zone 1	Zone 2	Zone 3	Average
Metals	Zone 1	Zone 2	Zone 3	Average
Fe	402,00	290,50	245,30	312,60
Cu	212,40	200,60	166,80	193,27
Ni	70,00	47,00	39,40	52,13
Pb	462,30	387,20	325,60	391,70
Zn	366,10	199,50	136,00	233,87
Cd	45,00	40,00	28,00	37,67
Cr	196,80	176,50	124,00	165,77
Total	1754,60	1341,30	1065,10	1387,01

Table 5. Concentrations of heavy metals in Aleppo pine litter at the Telagh gas station (mg kg^{-1})

Metals	Zone 1	Zone 2	Zone 3	Average
Fe	427,00	400,50	352,00	393,17
Cu	356,30	312,30	253,30	307,30
Ni	103,10	211,80	218,00	177,63
Pb	524,50	533,70	399,80	486,00
Zn	400,20	382,00	288,00	356,73
Cd	89,60	109,70	117,40	105,57
Cr	319,00	289,00	244,00	284,00
Total	2 219,70	2 239,00	1 872,50	2 110,40

Table 6. Summary of heavy metal concentrations results "mg kg^{-1}" at the two study sites

Metals	Sidi-Bel Abbes Bosquet		Telagh gas station		Deviations	
	"Urban site		" Rural site "			
	Needle	Litter	Needle	Litter	Needle	Litter
Fe	293,77	343,10	312,60	393,17	+ 18.83	+ 50.07
Cu	104,60	213,60	193,27	307,30	+ 88.67	+ 93.70
Ni	44,70	162,27	52,13	177,63	+ 7.43	+ 15.36
Pb	325,27	378,67	391,70	486,00	+ 66.43	+ 107.33
Zn	202,50	312,07	233,87	356,73	+ 31.37	+ 44.66
Cd	22,90	127,47	37,67	105,57	+ 14.77	- 21.90
Cr	161,87	233,67	165,77	284,00	+ 3.90	+ 50.33
Total	1155,60	1770,83	1387,01	2110,40	+ 231.40	+ 339.57

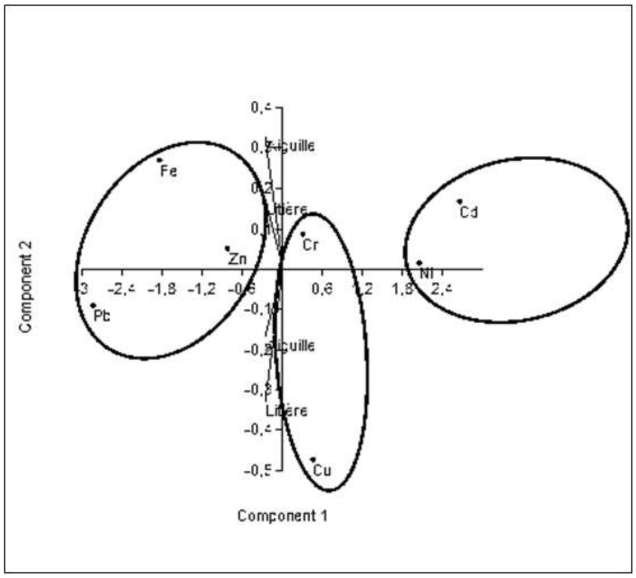


Fig. 5. Results of the analysis of the main components between the heavy metal content of pine needles and litter at the urban and rural site level

emissions, brake abrasion and vehicle corrosion. Cu was mainly derived from brake abrasion and combustion exhaust. Zinc concentration was influenced by vehicle emissions and tire wear (Duong and Lee2011). Copper in street dust may be a result of wear and tear on automobile engines, while tire wear and lubricating oils are possible sources of zinc and cadmium. Exposure to halogen and pollutant emissions from motor vehicle traffic is detrimental to human health and associated with an increased risk of respiratory disease (Hirshon et al2008).Al-Sarraj and Jankeer (2020), concluded that the toxic activity of various pollutants such as lead and cadmium lead to the inhibition of the activity of the enzyme acetylcholinesterase (AChE) in the brains of local fish.

Principal component analysis: The principal component analysis (PCA) based on the 7 variables (Table 6, Fig. 5) yielded three groups of correlation. On the factorial level (F1/F2), the F1 axis brings the most information in the PCA (F1= 97.90% inertia) compared to the F2 axis (F2= 1.42%), F1 separates the samples according to their chemical element content. These axes show a good distribution and representation of the studied variables. The F1 axis is expressed by the presence of Cd, Ni, Cr in the positive direction and Fe, Pb, Zn in the negative direction. The F2 axis is constituted by Cu in the negative direction.

Group 1: is located on the negative side of the F1 axis andis represented by pine needles and litter. It is mainly composed of iron (Fe) (-1.8277), lead (Pb)(- 2.8177) and zinc (Zn) (-0.82645).

Group 2*:* is located in the positive part of the F1 axis and part of the negative side F2 and is represented by needle and litter, it mainly includes Chromium (Cr)(0.30983) and Copper (Cu) (- 0.47657).

Group 3: is located in the positive part of the F1 axis, it mainly includes cadmium (Cd) (2.6556) and nickel (Ni) (2.0425). This grouping is dominated by heavy metals from air pollution, which highlights metal pollution of anthropogenic origin related to road activities.

CONCLUSION

The quantities of pollutants accumulated by plants are analyzed and quantified to allow a relative estimate of air quality. This correlation gives good assessments of the impact of air pollution on plants. The results obtained can be classified in the concept of plant bio-monitoring, they also aim at improving knowledge in the field of air pollution to assess air pollutants related to road traffic. Evaluation of the impact of automobile traffic on the air through vegetation at the two sites in the western region of Algeria (Sidi-Bel-Abbes and Telagh) resulted in a significant presence of heavy metals (Zn, Pb, Fe, Cu, Cd, Cr and Ni) in Aleppo pine needles and its litter. Road traffic is an important source of heavy metals for the environment. Aleppo pine is a very good accumulator of heavy metals. The litter accumulates more heavy metals compared to pine needles. The areas exposed to road traffic were more polluted . The rural site is more polluted than the urban site due to the presence of a service station containing the lubricants and has very frequent heavy truck traffic throughout the year. This study confirmed that plant species can act as bio-accumulators of airborne contamination. These biological methods contribute to an assessment of health risks by plants because they allow better identification of areas potentially exposed to air pollution. There is need to reduce polluting emissions from road traffic by renewing the vehicle fleet, improving engine combustion control, using less polluting fuels and extending green spaces.

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Comparative Evaluation of Ecotoxicity of Different Chemical Compounds of Bismuth by Dehydrogenases Activity of Soils

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Abstract: The effect of bismuth oxide, carbonate and nitrate 1.5, 3, 15, 30, 150 and 300 mg kg^{-1} on the activity of soil dehydrogenases was studied. The results of a comparative assessment of the ecotoxicity of different chemical forms of bismuth by the activity of dehydrogenases under contamination with chernozem ordinary (Haplic Chernozems Calcic), brown forest soil (Haplic Cambisols Eutric) and sierosands (Haplic Arenosols Eutric) are presented. It has been established that, regardless of the chemical form of the compound, contamination of soils with bismuth leads to a decrease in the activity of soil dehydrogenases. Based on the form of the chemical compound of bismuth, the averaged series of toxicity of bismuth for soils according to the activity of dehydrogenases is: bismuth nitrate (67) > bismuth carbonate (77) ≥ bismuth oxide (78). When comparing the resistance of soils by the activity of dehydrogenases to bismuth pollution, the following series was obtained: ordinary chernozem (83) > sierosands (73) > brown forest soil (66). The established sequence is determined by the genetic properties of the studied soils: particle size composition, the reaction of the soil environment, the content of organic matter, and the biological activity of the soils.

***Keywords**:* Bismuth, Enzymatic activity, Pollution, Ordinary chernozem, Sierosands, Brown forest soil

Soil pollution with heavy metals is a serious problem in all countries of the world (Alloway 2010, Suman et al 2017, Vodyanitskii 2010). Among heavy metals, bismuth is characterized by a low content in the Earth's crust (Kabata-Pendias and Pendias 2010). However, in modern technologies, bismuth is use along with nitrogen, carbon and chlorine (Kasimov and Vlasov 2012). The use of bismuth is growing every year (Cortada et al 2012, Minghuang et al 2015, Wei et al 2011, Xiong et al 2015). The widespread use of bismuth increases its total content in the soil, and as a result, the concentration of bismuth in the soil can reach 930-1891 mg kg^{-1}, (Elekes and Busuioc 2010). The results of the study showed a negative effect of bismuth on bacteria (Murata 2006), soil fauna (Omouri et al 2018), iron transport in microbial cells (Nagata 2015), enzymatic activity and cytotoxic effect of mammalian cells (Reus et al 2018, Shakibaie et al 2018). The Bi^{3+} inhibits urease activity by interacting with the plant cysteine residue (Zhang et al 2006). The most sensitive indicator of chemical contamination of soils with heavy metals are redox enzymes – activity of dehydrogenases (Kolesnikov et al 2020). Dehydrogenases are synthesized by soil microorganisms and plants that contain thiol (SH), carboxyl (COOH) and hydroxyl (OH) groups. The bismuth has a high affinity for these functional groups and causes inhibition of enzymes (Murata 2006). At the same time, the effect of different chemical compounds with bismuth in comparison with other heavy metals (Daud et al 2019) on the enzymatic activity of soils remains poorly understood. The aim of this study is to carry out a comparative assessment of the ecotoxicity of various chemical compounds of bismuth by the dehydrogenases activity of soils.

MATERIAL AND METHODS

Soil samples: The objects of this study used soils of the South of Russia – chernozem ordinary (Haplic Chernozems Calcic), brown forest acidic soil (Haplic Cambisols Eutric), sierosands (Haplic Arenosols Eutric) – sandy chernozem soils zones of the south of the European part of Russia. These soils have different particle-size composition, significantly differing in genetic properties that determine resistance to pollution with heavy metals. Ordinary chernozems are highly humified soils and are used for sowing agricultural crops. The characteristics of chernozems include: a high species diversity of soil microorganisms, high indices of enzymatic activity, a neutral reaction of the soil environment, and a heavy particle-size composition (Val'kov et al 2008). Brown forest soils have an acidic environment, have lower biological characteristics, in comparison with ordinary chernozem. Brown forest soils are characteristic of the forests of the Caucasus foothills. Seropeski are widely represented in the steppe regions. These soils are classified as poorer in humus content. A low number of microorganisms and low activity of soil enzymes are characteristic of sierosands. Chernozems and brown forest soils occupy a significant share of the soil cover in the world and play a huge role in providing humanity with food.The characteristics of the genetic properties of soils and sampling sites are presented in Table 1.

Experimental details: To conduct modelling experiments soil samples were taken from the top soil layer (0-10 cm), because major contaminants including heavy metals are generally held in the top layer (Kabata-Pendias and Pendias 2010). The bismuth content in soils was determined by inductively coupled plasma mass spectrometry (ICP-MS). The background content of bismuth in the objects of study is: in ordinary chernozem it is 0.27 mg kg^{-1} brown forest soil - 0.28 mg kg^{-1}, sierosands - 0.14 mg kg^{-1}. Information in what forms bismuth accumulates in the soil was not found. In this regard, oxides, nitrates and carbonates of this metal were studied. Most of the heavy metals in the soil are found in these forms of chemical compounds (Kabata-Pendias and Pendias 2010).

Measurement technique: The determination of the biological properties of soils was carried out 10 days after contamination. A longer incubation period increases the difference in the state of the soil incubated in the laboratory from its state in natural conditions. The simulation of the experiment on soil pollution was carried out in laboratory conditions using methods generally accepted in soil biology and ecology (Kazeev et al 2016). The analysis was carried out in triplicate - bismuth oxide Bi_2O_3, bismuth carbonate $(BiO)_2CO_3$, bismuth nitrate $Bi(NO_3)_3$ in different concentrations - 1.5, 3, 15, 30, 150 and 300 mg kg^{-1}. Bismuth (III) compounds were studied, since the trivalent state of bismuth is the most stable in nature (Egorysheva et al 2015). Considering the solubility of the compounds, the introduction of bismuth oxide, carbonate and nitrate into the soil was different. Bismuth nitrate was dissolved in water and added to the soil during the first single irrigation. Bismuth oxide and bismuth carbonate were ground with a low amount of dry soil, and then thoroughly mixed with the rest of the soil of the incubation vessel, after which watering was carried out.The soil (0.5 kg) was incubated at optimum humidity (60% of the field moisture capacity) and a temperature of 20-22 °C in three replicates.

Dehydrohenases activity: The activity of dehydrogenases was taken into account according to the rate of conversion of triphenyltetrazolium chloride to triphenylformazan, mg of TPF per 10 g of soil 24 hours after incubation of soil samples for 10 days at optimal temperature and humidity (n = 36: 3 growing vessels with soil in 3 biological replicates x 4 analytical replicates). To determine the activity of soil dehydrogenases, the colorless tetrazolium salt – 2,3,5-triphenyltetrazolium chloride, which is reduced to the red formazan compound – triphenylformazan - TPF, is most often used as a substrate. To determine the potential dehydrogenases activity, a dehydrogenation substrate as 0.1 M glucose solution was used. The analysis of the actual activity is carried out without dehydrogenation substrates. A weighed portion (1 g) of the prepared soil is carefully placed through a funnel on the bottom of a test tube with a capacity of 12-20 ml, and mixed thoroughly. Add 1 ml of 0.1 M glucose solution (18 g of glucose is dissolved in 1000 ml of distilled water) and 1 ml of a freshly prepared 1% solution of 2,3,5-triphenyltetrazolium chloride. The tubes are placed in an anaerostat or vacuum desiccator. The determination is carried out under anaerobic conditions, for which the air is evacuated at a discharge of 10-12 mm Hg for 2-3 min and put in a thermostat for 24 hours at 30°C. The control is sterilized soil (at 180°C for 3 hours) and substrates without soil. After incubation, add 10 ml of ethanol to the flasks, shake for 5 min. The resulting colored TPF solution was filtered and colorimetric analysis on PE 5800. We used 10 mm cuvettes and a light filter with a wavelength of 540 nm. The amount of formazan in mg is calculated from the standard curve (0.1 mg in 1 ml). The activity of dehydrogenases is expressed in mg of TPF per 10 g of soil in 24 hours (Kazeev et al 2016).

Statistical analyses: To check the reliability of the results, an analysis of variance was carried out followed by the determination of the least significant difference (LSD). Variation statistics (mean values, dispersion) was determined, reliability of different samples was established by using dispersion analysis (Student-t) and the correlation analysis (Pearson correlation coefficient) was conducted.

Table 1. Characteristics of soil genetic properties and soil sampling areas

Soil type	Particle-size composition	Sampling area	Geographical coordinates	Ecosistem type	Humus content (%)	pH
Chernozem ordinary (Haplic Chernozems Calcic)*	HL	The Botanical Garden, Southern Federal University, Rostov-on-Don	47°14'17.54"N 39°38'33.22" E.	arable land	3.7	7.8
Sierosands (Haplic Arenosols Eutric)*	SL	Rostov Region, Ust'-Donetskiy district	47° 46.015' N 40° 51.700' E.	grass and cereal steppe	2.3	6.8
Brown forest acidic soil (Haplic Cambisols Eutric)*	HL	Republic of Adygea, Nickel settlement	44° 10.649' N 40° 9.469' E	hornbeam and beech forest	1.8	5.8

Note
[1]According to IUSS Working Group WRB (2015)
[2]HL - heavy loam
[3] SL - sandy loam

RESULTS AND DISCUSSION

Changes in the activity of dehydrogenases in ordinary chernozem when contaminated with bismuth: For ordinary chernozem, under the influence of low doses of bismuth oxide and carbonate (1.5 and 3 mg kg^{-1}), an statistically unreliable stimulation of the indicators of dehydrogenases activity was noted. Similar results were obtained by Scryabin (2016) when exposed to 2.8 and 5.6 mg kg^{-1} of nanoparticles bismuth on wheat seedlings. At a dose of 15 mg kg^{-1} of bismuth in the soil, inhibition of the activity of dehydrogenases by 16 and 18% was found when bismuth carbonate and nitrate were added, respectively. With an increase in the concentration of bismuth to 30 mg kg^{-1}, inhibition of the activity of dehydrogenases by 21 and 29% for bismuth carbonate and nitrate was also observed. When high doses of bismuth (150 and 300 mg kg^{-1}) are introduced into the soil, the tendency to inhibition of the activity of dehydrogenases persists for all forms: from 26-29% (bismuth oxide) and 31-34% (bismuth carbonate) to 50% (bismuth nitrate). It has been established that the most toxic compound for ordinary chernozem in terms of dehydrogenases activity is bismuth nitrate (Fig. 1). Oxides, as insoluble compounds of heavy metals, have less toxic effect on the soil than water-soluble metal salts (Kolesnikov et al 2019).

Changes in the activity of sierosands dehydrogenases upon contamination with bismuth: An unreliable stimulation of the activity of dehydrogenases was established for sierosand after the introduction of low doses of bismuth (1.5-3 mg kg^{-1}). With an increase in the dose of bismuth (15-300 mg kg^{-1}), the indicator decreased: by 23-58% - for bismuth oxide, by 14-52% for carbonate, bismuth nitrate reduced the activity of dehydrogenases by 22-61%. Bismuth nitrate, according to the activity of dehydrogenases, turned out to be the most toxic for sierosand (Fig. 2).

Changes in the activity of dehydrogenases in brown forest soil upon contamination with bismuth: The introduction of low doses of 1.5-3 mg kg^{-1} of bismuth oxide and carbonate did not cause a significant decrease in the activity of dehydrogenases. The addition of 1.5 mg kg^{-1} of bismuth nitrate reduced the activity of dehydrogenases by 12%. The introduction of 3 mg kg^{-1} of bismuth nitrate into brown forest soil reduced the activity of dehydrogenases by 40%. Increasing the dose (15-300 mg kg^{-1}) of different forms of bismuth inhibited the activity of dehydrogenases, which is: for bismuth oxide-14-63%, for bismuth carbonate – 12-54%, for bismuth nitrate-51-54%. The high toxicity of bismuth oxide and nitrate was established by the activity of dehydrogenases for brown forest soil (Fig. 3). Murata (2006) established inhibition of dehydrogenases activity for brown

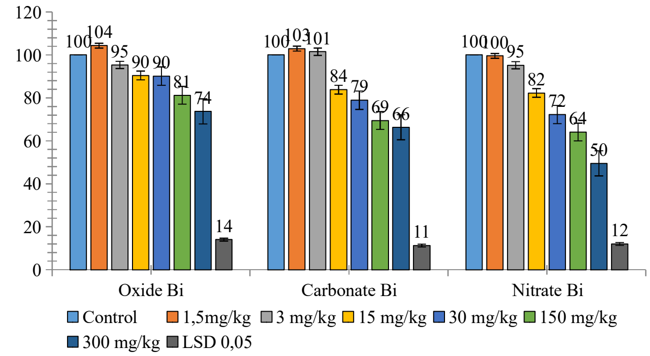

Fig. 1. Changes in the activity dehydrogenases of chernozem ordinary after bismuth contamination, % of the control. Data are means of three replicate biological samples. Error bars show least significant difference (LSD) at p ≤ 0.05 level

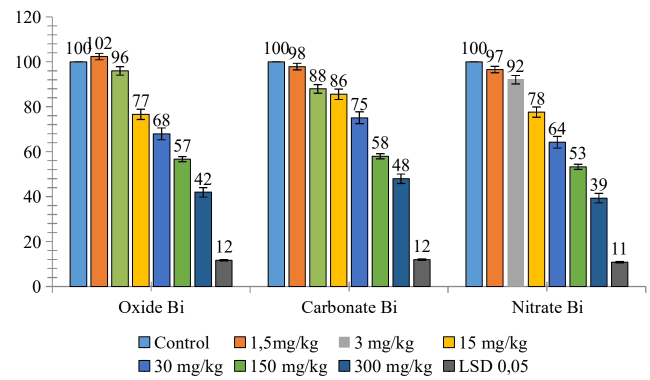

Fig. 2. Changes in the activity of dehydrogenases of sierosands during bismuth contamination, % of the controlData are means of three replicate biological samples. Error bars show least significant difference (LSD) at p ≤ 0.05 level.

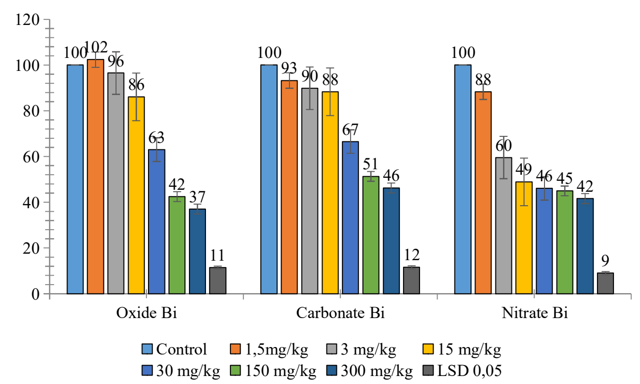

Fig. 3. Changes in the activity of dehydrogenases of brown forest acid soil during bismuth contamination, % of the control. Data are means of three replicate biological samples. Error bars show least significant difference (LSD) at p ≤ 0.05 level

forest soil by thiol (complex compounds of bismuth with amino acids) bismuth compounds when 25 and 50 μM were added from 23.8 to 54% after incubation for 3 weeks.

Assessment of bismuth contaminated biological state in soils: sensitivity values and toxicity forms: The decrease in the values of the activity of dehydrogenases increases with an increase in the applied dose of bismuth to the soil. The change in the activity of soil enzymes is due to their high response to pollution. The ability of bismuth compounds to suppress dehydrogenase activity in brown forest soil may be associated with adsorption by mineral components of the soil, with the formation of oxides or hydroxides. The solubility and lipophilicity of bismuth increases in complex compounds of bismuth with thiol (Murata 2006). Thus, a significant decrease in the activity of dehydrogenases in most cases was observed. Under the influence of low doses of bismuth oxide and carbonate (1.5 and 3 mg kg^{-1}), an statistically unreliable stimulation of the indicators of dehydrogenases activity was noted for the studied soil types. When studying the effect of toxic compounds on living organisms or soil, cases of their stimulating effect in low amounts are known (Kabata-Pendias and Pendias 2010). An exception was bismuth nitrate (1.5 mg kg^{-1}): when introduced into brown forest soil, it inhibited the activity of dehydrogenases by 12%. The greatest toxic effect on the activity of dehydrogenases in the studied soils was observed for bismuth nitrate and carbonate, and the least for bismuth oxide. Based on the chemical form of the pollutant, the average range of the toxicity of bismuth for soils by the activity of dehydrogenases is as follows: bismuth nitrate (67) > bismuth carbonate (77) ≥ bismuth oxide (78). The most bismuth-resistant soil is ordinary chernozem. The high humus content of the soil and the neutral pH values of the soil solution ensure the presence of a sufficient number of microorganisms for resistance to pollutants. Formed the following series of resistance to dehydrogenases activity: ordinary chernozem (83) > sierosands (73) > brown forest soil (66). The least resistant soil to pollution with various forms of bismuth chemical compounds is brown forest soil. Analogouses results were obtained by Tsepina et al. (2020) when studying the effect of silver pollution on the activity of soil dehydrogenases in the South of Russia. With an increase in the applied dose of silver nitrate to the soil, the activity of dehydrogenases in brown forest soil decreased more intensively (by 21-58% of control) than in ordinary chernozem (by 10-56%) and sierosands (by 16-40% of control). The highest resistance of ordinary chernozem and the sensitivity of brown forest soil to contamination with bismuth, as well as with silver, is probably due to the genetic properties of these soil types, which provide resistance to contamination with heavy metals. The light particle-size composition of sierosands and the acidic reaction of the environment of brown forest soils (pH = 5.8), as well as the low content of organic matter (2.3 and 1.8%, respectively), contribute to high mobility, and, consequently, high ecotoxicity of bismuth in these soils. Ordinary chernozem has a high humus content, buffer capacity, high capacity of the soil absorbing complex, and neutral reaction of the environment. Heavy metals, getting into chernozem, pass into immobile and, therefore, low-toxic forms (Kabata-Pendias and Pendias 2010). A wide variety of soil fauna and microorganisms contribute to the transformation of bismuth in sandy soils and an increase in the mobile forms of bismuth compounds (Omouri et al 2018).

CONCLUSIONS

When studying the effect of different chemical forms of bismuth compounds on the activity of dehydrogenases of different types of soils, inhibition of the activity of this enzyme, regardless of the chemical form, was established. The activity of dehydrogenases decreased with an increase in the concentration of bismuth in the soil inversely. The most toxic chemical form of bismuth for soils is bismuth nitrate. The most bismuth-resistant soil is ordinary chernozem. The high humus content of the soil and the neutral pH values of the soil solution ensure the presence of a sufficient number of microorganisms for resistance to pollutants. The least resistant soil to pollution with various forms of bismuth is brown forest soil. This is due to the adsorption of the acidic brown forest soil by mineral components and the formation of bismuth oxides and hydroxides. The toxic effect of bismuth depends on the dose of metal in the soil, the reaction of the soil environment, the humus content and the particle-size composition of the soil.

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Assessment of Microbial Diversity and their Role in Deterioration of Jantar-Mantar, Jaipur, India

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Abstract: The Jantar Mantar is one of the great UNESCO World Heritage site built in the 1720's which collection of nineteen architectural astronomical instruments and also houses the world's largest sundial. In this article, we discussed the microbial diversity and deterioration of the Jantar-Mantar. Microorganism colonizing on monuments produced various organic, inorganic acids, chelating compounds extracellular polymers and pigments due to the metabolic activities. These excreted products further alter, damage, discoloration and dissolution of the material of the monument. In this study, a total of 92 bacterial and 82 fungal colonies was identified among them *Pseudomonas aeruginosa* and, *Aspergillus niger* most abundant one. Further, the isolated bacteria and fungi with the help of FE-SEM analysed the degenerative potential also. This study helps to find the culturable biodeteriogens mainly bacteria and fungi which excreted most of enzymes, acids and pigments to deteriorate the site and appearance. This study also helps to plan a strategy to maintain this heritage site and for providing a healthy environment for people who come to visit and admire the beauty of Jantar-Mantar and other monuments.

Keywords: Biodeterioration, Bacteria, Fungi, FE-SEM, Jantar-Mantar

The large proportion of the world's tangible cultural heritage is made from stone, and these are slowly but irreparably disappearing. The change of stone into the soil is a natural recycling process, necessary to sustain life on earth. However, the deterioration of monuments depicts a constant loss of our cultural heritage. Damage to monuments due to microorganisms is generally cited as biodeterioration (Gorbushina and Krumbein 2004). The biological degradation of monuments is well known and has been studied for a long time and is one of the weathering mechanisms responsible for the formation of microbes. The Jantar Mantar is one of the great observations built in the 1720s which combine religion, science and art. It is a UNESCO World Heritage site (UNESCO 2012). Heterotrophic pigmented bacteria (*Micrococcus roseus, Flavobacterium*) (Tiano and Tomaselli 1989) and chemoorganotrophic bacteria (*Bacillus, Arthrobacter, Rhodococcus, Brevibacterium*) (Warscheid and Braams, 2000, Pinna and Salvadori 2008) produced pigments causes bright orange, pink and red stains on deteriorated sites. *Bacillus, Arthobacter* and *Pseudomonas* produced salt efflorescence causes disintegration, powdery appearance, decay and crumbling of plaster. The genus *Bacillus* often identified from monuments (Laiz et al 2003, Ortega Morales et al 2004) and has degradative potential. *Bacillus* isolates produced acids and have the capacity to accelerate deterioration (Kiel and Gaylarde 2006). *Arthrobacter, Bacillus, Paenibacillus, Micrococcus, Staphylococcus* and *Kocuria* genus were found from deteriorated sites (Laiz et al 2002). Fungi such as *Fusarium solani* grow irregular heterotrophic colony with puff due to white fungal mycelia (Bastian and Alabouvette 2009) and bacteria such as *Pseudomonas fluorescens* powdering aspect due to the bacterial sorted colonies (Nugari et al 2008, 2009). Fungi excreted various metabolic substances, acids (oxalic, acetic, citric, and other carbonic acids), pigment and chelating compounds (Tiano 2002, Burford et al 2003). Chelating compounds deteriorate the stone minerals by a solubilizing and chelating effect (Sterflinger 2000). These substances are leading to discoloration, significant aesthetic alterations, and physical stress. Due to fungal activity on monuments oxidation and reduction of mineral cations were triggered (Gadd 2007) and with the redox process, the iron and manganese were removed from the stone lattice (Warscheid and Braams 2000). This exchange of minerals on the stone surface can lead to the formation of patina or crusts, hardening of the surface layer and exfoliation (Tiano 2002). The aim of the study was to characterize the microbes on the surfaces of Jantar-Mantar monuments, with special reference to bacterial and fungal species. In this article, the assessment of the ability of bacterial and fungal communities colonizing stone probes under laboratory conditions.

MATERIAL AND METHODS

Sampling: Sample collection was done from Jantar-Mantar under aseptic conditions without harming the site in November. The Jaipur weather is semi-arid type. The November month average maximum temperature is 29°C, and minimum 13°C and the 601 mm (23.7 inch) is annual average rainfall. From Jantar-Mantar ten samples (Jantar-Mantar Stair's, Jantar-Mantar Stair's Round, Jantar-Mantar Half moon Taurus, Jantar-Mantar Aries, Jantar-Mantar Sagittarius, Jantar-Mantar Ram Yantra A, Jantar-Mantar Ram Yantra B, Jantar-Mantar Digamsha Yantra, Jantar-Mantar Laghu Samrat Yantra and Jantar-Mantar Nadivalaya uttar gola) were collected from deteriorated sites with the help of sterilized cotton swab (Gorbushina et al 2004) and collected in a sterile plastic airtight pouch for further microbial analysis. The adequate amount of sample was collected aseptically with sterilizing tools.

Cultivation of bacteria and fungi: The swab samples were suspended in bottles containing peptone water to shift microbial cells. Afterwards, aliquant part (0.1ml) of that mix was inoculated on respective media (Obidi and Okekunjo 2017) for bacteria (Nutrient agar) media containing Fluconazole to control the fungal growth and fungi (Potato Dextrose Agar/Czapek–Dox agar) media having chloramphenicol as an antibacterial agent. The inoculum was spread to entirely on the plates with the sterile spreader. The fungi plates were incubated at 28 ± 1°C for 3-5days, and bacteria plates were incubated at 37 °C for 24 h (Rojas *et al.* 2012). After incubation, developed and well-defined colonies were routinely sub-cultured on fresh plates of respective media to purify and identified. All tests were carried out in duplicates and stored at 4°C for further use.

Morphological and microscopic observation of bacteria and fungi: The morphological studies were carried out to discover colonies size, shape, elevation and pigmentation (Cheesbrough 2008). The bacterial and fungal colonies show coloration on nutrient agar and potato dextrose agar plates respectively due to pigment production (Rojas et al 2012). To determine microbial viability, microscopic observations were carried out using an optical microscope (Fig. 2). According to Bergey's manual of systematic bacteriology, the isolated bacterium was identified (Krieg and Holt 1984). According to authentic fungal identification keys, fungal isolates were identified morphologically (Raper and Fennell 1965, Ellis and Ellis 1997, Samson et al 2004, 2010).

Biochemical identification tests: The isolated pure, dominated and morphologically different bacterial colonies were carried out conventional biochemical tests (Table 1, 2) like gram staining, motility, catalase, oxidase, coagulase, indole production, MRVP and urease activity. Some additional tests were also included nitrate reduction, citrate utilization, H2S production, starch hydrolysis (Cheesbrough 2008). Subsequently purified fungal isolates were examined by a light microscope as described by Harrigan and Mc Cance (1976). Consequently, all the isolates were identified to the genus level based on their morphology and sporing structures.

Molecular characterization of bacteria and fungi: The DNA isolation was done by using the EXpure Microbial DNA isolation kit from bacterial and fungal pure colonies. Amplification of 16S/18S rRNA was done by using, Forward Primer 27F (5' AGAGTTTGATCMTGGCTCAG 3'), Reverse Primer 1492R (5' TACGGYTACCTTGTTACGACTT 3') and Internal Transcribed Spacer (ITS) primers consisted of ITS-1 (5′-TCC GTA GGT GAA CCT GCG G-3′), ITS-4 (5′-TCC TCC GCT TAT TGA TAT GC-3′) respectively for bacteria and fungi. By using the Montage PCR Clean up kit (Millipore), the amplified genomic DNA was purified and the purified

Table 1. Staining and motility test of isolated bacteria

Isolates	Gram reaction	Motility	Shape
JMS1	+ve	Motile	Rod
JSR2	+ve	Non-Motile	Cocci
JMT3	+ve	Non-Motile	Cocci
JMA4	+ve	Non-Motile	Cocci
JMS5	+ve	Non-Motile	Cocci
JRA6	-ve	Motile	Rod
JRB7	+ve	Non-Motile	Cocci
JDY8	-ve	Motile	Rod
JSY9	+ve	Motile	Rod
JNG10	-ve	Motile	Rod

Fig. 1. Jantar-Mantar of Jaipur, India

Fig. 2. Culuture plate and Microscopic view (400x) of *Aspergillus niger*

products were sequenced commercially (Yaaz Xenomics, Coimbatore, India) to get partial 16S/18S rRNA gene sequences. Afterwards, the sequence was blast using NCBI (National Centre for Biotechnology Information; http://www.ncbi.nih.gov/) blast similarity search tool and Phylogenetic tree was constructed (Figs. 3, 4) by using the program Tree Dyn 198.3 (Dereeper et al 2008).

Analysis of stone sample deterioration by mixed culture isolates: Further to test the degenerative potential of dominant microbial isolates from Jantar-Mantar, an experimental set up was prepared. For this a stone piece was collected from the same environment and wash and autoclave for 121°C (250°F) at 100 kPa (15 psi) above atmospheric pressure for 15 minutes for sterilization (Wiktor et al 2009) and for the record of the condition of the sample, FE-SEM images were taken. FE-SEM mainly used for the surface characterization of materials and depth observation of the field at a higher resolution with the help of a conventional optical microscope. Prepared mixed cultural by mixing bacterial and fungal pure colonies mainly *Fusarium solani, Aspergillus flavus, Aspergillus niger, Aspergillus fumigation* and *Pseudomonas aeruginosa, Escherichia coli, Staphylococcus haemolyticus, Staphylococcus aureus* into 0.9% saline (0.5 McFarland). The stone piece was placed in a pre-sterilized container and sprinkles the sterile water to maintain the moisture. Subsequently, the mixed inoculums poured on the stone piece and closed the lid of that container (Miller et al 2008). This container was placed under natural environment. After every 24 hr sprinkle the sterile water to the stone piece aseptically and after 2 years the degenerative potential of the sample was identified with the help of a field emission scanning electron microscope (FE-SEM).

RESULTS AND DISCUSSION

Isolation of bacterial and fungal isolates: Diverse bacterial and fungal colonies were recovered from 10 samples collected from Jantar-Mantar but the most common colonies which were present on all the samples were processed for further study. Total of 92 bacterial and 82 fungal colonies was identified from which dominated bacterial genera were *Escherichia, Pseudomonas, Paenibacillus, Enterobacter, Proteus, Bacillus, Acidobacter, Clostridium, Micrococcus, Staphylococcus and Streptococcus* and fungal genera *Penicillium, Aspergillus, Fusarium, Rhizopus, Trichoderma, Alternaria, Mucor,* and *Cladosporium*. The isolated bacterial species (Table 3) were *Pseudomonas aeruginosa, Escherichia coli, Staphylococcus*

Table 3. Accession number of samples sequence collected from Jantar-Mantar site

Sample ID	Microorganism	Accession numbers
JRA6	*Pseudomonas aeruginosa*	MN483330
JMS1	*Aspergillus niger*	MN493124

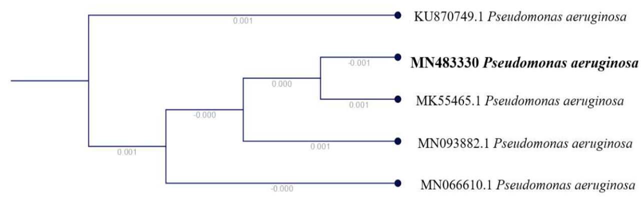

Fig. 3. Phylogenetic trees of JRA6

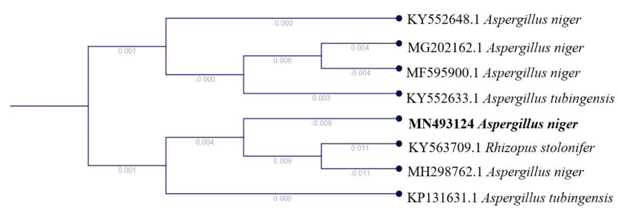

Fig. 4. Phylogenetic trees of JMS1

Table 2. Biochemical tests of isolated bacteria

Isolates	Catalase	Oxidase	Coagulase	Citrate utilization	Indole	Urease	MR(Methyl Red)	VP (Voges Proskauer)	H_2S production	Nitrate reduction	Starch hydrolysis
JMS1	+	+	-	+	-	-	-	+	-	+	+
JSR2	-	-	-	-	-	-	+	-	-	-	+
JMT3	-	-	-	-	-	-	+	-	-	-	+
JMA4	+	+	-	+	-	+	+	-	-	+	-
JMS5	+	-	-	+	-	+	+	+	-	+	-
JRA6	+	+	-	+	-	-	-	-	-	+	-
JRB7	+	-	+	+	-	+	+	+	-	+	-
JDY8	+	-	-	-	+	-	+	-	-	+	-
JSY9	+	+	-	+	-	-	-	+	-	+	+
JNG10	+	+	-	+	-	-	-	-	-	+	-

(+) = presence of species; (-) = absence of species *haemolyticus,* and *Staphylococcus aureus,* and isolated species of fungi (Table 4) were *Fusarium solani, Aspergillus flavus, Aspergillus niger* and *Aspergillus fumigation* selected on the basis of dominance.

Molecular characterization of the isolates: The isolated nucleotide sequences from Jantar-Mantar were deposited in the GenBank (NCBI database) and accession numbers regenerated i.e., JRA 6 (*Pseudomonas aeruginosa*) - MN483330 and JMS1(*Aspergillus niger*)- MN493124.

Analysis of stone sample deterioration by FE-SEM: With the help of a Field emission scanning electron microscope (FE-SEM), the degenerative potential of the sample was identified. The deterioration of stone piece by a mixed culture of bacteria and fungi was exhibited by FE-SEM images (Fig. 5). The FE-SEM images (Fig. 5b-d) reveal the microbial growth, pit formation (with arrow), disintegration (with pointed arrow) and pigmentation on the stone piece. In the FE-SEM image (Fig. 5a) as such, no damage and no microbial growth appeared. These results demonstrated bacteria and fungi both were responsible for the deterioration of Jantar-Mantar and many other cultural heritage sites by aesthetical, mechanical and physical damage. *Pseudomonas aeruginosa* and *Escherichia coli* both found on the Jantar-Mantar site helps in biofilm formation (Laverty et al 2014) and further these bacteria by forming biofilms and excretion organic products and enzymes, provide the nutrient or growth environment for fungi which can cause further deterioration. The chemical and physical changes were due to metabolic products generated by microbes and due to adhesion of microbes and penetration of fungal hyphae respectively (Ascaso et al 2002). These changes result in the dissolution, chelating processes, erosion and the breaking of surface layers (Koestler 2000).

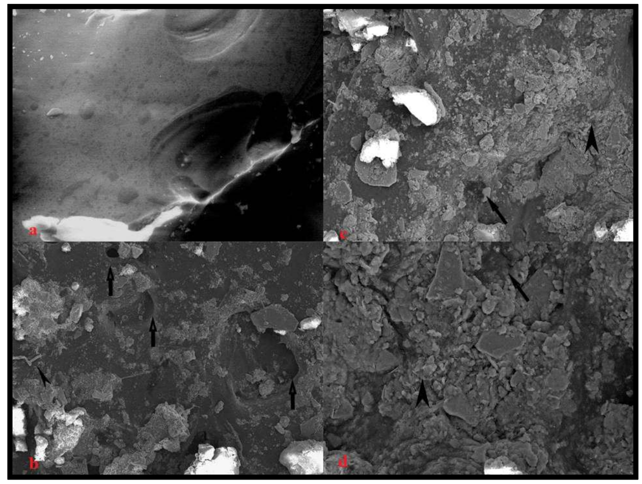

Fig. 5. FE-SEM image (a-d) of biodeterioration of stone piece by mixed inoculums (bacteria and fungi isolates) before (a) and after (b-d)

The composite results indicate that in all the samples of bacteria and fungi each was mainly dominated by *Pseudomonas aeruginosa* and *Aspergillus niger* respectively due to their high percentage relative values. The frequency and relative frequency of microorganism are directly or indirectly related with climatic conditions (Chandel 1990). Study of importance value index of a species in the

Table 3. RF, RD, RA and IVI of different bacterial species into Jantar-Mantar

Isolated bacteria	Number of bacteria colonies										RF %	RD %	RA %	IVI
	JMS1	JSR2	JMT3	JMA4	JMS5	JRA6	JRB7	JDY8	JSY9	JNG10				
Pseudomonas aeruginosa	3	1	7	2	5	2	3	4	1	5	32.25	35.86	28.44	96.55
Escherichia coli	-	3	2	1	3	4	-	3	2	2	25.80	21.73	21.55	69.08
Staphylococcus haemolyticus	3	2	-	-	1	3	-	2	-	1	19.35	13.04	17.24	49.63
Staphylococcus aureus	4	-	3	2	-	5	7	2	-	4	22.58	29.34	32.75	84.67

Table 4. RF, RD, RA and IVI of different fungal species into Jantar-Mantar

Isolated fungal	Number of fungal colonies										RF %	RD %	RA %	IVI
	JMS1	JSR2	JMT3	JMA4	JMS5	JRA6	JRB7	JDY8	JSY9	JNG10				
Aspergillus niger	4	1	2	4	3	2	5	2	3	2	32.25	34.14	26.92	93.31
Aspergillus flavus	3	4	1	-	2	4	2	-	3	1	25.80	24.39	24.03	74.22
Aspergillus fumigation	-	3	2	1	4	-	3	2	-	3	22.58	21.95	24.03	68.56
Fusarium solani	3	-	-	3	-	4	-	1	3	2	19.35	19.35	25	63.86

community provides idea of the relative importance of that species (Ramya et al 2020). FE-SEM images manifest by the analysis of stone piece deterioration that these isolated bacteria and fungi both were responsible for the deterioration of heritage sites. Some of the genera have spore production capacities such as *Pseudomonas*, *Aspergillus* and *Fusarium* (Shirakawa et al 2002). Due to microorganism's metabolic activity, complex biochemical deterioration occurs on the monument substrate (Gorbushina and Krumbein 2004). It involves a bio-corrosion process whereby acidic and pigmented organic and inorganic products are excreted (Sterflinger 2000). Which can etch and stain the object, weakening the matrix of the material, leading to more favourable conditions for further attachment and growth and therefore continuing to add to the degradative process (Dakal and Cameotra 2012)? *Pseudomonas* genera were reported to possess abilities to hydrolyze polymers such as paints and degradation (Cappitelli et al 2007). *Aspergillus* sp. facilitates the discoloration and subsequent structural damage of monument by virtue of their mycelia production (Rolleke et al 1996). These monuments attract a bunch of tourists; hence it is an important aspect of health and maintenance of cultural heritage (Sharmistha et al 2020).

CONCLUSION

Microorganism colonizing on monuments produced various organic, inorganic acids, chelating compounds extracellular polymers and pigments due to the metabolic activities. As the microbes grow, their growing structures exert the mechanical pressure on a substrate such as fungal hyphae. These physical and chemical changes influence different types of damage on monument surfaces. Through chemical and physical processes, the monument alteration occur lead to the increased surface area by the formation of fissures that provide an area for colonization for the more living organism. These alterations are usually indicative of an advanced state of deterioration generated by microorganisms. This study identified the microbial communities present on discoloured painted monument and provides data for a more detailed study of the ecology and physiology of these groups of organism on the cultural heritage of Jaipur.

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Spatial and Vertical Distribution of Sulphur in Acidic Soils of Western Himalayas

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Abstract: Deficiency of sulphur in soil is increasing day by day and it is the present era need to address this problem to achieve the goal of sustainability. In order to study the status of sulphur in acidic soils, the present investigation was carried out in Western Himalayas. Around 500 soil samples were collected randomly from cultivated soils. Processed soil samples were analysed for pH, clay content and available S following standard procedures. Five soil profiles were also studied to understand the vertical distribution of sulphur fractions through the soil profile. In study area, textural class, pH (1:2.5) and available sulphur ranged from loamy sand to clay, 4.23 to 7.00 (extremely acidic to neutral) and 11 to 65 kg ha^{-1} (deficient to sufficient), respectively. Around 35 per cent of the soil samples were deficient in available sulphur. Available S exhibited a significant positive correlation with clay and silt, whereas significant negative correlation was found with sand and pH. In soil profiles study, all the S fractions decreased with increase in depth and highest contents of all the S fractions were found in surface layer. Sulphur fractions followed the order as total-S>organic-S>heat soluble-S>sulphate-S>water soluble-S in all the studied locations.

Keywords: Sulphur status, Soil profiles, Sulphur correlation, Texture, pH

Accessing the distribution of sulphur and other nutrients in soils is important to achieve the goal of sustainability in agriculture. Among major nutrients, sulphur (S) is one of the essential elements for crop production and the fourth most important nutrient after nitrogen, phosphorus and potassium. Sulphur is best known for its role in the synthesis of proteins, oils, vitamins and flavoured compounds in plants. It is a constituent of three essential amino acids *viz.* methionine (21% S), cysteine (26% S) and cystine (27% S), which are the building blocks of protein. Over the last decade, sulphur deficiency was recognized as a constraint to crop production all over the world (Scherer 2009). According to recent estimates, about 39·0 per cent of Indian soils are deficient in S, although the level of deficiency varied with soil types, agro-ecosystems, cropping systems and anthropogenic activities (Shukla et al 2014). Sulphur deficiencies in India are widespread and scattered throughout 120 districts out of 400 districts (Ghosh and Dash 2012). Major reasons for sulphur deficiency in crop production are the use of high analysis S-free fertilizers, decreased or no use of organic manures and reduced atmospheric inputs (Divito et al 2015). Historically, the inputs of S from the atmosphere into soils were sufficient to meet plant demands, particularly within heavily industrialized areas of the northern hemisphere (Eriksen 2008). However, the continuing decrease in these atmospheric inputs due to the restrictions by the government on sulphur dioxide ($S0_2$) emissions by coal-based industries and power stations, coupled with decreased additions of S through high-analysis P fertilizers, have increased the S deficiency (Srinivasarao et al 2008). The major transformations of sulphur in the upland agriculture system are mineralization, immobilization and oxidation (Piotrowska-Długosz et al 2017), which govern its gains and losses in the soil-plant system through leaching and adsorption, in various agro-climatic conditions. Sulphur is found in organic and inorganic forms in soil, whereas its pools are extremely dynamic in the terrestrial ecosystem. Sulphate (SO_4^{2-}) is the predominant form of inorganic S present in most soils, although some reduced S forms (elemental S, thiosulphate or sulphide) may also be found in soils under anaerobic conditions. Researchers have done a lot of work on the key processes of sulfur biogeochemical cycling, which is mainly focus on the spatial pattern of sulfur. Researchers have already studied the key processes of sulphur like (Zheng et al 2019, Wang et al 2019), the distribution and accumulation of sulphur in soil-vegetation system (Chen et al 2020, Wu et al 2020), the mineralization and immobilization of organic sulphur (Tanikawa et al 2014), the dissmilatory reduction process of sulphate and its coupling mechanism with carbon, nitrogen and iron (Karimian et al 2018, Schoepfer et al 2019) and the emissions of sulphur gas (Wang et al 2017). The knowledge of different forms of sulphur is of much relevance in assessing the long-term availability of sulphur and in formulating strong sulphur fertilizer recommendations. The sulphur in the soil can be grouped in to four forms viz. total-S organic-S, non-sulphate-S and available-S.Soils, which are deficient in sulphur, cannot on their own provide adequate sulphur to meet crop demand resulting in sulphur deficient crops and sub-optimal yields. The knowledge of sulphur status throughout root zone is essential for improving sulphur nutrition of crops. Several soil factors influence the availability of sulphur and hence the status of sulphur in soils varies widely with soil type. (Trivedi et al 2000). The recovery of added sulphur through external sources is very low, being only 8 to 10 per cent (Hegde and Murthy 2005). The demand for sulphur by plants is not constant with time because it is regulated internally in response to the environmental conditions and stage of plant development. The availability of S may vary in space and time across management units. In Indian soils, spatial variability of S is presumed to be high owing to small farms and varied management practices. Understanding the spatial variability of sulphur in soils is essential for devising sulphur management strategies with the aim of better farm economy and sustainability in crop production. The information regarding spatial and vertical variability of S in acidic soils of Himachal Pradesh is limited that's why the present investigation was proposed to determine the spatial and vertical distribution of S in acidic soils.

MATERIAL AND METHODS

The present investigation entitled "Spatial and vertical distribution of sulphur in acidic soils of Western Himalayas" was undertaken to study the status of sulphur in acidic soils of Himachal Pradesh. Himachal Pradesh (H.P.) is located between the 30°22′40″N to 33°12′40″N latitude and 75°45′55″E to 79°04′20″E longitudes, having an area of 55, 673 sq km. The net cultivated area of Himachal Pradesh is only 5,820 sq km (10.5%). The state has highly dissected mountain ranges interspersed with deep gorges and valleys. Its altitude ranges from 350 meters to 6975 meters above mean sea level.

Based on the previous survey conducted by the Department of Soil Science, CSKHPKV Palampur, acidic regions of the state were selected for sampling. Five hundred surface soil samples (0.0-0.15 m depth) were collected randomly from the cultivated land and used in the present study. Soil sampling sites in various districts of Himachal Pradesh are represented by mapping the coordinates (Fig. 1). Samples collected from different sites were air dried and crushed in wooden pestle and mortar to break clods and then subsequently passed through a 2 mm sieve. The processed soil samples were analysed for pH, clay content and available sulphur (S) by standard methods (Table 1). Five

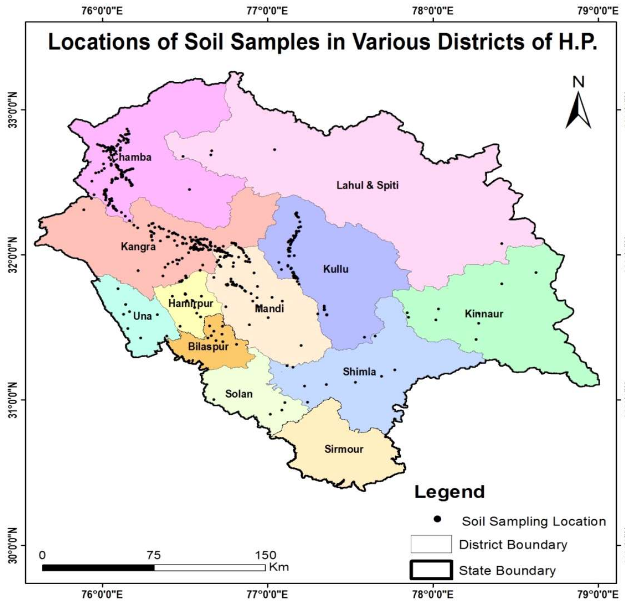

Fig. 1. Soil sampling sites in various districts of Himachal Pradesh

Table 1. Methods used for soil analysis

Soil properties	Method employed	Reference
Soil pH	(1: 2.5, soil : water)	Jackson (1973)
Mechanical analysis	International pipette	Piper (1966)
Available sulphur	Turbidimetric method	Chesnin and Yein (1950)

soil profiles were also selected in the acidic region of Himachal Pradesh and the mobilization of sulphur down the soil profiles was studied by analyzing different fractions of sulphur *viz.,* sulphate-S, water soluble-S, heat soluble S, organic-S, and total-S.

Total sulphur: It was estimated turbidimetrically using $BaCl_2$, after digesting the soil with HNO_3 and $HClO_4$, di-acid mixture (Chapman and Pratt 1961).

Water soluble sulphur: It was estimated turbidimetrically using de-ionized water as extracting solution (Chesnin and Yien 1950).

Heat soluble sulphur: Soil samples were hydrolyzed with the addition of distilled water and then evaporated to dryness on a gently boiling water bath. Thereafter, soil was dried in an oven at 102°C for 1 hour and then extracted with 0.15 per cent $CaCl_2$. The sulphur in the solution was determined turbidimetrically (Williams and Steinbergs 1959)

Sulphate sulphur: The soil was extracted with 0.15 per cent $CaCl_2$, using a soil: extract ant ratio of 1:5. The sulphate sulphur in soil extract was determined calorimetrically by developing $BaSO_4$ turbidity in the presence of sodium acetate-acetic acid buffer (Chesnin and Yien 1950).

Organic sulphur: Organic sulphur content in soils was estimated as described by Bardsley and Lancaster (1965).

The data generated from present investigation were subjected to statistical analysis using the various techniques for the interpretation of results as described by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Texture and pH of soils: Sand, silt and clay contents varied appreciably with respect to different locations. Sand fraction in cultivated soils varied from 12 to 83 per cent with a mean of 59.73 per cent. In depth exploration of the data showed that about 83 per cent soil samples had more than 50 per cent sand, whereas, 45 per cent soils had more than 60 per cent sand. Around 38 per cent soils had the sand content between 50 to 60 per cent. Silt content ranged between 7 to 55 per cent having an average of 23.66 per cent. About 37 per cent soil samples had silt content more than 25 per cent. Similarly, the clay content of samples varied from 6 to 45.1 per cent with a mean of 16.54 per cent. Further, a close look on the data revealed that around 80 per cent soil samples had less than 20 per cent clay content. On the basis of relative proportion of different soil separates, the textural classes of the soils were determined. The texture of the soils under study varied from loamy sand to clay. About 61 per cent samples were sandy loam indicating the dominant textural class in the study area.

The soil pH (1:2.5) ranged from 4.23 to 7.00 with a mean of 5.94 (Table 2). Around 15 per cent soil samples were neutral in nature (pH>=6.5 to 7.0). The variation in soil pH might be ascribed to the difference in the parent material, vegetation, topography, climatic conditions and agronomic practices under which these soils have been developed. There was no specific trend in pH of areas under study.

Available sulphur of soils: Available sulphur ranged from 11 to 65 kg ha^{-1} with an average of 30.20 kg ha^{-1}. The available sulphur was higher in fine textured soils followed by medium textured and coarse textured soils. Although with increasing pH, the available S slightly decreased in some soil samples. Higher concentration of available sulphur in some soils might possibly be due to a greater plant and microbial activities resulting in the subsequent accumulation of organic matter. Similar were the findings of Saharan et al (2001). Around 35 per cent of the soil samples were deficient (< 22.4 kg ha^{-1}) in available sulphur in the study area. Majority of the farmers in the study area adopt traditional management practices for growing different crops and such variation in cultural practices may also account for spatial variability of nutrient status of soils. Similar observations were also made Sharma and Kumar (2003). Soils were highly variable in view of availability of sulphur and this might be due to the conditions that were present during soil formation as such conditions determine the soil forming factors and processes.

Table 2. Sand, silt, clay and pH of selected soils of Himachal Pradesh

	Sand (%)	Silt (%)	Clay (%)	pH
Minimum	12	7.0	6.0	4.23
Maximum	83	55	45.1	7.00
Mean±SD	59.73± 11.52	23.66±8.90	16.54±5.47	5.94±0.51

*SD: Standard Deviation

Interrelationship of available sulphur with soil properties: In study area, available S exhibited a significant positive correlation with silt (r = 0.122**) and clay (r=0.459**) and significant negative correlation with sand (r = -0.309**). Available S exhibited a significant and negative correlation with pH (r = -0.099*). The positive and significant relationship of available S with clay indicated that with increase in clay content there was an increase in S adsorption capacity of soil and hence sulphur availability increases as it led to decrease in leaching.

The negative correlation of available S with soil pH might be due to the abundance of Fe and Al oxides in soils that caused higher adsorption of S from soil solution. Lower solution pH, which controls the polarity and surface density of adsorption plane, like Fe and Al oxides, enhances the S adsorption (Basumatari et al 2010). As pH increases sulphur sorption decreases, which in turn supplements the water soluble S in soil solution. Das et al (2011) also recorded a negative correlation between water soluble S and pH and concluded that soil pH was responsible for regulating concentration of S in soil solution. Similar results were obtained by Gourav et al (2018) while studying the interrelationship of S fractions with soil properties in long term fertilizer experiment.

Vertical Distribution of Sulphur in Soil Profiles

Location I (Palampur, 32°07'14.3"N, 076°32'01.3"E): Typically, Palampur soil is deep, well drained, fine loamy soils with loamy surface and slight erosion. Taxonomically it can be named as *Typic hapludalfs* (Anonymous 1996). This soil profile was under maize-wheat land use. Available S ranged from 14.5 mg kg^{-1} in 0-0.15 m soil layer to 6.9 mg kg^{-1} in 0.90-1.20 m soil depth (Table 3). Water soluble S varied between 7.2 mg kg^{-1} in surface layer (0-0.15 m) and 1.8 mg kg^{-1} in 0.90-1.20 m soil layer. Heat Soluble S which include organic plus sulphate S ranged from 80.2 mg kg^{-1} in surface soil (0-0.15 m) to 22.4 mg kg^{-1} in 0.90-1.20 m soil depth. Similarly organic S and total S ranged from 163.4 mg kg^{-1} to 68.8 mg kg^{-1} and from 210.2 mg kg^{-1} to 98.6 mg kg^{-1}, in surface layer (0-0.15 m) and 0.90-1.20 m soil layer, respectively. The mean values of available S, water soluble S, heat soluble S, organic sulphur and total sulphur in soil profile were 10.66, 4.06, 47.88, 115.78 and 154.84 mg kg^{-1} respectively.

Location II (Bagora, 32°07'22.2"N, 076°29'12.9"E): Typically, Bagora soil is medium deep, well drained, coarse loamy soils with loamy surface and moderate erosion. This soil is a member of the family of *Typic Udorthents* (Anonymous 1996). This profile was situated in the area, where maize- potato was grown widely. The mean values of available S, water soluble S, heat soluble S, organic sulphur and total sulphur in soil profile were 6.76±3.65, 3.52±2.36, 43.58±22.90, 102.28±38.98 and 135.14±45.95, mg kg^{-1} respectively (Table 4). Available S ranged from 12.2 mg kg^{-1} in 0-0.15 m soil layer to 3.2 mg kg^{-1} in 0.90-1.20 m soil depth. Water soluble S varied between 6.7 mg kg^{-1} in surface layer (0-0.15 m) and 1.3 mg kg^{-1} in 0.90-1.20 m soil layer. Heat Soluble S which include organic plus sulphate S ranged from 77.9 mg kg^{-1} in surface soil (0-0.15 m) to 20.3 mg kg^{-1} in 0.90-1.20 m soil depth. Similarly organic S and total S ranged from 163.4 mg kg^{-1} to 64.5 mg kg^{-1} and from 207.2 mg kg^{-1} to 90.6 mg kg^{-1}, in surface layer (0-0.15 m) and 0.90-1.20 m soil layer, respectively.

Location III (Kothi Kohar, 32°04'48.6"N, 076°47'45.9"E): Soils of Kothi Kohar are medium deep to deep, well drained, fine loamy soils with loamy surface and moderate erosion. Typically, Kothi Kohar soil is a member of the family of *Dystric Eutrochrepts* (Anonymous 1996). Soil profile was selected in the area where major land use is vegetable production. The range of available S was from 27.6 mg kg^{-1} in 0-0.15 m soil layer to 12.8 mg kg^{-1} in 0.90-1.20 m soil depth (Table 5). Water soluble S and heat soluble S varied between 12.2 mg kg^{-1} in surface layer (0-0.15 m) to 1.2 mg kg^{-1} in 0.90-1.20 m soil layer and from 127.82 mg kg^{-1} in surface soil (0-0.15 m) to 24.6 mg kg^{-1} in 0.90-1.20 m soil layer, respectively. Similarly organic S and total S ranged from 362.4 mg kg^{-1} and 444.5 mg kg^{-1} in surface layer (0-0.15 m) to 182.4 mg kg^{-1} and 232.7 mg kg^{-1} in 0.90-1.20 m soil layer, respectively. The mean values of available S, water soluble S, heat soluble S, organic sulphur and total sulphur in soil profile were 20.48, 6.04, 68.76, 258.86 and 324.38, mg kg^{-1}, respectively.

Location IV (Mohanghati, 32°01'35.4"N, 076°41'31.14"E): Soils of Mohanghati are shallow, well drained, thermic, loamy soils on very steep slopes with loamy surface and very severe erosion. Typically, Mohanghati soil is a member of the family of *Lithic Udorthents* (Anonymous 1996). The available S ranged from 8.3 mg kg^{-1} in 0-0.15 m soil layer to 3.2 mg kg^{-1} in 0.90-1.20 m soil depth (Table 6). Water soluble S and heat soluble S varied between 3.4 mg kg^{-1} in surface layer (0-0.15 m) to 0.7 mg kg^{-1} in 0.90-1.20 m soil layer and from 63.7 mg kg^{-1} in surface soil (0-0.15 m) to 28.6 mg kg^{-1} in 0.90-1.20 m soil layer, respectively. Similarly organic S and total S ranged from 126.7 mg kg^{-1} and 157.2 mg kg^{-1} in surface layer (0-0.15 m) to 53.2 mg kg^{-1} and 68.2 mg kg^{-1} in 0.90-1.20 m soil layer,

Table 3. Vertical distribution of S fractions (mg kg^{-1}) in soil profile at Palampur

Depth (m)	Available sulphur	Water soluble sulphur (WSS)	Heat soluble sulphur (HSS)	Organic sulphur	Total sulphur
0-0.15	14.5	7.2	80.2	163.4	210.2
0.15-0.30	12.7	5.7	60.4	138.3	179.2
0.30-0.60	10	3.1	45.8	110.2	150.8
0.60-0.90	9.2	2.5	30.6	98.2	135.4
0.90-1.20	6.9	1.8	22.4	68.8	98.6
Mean±SD	10.66±2.98	4.06±2.29	47.88±23.20	115.78±36.48	154.84±42.47
Range	6.9-14.5	1.8-7.2	22.4-80.2	68.8-163.4	98.6-210.2

Table 4. Vertical distribution of S fractions (mg kg^{-1}) in soil profile at Bagora (pH=4.9)

Depth (m)	Available sulphur	Water soluble sulphur (WSS)	Heat soluble sulphur (HSS)	Organic sulphur	Total sulphur
0-0.15	12.2	6.7	77.9	163.4	207.2
0.15-0.30	8.6	5.3	54.2	115.7	150.8
0.30-0.60	5.5	2.5	36.7	89.4	120.3
0.60-0.90	4.3	1.8	28.8	78.4	106.8
0.90-1.20	3.2	1.3	20.3	64.5	90.6
Mean±SD	6.76±3.65	3.52±2.36	43.58±22.90	102.28±38.98	135.14±45.95
Range	3.2-12.2	1.3-6.7	20.3-77.9	64.5-163.4	90.6-207.2

respectively. The mean values of available S, water soluble S, heat soluble S, organic sulphur and total sulphur in soil profile were 5.34, 1.82, 42.46, 84.22±28 and 106.14, mg kg^{-1}, respectively.

Location V (Arla, 32°4'41.34"N, 76°29'15.96"E): Soils of Arla are deep, somewhat excessively drained, thermic, coarse-loamy soils on gentle slopes with loamy surface and moderate erosion. Typically, Arla soil is a member of the family of *Typic Udorthents* (Anonymous 1996). Soil profile was located where rice-wheat was grown throughout the year. The mean values of available S, water soluble S, heat soluble S, organic sulphur and total sulphur in soil profile were 10.42, 2.7, 65.56, 146.32and 190.58, mg kg^{-1} respectively (Table 7). Available S ranged from 15.3 mg kg^{-1}in 0-0.15 m soil layer to 5.0 mg kg^{-1} in 0.90-1.20 m soil depth. Water soluble S varied between 4.8 mg kg^{-1} in surface layer (0-0.15 m) and 1.1 mg kg^{-1} in 0.90-1.20 m soil layer. Heat Soluble S which include organic plus sulphate S ranged from 97.4 mg kg^{-1}in surface soil (0 - 0.15 m) to 40.3 mg kg^{-1} in 0.90-1.20 m soil depth. Similarly organic S and total S ranged from 215.7 mg kg^{-1} to 80.4 mg kg^{-1} and from 277.5 mg kg^{-1} to 110.6 mg kg^{-1}, in surface layer (0 – 0.15 m) and 0.90 – 1.20 m soil layer, respectively.

A close look on the vertical distribution of S in soil profiles revealed that all the S fractions decreased with increase in the depth of soil. All the forms of S were comparatively higher at location III (Kothi Kohar) and lowest at location IV (Mohanghati). This might be due to that at Kothi Kohar, the soil profile was under vegetable cultivation and farmers used organic manures for vegetable production, which might have

Table 5. Vertical distribution of S fractions (mg kg^{-1}) in soil profile at KothiKohar (pH =4.6)

Depth (m)	Available sulphur	Water soluble sulphur (WSS)	Heat soluble sulphur (HSS)	Organic sulphur	Total sulphur
0-0.15	27.6	12.2	127.8	362.4	444.5
0.15-0.30	23.5	9.2	93.6	296.5	370.2
0.30-0.60	21.8	4.8	60.2	248.2	314.2
0.60-0.90	16.7	2.8	37.6	204.8	260.3
0.90-1.20	12.8	1.2	24.6	182.4	232.7
Mean±SD	20.48±5.80	6.04±4.56	68.76±42.12	258.86±72.50	324.38±85.36
Range	12.8-27.6	1.2-12.2	24.6-127.8	182.4-362.4	232.7-444.5

Table 6. Vertical distribution of S fractions (mg kg^{-1}) in soil profile at Mohanghati (pH=6.3)

Depth (m)	Available sulphur	Water soluble sulphur (WSS)	Heat soluble sulphur (HSS)	Organic sulphur	Total sulphur
0-0.15	8.3	3.4	63.7	126.7	157.2
0.15-0.30	5.5	2.1	48.8	94.5	119.5
0.30-0.60	5	1.8	38.7	78.4	99.2
0.60-0.90	4.7	1.1	32.5	68.3	86.6
0.90-1.20	3.2	0.7	28.6	53.2	68.2
Mean±SD	5.34±1.86	1.82±1.04	42.46±14.11	84.22±28.10	106.14±34.11
Range	3.2-8.3	0.7-3.4	28.6-63.7	53.2-126.7	68.2-157.2

Table 7. Vertical distribution of S fractions (mg kg^{-1}) in soil profile at Arla (pH=5.9)

Depth (m)	Available sulphur	Water soluble sulphur (WSS)	Heat soluble sulphur (HSS)	Organic sulphur	Total sulphur
0-0.15	15.3	4.8	97.4	215.7	277.5
0.15-0.30	11.5	3.9	75.5	167.8	217.1
0.30-0.60	10.7	2.5	63.4	139.8	180.5
0.60-0.90	9.6	1.2	51.2	127.9	167.2
0.90-1.20	5.0	1.1	40.3	80.4	110.6
Mean±SD	10.42±3.71	2.7±1.63	65.56±22.14	146.32±50.00	190.58±61.85
Range	5.0-15.3	1.1-4.8	40.3-97.4	80.4-215.7	110.6-277.5

increased the organic matter content of soil and ultimately the sulphur, as organic matter is the direct source of sulphur in soil. Besides this, Kothi Kohar located in the temperate region, which decreased the oxidation of organic matter and increased its accumulation. At Mohanghati, intensive cultivation of rice-wheat was carried out without any addition of organic manures, which have resulted in the mining of sulphur from the soil and this might be the reason for lower sulphur fractions. The total sulphur decreased with the depth in all the soil profiles under study might be due to the reason that the most of soil sulphur is primarily in the organic form. In general, the organic matter content decreases regularly down the profiles and total sulphur also exhibits similar trend in all the soils. The results of present study are in agreement with the findings, Trivedi et al (2000), Parkash et al (2003) and Ghodke et al (2016).

CONCLUSIONS

The texture of the soils under study varied from loamy sand to clay. About 85 per cent of soil samples were found acidic in pH. Around 35 per cent of the soil samples were deficient in available sulphur. Available S exhibited a significant positive correlation with clay and significant negative correlation with sand and pH. All the soil profiles exhibited the decrease in sulphur fractions with increase in the depth.

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Fluoride Health Hazard Assessment in Ground Water Resources of Tiruchirappalli District, Tamil Nadu

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Abstract: Hydrogeochemistry of the groundwater is controlled by rock-water interaction was characterized using Gibbs plot. The groundwater in the study area is dominated by HCO_3^- and Na^+ facies character with alkaline nature. The correlation technique has been used to understand the relationship between chemical parameters. The adversative health effect by in taking fluoride contaminated groundwater by humans including male, female and children are the major concern in this study by using secondary data. Among all the samples, seven samples were recorded above the permissible limit of fluoride during the post-monsoon season. Oral intake of fluoride and total hazard index resulted in 15 per cent of children in pre-monsoon and 13 per cent of male, female and children during the post-monsoon season were categorized under fluoride risk. Dermal intake of fluoride is normal in all the samples studied.

Keywords: Fluoride, Pre-monsoon, Post monsoon, Dermal and oral intake, Health risk

The rapid growth of population and industrialization increases the utilization of groundwater which leads to depletion of the water table as well as the quality. It is one of the major resources where surface water does not fulfil even domestic needs. The quality of the water is determined by its physical, chemical and biological properties (Vinothkanna et al 2019). The groundwater chemistry is altered by anthropogenic activity as well as nature-based on geological setup and rock water interaction. The quality of groundwater is difficult to retain its original content once it is getting polluted (Vinothkanna et al 2020). The poor quality of drinking water is responsible for 80 percent of the disease spread in the world. In developing countries, the quality of drinking water has direct control over human health due to the intake of contaminated water and also causes numerous health issues (Adimalla and Qian 2019). One of the health problems associated with the intake of contaminated drinking water is fluorosis. The high and low level of fluoride causes significant effects on human health. High fluoride ions in the human body may result in dental as well as skeletal fluorosis which may also lead to bone fractures (Pathak et al 2012). Arid and semi-arid regions reported 65 percent of fluorosis due to high amounts of fluoride in drinking water around the world (Narsimha and Sudarshan 2017).

In India, 21 states with approximately 66 million population including 6 million children are affected by fluorosis (Adimalla et al 2018). The maximum permissible limit for fluoride is 1.5 mg l^{-1} (BIS 2012). Due to drinking water contamination, health risk evaluations are widely used to assess human health hazards. However, health risks associated with fluoride get more attention worldwide. Therefore, the health risk assessment through ingestion and the dermal pathway is more important. The study area was Tiruchirappalli district, which is one among the eight districts affected by fluorosis, rest of the districts are Salem, Erode, Dharmapuri, Vellore, Coimbatore, Madurai and Virudhunagar of Tamil Nadu. So many researchers made their contribution in fluoride assessment in various parts of India (Acharya and Mathi 2010) and for Tamil Nadu (Jothimani et al 2017, Arya et al 2019). Subha and Brahmaji (2017) assessed fluoride in groundwater samples of Thiruverumbur taluk of Trichy district and identified all the samples collected were above the permissible limit. So, an attempt has been made to study the health effects of fluoride concentration in drinking water over Tiruchirappalli district, which is located in the central part of Tamil Nadu and also the district was fully covered by Cauvery Delta Zone (CDZ).

MATERIAL AND METHODS

Study Area: Tiruchirappalli (Trichy) is located on the bank of river Cauvery and it is the fourth largest district of the state of Tamil Nadu lies between 10°15' and 11°12' north and 78°10' and 79°05' east latitude having an area of 4,404 km^2 (Fig. 1). For irrigation and domestic purposes, river Cauvery is the only major water source for the district. The major soils in the district are loamy, clayey and sandy alluvium. Geologically, hard rocks of Archean age cover nearly 90 per cent of the district. They are dominated largely by granitic gneiss and

Charnockite intruded by pegmatite veins. However, sedimentary formations such as Gondwana, Cretaceous and Quaternary formation also occurred in this district. The secondary data collected from the state ground and surface water resource data center, Tharamani, Chennai has been used for this impact study. The common well for both pre and post-monsoon seasons were identified. There are 52 common wells noted to assess the fluoride-oriented health hazard (Table 1). The base map is prepared using SOI Toposheets on a scale of 1:50000. The correlation technique was used with the help of MS-Excel software to find out the relationship between the ions.

Health risk assessment: Several pathways such as inhalation, dermal and ingestion were used to study the human health risk when exposed to chemicals. As suggested by USEPA (1992), the chronic daily dose of fluoride for ingestion and dermal were assessed using the following equations.

Chronic daily intake of fluoride is calculated using equation 1.

$$CDI = (C \times IR \times ED \times EF) / (BW \times AT) \text{ -----------------------1}$$

CDI values were compared with fluoride reference dose (RfD) to find the hazard index using equation 2.

$$HQ_{Oral} = CDI/RfD \text{ ---2}$$

Chronic daily dose via dermal and dermal hazard quotient (HQ) of fluoride was calculated using the equation 3 and 4.

$$CDD\ dermal = (C \times ESA \times K \times EF_r \times ED \times CF) / (BW \times AT) \quad 3$$

$$HQ_{Dermal} = CDD/RfD \text{ ---4}$$

The total hazard quotient (THQ) is calculated using equation 5,

$$THQ = HQ_{Oral} + HQ_{Dermal} \text{ --------------------------- 5}$$

Where, C – fluoride concentration (present study) mg l^{-1}, IR_w, Ingestion rate (L day^{-1}), EF_r – Exposure frequency (days $year^{-1}$), ED- Exposure duration (WHO 2013), BW – Body weight (Allowances 2009), AT_r– Average time (WHO 2013), SA - Skin surface area (cm^2) (Zhai et al 2017), CF - Conversion factor (L cm^{-3}) and K - Skin adherence factor (cm h^{-1}), RfD - Reference dose (USEPA 2014). According to USEPA (1993), HQ values <1 is an acceptable limit for non-carcinogenic risk and >1 value is responsible for severe health effects. The Geographic Information Systems (GIS) interpolation technique mainly inverse distance weight (IDW) method was used in this study. The ArcGIS software was used extensively to portray the results cartographically.

RESULTS AND DISCUSSION

Process controlling groundwater chemistry: Groundwater chemistry can be altered about time and space based on hydro-geochemical processes. There are so many processes that control groundwater chemistry. Gibbs (1970) and Piper (1944) plot were used to understanding the controlling mechanism of groundwater chemistry. Most of the groundwater samples fall in rock dominance and slightly tending towards evaporation dominance (Fig. 2 and 3). It indicates that groundwater chemistry is controlled by the leaching of ions from the rocks (Subramani et al 2010).

To understand the hydrochemical evaluation, a graphical representation of the piper plot is useful (Fig. 4). In the left triangle, cations represent that the groundwater samples were dominated by sodium and potassium ions and in the abundance order of Na > K >Ca> Mg. Similarly, the right triangle depicted that anions dominated by bi-carbonates

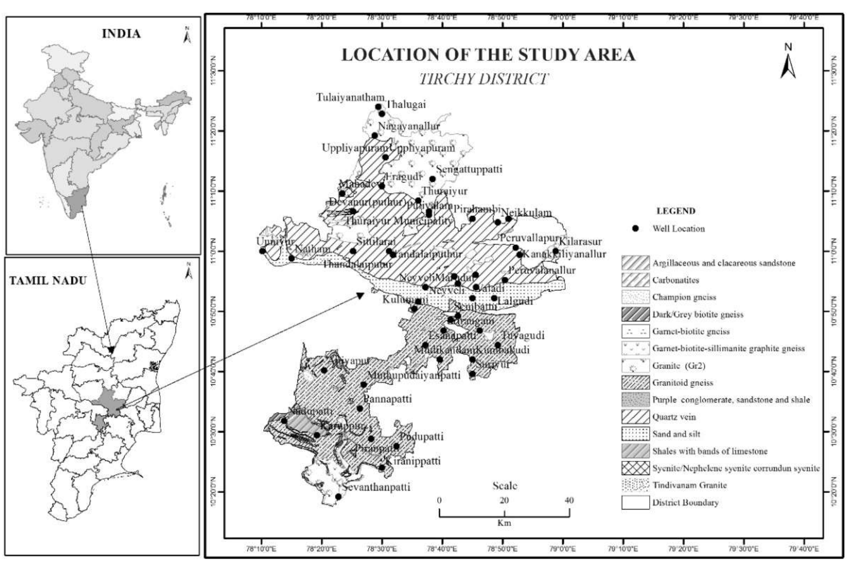

Fig. 1. Sampling location of the study area

Table 1. Well Location and season wise Fluoride (ppm) concentration in groundwater of Tiruchirappalli District-2018

Well type	Village	Latitude	Longitude	Season	
				Pre	Post
Bore	Sembattu	10°49'40"	78°43'00"	0.41	0.30
Bore	Neyveli	10°54'00"	78°37'30"	0.44	0.59
Bore	Thandalaiputur	10°59'50"	78°32'00"	1.30	0.55
Bore	Uppliyapuram	11°15'40"	78°30'40"	0.63	0.53
Bore	Aniyapur	10°40'15"	78°20'35"	1.51	2.00
Bore	Nadupatti	10°31'50"	78°14'20"	0.70	0.54
Bore	Pudupatti	10°28'00"	78°32'50"	1.20	2.20
Bore	Karuppur	10°29'25"	78°19'30"	1.50	2.00
Bore	Mudikandam	10°42'10"	78°40'00"	0.56	0.80
Bore	Kulumani	10°50'35"	78°35'40"	0.54	0.59
Bore	Suriyur	10°40'10"	78°45'15"	0.20	0.43
Bore	Pulivalam	11°00'50"	78°38'15"	1.00	1.03
Bore	Mahadevi	11°09'50"	78°23'50"	0.05	0.47
Bore	Sengattuppatti	11°12'15"	78°38'50"	0.69	0.39
Bore	Thalugai	11°23'20"	78°30'15"	0.36	0.14
Bore	Nagayanallur	11°19'45"	78°28'55"	0.32	0.29
Bore	Pirahambi	11°05'50"	78°45'20"	0.18	0.15
Bore	Kiranippatti	10°24'20"	78°30'30"	0.66	0.65
Bore	Tulaiyanatham	11°02'45"	78°29'45"	0.17	0.32
Bore	Thuraiyur	11°08'45"	78°36'05"	0.39	0.49
Bore	Eragudi	11°11'05"	78°30'32"	0.50	0.43
Bore	Pannapatti	11°41'25"	78°19'04"	1.51	2.20
Bore	Muthupudaiyanpatti	10°38'13"	78°27'16"	1.00	1.60
Bore	Sevanthanpatti	10°19'23"	78°23'09"	0.53	0.09
Bore	Piranpatti	10°28'48"	78°28'17"	0.52	2.40
Bore	Kumbakudi	10°42'05"	78°45'33"	0.10	0.65
Bore	Rajampalayam	10°56'08"	78°42'25"	1.20	1.10
Bore	Natham	10°58'58"	78°15'34"	0.81	0.64
Bore	Neikkulam	11°03'21"	78°20'22"	0.62	0.39
Bore	Peruvallapur	11°00'44"	78°52'25"	1.51	1.10
Bore	Periyakaruppur - II	10°51'54"	78°36'28"	0.32	0.53
Dug	Thiruverumbur	10°47'05"	78°46'35"	0.31	0.49
Dug	Teranippalaiyam	11°05'15"	78°53'00"	0.52	0.23
Dug	Uppliyapuram	11°15'39"	78°30'54"	0.52	0.70
Dug	Devanur(puthur)	11°06'40"	78°25'45"	0.56	0.19
Dug	Unniyur	11°00'00"	78°10'40"	0.14	0.41
Dug	Sittilarai	11°00'00"	78°25'35"	0.41	0.74
Dug	Tandalaiputhur	11°00'00"	78°31'45"	0.05	0.05
Dug	Kanakkiliyanallur	10°59'45"	78°53'00"	0.05	0.82
Dug	Kilarasur	11°00'30"	78°59'00"	0.12	0.16

Cont...

Table 1. Well Location and season wise Fluoride (ppm) concentration in groundwater of Tiruchirappalli District-2018

Well type	Village	Latitude	Longitude	Season	
				Pre	Post
Dug	Neyveli	10°54'15"	78°37'30"	0.73	0.58
Dug	Kalpalaiyam	10°55'00"	78°42'45"	0.80	0.68
Dug	Esanapatti	10°44'34"	78°37'40"	1.40	2.60
Dug	Tuvagudi	10°44'50"	78°49'15"	0.19	0.38
Dug	Marudur	10°54'35"	78°46'05"	0.11	0.21
Dug	Thiruchirapalli Municipal	10°48'50"	78°41'45"	0.17	0.09
Dug	Thuraiyur Municipality	11°07'00"	78°38'00"	0.78	0.78
Dug	Srirangam	10°47'15"	78°40'20"	0.49	0.65
Dug	Peruvalanallur	10°55'26"	78°50'44"	0.22	0.51
Dug	Lalgudi	10°52'21"	78°49'03"	0.85	0.55
Dug	Valadi	10°52'29"	78°45'26"	0.32	0.59
Dug	Valmalpalaiyam (south)	10°00'48"	78°47'33"	0.62	0.85

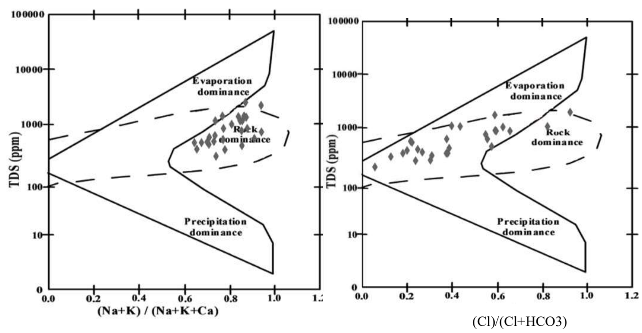

Fig. 2. Gibbs plot for pre-monsoon seasons (2018)

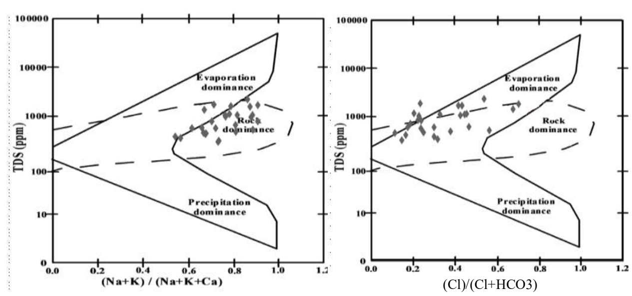

Fig. 3. Gibbs plot for post-monsoon seasons (2018)

and were in the order of HCO_3>Cl> SO_4. The dominant water type present in the study area was in the order of Na-K-Cl-SO_4> Na-K-HCO_3> Ca-Mg-HCO_3> Ca-Mg-Cl-SO_4. The dominance of alkalis exceeds alkaline piles of earth and weak acids exceed strong acids in both pre and post-monsoon seasons.

Occurrence of fluoride ion: To understand the dissolved solids in the groundwater samples, SO_4^{2-} + HCO_3^- versus Ca^{2+} + Mg^{2+} were plotted. It is widely used to understand the possibility of silicate weathering in the groundwater (Rao et al 2012). Most of the samples fall below the equiline due to excess HCO_3^- in the groundwater (Fig. 5). It inveterate the role of silicate weathering, which is a major factor for dissolved salts in the groundwater (Subba Rao and Surya Rao 2010). Further, Na^+ against Cl^- in the study area portrays that most of the samples found above the theoretical line infer the excess concentration of Na^+ in the groundwater samples (Fig. 6). This is mainly due to silicate weathering (Subba Rao and Surya Rao 2010).

The groundwater having high bicarbonate is due to weathering of silicate minerals because sodium ion dominates the chloride ion (Rao et al 2017). Generally, the areas having high bicarbonate in drinking water have been classified as fluoride endemic areas (Viswanathan et al 2009). A bivariate plot of Mg^{2+}/ Na^+ versus Ca^{2+}/ Na^+ further validated that silicate weathering is the leading process contributing to chemical quality in the study area. To understand the relationship between the chemical parameters of the post and pre-monsoon seasons, a correlation technique has been used. Adams et al (2001) represented correlation as weak (r < 0.4), moderate (r > 0.5-0.7) and strong (r > 0.7). During pre-monsoon seasons, fluoride shows a weak to a moderate positive correlation with all the ions except K^+ (Table 2). But in post-monsoon seasons, a strong positive correlation exhibits between TDS vs Cl^-, Mg^{2+}, Na^+ and Cl^- vs Ca^{2+} and Na^+. Fluoride exhibited a negative correlation with all the ions except HCO_3^- and Na^+ (Table 3). This may be due to the decrease of water level and increases the concentration of all the ions in the groundwater (Aravinthasamy et al 2019). The chemicals such as potassium and sulphate have not significant relation with fluoride and are negatively correlated in post-monsoon seasons. This specifies that fluoride in the study area is not due to the influence of chemicals (Subba Rao et al 2020). pH, HCO_3^- and Na^+ have a significant correlation with fluoride ions. The alkaline water with high HCO_3^- and Na^+ increases the solubility of fluoride in the groundwater (Narsimha and Rajitha 2018). During the post-monsoon season, F^- have negatively correlated with TDS may due to the influence of rock-water interaction. The fluoride content in the water has a negative association with Ca^{2+} leads to higher fluoride levels in the groundwater.

Spatial distribution of fluoride: The fluoride level in the study area varied from 0.05 to 1.50 mg l^{-1} with an average of 0.59 mg l^{-1} during pre-monsoon and 0.05 to 2.60 mg l^{-1} with an average of 0.72 mg l^{-1} during post-monsoon season. Aniyapur, Karuppur, Pannapatti and Peruvallapur villages of Thiruchirappalli district have high levels of fluoride (>1.5 mg l^{-1}) during the pre-monsoon season. Aniyapur, Pudupatti, Karuppur, Pannapatti, Muthupudaiyanpatti, Piranpatti) and Esanapatti, villages have high fluoride ion above the permissible limit during the post-monsoon season. Among the 52 samples, 46 and 42 per cent of the samples were below <0.5 mg l^{-1} during pre and post-monsoon, respectively (Table 4). The fluoride level exhibited between 0.5-1.5 mg l^{-1}, was 54 and 44 per cent in pre and post-monsoon season respectively. About 13 per cent of the samples were above the permissible limit noticed only in the post-monsoon season. The spatial distribution of the fluoride map portrays that, the southern part of the district covering the blocks of Marungapuri, Vaiyampatti, Manapparai and part of Manikandam have fluoride

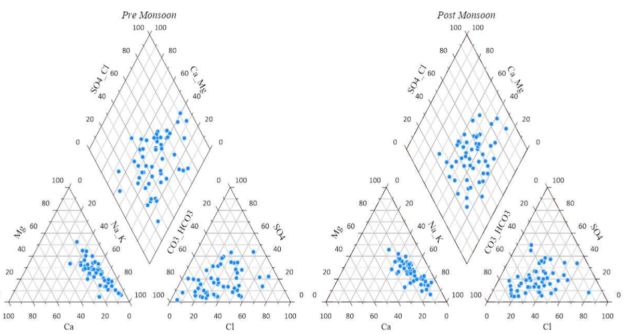

Fig. 4. Piper Tri-linear diagram for water chemistry pre and post-monsoon season

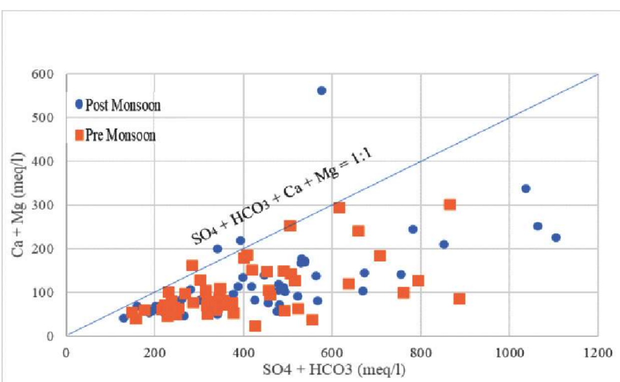

Fig. 5. Relationship between SO_4^{2-} + HCO_3^- vs Ca^{2+} + Mg^{2+}

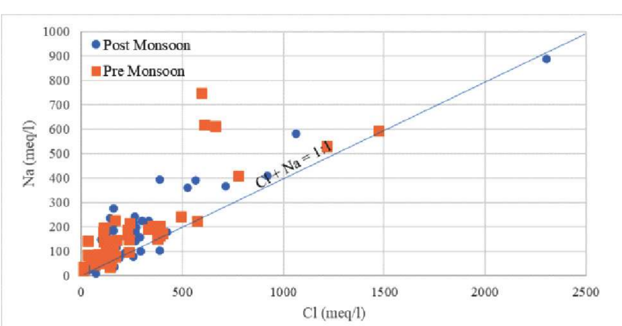

Fig. 6. Relationship between Cl^- vs Na^+

concentration above the permissible limit during post-monsoon seasons (Fig. 7).

Health risk assessment of fluoride: Oral intake specifies that during the pre-monsoon season for children 85 per cent of samples were within safe limits and 8 percent of samples were above 1 which is considered as a non-carcinogenic risk for human health. Oral intake for women and men was below 1 indicates that all the samples in the study area fall under safe limits. In the post-monsoon season for all categories, 87 and 13 per cent of samples were under safe and risks for human health respectively. Hazard Quotient (HQ) values of fluoride for oral exposure in pre and post-monsoon season were 0.03-0.96 and 0.03-1.66 for men, 0.03-0.90 and 0.03-

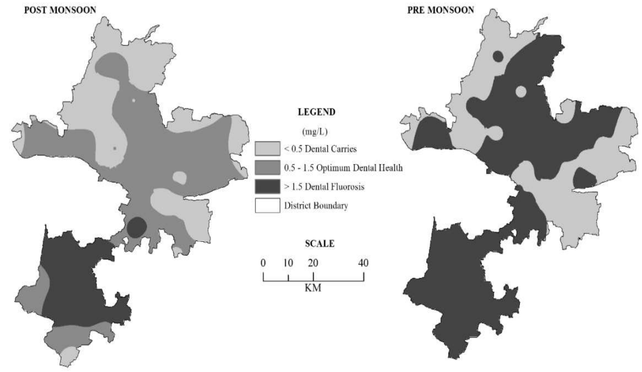

Fig. 7. Spatial distribution of fluoride in post and pre-monsoon seasons (2018)

Table 2. Physio-chemical correlation of groundwater samples for pre-monsoon seasons

Parameters	TDS	Ca	Mg	Na	K	Cl	SO4	HCO3	F	pH
TDS	1									
Ca	0.77	1								
Mg	0.74	0.81	1							
Na	0.93	0.54	0.47	1						
K	0.50	0.42	0.31	0.39	1					
Cl	0.93	0.79	0.76	0.82	0.53	1				
SO4	0.80	0.64	0.54	0.76	0.20	0.63	1			
HCO3	0.25	-0.01	0.16	0.28	0.24	0.09	-0.04	1		
F	0.13	0.01	0.09	0.20	-0.22	0.09	0.09	0.18	1	
pH	0.01	-0.33	-0.19	0.14	0.15	-0.11	-0.09	0.48	0.07	1

Table 3. Physico-chemical correlation of groundwater samples for post-monsoon seasons

Parameters	TDS	Ca	Mg	Na	K	Cl	SO4	HCO3	F	pH
TDS	1									
Ca	0.84	1								
Mg	0.90	0.76	1							
Na	0.90	0.80	0.68	1						
K	0.33	0.00	0.35	0.00	1					
Cl	0.91	0.90	0.78	0.90	0.12	1				
SO4	0.69	0.46	0.68	0.60	0.08	0.48	1			
HCO3	0.32	0.25	0.34	0.35	-0.02	0.14	0.19	1		
F	-0.07	-0.10	-0.14	0.03	-0.04	-0.13	-0.14	0.34	1	
pH	-0.39	-0.52	-0.49	-0.31	0.15	-0.44	-0.32	-0.01	0.20	1

Table 4. Fluoride concentration in Tiruchirappalli district

Seasons	Total samples	Fluoride Concentration (No. and %)			Max. Fluoride Level (mg l^{-1})	Mean mg l^{-1}
		<0.5 mg l^{-1}	0.5 - 1.5 mg l^{-1}	> 1.5 mg l^{-1}		
Pre Monsoon	52	24 (46%)	28 (54%)	0 (0%)	1.5	0.59
Post Monsoon		22 (42%)	23 (44%)	7 (13%)	2.6	0.72

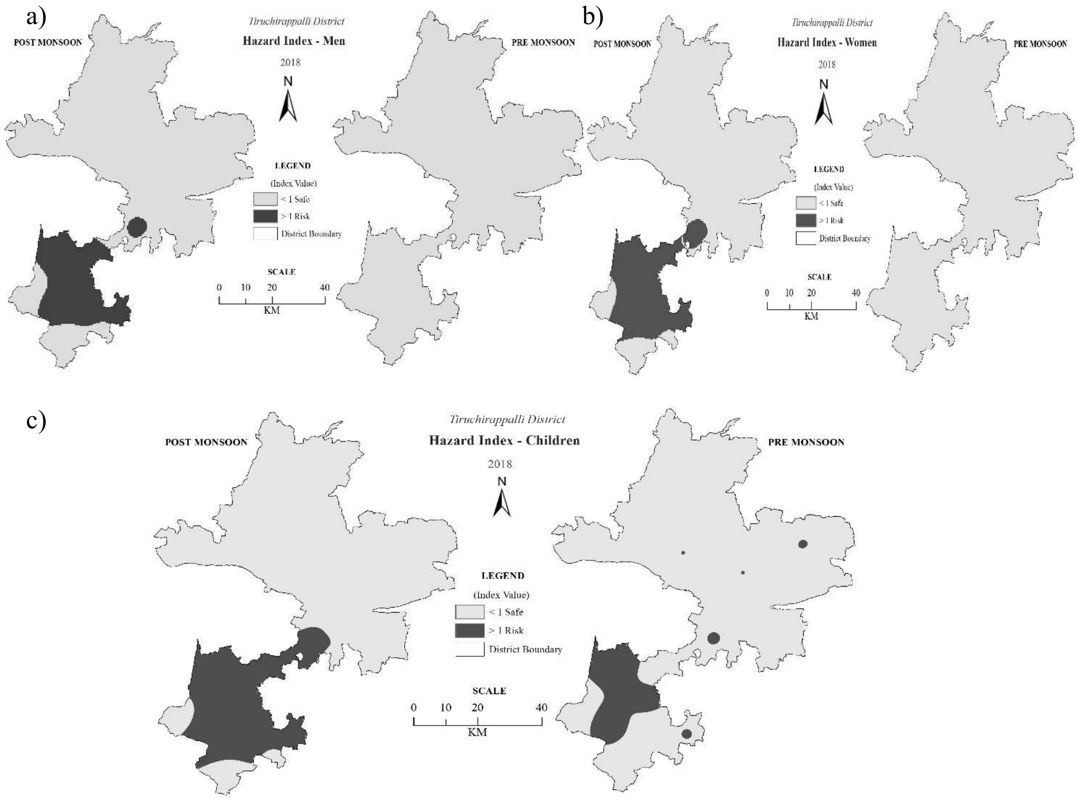

Fig. 8. Spatial distribution of THQ for a) men, b) women and c) children

Table 5. Health risk assessment of fluoride in Tiruchirappalli district (2018)

Category	HQ Oral Intake				HQ Dermal Intake		Total Hazard Quotient (THQ)			
	Pre-monsoon		Post Monsoon		Pre-monsoon	Post Monsoon	Pre-monsoon		Post-Monsoon	
	Safe (<1)	Risk (>1)	Safe (<1)	Risk (>1)	Safe (<1)	Safe (<1)	Safe (<1)	Risk (>1)	Safe (<1)	Risk (>1)
Children	44 (85%)	8 (15%)	45 (87%)	7 (13%)	52 (100%)	52 (100%)	44 (85%)	8 (15%)	45 (87%)	7 (13%)
Women	52 (100%)	0 (0%)	45 (87%)	7 (13%)	52 (100%)	52 (100%)	52 (100%)	0 (0%)	45 (87%)	7 (13%)
Men	52 (100%)	0 (0%)	45 (87%)	7 (13%)	52 (100%)	52 (100%)	52 (100%)	0 (0%)	45 (87%)	7 (13%)

1.96 for women, 0.04-1.3 and 0.04-2.25 for children respectively. The high value of HQ_{Oral} fluoride ion was 1.66, 1.96 and 2.25 for men, women and children, respectively. This study indicates children were more vulnerable to fluorosis health risk followed by women and men in the study area (Vinothkanna et al 2019).

Dermal intake of fluoride level indicated that all the samples in the study area were under safe for children, women and men respectively. The total hazard quotient indicates the adults (men and women) were safe and 15 percent of children in the study area were under non-carcinogenic health risk during the pre-monsoon season. But in the post-monsoon season, 13 percent of men, women and children are at health risk of fluoride ion (Table 5). The spatial distribution map THQ is shown in Figure 8.

CONCLUSION

Rainfall and geology of the location will determine the concentration of fluoride ions in the groundwater resources. Gibbs plot shows that the majority of the samples signify the rock-water interaction. The fluoride ions present in groundwater in pre-monsoon seasons were under permissible limits but in post-monsoon seasons 13 per cent of the samples had high fluoride ion concentration. pH, HCO_3^- and Na^+ have a significant correlation with fluoride ion, and also increases the solubility of fluoride in the groundwater. The maximum values were in the post-monsoon season indicating the dissolution of rocks is one of the factors for the increase of fluoride ion in the groundwater. The health risk assessment identifies that the children are more at risk for fluorosis compared to adults both men and women. About 15 percent of children in pre-monsoon and 13 per cent of children, women and men in post-monsoon seasons were prone to fluorosis risks in the study area. The population data along with fluoride ions in the groundwater sample information will be significant to do protection measures among the community. During the post-monsoon season, the areas under high fluoride need to take good quality water to avoid fluorosis and associated health issues. Adopting reverse osmosis (RO), implementing rainwater harvesting on a large scale, creating well recharge pits and providing awareness among the people may eradicate these kinds of problems and safeguard future generations from health risks.

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Optimized Multiresolution Segmentation for Mapping Glaciers

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Abstract: In the object-oriented classification approach, image segmentation is a prerequisite that directly affects the accuracy of classification. For glacier mapping, multi-resolution segmentation is a widely used segmentation technique that depends on three user-defined parameters i.e., scale, shape, and compactness. Previous studies involve rigorous exercise in selecting the optimal combination of these parameters. Therefore, this study introduces an optimum parameterization approach for multi-resolution segmentation that utilizes the contrast in spectral reflectance of ice/snow in Green and SWIR bands and compactness feature for defining color and compactness criterion, respectively. The scale parameter is estimated by local variance. This optimized segmentation approach is tested on Landsat images to map the glacier ice/snow area. This approach has sped up the segmentation process as it generated optimum segments in a single iteration, unlike the trial and error technique.

Keywords: Segmentation, Object-based classification, Parameter optimization

With the significant improvement in spatial resolution of sensors, geographic object-based image analysis has gained prominence in the field of remote sensing. The pixel-based image analysis (PBIA) method utilizes the spectral characteristics of each pixel for image classification (Nagajothi et al 2019). Whereas, the object-based image analysis (OBIA) technique not only uses spectral characteristics but also considers shape, geometry, and texture features of image objects for image classification (Blaschke 2005, Chandra et al 2015). In OBIA, the foremost and crucial step is the segmentation process that merges individual pixels into image objects based on the homogeneity criteria (Blaschke 2010, Kavzoglu et al 2016, Tian et al 2007). Multiresolution segmentation is the most popular algorithm in OBIA applications. It has three user-defined parameters like scale, shape/color, and compactness/ smoothness. The selection of the most suitable parameters for image segmentation is very tricky. For glacier surface mapping, researchers have mainly used the trial and error method to find the optimal segmentation parameters (Meinel et al 2004, Jia et al 2013, Mitkari et al 2017, Wang et al 2020).

Dragut has introduced scale optimization tools named Estimation of Scale Parameter (ESP) for a single band and ESP-2 for multiband images based on the Local Variance (LV) (Dragut et al 2010, Dragut et al 2014). These tools automated the selection procedure of suitable scale parameter. Building on the work of Dragut, this paper attempts to improve the selection procedure of the other two parameters (shape and compactness) that will speed up the segmentation process, unlike the trial and error method. For glacier surface mapping, the shape parameter plays the least role as their shape is not definite. Therefore, the spectral information linked to Green and Shortwave Infrared (SWIR) bands is used to define color criteria. The compactness parameter value is determined by object-based compactness polygon feature. These parameters have been incorporated with the existing ESP-2 technique. The optimal segmentation results have been observed by the proposed approach. Furthermore, the homogenous image objects obtained are then classified into desired classes by using a rule-based classification approach.

MATERIAL AND METHODS

Study area: Karakoram range is a mountain range spanning over India and China borders that cover 500 km glacierized area in length. Various test areas are chosen over the Karakoram range to assess the performance of proposed technique (Fig. 1). The test area T1 is located in Aghil mountains. The T2, T3, T4 and T5 are test areas in Siachen glacier region. Siachen glacier is longest glacier in the Karakoram that stretches over 76 km. The T6 and T7 test areas are in Saksham valley that is located in north of the Karakoram. They have different glacier faces such as ice, debris, rocks, lakes, etc. However, the focus of this study is only on mapping the glacier ice surface. The Landsat 4-5 Thematic Mapper (TM) dataset is used. It has seven bands (Blue, Green, Red, NIR, SWIR1, Thermal, and SWIR2) of 30m each spatial resolution.

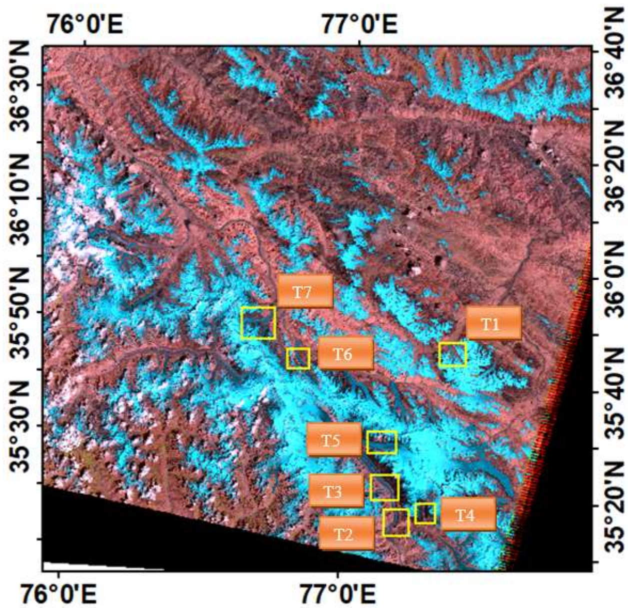


Fig. 1. Different test areas highlighted with yellow box

Parameter Optimization of Multi-resolution Segmentation

The multi-resolution image segmentation is a bottom-up region-merging approach that considers each pixel as a separate object and subsequently merges image objects to form bigger objects based on homogeneity criteria that describe the degree of similarity between adjacent image objects (Baatz et al 2000). A customized tool ESP2 is used within the eCognition Developer Software suite for identifying a suitable range of scale parameters for segmentation on glacier imagery. This tool automatically segments the image with user-defined increment value for scale parameter and generates three hierarchy levels. This methodology measures Local Variance (LV) over the entire scene. The automatic selection of scale parameter is based on a threshold calculated at a point where the LV value at the current level (LV_n) is equal to or lower than the LV value generated at the previous level (LV_{n-1}). Then, the scale parameter value of layer n-1 is then considered as an optimal parameter for segmentation.

In addition to scale, shape and color/intensity are another important parameter that influences the segmentation process. Shape feature plays an important role in extracting structures like buildings, roads, etc. These structures have a well-defined shape. The ice doesn't have a definite shape, but it differs from neighboring objects with its pixel color/intensity information. Therefore, in addition to optimization of scale parameter through the ESP-2 tool, features related to intensity values of pixels have been included during segmentation. To monitor glacial ice cover, the spectral information stored in green and shortwave infrared bands widely known as Normalized Difference Snow Index (NDSI) is used. Equation 1 defines NDSI ratio that separates the snow/ice area from the rest part of the glacier.

$$NDSI = \frac{TM_{Green} - TM_{SWIR1}}{TM_{Green} + TM_{SWIR1}} \quad (1)$$

The measure of shape compactness feature is used to represent the degree to which shape is compact (Gillman 2002). The compactness is acknowledged as the alluring property of the shape that defines the homogenous region sharing common attributes and properties (Tobler 1970, Angel et al 2010, Wenwen et al 2013). A compact polygon has its vertices equidistant from the centroid. It can be quantified by comparing its area with an ideal shape like a circle (having maximum compactness). Equation 2 defines the polygon compactness that is computed by perimeter and area.

$$C_{IPQ} = \frac{4\pi Area}{Perimeter^2} \quad (2)$$

Feature value range: [0; 1 for a circle]. Higher the value of C_{IPQ}, the more compact is the shape. A circle is considered to be the most compact shape having a compactness value of 1. It is appropriate in estimating the compactness index for multispectral data. The existing trial and error method of finding optimal compactness parameter is compared with this Iso-perimetric Quotient measure of computing compactness.

RESULTS AND DISCUSSION

This paper has discussed two different ways of optimizing the compactness parameter for multi-resolution segmentation. One is the trial and error technique and the other is the iso-perimetric quotient to measure optimal compactness parameter. Both methods have been tested on the seven test areas. Table 1 summarizes the segmentation results for T1 at different compactness parameters by keeping shape parameter constant. Level L1 being the finest object-level is considered that formed the segments similar to the real world. The tool automatically updates the Scale Parameter (SP) for different values of the compactness parameter. The SP is computed based on LV and graphically presented through LV graph where objects are well-defined in a meaningful manner. Figure 2a shows the SP value at which an optimum segmentation result is obtained for trial and error. Figure 3 shows the segments (homogenous region) formed at different compactness values ranging from 0.2 to 0.9. The problem of over-segmentation and under segmentation occurred and are represented by white and

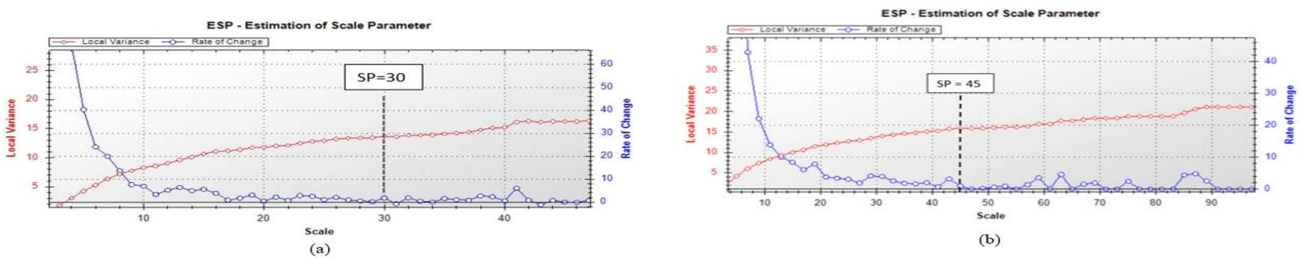


Fig. 2. LV graph generated by ESP2 tool representing dark black dotted line indicating the SP that results in optimum segments for the area T1 obtained by (a) Trial and Error method and (b) Proposed method

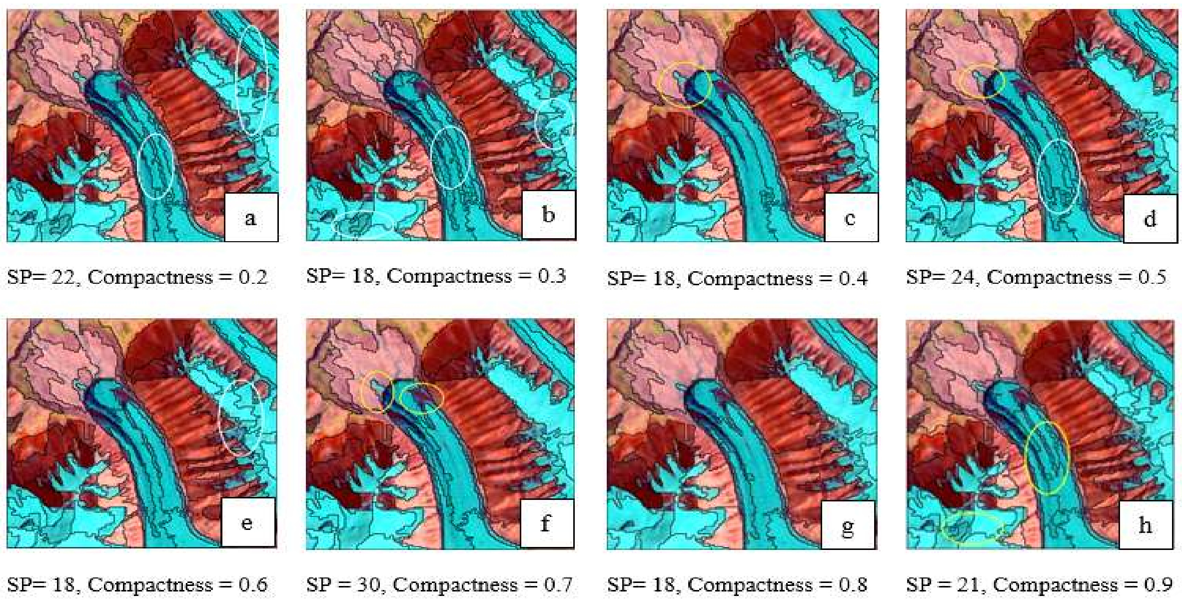


Fig. 3a-h. Detail of segmentation results for test area T1: at different combinations of scale and compactness parameters

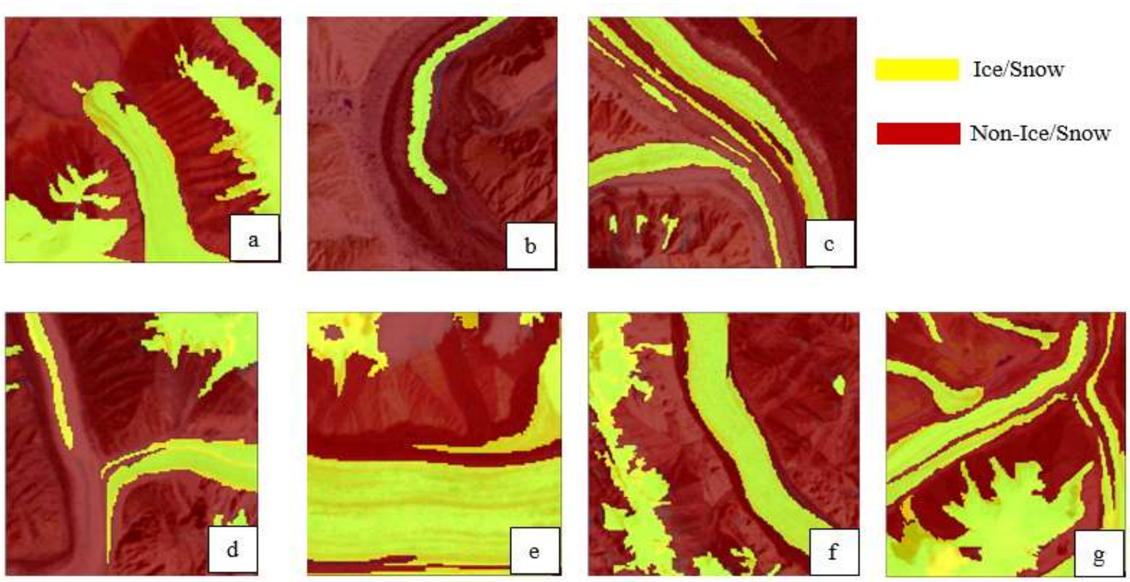


Fig.4a-g. Rule-based classification results of seven different test areas

Table 1. Segmentation results at different compactness value for test region T1

Trial	Hierarchy level	Scale	Shape	Compactness	Number of objects
TR1	L1	22	0.1	0.2	119
	L2	72			20
	L3	272			4
TR2	L1	18	0.1	0.3	177
	L2	88			14
	L3	288			4
TR3	L1	29	0.1	0.4	73
	L2	69			18
	L3	269			4
TR4	L1	24	0.1	0.5	103
	L2	104			11
	L3	204			4
TR5	L1	25	0.1	0.6	94
	L2	95			12
	L3	395			1
TR6	L1	30	0.1	0.7	68
	L2	100			13
	L3	200			4
TR7	L1	30	0.1	0.8	70
	L2	90			15
	L3	190			4
TR8	L1	21	0.1	0.9	125
	L2	71			20
	L3	271			4

yellow circles respectively. Based on visual assessment, the best segments are obtained for the combination of SP = 30 and compactness = 0.8 (Fig. 3g). This technique involves a rigorous exercise in finding the optimal compactness parameter and hence, making it a time-consuming task. Therefore, an effort is made to optimize the selection procedure of the compactness parameter that will speed the process.

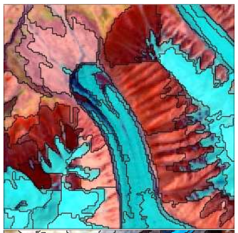
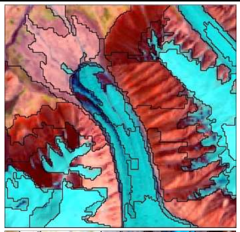
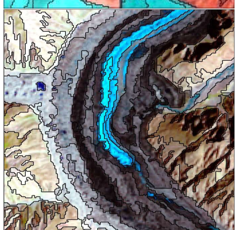
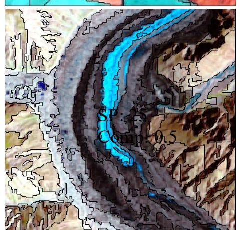
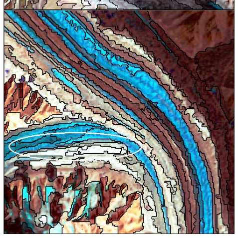
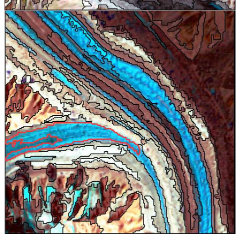
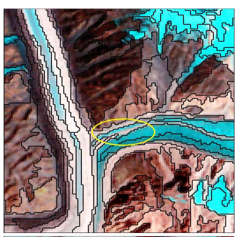
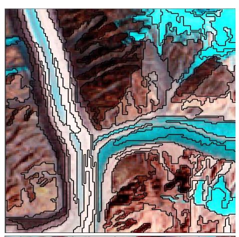
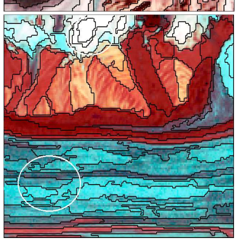
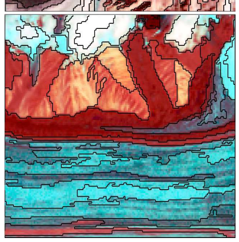
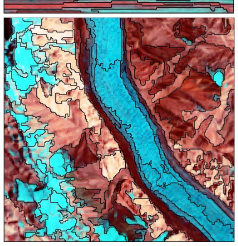
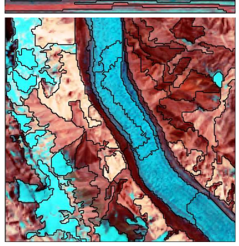
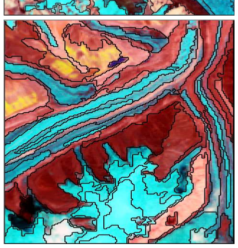
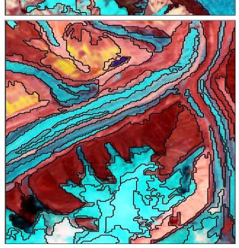
The object-based feature iso-perimetric quotient is used to define compactness parameter that successfully obtained the optimum segments at SP = 45 in a single iteration as shown in Table II (refer Test area 1). In addition to this, NDSI is also used to define the color parameter. Figure. 2b shows LV graph highlighting the SP value at which an optimum segmentation result is obtained by the proposed method. The efficacy of the proposed approach is tested on remaining six areas and results are compared with trial & error technique. Table 2 summarizes the optimal segmentation results. It is observed that the ice/snow area is properly segmented in a single iteration by proposed approach. Based on the visual assessment, an optimal segmentation is achieved that has minimized over-segmentation as well as under segmentation. Therefore, it can be concluded that the proposed technique has sped the segmentation process in comparison to traditional trial and error technique and have shown acceptable results.

The next step is to classify these homogenous image objects into desired classes. NDSI feature is used to map ice/snow cover area (refer to equation 1). The threshold value of 0.2 is used to differentiate the glacier ice region from the non-glacier ice region. Fig. 4 shows classified maps of all the seven areas highlighting ice area in yellow color. The overall classification accuracy of 97.3% to 98.5% is observed computed by an error matrix within eCognition developer software.

CONCLUSIONS

The selection of optimal segmentation parameters was dependent on the Trial and Error approach. This approach has proven to be very time-consuming in finding the best combination of the three user-defined parameters (scale, shape, and compactness) to get an effective segmentation result. This paper has sped up the selection procedure of segmentation parameters. The scale parameter was estimated by using ESP2 tool within the eCognition software. The object-based features NDSI and IPQ, were used to calculate the color and compactness parameters. The inclusion of these features has reduced computational complexity. The proposed approach has appeared to produce the generalized results and a better partition of the glacier surface from the land classification perspective in a single iteration.

Table 2. Optimal segmentation results for different test areas obtained by trial & error and proposed technique

Trial and error technique (Shape = 0.1)		Proposed technique (NDSI & ISO-perimetric quotient for compactness)	
	SP: 30 Comp: 0.8		SP: 45
	SP: 25 Comp: 0.5		SP: 37
	SP: 27 Comp: 0.2		SP: 37.2
	SP: 25 Comp: 0.2		SP: 25
	SP: 29 Comp: 0.9		SP: 40
	SP: 34 Comp: 0.5		SP: 38.5
	SP: 34 Comp: 0.5		SP: 35

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Artificial Photoperiod Influence on Survivability, Pigmentation and Hematological Parameters in Live-Bearer Ornamental Fish, *Poecilia sphenops*

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Abstract: Effect of photoperiod manipulation was conducted on survival, body color and hematological parameters of *Poecilia sphenops,* Red eyed orange molly (average weight 0.52 g) reared in laboratory under three photoperiods *viz.,* long (18L:6D) and short (12L:12D and 10L:14D) regimes for 60 days with constant light intensity of 1500 lux on the water surface. All fish groups were fed with formulated feed. At the end of 60 days experiment the survival rate was 100% and no mortality was observed. The body colour showed bright skin colour measured by higher values of carotenoid content of fish group exposed to long photoperiod. Significant higher values of RBC, Hb, MCHC and MCV was noted in fish exposed to long-day photoperiod when compared to those exposed to short-day photoperiods. No significant difference was observed in PCV of different experimental groups whereas WBC showed significantly lower values in 18L: 6D when compared to 12L:12D and 10L:14D. Therefore, results confirmed that long-day manipulated photoperiod was effective in enhancing skin color in *P. sphenops* without any measurable stress and mortality.

Keywords: Photoperiod, *Poecilia sphenops*, Survival rate, Skin color, Hematological parameters

Photoperiod is known to act as an artificial Zeitgeber (cue or synchronizer), which affects fish in regulating their daily endogenous rhythms, growth, locomotor activity, body pigmentation, metabolic rates, haematological parameters and reproduction. Hesser (1960) was pioneer in proposing the use of haematological parameters in assessing the physiological condition of fish and since then haematology is considered as index of fish health status in fish species. Many scientists have reported the importance of photoperiod as important environmental factors in physiology of fish with the combined influence of light quality (wavelengths absorbed by water to various extents), light quantity (different light intensities) and light periodicity (different photoperiod) which in turn helps to improve the production of species (Wang et al 2015). Therefore, light has many important roles in survivability of fish which affect the hematological parameters (Leonardi and Klempau 2003) and skin colour (Gines et al 2004). Although survival is first and foremost characteristic in aquaculture but the percentage of survivability of ornamental fish is variable and species specific.

Fish skin colour an essential factor, depends on the presence of chromatophores which consists of lipid soluble pigments and the colour variation maybe due to environmental stress and light intensity which synchronizes distribution of pigments by regulating hormone secretions (Hill 2002). Many scientists have studied improvement of skin colour in various fish species by exposing them to different photoperiodic regimes which helps to determine their commercial value. Change in the environmental condition such as photoperiod and temperature causing variation in the physiology of fish can be assessed by measuring the hemato-biochemical parameters (Shahkar et al 2015). These parameters also help in understanding the relationship of blood characteristics to the adaptability of the different species to the environmental condition.

Poecilia sphenops (red eyed orange molly) the test fish, belonging to family Poeciliidae is one of the demanding ornamental fish in India used as fish keeping in home and is found in the streams and ponds of Mexico and United States (Froese and Pauly 2010). There is lacunae on the studies related to the effect of photoperiodic on colour and haematological performance of live-bearer ornamental fish. Therefore, present study was designed to assess these effects and a novel observations on colour and blood parameters has been reported on *P. sphenops* without causing any stress to fish.

MATERIAL AND METHODS

Experimental fish: The experiment was conducted with test fish *P. sphenops* obtained from brood stock in Ornamental Fish Research Center, Hebbal, Bengaluru with an average initial weight of 0.52±0.003 g and average total length of 3.2±0.03 cm.

Experimental design and procedure: To assess the objectives of the experiment, fish were subjected to three artificial photoperiod regimes (18L:6D, 12L:12D and 10L:14D). The experiment was conducted in the laboratory using a fiberglass tank with a capacity of 50L for each experimental group. Water was aerated by a constant supply of air pump and 25% of water in each tank was renewed daily with fresh dechlorinated water so as to remove the feces and uneaten feed. Each experimental tank was provided by a florescent lamp of 28 W suspended by about 40cm over the water surface with a light intensity at 1500 lux kept constant by timer control throughout the study. The water temperature of each experimental tank was also kept constant at 28°C with the help of thermostatically controlled 50 W heaters (model no. RS008-A) kept in all the tanks arranged in closed wooden chamber. The test fish was acclimatized for a period of one week before the start of experiment. Each tank was stocked with 4 fish (1M:3F) with 3-replicates for each experimental group and the experiment was conducted for a period of 8 weeks. Prior to the experiment the fish were starved for 24 hours and total length and weight measured keeping the initial weight of fish with a difference of 0.52 g $fish^{-1}$. Fish were fed with a formulated pellet diet twice per day (morning 9.00 am and evening 16.00 pm) at the rate of 10% of body weight for the experimental period. The physico-chemical parameters of experimental water were analyzed every week. The dissolved oxygen (DO), free ammonia (NH3), hardness and alkalinity, were analyzed by a standard method of APHA et al (2005). pH was measured using a Digital pH meter (MK-VI).

Carotenoid content estimation: The skin colour of fish, *P. sphenops* was estimated by measuring total carotenoid concentration of skin and muscle tissue at the end of 60 days in accordance with the pigment extraction method as described by Olson (1979). At the end of the experiment the fish was anesthetized using MS-222 or clove oil (dissolved in 95% ethanol at 1:10). One gram of whole fish body tissue, excluding head and alimentary canal was transferred to a glass homogenizer. The skin was grinded well with 2.5 g of anhydrous sodium sulphate and 5ml of chloroform. It was later kept overnight at 0° C in a refrigerator. After diluting chloroform (0.3 ml) with 3 ml of absolute ethanol, the optical density was read at 380, 450, 470 and 500 nm, in a Systronic spectrophotometer (Model no.104) and maximum absorption was recorded at 470 nm wavelength. A blank was prepared in a similar manner without using the fish body tissue. Carotenoid concentration was calculated by using following standard formula:

$$\text{Total carotenoid concentration } (\mu g/g \text{ wet weight}) = \frac{\text{Absorption at maximum wave length}}{0.25 \text{ sample weight (g)}} \times 100$$

Where, 10 = dilution factor, 0.25 = Extinction coefficient.

Hematological analysis: Three fishes were randomly selected from each treatment at the end of the experiment and later sacrificed by a dose of anesthesia MS-222. Blood was collected from the caudal vein of fish using heparinized syringes in heparinized tubes, and then centrifuged at 3500 rpm at 4°C. The hematological parameters *viz.,* RBC and WBC were evaluated by Neubauer's improved hemocytometer (Samuel 1986), the packed cell volume (PCV) or hematocrit values (Wintrobe's method), and hemoglobin (Hb) (Sahli's hemoglobinometer). Mean corpuscular hemoglobin concentration (MCHC), and mean corpuscular volume (MCV) were calculated by compliance with the following standard formulae (Dacie and Lewis 1991) in accordance with Zutshi et al (2010).

$$\text{MCHC} = \frac{\text{Hb in g/100 ml blood}}{\text{PCV/100 ml}} \times 100 = \text{g/dl}$$

$$\text{MCV} = \frac{\text{PCV/1,000 ml blood}}{\text{RBC in millions/mm}^3} = \text{fl}$$

Survival rate: Survival rate was calculated by the following standard formula:

Survival rate % = (Final fish number - Initial fish number) × 100/Initial fish number

Data analysis: The statistical significance of the parameters was computed using one-way analysis of variance with Tukey's multiple comparison tests with the help of Graphpad prism ver. 6.00.

RESULTS AND DISCUSSION

DO measured as 7.1 mg l^{-1}, free ammonia as 0.73 mg l^{-1}, hardness as 240 ppm, alkalinity as 213.5 mg l^{-1}, and pH values were 7.5 in all the tanks throughout the experimental period. Color performance and hematological parameters of *P. sphenops* have revealed statistically significant differences between the experimental groups of fish exposed to different photoperiods. Photoperiod is an important environmental factor which affects many metabolic features *viz*., survivability, skin colour, growth, blood parameters, reproduction in any animal (Rad et al 2006, Zhu et al 2014). In the present study, 100% survivability was observed in molly fish, *P. sphenops* when exposed to short and long photoperiodic conditions. Similar result was reported by El-Sayed and Kawanna (2004) in *Oreochromis niloticus* L. when exposed to the long light photoperiod (24L:0D and 18L:6D).

Various scientists have demonstrated effect of light intensity on the survivability of fish *Leiocassis longirostris* (Gunther) and *Haliotis discus* (Hannai) fish (Han et al 2005, Goa et al 2016), respectively. Thus, exposure of ornamental fish to light and dark condition showed improvement in the health of fish and also kept them alive for a longer period benefitting the aquarist. However, many workers have reported about mortality in fish exposed to different pH, light and temperature (Honryo et al 2013, Hundt et al 2015).

Color is another important feature in the ornamental fish industry for its marketing (Gouveia and Rema 2005, Rajeswari et al 2017). In the present study, the value of carotenoid content in the skin and muscle tissue of fish exposed to different photoperiodic treatments was evaluated. The result were interesting since the carotenoid content of fish exposed to long photoperiod (18L:6D) was 22.26±0.47 µg g^{-1}, indicating that the skin color as well as carotenoid content exhibited positive response which was followed by those exposed to short photoperiod 12L:12D (20.53±7 µg g^{-1}) and 10L:14D (11.73±61 µg g^{-1}) (Fig. 1).

This positive result also demonstrated that light does regulate the chromatophore performance either by accumulating or dispersing the pigments as was suggested by (Fujii 2000). These results were in agreement with Gines et al (2004) and Ali et al (2013) who observed high values of carotenoid content in sea bream (*Sparus aurata* L.) and Nile tilapia (*Oreochromis niloticus*) respectively when exposed to continuous light period (24L:0D) which might also be attributed to its adaptation. Matsuno (2001) suggested that skin colour of fish can be altered when exposed to certain environmental conditions or if it is fed with carotenoids since its known that fish are unable to synthesize their own carotenoids which helps them to impart colour. The accumulation of melanophores caused dark colouration of dorsal body of red porgy was observed by Chatzifotis et al (2005).

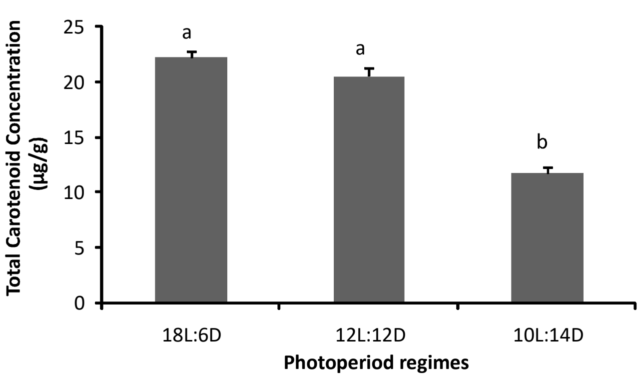

Fig. 1. Carotenoid analysis of *P. sphenops* exposed to different photoperiods

Higher RBC (0.49±0.004) and Hb (3.5±0.06) was recorded when fish were exposed to long day photoperiod (18L:6D) as compared to subjected under 12L:12D (0.42±0.004, 2.8±0.04 respectively) and 10L:14D (0.41±0.006, 2.6±0.04, respectively). Similarly, MCHC (83.8±0.02) and MCV (55.1±0.04) of fish reared under 18L:6D was higher and significantly different from those of fish exposed to 12L:12D (65.5±0.04, 44.4±0.04, respectively) and 10L:14D (53.3±0.04, 38.7±0.02, respectively) (Table 1).

Although no significant difference was detected in PCV under different photoperiods but it was found to be higher in long day photoperiod (18L:6D) (2.1±0.04) compared to those under other treatments (1.8±0.04) (Table 1). It is important to have the acquaintance regarding the various hematological parameters of fish so as to facilitate the development of indicators to identify the health status of fish in response to changes associated with their nutrition, water quality and disease. It is also a known fact that intrinsic and extrinsic factors affect the hematological values (Clauss et al 2008). A remarkable result emerged from the study is that the WBC was significantly higher in normal light and dark cycle (12L:12D) (19.1±0.04) followed by 10L:14D (18.6±0.04), when compared to 18L:6D (11±0.04) (Table 1). Some parameters also revealed statistically significant differences between the photoperiodic groups of fish. Although it is known that hematological parameters are observed as consistent indicators for assessment of health status in fish but any change in the different environmental factors viz., water quality, behavior, habitat and climate or season, temperature and photoperiod have been recognized as a threat to their health and thus causing loss in aquaculture (Noga 2000, Tavares-Dias and Moraes 2004).

Photoperiod is regarded as a standardized abiotic factor in affecting blood parameters in variety of fishes. Previous works relating to the effect of photoperiod on hematological

Table 1. Effect of different photoperiod regime on hematological parameters of *P. sphenops*

Hematological parameters	18L:6D	12L:12D	10L:14D
Red blood cell (RBC)	0.49±0.004^{a}	0.42±0.004^{b}	0.41±0.006^{b}
White blood cell (WBC)	11±0.04^{c}	19.1±0.06^{a}	18.6±0.06^{b}
Packed cell volume (PCV)	2.1±0.04	1.8±0.04	1.8±0.04
Hemoglobin (Hb)	3.5±0.06^{a}	2.8±0.04^{b}	2.6±0.04^{c}
Mean corpuscular hemoglobin concentration (MCHC)	83.8±0.02^{a}	65.5±0.04^{b}	53.3±0.04^{c}
Mean corpuscular volume (MCV)	55.1±0.04^{a}	44.4±0.04^{b}	38.7±0.02^{c}

Values are expressed as mean ± SE. The superscripts a, b and c indicate statistical mean difference at P<0.0001, 0.001 and 0.01 respectively parameters have been mostly conducted on food fishes and result observed were diverse (Bani et al 2009, Solomon and Okomoda 2012, Fazio et al 2016). In the present study, the manipulated long photoperiod (18L:6D) caused significant increase in the levels of RBC, Hb, PCV, MCV and MCHC with a simultaneous decrease in WBC values in *P. sphenops*. Similar result was reported in Caspian Roach by Shahkar et al (2015) when the fish was exposed to long photoperiod (24L:0D and 18L:6D) showing significant variation in RBC and Hb but not as much in PCV and WBC when compared to other photoperiodic treatments. In contrast to the above results and under prolonged photoperiod (18L:06D), a significant reduction in Hb and RBC, while an increased WBC and blood glucose level was reported during initial 07 days of exposure by Shahjahan et al (2020). Such results might be due to highest stress response during initial exposed period but later on with extended days of exposure the fish probably is adapted to the exposure and shows no further change. Thus the significant increase in values of RBC and Hb and a decrease in WBC in the present investigation in the fish under long light period (18L:06D) compared to other two photoperiod regimes confirms that fish was not under stress due to long light photoperiod. Additionally, PCV also showed high values in 18L:06D exposed *P. sphenops* fish group when compared to other treatments. In contrast to the present result a decrease in PCV was reported by Barcellos et al (2004) in fish exposed to a stressful situation whereas Pierson et al (2004) had reported an increase in PCV in rainbow trout in similar conditions. This increase in PCV credited to swelling of RBC. Therefore, in both the above mentioned conditions an increase in RBC was noticed due to its swelling.

Studies conducted by Solmon and Okomoda (2012) showed that the volume of average erythrocyte and the amount of haemoglobin present are related to the mean corpuscular values. MCHC corresponds to the concentration of Hb which is in accordance with the present result of increase in the values of RBC, Hb and MCHC in the fish exposed to long light period (18L:06D). However, similar to the result of the present study the juvenile of great sturgeon (*Huso huso*) when exposed to 12L:12D photoperiod by Bani et al (2009) showed high values of haemoglobin and erythrocyte (RBC) numbers when compared to other photoperiods while haematocrit values or leucocyte numbers did not show any significant difference. But lower levels in haemoglobin and erythrocytes in fish was observed under 24L:00D photoperiod which is in contrast to the result obtained in the present study. These experiments were performed on food fish under different laboratory conditions and using stressors. Akinrotimi et al (2010) observed that variations in value of MCHC and MCH are indicator of the stress induced which is expressed by the extent of the shrinkage of cell size of erythrocytes. Valenzuela et al (2006) demonstrated that the erythrocyte number and haematocrit values increased and MCH values decreased in rainbow trout fish blood in response to 24L:00D for a period of two months which was in accordance to the results of the present study. Thus, to evaluate physiological conditions as survival rates, health, growth, gonadal maturation in fish, analysis of hemato-biochemical indices of blood are an important objective (Biswas et al 2006, Kitagawa et al 2015).

CONCLUSION

The hypothesis that the number of circulating erythrocytes is developed under a continuous light regime holds good for the ornamental fish *P. sphenops*. This study therefore demonstrates the fact that exposure of long light photoperiod leads to survivability, color enhancement and significant changes in haematological profile of a fish. According to various citation lacunae found in the studies related to exposure of live-bearer ornamental fish to various photoperiods is fulfilled by this first report for successful survivability, coloration and blood profile.

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Comparative Study of Amino and Fatty Acids Synthesis in Two Different Groups of Common Carp (*Cyprinus carpio* L.) Cultured in Floated Cages

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Abstract: The purpose of this research was to show the comparative analysis for fatty acids and amino acids in muscle tissues of two groups of common carp (*Cyprinus carpio* L.) H1 (old production line, 1982) and H2 (the new production line,2009)which are important from economical, commercial and nutritional point of Iraqi consumer. These groups were farmed in floating cages at Euphrates River, Babylon province, Iraq lasted for 90 days. The fishes were fed on commercial diet (Alear, Denmark®) with 30% protein and 7% fat. After finishing the experiment, all samples were analyzed. There was a similarity in body components regarding to moisture, protein and ash proportions from both H1 and H2, whereas the total amount of fat content was high in H1(7.21%) and low in H2(4.12%). H2 has ability for body protein synthesis higher than fat deposition as compared with H1.The saturated fatty acids (SFA) in fishes muscle was 34.24 and 27.79% in relation to total fatty acids (TFA) for H1 and H2 respectively. This is in turn reflects on SFA/ unsaturated fatty acids (USFA) which was in high ratio in H2 (2.61%) compared to H1(1.29%). Monounsaturated fatty acids constitute high part of TFA (45.08%) in H2 whereas was 39.23% in H1. The total SFA and MUFA was low in muscle of H2. The SFA/PUFA nearest to 1 in H2 (0.98%). The ω6/ ω3 in H1 and H2 were 0.44-0.48. The muscles of common carp for both groups contain all essential amino acids (EAA) but in different proportions. Although there were individual differences, some of them were significant in the ratios of essential and nonessential amino acids between the two groups of fish. The total ratios of essential and nonessential amino acids did not show significant differences and were similar between the two groups. High levels in EAA especially lysine (Lys), arginine (Arg) and valine (Val) was in new production line (H2). It should take in consideration importance of H2 as one of valuable common carp which was introduced to Iraq in 2009, and is characterized by its high nutritional value due to its contents of USFA and EAA compared to old production line H1.

Keywords: *Cyprinus carpio,* Fatty acids, Amino acids, GC-MS, HPLC

Fishes contribute by 60-70% of protein consumption for many countries (Osman 2001). The amino and fatty acids in protein and fat of muscles and tissues are the key fish meat quality parameters (Saffar et al 2017). Fish protein is belong to high valuable quality and it can exceed the standard chicken egg protein (Krystyna et al 2013). The chemical composition of fish muscle is one of good indicators for physiological and hygienic state (Ali et al 2005). The fresh water fish characterized by high nutritional value and it has been recommended for essential biological protein and amino acids, PUFA and fat soluble vitaminsin addition to major and minor elements (Maqsood and Benjakul 2010). Common carp muscle has low and high protein content compared to trout and fish flat (USDA 2004). Rearing of common carp has much more systemic attention all over the world because of its high productive characteristics and nutritional value (Kocour et al 2005). Based on production changes and nutritive composition of muscles, the efficiency of genetic selection for different lines of common carp are done (Gela et al 2003). There are now two groups or lines of common carp *Cyprinus carpio* L., first group was imported from Indonesia in 1952 (AL- Hamed1971) and was reared in 1982. The second group of common carp was introduced in 2009 to Iraq which was imported from Hungary and it was reared in 2009 in different farming system. There is no available studies regarding to chemical composition and amino and fatty acids contents in common carp. Therefore, the current study was implemented to measure the nutritive value content in fish muscles for each species and to determine the beneficial species in human nutrition.

MATERIAL AND METHODS

Fish samples: After the end of the growth experiment which lasted for a period of 90 days, two groups (2 replicates/ group) of common carp cultured in intensive culture systems in floating cages on the Euphrates River, Iraq.

1^{st} group (H1): common carp fish, the old production line,1982.

2^{nd} group (H2): common carp fish, the new production line-, 2009.

Fish was fed on a commercial floating diet from Danish origin (Alear) with 3% of body weight, with a protein and fat contents of 30 and 7%, respectively. After the completion of the experiment, samples were taken *Cyprinus carpio* from both groups (H1) and H2) with an average weight 557.5 and 670 grams, respectively chemical analysis.

Chemical analysis: The chemical analyzes were carried out at the Ministry of Science and Technology, Environment and Water Department, Baghdad, Iraq using the (GC-MS) Gas Chromatographic-Mass, (LC-10A Shimadzu) and the fatty acids were estimated according to the methods mentioned by Feng et al (2004).Meat from the dorsal muscles was used for chemical analysis and, the chemical composition of the muscle tissue of the fish was determined by the standard methods AOAC (2000). The water content was estimated, by drying at a temperature of 105 ±2ºC until the weight is stable. The protein content determination was carried out by Kjeldahl apparatus and then multiply the nitrogen content by 6.25. The raw fat is extracted from the muscles by using the organic petroleum ether solvent by using the Soxhlet apparatus. Ash was estimated by combustion for 8 hours in the dry sample by taking 5 grams of the sample and then placed in the Muffle furnace at 550°C (Trbovicet al 2009).

Fatty acid analysis: Total fat was extracted to determine fatty acids from fish muscle tissue by extracting with solvents chloroform / methanol (2/1, v / v) based on method Bligh and Dyer (1959). The resultant oil in this way is called crude oil, and methyl esters of Trimethyl sulfonium hydroxide estimated according to the method of (Spiric et al 2010).

Amino acid analysis: The amino acids of the two groups were estimated from five fish from each group after finishing the field experiment in floating cages, and about 10 grams of meat from the area between the side line and the dorsal fin of each fish was taken and then placed in an electric mixer to mix the meat samples uniformly for each group. Thereafter was placed in tight plastic bottles and preserved at -20°C (Saffaret al 2017) for analysis. The amino acids in fish muscle tissue were identified by High- Performance Liquid Chromatography (HPLC). Amino acids were extracted according to the method Rasmus Dahl – Lassen (2018).

Statistical analysis: The data was statistically analyzed using IBM SPSS statistics 22.

RESULTS AND DISCUSSION

Chemical composition of muscles: There was no significant differences in body components (moisture, protein and ash) of common carp fish of the two groups (H1 and H2). Common carp fish in group (H1) indicated significant increase in the percentage of fat (7.21%) as compared to common carp fish in group H2 (4.12%) after three months of rearing. Ćirkovićet al (2012) also made similar observations. The fat content was compensated by the water content. Özogulet al(2007)observed an inverse relationship between fat and water content. The fat contents were higher in H2 than in H1.

Fatty acids composition: The analysis for crude oil extracted from the muscles of carp fish in the two groups identified group of fatty acids includes SFA (saturated fatty acids), MUFA (monounsaturated fatty acids), PUFA (polyunsaturated fatty acids) and the relationship between them, and n-3 and n-6 omega acids (Table 2). The saturated fatty acids SFA was significantly high in H1 fish by 34.24%, while this percentage decreased significantly to 27.79% in the new group H2 of total fatty acid content in muscle fat. Ćirković et al (2012) observed that the percentage of SFA was 24.23% in the muscles of carp fish, while SFA (myristic acid, palmatic acid and stearic acid) were prevalent in the muscles of fish of two groups which are considered one of the most fatty acids present in saturated fatty acids of carp fish. Similar trend was observed by in earlier studies (Mahmoudet al 2007, Özogul et al 2007) which indicated that myristic fatty acids, stearic and palmatic are the major acids prevalent in SFA whereas palmitic acid has been the major in other saturated fatty acids in common carp. There was significant decrease in the percentage of these saturated acids in H2. Palmatic acid was major among the saturated acids in muscles of the two groups fish, with a significant decrease in H2 by 16.05% compared with H1 by 20.34%. Mehmet et al (2011) documented that palmatic acid reordered the highest ratio of saturated fatty acids. Analysis of fatty acids showed that the total content of USFA in H2 increased by 72.20% compared to 65.75% inH1. The increase in the percentage of PUFA was observed in fat tissue of the two groups muscles.

PUFA are one of the most beneficial acids for to the human body (Mindaugas et al 2016). PUFA in meat and muscle tissues in common carp ranged from 12.05% (Fajmonovâ et al 2003) to 32.58% (Stanchev et al 2014). The results of the analysis of the muscles of the two groups fish also showed that the content of MUFA in the muscles of the two groups differed significantly in favor of H2 (45.08%) compared to H1 (39.23%). Łuczyńska et al (2012) pointed out that content of MUFA in fish oil in common carp muscle tissue may reach 55%. The concentration of fatty acids, (MUFA and PUFA) in common carp muscles are affected by several environmental and other genetic factors depending on the season and nutrition. Mindaugas et al (2016) also concluded that the highest content of MUFA was 57% in common carp fish. Trbovic (2013) indicated a decrease in the content of saturated fatty acid (SFA) in the muscles of common carp. The SFA in the muscles of common carp fish in H2 was 27.79% compared to 34.24% in H1. The relationship between PUFA / SFA is used as indicator to assess the quality of fats in fish and should be above 0.45% in fats (Department of Health and Social Security 1994). Woodet al (2008) concluded that the ratio of PUFA / SFA should be higher than 0.4% and this was observed in the muscles of the two fish groups in current study. Therefore, the percentage of SFA / PUFA was close to 1%, especially in the H2 which had a concentration of 0.98% compared to H1with 0.77%.The relationship between the PUFA / SFA ratio is an indicator of the quality of fats in fish. Mayra et al (2017) indicated that low values in the PUFA / SFA ratio are undesirable because they cause increased cholesterol level in blood. Although the relationship between the percentage of PUFA / SFA was high in the fish of the two groups (0.77 and 0.98%) due to the high content of PUFA with a significant superiority in favor of H2, Ivanovo and Hadzhinikolova (2015) observed that feeding common carp fish on complex diets resulted in more appropriate ratio of PUFA / SFA in fat of fish muscle. Simopolous (2013) observed that the percentage of fatty acids (PUFA / SFA) closer to 1% is evident of a balanced distribution of groups of fatty acids in fish meat, and was found in fat muscle of carp fish common in group H1.

Common carp contain the highest levels of ω-3 compared with levels of ω-6 in fatty acids (PUFA) and similar trend was observed by Tocher (2003). The ratio between ω-6 / ω-3 is an important measure in assessing the quality of fats in fish and important in human health. Some studies indicated the that fatty acids (ω-3 and ω-6) in fish muscles prevent heart disease and blood pressure (Kris-Etherton et al 2002). However, excessive quantities of ω-6 have the opposite effect and a balanced relationship between ω-3 and ω-6 in the diet should be maintained. The optimum range for ω-3 / ω-6 ratio for human health ranges from 0.2-0.5 (Steffens et al 2005). The current study indicates that the ratio of ω-6 / ω-3 in fish of two groups was less than 4%, which is recommended by WHO and FAO. The study related to ratio of ω-3 / ω-6 in common carp ranges between 0.8-2.4% (Boukortt et al 2004). Many other observations indicated percentage 0.5 (Ljubojević et al 2013) or 0.2% (Komprda et al 2003). Since the two groups H1 and H2 are omnivorous and fish are on the same commercial diet, so the no variation was observed in PUFA content and in ω-3 and ω-6 ratio between the two groups. The significant increase was observed in the relationship between the ratio (ω-3 / ω-6) and was the highest in the H2 by 2.31% and also the ratio between the USFA / SFA reached a higher percentage in the H2 by 2.61 % compared to H1 group (1.92%). Simopolous (2013) revealed that the balanced distribution of fatty acid groups in muscle tissues of fish is an indication of the high nutritional value, and similar was trend was observed in fat of H2.

Amino acids composition: The total protein ratio of 18.16-19.38 was observed in the tissues of the two groups (Table 3). Polak-Juszczak and Adamczyk (2009) indicated that most of the freshwater fish have an average protein ratio ranging between 16.9-19.5%. The composition of 19 amino acids in the muscles of common carp fish in the two groups was estimated. Dorsal muscle tissue represent the edible part of the muscles, as constitutes 43% of the muscles with a low fat content and makes it easy to extract amino acids (Mayara et

Table 1. Chemical composition of the muscles of two common carps reared in floating cages in the Euphrates river

Parameters (%)	H2	H1
Water content	72.56+1.23[a]	70.07+2.70[a]
Protein content	19.38+0.95[a]	18.16+0.78[a]
Fat content	4.12+0.70[a]	7.21+0.51[b]
Ash content	3.94+0.42[a]	4.57+1.40[a]

The different subscripts in the same row indicate the significant differences ($P \leq 0.05$)

Table 2. Fatty acid composition (%) of muscle of two common carps reared in floating cages in the Euphrates river

Fatty acid	Percent of total fatty acids	
	H2	H1
Myristic (C14:0)	5.68 + 0.41[a]	5.10 + 0.70[a]
palmitic (C16:0)	16.05 + 0.62[b]	20.34 + 0.59[a]
Stearic (C18:0)	6.07 + 0.44[b]	8.81 + 0.30[a]
Palmitoleic (C16:1)	11.02 + 0.92[a]	9.54 + 0.71[b]
Oleic (C18:1)	34.07 + 1.20[a]	29.69 + 1.69[b]
Linoleic (C18:2)	18.79 + 0.83[a]	17.91 + 0.71[a]
Linolenic (C18:3)	8.34 + 0.90[a]	8.62 + 0.40[a]
Σ SFA	27.79 + 1.01[a]	34.24 + 1.43[b]
Σ MUFA	45.08 + 1.23[a]	39.23 + 2.39[b]
Σ PUFA	27.12 + 1.73[a]	26.53 + 1.10[a]
Σ USFA	72.21+1.01[a]	65.76+1.43[b]
ῳ3	8.34 + 0.90[a]	8.62 + 0.40[a]
ῳ6	18.79 + 0.83[a]	17.91 + 0.71[a]
ῳ3/ῳ6	0.44+0.03[a]	0.48+0.01[a]
ῳ6/ῳ3	2.26+0.14[a]	2.08+0.04[a]
Σ PUFA/Σ SFA	0.98+0.09[a]	0.77+0.02[b]
Σ USFA / Σ SFA	2.60+0.13[a]	1.92+0.12[b]

The different subscripts in the same column indicate the significant differences ($P \leq 0.05$). SFA saturated fatty acids, MUFA monounsaturated fatty acids, USFA unsaturated fatty acids, PUFA polyunsaturated fatty acids from the ῳ3 (ῳ3PUFA) and ῳ6(ῳ6 PUFA) al 2017). The nutritional value in a food product, including fish protein, it must be evaluated through its content of amino acids, especially the essential ones. Human beings are unable to synthase essential amino acids in the body which included histidine (His), isoleucine (Ile), lysine (Lue), phenylalanine (Phe), lysine (Lys), methionine (Met), tryptophan (Try) and valine (Val) (Peckenpaugh 2011). Amino acids composition in fish muscle protein are similar to that in humans. The current study indicates that muscles of the two types or groups of common carp are currently used in different culture systems and contain all the essential amino acids in different proportions. The analysis indicated differences in the levels of the presence of those acids.

In the current muscles of common carp for both studied groups contain all essential amino acids (EAA) but in different proportions. Although there were individual differences, some of them were significant in the ratios of essential and nonessential amino acids, the total ratios of essential and nonessential amino acids did not show significant differences and were similar between the two groups of studied fish. However, Krystynaet al (2013) also indicated that there were no significant differences in essential amino acids of carp fish. The muscles of the common carp fish in H2 can be considered a source of a protein of good nutritional value because essential amino acids constitutes 39% of total amino acids compared to H1. Fish muscles are considered to be of high and good nutritional value (Jensen et al 2013), or perhaps the difference in the ratios of essential amino acids in the muscle protein of the two groups might explain the degradation of the genetic traits of H1 (old production line) as a result of inland inbreeding for more than thirty-six years in different culture systems. Hana et al (2009) observed that genetic characteristics of the common carp groups differed in the composition of total essential amino acids and in different proportions between different lines in common carp fish. Perhaps these differences in EAA are linked to changes in the genetic makeup. AL-Jubouri (2012) and Isa and Al-Azzawi (2019) also stated that carp fish in the new production line have better genetic traits than the old production line fish. In the current study it was observed that there are differences between the ratios of essential amino acids between the muscle content of the fishes of the two groups showed a significant superiority in the ratio of Val by 4.37% Val is one of the acids that determines the nutritional value of the common carp muscle protein (Krystyna et al 2013). Val presence is an important essential amino acid in fish muscle protein. Gertig and Przyslawski (2006) indicated that any deficiency or decrease in percentage of Val can cause movement disorders, weight loss and loss of appetite. The ideal content of Val in fish muscles has a positive effect on the normal

Table 3. Amino acid composition (%) of muscle of two common carps reared in floating cages in the Euphrates river

No.	Amino acid (%)	Mean± SD	
	Amino acids	H2	H1
1	Tryptophan(Try)	2.67±0.62 [a]	3.66±3.39 [a]
2	Histidine (His)	1.28±1.16 [a]	2.27±1.19 [a]
3	Isoleucine (Ile)	5.74±0.84 [a]	4.93±2.75 [a]
4	Leucine (Leu)	3.75±0.65 [a]	2.64±1.13 [a]
5	Lysine (Lys)	8.73±1.01 [a]	3.46±1.85 [b]
6	Methionine (Met)	2.92±1.07 [b]	4.49±1.50 [a]
7	Phenylalanine (Phe)	3.54±0.29 [a]	2.56±2.19 [a]
8	Threonine (Thr)	2.60±1.18 [a]	5.48±2.89 [a]
9	Arginine (Arg)	1.22±0.03 [a]	0.96±0.03 [b]
10	Valine (Val)	4.37±0.05 [a]	3.14±0.64 [b]
Essential amino acids (sum EAA)		39.00±3.14 [a]	36.89±6.19 [a]
11	Alanine (Ala)	7.72±0.99 [a]	3.22±2.17 [b]
12	Tyrosine (Tyr)	3.36±1.68 [a]	4.77±2.04 [a]
13	Aspartic acid (Asp)	6.84±0.53 [a]	5.17±1.27 [a]
14	Glutamic acid (Glu)	3.43±1.62 [b]	8.01±1.19 [a]
15	Glycine (Gly)	15.83±0.54 [a]	14.82±1.14 [a]
16	Butyric acid (But)	2.75±0.62 [a]	2.03±1.79 [a]
17	Proline (Pro)	8.39±0.55 [a]	9.54±3.07 [a]
18	Serine (Ser)	6.39±1.56 [a]	3.79±4.35 [a]
19	Taurine (Tau)	8.38±0.2 [b]	15.51±3.45 [a]
Non-essential amino acids (sum NEAA)		60.99±3.14 [a]	63.10±6.19 [a]
	($_{sum}$ EAA / $_{sum}$ NEAA)	0.63 ±1.02 [a]	0.58 ±1.25 [a]
	($_{sum}$ NEAA / $_{sum}$ EAA)	1.56 ±1.42 [a]	1.71 ± 1.06 [a]

Means with the different small subscripts within a row were significantly different at ($P < 0.05$)

functioning of stem cells, especially in people with cirrhosis (Kakazu et al 2007). The higher acid content Lys was found in the muscles of H2 (8.4%) with significant superiority over H1. The presence of high-level of Lys in carp muscle tissue protein is a good indication of the high nutritional value of carp fish in the new production line group, and this is confirmed by Krystyna et al (2013) pointed out that the presence of Lys in a muscle tissue of common carp fish is a positive indicator of the nutritional value in human nutrition. In case of any deficiency in the Lys it must compensate in the body from other food sources, because any deficiency in Lys causes muscular dystrophy because it participates in the representation of calcium in the bone (Peckenpaugh 2011). In current study higher presence of methionine was in the muscles of H1 compared to H2 in which the ratio of methionine decreased. This is a good indication that the muscles of that group's fish are the best nutritional value. In the organs, Homocysteine in turn leads to high blood pressure and heart disease (Hashimoto et al 2007). On the other hand, a deficiency of the amino acid methionine in the protein intake can affect the liver and weaken the body's immune system (Gertig and Przyslawski 2006). The results of the amino acid analysis show the presence of all non-essential amino acids in the protein of the muscles of the two fish groups, but with different levels of occurrence. The significant difference in the alanine and taurine acids and glutamic acid was observed. The dominant amino acid (Gly) in H2 was 15.83%, while Taurine (Tau) was the dominant in H1 (15.51%). Hana (2009) indicated that there was only significant difference in the ratio of the amino acid (Gly) between the different lines of common carp and that Gly constituted the smallest ratio among other amino acids. There was no significant difference was recorded in the ratios of other non-essential amino acids (Pro, Tyr, Ser, and Gly). Maximum growth and feed conversion efficiency can be achieved by manipulating the formation of nutritional amino acids. However, it is not only the levels of dietary protein and amino acid profiles, but also body fat levels that affect levels of formation of amino acids in tissues (Yamamoto et al2000). H2 showed the higher amino acids and the lowest of non-essential amino acids as compared to H1.

CONCLUSION

The common carp muscles in H2 had high protein with medium content of fat whereas was high fat and medium protein in muscles of H1. Moreover, H2 is considered as a new production line and used as source of unsaturated fatty acids essential amino acids (lysine, arginine and valine), omega 3, omega 6, MUFS, medium content of PUFA. Therefore, can be part in nutritional diet to avoid the high consumption of saturated fatty acids, solidarity the health state and preserving body from diseases.

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Causes of *Pelagia noctiluca* Outbreak in M'Diq Beach, Northwest Moroccan Mediterranean Coastline

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Abstract: The M'Diq beach has seen a successive outbreak's of *Pelagia noctiluca* starting in 2011. During the summer season, which is also known as the blooming and stranding's jellyfish season has severe impacts on regional activities. For this reason, this research aimed at documenting the mean causes of *P. noctiluca* outbreaks on our coastline. As a result, the simple linear tests shows that *P. noctiluca* outbreaks have a very significant linear relationship and are positively correlated to sea surface temperature with P= 0.0079 with $y = 3.5254x - 59.616$, $R^2 = 0.2062$, sea salinity P= 0.0029 with $y = 14.741x - 507.54$, $R^2 = 0.2517$ and waves high P= 0.000000002 with $y = 20.473x - 4.4583$, $R^2 = 0.6893$. Moreover, the blooms of jellyfish along with the production of Pelagic fish and whitefish were respectively and share a strong correlation with P= 0.000001936, with $y = -0.0079x + 40.881$, $R^2 = 0.5063$ for Pelagic fish and $y = -0.0323x + 55.431$, $R^2 = 0.3008$ for whitefish production.

Keywords: *Pelagia noctiluca,* Jelly fish, Blooms, Fisheries productions, Moroccan Mediterranean northwest coastline

It is undeniable that long-term climatic change will influence the increase of jellyfish outbreaks, as weather factors such as temperature and precipitation change (Hecq et al 2009, Aouititen et al 2019). Some theories mentioned the impact of some hormone pollutants discharged into the ocean; notably, estradiol contained in drugs for the treatment of menopause and contraceptives, themselves included in human urine as well as the insecticide impacts (Dhawan et al 2012), case study observed of the insecticides toxicity on the marine crustacean the brine shrimp (Nwokwu Gilbert Nwogboduhu 2017); that would result in mutations in fish. Although in tiny quantities, these potent hormones can influence the sexual development of fish, the loss of male fish reduces breeding opportunities and can exacerbate declining fish populations leading to a proliferation of jellyfish. *Pelagia noctiluca*, because of their capacity for budding and asexuality, do not fear these hormones. If global warming persists in the years to come, jellyfish populations will likely increase dramatically in all the world's seas and oceans. Increasing jellyfish populations will directly damage fish populations through predation and competition. The decline of fish numbers risks becoming a vicious circle, although the port of M'Diq is an excellent sardine port, in 2011 there was an alarming indication of a real depletion of the stock. The economic contribution of this type of fishing is becoming increasingly small.

Moreover, the massive appearances of the scyphozoan jellyfish *P. noctiluca* are becoming more frequent in the western Mediterranean. The jellyfish stranding is interfering with fishing by plugging fishnets and competing with fish for food (Kogovšek et al 2010, Daly et al 2010). According to some observations, "jellyfish can also kill fish and their larvae in aquaculture pens, or clog the pipelines of desalting and power plants" (Malačič et al 2007). Another problem observed during surveys where fishers would cast their fishing nets, a large number of jellyfish can become ensnared with the fish become pulverized and contaminated the edible fish, reducing the market value of the catch. *P. noctiluca* is a crucial "non-selective planktonic predator feeding on almost all types of zooplankton and ichthyoplankton" (Daly et al 2010, Rosa et al 2013). Many types of fish, such as reef fish species, as well as pelagic fish species eating ephyrae and small individuals, compete for the same zooplankton prey as jellyfish (Graham 2001, Purcell et al 2001 2007). As argued here, the declination of those fishes will open up ecological niches for jellyfish proliferation (Lynam 2004, Purcell et al 2007). The objective of this research is to understand the causes of *Pelagia noctiluca* outbreaks observed since 2011 in the Moroccan Mediterranean coastal. Besides, the importance of this research is to document and to highlight as well the severe impact that jellyfish outbreaks have on fisheries production.

MATERIAL AND METHODS

Study area: M'Diq is known as a seaside city, located at the geographical coordinates 35° 41'N, and 5° 19 '31 W. Fishing and summer tourism are the mean economic resources for the local population. M'Diq covers an area of 480 hectares, of which 153 hectares are urbanized. The city is located 7 km from Tetouan city, and it is bounded on the east by the Mediterranean Sea (Aouititen et al 2019). The selection of this area to conduct the research is due to the critical numbers of *P. noctiluca* outbreaks recorded. The existence of permanent surface currents characterizes the marine hydrology in this area, and continuous flow from west to the east brings Atlantic waters into the Mediterranean, compensating for losses by evaporation and which result in heavy salinization. The winds are sometimes violent and play a role in the disturbance of these surface currents, creating currents opposite to those described above. The tides are of low amplitude, with the highest reaching barely two meters, and they generally remain poorly perceived because of the steep slope of the shoreline (Dakki 2004).

Sampling strategy: From 2011 to 2017, *P. noctiluca* was collected daily during each blooming season to conduct biometric measurements (Fig. 1). The selected transect in M'Diq was between the low tide and high tide limit. The transect start and endpoints were recorded and described as follows: "start: 35.683160 N, -5.319175 W; 35.698070 N, -5.328777 W; length: 963m". The variation in the production of pelagic and whitefish data in the M'Diq port was collected from the Moroccan national office of fisheries. The waves high were recorded from Copernicus online database. Sea surface temperature, as well as sea surface salinity, was recorded in situ (independent points) for each survey (Aouititen et al 2019). Both of these parameters have been recorded from June 2011 until December 2017 during each jellyfish stranding day, and a monthly average used for correlation analyses with jellyfish abundance. The calculation of jellyfish stranded density per square meter was performed by using a quadrate method (Aouititen et al 2019).

Source: Google Map

Fig. 1. The geographical location of our study area

Cluster analysis: The data obtained from the samples were statistically analyzed using SPSS 25 and Microsoft Office Excel 2010. Simple linear regression and ANOVA analysis was used to investigate whether there is a relationship between the quantitative variable, which is sea surface salinity, temperature, waves high and for both Pelagic fish and Whitefish production in the M'Diq port and the changes of *P. noctiluca* density during the blooming seasons to understand which type of correlation they share.

RESULTS AND DISCUSSION

The simple linear regression analysis proved that there is a strong significant relationship between the blooms of *P. noctiluca* collected and the high sea surface temperature recorded since 2011 till 2017 (Table 1). The P-value were $P < 0.05$, $P= 0.007937422$. Moreover, that these two parameters are correlated positively, which means when the sea surface temperature rises, then the outbreaks of our jellyfish will increase as well, with $y = 3.5254x - 59.616$, $R^2 = 0.2062$ (Fig. 2).

Scientists proved that sea temperature could influence jellyfish life cycles and its reproductive process (Purcell et al 2007, Boero et al 2008*)*. Seawater temperature, together with available resources of nutrients, were essential drivers of gonads development (Ben-David-Zaslow and Benayahu 1999). The increase in temperature is considered to be a key factor for the successful reproductive processes of *P. noctiluca.*

Sea Surface Salinity (SSS) and jellyfish blooms: In Table 1, the simple linear regression analysis along with ANOVA test has proved as well that there is a very significant relationship between the blooms of *Pelagia noctiluca* collected and the sea surface salinity recorded from 2011 till 2017 as it showed the P-value found to be $P < 0.05$, $P= 0.002931034$. Besides, we have found that these parameters correlated positively, which mean when the sea surface salinity increase then the blooms of our jellyfish will increase as well; with $y =14.741x - 507.54$, $R^2 = 0.2517$ (Fig. 3). Between 1976 until 1983, a research conducted by Tegaccia (1983) mentioned as well that the highest densities of *P. noctiluca* in the Adriatic Sea were recorded with high salinity and low nutrients.

Sea waves high and jellyfish blooms: After testing the relationship between Sea waves high and jellyfish blooms density using a simple linear regression analysis along with ANOVA test (Table 1) we have found that there is a significant strong relationship; as it showed the P-value was found to be $P < 0.05$, $P= 0.0000000023$. In fact, these parameters are found to share a positive correlation, which means when the waves start to be higher as results, the blooms of *Pelagia* *noctiluca* will increase in our shoreline; with y = 20.473x - 4.4583, R^2 = 0.6893 (Fig. 4).

Aouititen et al (2019) concluded that waves high as well as Est wind could lead to the prediction of jellyfish stranding in the Moroccan Northwest Mediterranean coastline.

Pelagic fish and Whitefish production and jellyfish blooms: There is a significant relationship, as it showed the P-value found to be $P < 0.05$, P= 0.000001936 (Table 2). However, these parameters were found to be negatively correlated, which mean when the Pelagic fish and whitefish production start to decrease then the blooms of *P. noctiluca* will increase in our area of study; with y = -0.0079x + 40.881, R^2 = 0.5063 for Pelagic fish production and y = -0.0323x + 55.431, R^2 = 0.3008 for whitefish production and blooms of our jellyfish (Fig. 5).

Outbreaks of *P. noctiluca* were reported in 2007 to cause mortalities of farmed fish in northeast Ireland and on the Scottish west coast (Doyle et al 2008). The outbreaks of *P. noctiluca* appear to be associated with affecting fish and

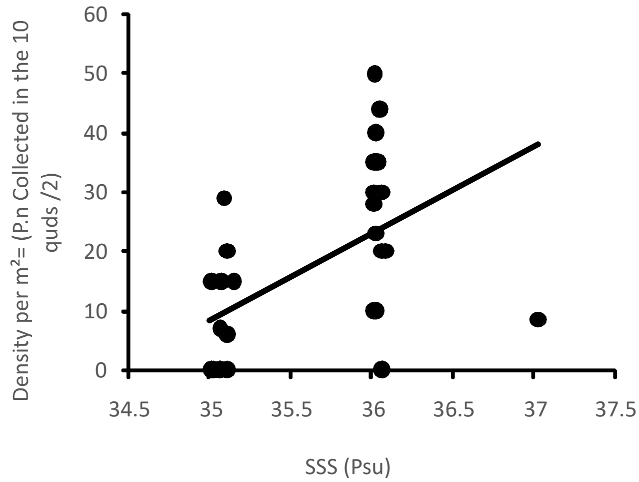

Fig. 3. Simple linear regression analysis of Sea Surface Salinity (SSS) and jellyfish blooms density

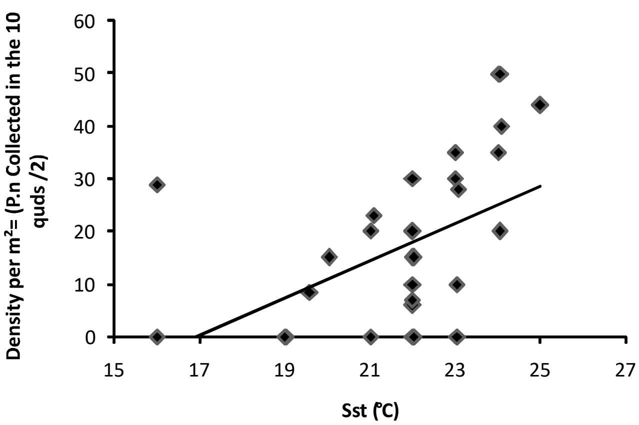

Fig. 2. Simple linear regression analysis of sea surface temperature (SST) and jellyfish blooms density

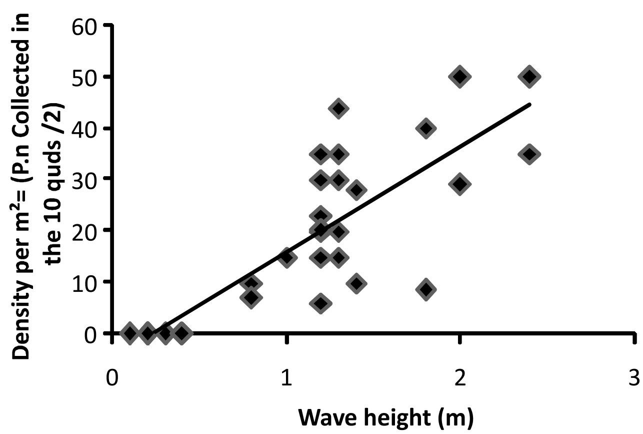

Fig. 4. Simple linear regression analysis of Sea waves high and jellyfish blooms density

Table 1. Simple linear regression and ANOVA analysis of the correlation between Sea waves high and jellyfish blooms density

Regression statistics	Correlation between SST & jellyfish blooms density	correlation between SSS & jellyfish blooms density	Correlation between Sea waves high & jellyfish blooms density
Multiple R	0.45412688	0.50173889	0.830223056
R Square	0.20623122	0.25174192	0.689270323
Adjusted R Square	0.18062578	0.22760456	0.679246785
Standard error	14.6319741	14.2063211	9.154766775
Observations	33	33	33
SS	1724.360006	2104.888361	5763.192295
MS	1724.36	2104.888	5763.1923
F	8.054194	10.42956	68.76517
Significance F	0.007937422	0.002931034	2.2895E-09

Table 2. ANOVA analysis between Pelagic fish and Whitefish production with jellyfish blooms density

ANOVA						
SUMMARY						
Groups	Count	Sum	Average	Variance		
Pelagia noctiluca females	7	127.339	18.19129	173.119256		
Pelagia noctiluca males	7	20114	2873.429	1405746.29		
Pelagia noctiluca juvenile	7	8061	1151.571	49790.619		
Source of variation	SS	df	MS	F	P-value	F crit
Between groups	28937353	2	14468676	29.8177715	1.93601E-06	3.554557146

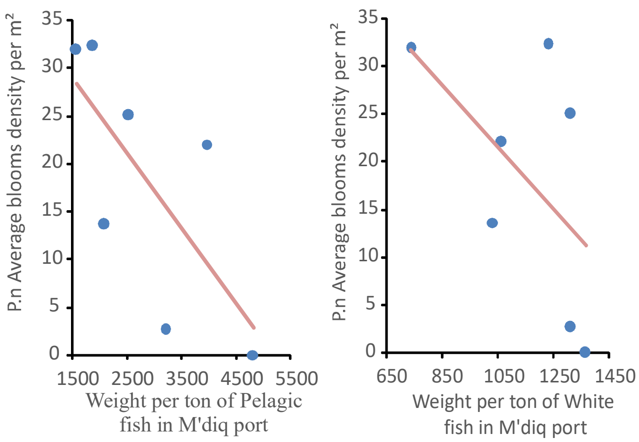

Fig. 5. Simple linear regression correlation between weight per ton of Pelagic and Whitefish with Pelagia noctiluca blooms density

Fig. 6. *Pelagia noctiluca* trapping and in the process of swallowing a small fish

zooplankton abundance by preying on fish larvae and competing for nutrients (Purcell 2001, Lynam et al 2005). *P. noctiluca* is an important planktonic predator of fish larvae so they can affect fish larval abundance (Fig. 6) (Daskalov et al 2007, Purcell et al 2007).

CONCLUSION

In this research study, we found that sea surface temperature with P= 0.007937422, sea salinity P= 0.002931034 as well as waves high P= 0.0000000023 positively correlated to *Pelagia noctiluca* outbreaks on our area of study; those parameters are the principal causes which lead to the blooms of jellyfish along our Moroccan Mediterranean northwest coastal. Apart from this, the production of Pelagic fish and whitefish was recorded to have a negative correlation with jellyfish stranding, and it was found to be very significant P= 0.000001936, which means when the production of Pelagic fish and whitefish decrease, we are going to observer significant outbreaks of *Pelagia noctiluca*. As a consequence, we predicate not only to observe consecutive long blooming seasons but as well we may document a long-term decrease in marine stocks of fish in our area.

CONTRIBUTION

We declare that Ms. Majda AOUITITEN has collected, analyzed the data, and wrote the paper. Dr. Mohammed MRHRAOUI provides us with a laboratory where we conducted some of our analysis and Dr. Aravinda RAVIBHANU as well as Pr. Dr. Xiaofeng LUAN reviewed the manuscript. We would like to address our sincere appreciation for all the motivation and support we've received from Mrs. Jamila Semlal.

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Seasonal Habitat Selection of *Gyps himalayensis* in Hirpora Wildlife Sanctuary, Jammu and Kashmir

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Abstract: Himalayan vulture (*Gyps himalayensis*) performs a significant ecological role. The current study was initiated at Hirpora Wildlife sanctuary of Jammu and Kashmir to know the seasonal variation in habitat selection of Himalayan vulture (*Gyps himalayensis*). *Manly's selection index* and modified X^2: log-likelihood chi-square test (X_L^2) via ECOLOGICAL METHODOLOGY (version 7.3) was used to analyse the data. The total of 289 individuals (comprising of 226 adults and 63 sub-adults) of Himalayan vulture were sighted. The results of the X_L^2 test showed that selection of different habitat types by Himalayan vulture during different seasons differed significantly. Various calculations and comparisons from Manly's selection index indicate significantly high preference for pastures during summer and autumn, and rocky areas during winter and spring. This will help to prioritize investments and assess conservation intervention regarding Himalayan vultures and other related species in the region.

Keywords: Vultures, Hirpora, Cliffs, Season, Selection index, Habitat

Habitat features including floristic composition, cover and vegetation density are important drivers that determine the status of birds and mammals in a landscape (Zhang et al 2019). Birds are very much choosy when it comes to habitat utilization, some occupy and utilize more than one habitat type while others are confined only to a particular habitat. However, due to land use-land pattern changes, most birds have been displaced from their original habitats (Mushtaq 2020). Response of birds to habitat changes vary from species to species, depending on their ways of living, some are benefitted from the changes while for others it results in the threat for survival (Wani et al 2018). Understanding the factors influencing the distributional pattern of birds and mammals in time and space is of prime importance for ecologists and when this is properly comprehended for a particular species it becomes plausible to identify various habitats for the survival of that species (Wani et al 2020). Therefore, in order to achieve ecological and conservation goals it is necessary to study the influence of various habitat types on the overall needs essential for long term sustenance of the animals (Kija et al 2020).

Vultures, the most successful scavenging bird group, which dispose of carcass and other organic wastes, provide cost effective ecosystem sanitation services and protect humans, domestic and wild faunal elements from deadly diseases. Therefore, they perform significant ecological services throughout their distributional range. In their absence, the population of some well-established disease reservoir scavengers increase at carcass (Pain et al 2008). Himalayan Griffon, one of the nine vulture species that have been reported from Indian subcontinent is the largest *Gyps* vulture found in Asia (Wani et al 2018). It mostly lives above an elevation of 3000 m (range 600-6000 m), the highest elevation occupied by any Old World *Gyps* vultures. Being a typical mountain species roosts gregariously on crags and takes to the air and soars over hills and mountains at great heights and often for long periods. It breeds on rocky crevices of cliffs in the upper reaches of Himalayan and Trans-Himalayan region (Kichloo et al 2020) descends to lower elevations in search of food during extreme circumstances. The species has an extensive geographical range and distribution consisting of high uplands of Southern and Central Asia, from Afghanistan and Kazakhstan in the West through Tien Shan and Altai ranges, Himalayas east and Tibetan plateau to Western China and Mongolia (Birdlife international 2020). Despite its great ecological importance, no significant data is available on the habitat utilisation by this Himalayan vulture species. So it is pertinent to generate baseline information on the use and selection of habitat by this vulture species essential from its conservation perspectives.

MATERIAL AND METHODS

Study area: Hirpora Wildlife Sanctuary (WLS), located (33°39' 55" N latitude and 74°39' 40" E longitude) in District Shopian of Jammu and Kashmir, spread on an area of about

342 km^2, is beautified by forests, pastures, waste-land, scrub land and water bodies. It is bounded in south by Saransar, north by lake Gumsar, west by Pir Panjal pass, east by Rupri and north east by Hirpora village. The slopes are moderately steep on the eastern aspect and extremely steep with many cliffs on the northern and western aspect. The WLS is known for its rich flora and fauna, the vegetation of which is divided into mixed coniferous forests, deciduous subalpine scrub forests and subalpine pastures. The coniferous forests are dominated by Kail pine, the sub alpine forests by fir (*Abies pindrow*) and the deciduous subalpine scrub forests by Himalayan birch (*Betula utilis*) and Juniper (*Juniperus communis*). The main faunal elements of the area include- Pir Panjal Markhor (*Capra falconeri*), Himalayan musk deer (*Moschus leucogaster*), Himalayan black bear (*Ursus thibetanus*), Himalayan brown bear (*Ursus arctos*), Leopard (*Panthera pardus*), Himalayan palm Civet (*Paguma larvata*), Red fox (*Vulpes vulpes*) and Tibetan Wolf (*Canis lupus*) (Ahmad et al 2014) and prominent bird species viz., Himalayan vulture (*Gyps himalayensis*), Bearded vulture (*Gypaetus barbatus*) and Golden eagle (*Aquila chrysaetos*). Every year (May to November) hundreds of nomadic families from Pooch, Rajouri and other adjacent areas bring thousands of their domestic livestock to Hirpora Wildlife sanctuary for grazing purpose (Ahmad et al 2011).

Habitat availability: Hirpora Wildlife sanctuary is a mosaic of different habitat types with differential area availability ranging from 0.06 km^2 under agricultural cropland to 253.33 km^2 under barren rocky habitat (Table 1).

Data collection: Data was collected from June 2018 to May 2020 by conducting regular field visits. Each year was divided into spring (March, April and May), summer (June, July and August), autumn (September, October and November) and winter (December, January and February) seasons. The observations were recorded by walking along trails in eight habitat types including agricultural, rocky, dense forest, scrub, pasture, glacial, riverine and sandy. Trails were walked between 8:00 am and 5:00 pm at a speed of about 3 km/h and the observations were made with the help of 10X binocular. Birds were identified by using field guide (Grimmett and Inskipp 2016). When spotting vultures, their number, activity and the major habitat type in the surrounding area were recorded. GPS handset was used to record the geographical coordinates of all vulture sightings during the study period (Samson et al 2016).

Statistical analysis: Data regarding habitat selection by Himalayan vultures was analysed by using "*Manly's selection index*". This index was chosen because it does not fluctuate with inclusion or exclusion of seldom-used resources and is considered more versatile than other selection preference indices (Mushtaq 2020). The index is based on selection ratio which is proportional use divided by the proportional availability of each resource.

$$Wi = \frac{Oi}{Pi}$$

Where: *Oi*= proportion of the sample of used resource units in category *i* or frequency of sightings.

P_i = Proportion of available resource units in category *i* or landscape/area.

Selection indices may range from 0 to infinity. Selection indices above 1.0 indicate preference, less than 1.0 indicate avoidance. These values are presented as Standard ratios. Standard ratios of (1/number of resources) indicate no preference. Values below this indicate relative avoidance, values above indicate relative preference. To test the null hypothesis that Himalayan vultures select habitat randomly, X_L^2 test was applied. All calculations were made by using MINITAB statistical software (version 6.3.9600) and ECOLOGICAL METHODOLOGY (version 7.3)

RESULTS AND DISCUSSION

Presence or absence of bird species is largely affected by key environmental resources, like food and cover (McCain 2009) which are determined mainly by the vegetation composition and seasonality (Mengesha and Bekele 2008). Therefore, as seasons and vegetation change along complex geographical and environmental gradients, a particular bird species may appear, increase or decrease in number and disappear (Lee and Rotenberry 2005). Several studies have shown that habitat type plays a crucial role in shaping and structuring bird communities (Draycott et al 2008, Earnst and Holmes 2012, Tanalgo et al 2015, Nsor et al 2018). During the present study, a total of 289 individuals of Himalayan vulture were sighted in Hirpora wildlife sanctuary. Among them 78.20% were adults (226) and 21.80% were

Table 1. Availability of different habitat types in Hirpora wildlife sanctuary

Habitat type	Area (Km^2)	Percentage
Agricultural	0.06	0.02
Rocky	253.33	78.16
Scrub	29.43	9.08
Dense forest	25.17	7.77
Pasture	0.78	0.24
Glacial	11.21	3.46
Riverine	3.70	1.14
Sandy	0.43	0.13
Total	324.11	100

Source: Naqash and Rather (2016)

sub-adults (63). Total number of sighted individuals were highest for rocky areas (167), followed by pastures (93) and so on (Fig. 2). Pastures and rocky habitats supported highest number of Himalayan vultures (Fig. 2), probably due to predation-free cover for nesting and breeding in rocky cliffs and availability of food in pastures.

Summer and autumn: During summer a total 110 individuals of Himalayan vulture comprising of 78.18% adults (86) and 21.82% sub-adults (24) were observed (Fig. 1). The calculated X_L^2 static was significant, indicating that at least one habitat category was selected by Himalayan vulture. The habitat category "Pasture" was selected significantly more than expected from the available proportion of this category (P_5= 0.0024, below the lower limit of the confidence interval 0.2809-0.5373) (Table 2). The upper confidence limits for rocky, glacial and sandy areas were lower than their respective available proportions, thereby indicating the avoidance of these categories of habitats (Table 2). It also avoided agricultural, scrub, dense forests and riverine habitat, although not significantly. During summer the probability of using pasture (B_5=0.9831) was also markedly higher than other habitat types (Fig. 3). During Autumn a total 61 individuals of Himalayan vulture comprising of 73.77% adults (n=45) and 26.23% sub-adults (n=16) were observed (Fig. 1). During the season, the null hypothesis that all habitat categories are used in proportion to their availability was rejected thereby supporting the hypothesis that atleast one habitat category was used disproportionately (X_L^2=441.086, df=7, p=0.000). The probability of pastures being used by Himalayan vulture was highest (B_5=0.9890) followed by the probability of riverine (B_7=0.0050) (Fig. 3). The available sample proportion for "pasture" (P_5=0.0024) was below the lower limit of the 95% confidence interval (0.5264-0.8507), which indicates that this category is selected significantly (Table 5). Himalayan vulture avoids agricultural, rocky, glacial and sandy habitats. It also avoids scrub, dense forest and riverine habitats, although not significantly.

The significantly high preference for pastures during summer and autumn is perhaps due to availability of livestock carcass as nomads occupy these areas in the sanctuary

Table 2. Estimated selection indices and Bonferroni confidence intervals for habitat use by Himalayan vulture during summer season

Habitat	Sample		Selection index (W_i)	Bonferroni CI	
	Proportion available (P_i)	Proportion used (O_i)		Lower 95%	Upper 95%
Agricultural	0.0002	0.0000	0.0000^{ns}	0.0000	0.084
Rocky	0.7816	0.4685	0.5994^{-}	0.3389	0.5980
Scrub	0.0909	0.0721	0.7930^{ns}	0.0049	0.1392
Dense forest	0.0777	0.0360	0.4630^{ns}	0.0000	0.0844
Pasture	0.0024	0.4054	168.9358^{+}	0.2780	0.5328
Glacial	0.0346	0.0090	0.2604^{-}	0.0000	0.0335
Riverine	0.0114	0.0090	0.7903^{ns}	0.0000	0.0335
Sandy	0.0013	0.0000	0.0000^{-}	0.0000	0.0000

Selection (+), avoidance (-) and non-significant trends (ns)

Table 3. Estimated selection indices and Bonferroni confidence intervals for habitat use by Himalayan vulture during winter season

Habitat	Sample		Selection index (W_i)	Bonferroni CI	
	Proportion available (P_i)	Proportion used (O_i)		Lower 95%	Upper 95%
Agricultural	0.0002	0.0000	0.0000^{-}	0.0000	0.0000
Rocky	0.7816	0.9070	1.1605^{+}	0.7858	1.0281
Scrub	0.0909	0.0233	0.2559^{-}	0.0000	0.0861
Dense forest	0.0777	0.0000	0.0000^{-}	0.0000	0.0000
Pasture	0.0024	0.0698	29.0727^{ns}	0.0000	0.1760
Glacial	0.0346	0.0000	0.0000^{-}	0.0000	0.0000
Riverine	0.0114	0.0000	0.0000-	0.0000	0.0000
Sandy	0.0013	0.0000	0.0000^{-}	0.0000	0.0000

Selection (+), avoidance (-) and non-significant trends (ns) along with their livestock from late spring till autumn. Lu et al (2009) observed that Himalayan vulture depends predominantly on livestock carcass as food resources and the difference in percentage number of individuals sighted among habitat types may be attributed to differences in livestock availability. Therefore, in open habitats like grasslands and pastures, high livestock densities and better visibility for finding carcass are expected to attract more griffons and facilitate the information of larger foraging groups. In the open habitats, the Himalayan vulture could also benefit from the greater visibility of approaching terrestrial predators (Gavashelishvili and Mc Grady 2006). Similarly, poor accessibility to carcass in forest habitats may limit griffon population size, restricting them to a low density in these habitat types (Lu et al 2009). Schultz (2007) concluded that Cape Vultures *Gyps coprotheres* were unable to locate carcasses when the vegetation density was greater than 2,600 trees hectare^{-1}.

Winter and spring: Of the 43 individuals observed during the season, 79.06% were adults (n=34) and 20.94% were sub-adults (n=9) (Fig. 1). The X_L^2 test static for Himalayan vulture's habitat selection during winter season was highly significant (X_L^2=29.105, df=7, p=0.0002), indicating non-random use of at least one habitat category. The available proportion for rocky habitat (P_2=0.7816) was below the lower limit of the 95% confidence interval (0.7858-1.0281). However, the probability of selecting a particular habitat category was highest for pastures (B_5=0.9535) during the season (Fig. 3). The upper confidence limits for agricultural, scrub, dense forest, glacial, riverine and sandy habitats were lower than their respective available proportions thereby indicating the avoidance of these categories during the season. Himalayan vulture also selected pastures, although insignificantly.

During spring a total 75 individuals of Himalayan vulture comprising of 81.33% adults (n=61) and 18.67% sub-adults (n=14) were observed (Fig. 1). The alternative hypothesis of Himalayan vulture selecting at least one habitat category was supported (X_L^2=25.930, df=7, p=0.0006). The Bonferroni adjusted 95% confidence intervals for the categories, agricultural, rocky, scrub, dense forest, glacial and sandy habitats excluded their respective available proportions, which indicate that these habitat types are used non-randomly. The lower confidence limit for the habitat category 'rocky' excluded the available proportion thus indicating its selection; the upper confidence limits for agricultural, scrub, dense forest, glacial and sandy habitats were lower than their respective population proportions thereby indicating the avoidance of these categories (Table 4). However, the standardised selection ratio for the use of pastures by Himalayan vulture (B_5=0.8497) was greater than the corresponding ratios for riverine habitat (B_2=0.0583), which reveals that the probability of using pastures is higher than that of using rocky areas (Fig. 3). During the season Himalayan vulture also tends to select pasture and riverine habitats (Table 4).

In short, during winter and spring seasons the Himalayan vultures remained highly associated with rocky areas as compared to other habitat types and this is perhaps due to the breeding activities which mainly occur on rocky cliffs. These observations seem to be in line with the earlier

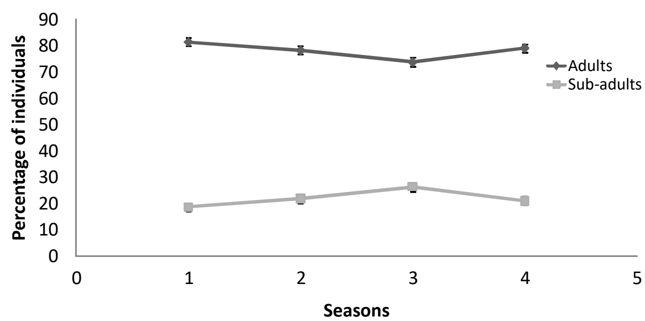

Fig. 1. Percentage of adults and sub-adults observed during different seasons

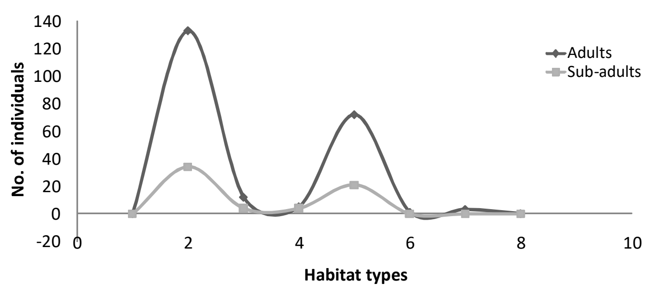

Fig. 2. Number of adults and sub-adults observed during different habitats

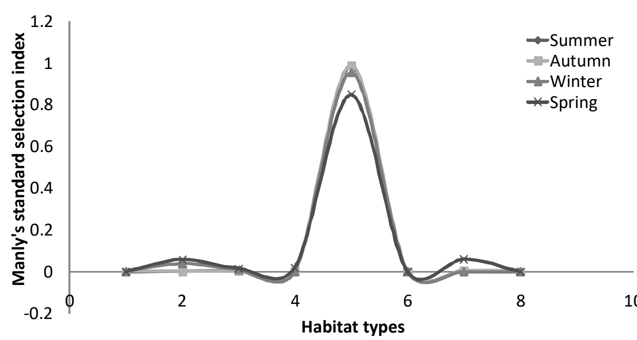

Fig. 3. Probability of habitat selection for different seasons in the study area as determined by Manly's standard selectivity measure (*Bi*)

Table 4. Estimated selection indices and Bonferroni confidence intervals for habitat use by Himalayan vulture during spring season

Habitat	Sample		Selection index (W_i)	Bonferroni CI	
	Proportion available (P_i)	Proportion used (O_i)		Lower 95%	Upper 95%
Agricultural	0.0002	0.0000	0.0000⁻	0.0000	0.0000
Rocky	0.7816	0.8933	1.1431⁺	0.7959	0.9908
Scrub	0.0909	0.0267	0.2934⁻	0.0000	0.0775
Dense forest	0.0777	0.0267	0.3432⁻	0.0000	0.0775
Pasture	0.0024	0.0400	16.6683 ns	0.0000	0.1019
Glacial	0.0346	0.0000	0.0000⁻	0.0000	0.0000
Riverine	0.0114	0.0133	1.1697 ns	0.0000	0.0496
Sandy	0.0013	0.0000	0.0000⁻	0.0000	0.0000

Selection (+), avoidance (-) and non-significant trends (ns)

Table 5. Estimated selection indices and Bonferroni confidence intervals for habitat use by Himalayan vulture during autumn season

Habitat	Sample		Selection index (W_i)	Bonferroni CI	
	Proportion available (P_i)	Proportion used (O_i)		Lower 95%	Upper 95%
Agricultural	0.0002	0.0000	0.0000⁻	0.0000	0.0000
Rocky	0.7816	0.1639	0.2098⁻	0.0343	0.2936
Scrub	0.0909	0.0820	0.9018 ns	0.0000	0.1780
Dense forest	0.0777	0.0492	0.6330 ns	0.0000	0.1249
Pasture	0.0024	0.6885	286.9139⁺	0.5264	0.8507
Glacial	0.0346	0.0000	0.0000⁻	0.0000	0.0000
Riverine	0.0114	0.0164	1.4382 ns	0.0000	0.0609
Sandy	0.0013	0.0000	0.0000⁻	0.0000	0.0000

Selection (+), avoidance (-) and non-significant trends (ns)

findings, which have reported that the breeding season of Himalayan vulture extends from ending December April and initiated with the preparation of nests on inaccessible ledges on cliffs with peak breeding activities that are concentrated around their nesting sites during winter and spring (Bhusal 2011, Siddique 2016). The presence of Himalayan vulture during winter and spring season in Hirpora wildlife sanctuary, combined with the fact that there is absence of livestock (that serves as food to Himalayan vulture) in the area specifies that they show daily-local migration from the breeding areas in response to food availability.

On the other hand, despite their opportunistic diet, Himalayan vultures clearly avoided agricultural habitats mainly represented by some potato fields and possibly related to very intensive agricultural practices affecting sizeable areas in and around the sanctuary, which usually involve the use of large amounts of broad-spectrum pesticides which also disperse the populations of invertebrate species as well as reptiles, amphibians, mammals and birds (Parsons et al 2010).

CONCLUSION

Prediction of future bird-habitat specific preference may be possible because demographic effect of habitat heterogeneity will be modified by habitat-selection behaviours, since the subset of habitats that are actually used will determine the population's demographics. Therefore, vulture habitat preference in Hirpora WLS could help to predict the spatiotemporal distribution and abundance of vultures.

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Examination of Power Relations in Fishers' Resilience: Evidences from Wetland Fisheries in Bangladesh

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Abstract: Social relations of power influence fishers' access to wetland fisheries and their resilience to social-ecological disturbances to comanage fisheries in Bangladesh. This study deploys a survey and in-depth interviews to examine power relations and their effects on fishers' resilience drawing lessons from Boishgoan fishery of the northeastern wetland areas in Bangladesh. The results reveal that the sharing of power is characterized by disparities and inequities in fisheries co-management. Although co-management devolves fishing rights to fishers, the rich and powerful lease the fishery with the help of government officials (Department of Fisheries (DoF) and Local Government) and political leaders. The lack of political affiliations and resources mainly impede fishers' access to the fishery and their resilience to social-ecological disturbances in fisheries co-management. The existing power structure strengthens powerful persons' and hinders fishers' access to fisheries. The exclusion from benefits and management leads to fishers' marginalization and failure in co-management. Without reversing power asymmetries and inequalities, it is hardly possible to establish fishers' rights and resilience in co-management.

Keywords: Power relations, Co-management, Leasing process, Fishers' rights, Fishers' resilience, Bangladesh

The term power characterizes the ability of people to acquire resources, social relations based on power are assumed to facilitate people's access to resources (Njaya et al 2012). To ensure access to common resources, people tend to use their social relations of power to influence management processes (Brisbois and de Loë 2016, Myers and Hansen 2020). The procedures to manage a fishery are often created and controlled by powerful individuals, groups, and organizations inclined to obtain their own benefits to the extent of unprivileged and powerless fishers (May 2016, Singh et al 2019). Such power relations between and among stakeholders (fishery users, government agencies, and local people) often decline fishers' participation in fisheries co-management and their resilience (Fabinyi et al 2014, Quimby and Levine 2018, Rashid et al 2020). The ability of fishers to adapt, reorganize, and substitute their social-ecological disturbances in fisheries co-management may be restricted by the social structure characterized by hierarchical and one-sided patron-client type power relations between fishery users, local groups, and organizations (Kininmonth et al 2017, Quimby and Levine 2018, Jentoft et al 2018, Frawley et al 2019). The unequal power in social relations seems to appear as a long-term disturbance to sustainable fisheries and fishers' resilience in small-scale fisheries management (Frawley et al 2019, Hossain and Rabby 2019).

The resilience in a social ecological system (SES) includes three key elements of which adaptation means the ability of actors to adjust with disturbances, self-organization indicates the ability of actors to perform activities in various phases of disturbances and also to stress equal benefits and roles to obtain results, and transformation indicates the ability of actors to keep performing activities to tackle disturbances and substitute the existing untenable systems for tenable systems (Folke et al 2010, Anderies et al 2013). Institutional Analysis and Development (IAD) framework suggests that the results of a SES are related to the interconnections between operational choice rules, collective choice rules, and constitutional choice rules (McGinnis and Ostrom 2014). These rules often ignore localized rules and interactions among stakeholders in a SES, the inconsistent local rules (overexploitation, unequal participation and benefit distribution among stakeholders) may also ignore the formal rules in a SES (McGinnis and Ostrom 2014). The discrepancy between formal and informal rules often undermines the outcomes in managing common resources.

Fishers' access and ability to manage wetland fisheries in Bangladesh is undermined by the leasing system that permits the rich and established persons and groups to lease fisheries for paying the maximum revenue (Khan et al 2016). The leaseholders engage local fishers to produce fish for generating more revenues within their tenure instead of developing fisheries (Khan et al 2016). To improve fisheries for long-term use, the government of Bangladesh commences community based fisheries management

(CBFM) in the 1990s to delegate the right of fishing to local fishery users (Sultana and Thompson 2007). CBFM involves fishers in decision-making about growing, catching, selling fish, and governing fisheries (Sultana and Thompson 2007). CBFM, however, fails to enhance fishers' ability for self-governing fisheries in Bangladesh mainly because of the absence of fisheries development efforts and the top-down fisheries management system (Newaz and Rahman 2019). The rigid and centralized management approach restrains fishers to act collectively and freely to address their disturbances may lead to the disparity among stakeholders and the exclusion of fishers in fisheries co-management (Njaya et al 2012, May 2016, Mamun et al 2016, Mosepele and Kolawole 2017). A few powerful persons exclude the most from managing the fishery (Newaz and Rahman 2019).

The growing body of literature focuses on the pattern of power relations (Njaya 2007, Njaya et al 2012), but it is still important to study the dynamics of power relations and their consequences to enable fishers to sustain their social-ecological disturbances and livelihood in fisheries co-management. This study aims to examine the extent to which the social aspects of power relations (nature, distribution, and determinants) impede fishers' livelihood and resilience to their social-ecological disturbances in fisheries co-management. The objectives of this study are twofold: (a) To examine the distribution, determinants, and nature of power relations in wetland fisheries co-management, and (b) to examine the influence of power relations on fishers' resilience. This study describes the subtleties of power relations drawing on the lessons from Boishgoan fishery located in northeastern wetland areas in Bangladesh.

MATERIAL AND METHODS

Fishers' profile: Most fishers are landless, illiterate, and can be categorized as lower income groups (Table 1). Fishing is their main employment. The wetland fisheries are a key source of livelihood for fishing communities in floodplain areas. Fishers mainly engage in catching, selling, processing or trading fish. Some fishers also work as day laborers (agricultural and household work, rickshaw pulling, and boatman) when they have no work in the fishery during the monsoon season (from May-August). A small group of people who possess land, literacy, income but no fishing experience take the lease of the fishery. They control the fishery and employ fishers to catch fish. Fishers receive no incentives in cash or goods from the government for fishing.

Study area: Boishgoan fishery is the part of greater north-eastern floodplain areas in Bangladesh. It is located in South Sunamganj Upazila under Sunamganj district in Bangladesh (Fig. 1). The north-eastern floodplain areas form a greater capture fishery in Bangladesh. This larger water body provides numerous small-scale commercial and subsistence wetland fisheries.

Fishers mainly use seine nets for fishing in the fisheries. There are more than 100 fish species in wetland fisheries. The main species include carp fishes, rohu, catfish, trout, and snakehead. The fishery is 23 acres in size comprising a sanctuary and a few little bushes. The leaseholders form a 26-member (21 male and 5 female) Chandpur-Roypur Duel Fishers' Cooperative Association to lease Boishgoan fishery from the government for 2014-2020.

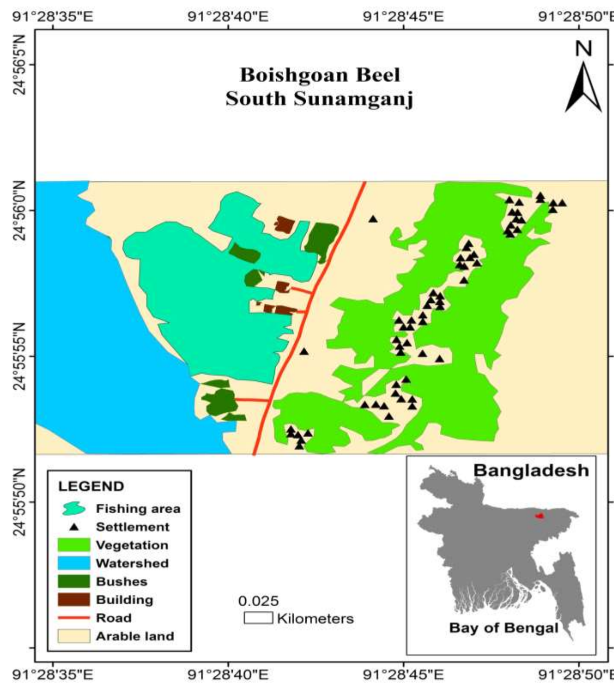

Fig. 1. Topography of the study area

Table 1. Profile of interview respondents

Variables	Description of variables	Percentage	Average
Age	Years	---	50
Gender	Male	81	---
	Female	19	---
Education	literate	19	---
	Illiterate	81	---
Occupation	Fishing	58	---
	Non-fishing	42	---
Household size	Total members	---	9
Income	Annual income from fishing	---	BDT 24,000
	Annual household income	---	BDT 55,000
Amount of land	Having land	38	1 Acre
	Landless	62	

Data collection: This study deploys a survey and in-depth interviews to collect primary data for examining power relations and their effects in wetland fisheries co-management. The survey is conducted among all 26 current Boishgoan fishery users. The convenience sampling is used to select five respondents for in-depth interviews based on their thorough knowledge about co-management in wetland fisheries. In-depth interviews provide deeper insights about fishers' livelihood, social position, and fisheries co-management. The semi-structured and unstructured questionnaires are used to carry out the survey and interviews respectively. Informed consent is taken before interviews and their recordings. All interviews take an hour on average. The duration of data collection ranges from November 2019 through January 2020. The privacy of data and interviewees are severely preserved. Likert scale is used to evaluate fishers' perceptions about power relations in fisheries co-management based on five points starting from '1=strongly agree' to '5=strongly disagree'.

Data analysis: This study describes the use of power relations to access and manage the fishery, fishers' socioeconomic profile, and the effects of power relations on fishers' resilience based on interview texts and descriptive data. It also uses Institutional Analysis and Development (IAD) framework to describe inconsistencies between formal and informal choice rules created and prolonged by power relations and their outcomes in fisheries co-management.

RESULTS AND DISCUSSION

Distribution of power relations: Community based fisheries management (CBFM) is likely to promote sustainable livelihood of fishers and maintenance of wetland fisheries in Bangladesh. CBFM delegates the responsibilities to local fishers for decision-making and implementing rules for managing fisheries. It connects all stakeholders (fishers, government officials, local people) to facilitate fishers' disturbances (conflicts, catch decline) in fisheries management. CBFM creates the condition for fishers to share power to manage fisheries. The sharing of power is, however, often characterized by disparities and inequities in wetland fisheries co-management. Interviewees inform the participation of many rich and non-fisher members in the fishery users' association and the committee to manage Boishgoan fishery. The rich and powerful members form the fishers' cooperative to lease the fishery with the help of government officials (Department of Fisheries (DoF) and Local Government) and political leaders. Fishers work for the leaseholders and receive a portion of the benefit. They are excluded from decision-making and their customary fishing rights. The nominal participation of fishers means formal

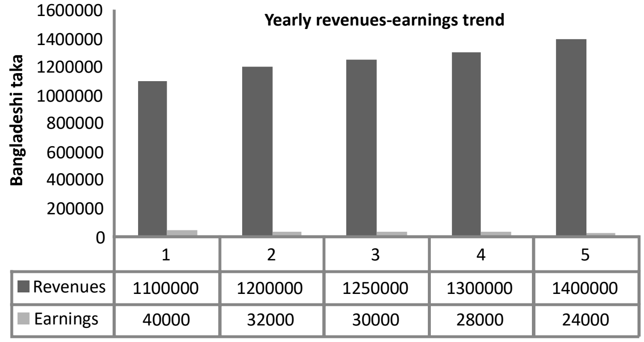

Fig. 2. Comparison between yearly revenues and fishers' earnings from the fishery

constitutional choice rules deny informal constitutional choice rules in fisheries management. The role of government bodies is not effective to resolve the variations between formal and informal constitutional choice rules. Fishers feel such situation restricts their resilience (the ability to adapt) to social-ecological disturbances (livelihood uncertainty, unequal benefit, catch decline, habitat degradation) in fisheries management. There are 26 members in our fishery users' association. More than half members are fishers and have no land, money and mostly depend on fisheries for livelihood. Some members possess land, money, and political connections but not fishing experience. A few non-fishers lead the management committee and take benefits. Non-fishers justify that they spent money to manage the lease with the help of government officials and political leaders. DoF, Local government officials, local leaders (Member of the parliament (MP), Union Parishad (UP) chairmen) help them obtain the lease. We fishers grow and catch fish, but non-fishers take benefits. A few powerful members capture our rights.

The unequal distribution of power and benefits reinforces differences and discriminations among fishers in fisheries management. Fishers consider the leasing process as a barrier to their fishing rights. Although registered fishers are entitled to apply for the lease, rich and non-fishers apply and obtain the lease. The rich form a cooperative with some fishers to obtain the fishery. The fishery association which offers the highest revenue obtains the fishery. Fishers are insolvent and have no relation with local leaders. The leasing process allows only the rich to get the fishery. It is hard for fishers to get the fishery without local rich and powerful persons.A few powerful persons manage the fishery. The exclusion from the management constrains fishers to develop their ability to adapt to disturbances in livelihood and fisheries maintenance.

Components of power relations: Social position (access to resources and/or affiliation with political parties or leaders) may facilitate fishers' access to fisheries, fishers' social position may strengthen their power in social relations to influence procedures to access fisheries. Using power relations, some people form a fishers' cooperative to lease out the fishery and then hire local fishers for fishing. Fishers get dispossessed of their entitlements to lease out the fishery. This situation implies that the formal leasing rules of CBFM and the existing leasing practices are completely inconsistent and conflicting. The lack of access to resources and political affiliations restricts fishers' resilience (the ability to reorganize habitat damage, catch decline, decisions, benefits). The government rules allow only fishers to lease the fishery, whereas wealthy and powerful persons take the lease. Fishers fail to obtain the lease. The existing power structure hinders fishers' access to fisheries. While powerful persons capture the fishery in the name of fishers, fishers' rights and choices are fully ignored in the fishery management.

Nature of power relations: The power relations based on existing rules and practices advantage the rich and powerful leaseholders to access and manage fisheries. Co-management arrangements reinforce the control of powerful persons over fisheries. Many fishers participate in fisheries management because of their dependence on fisheries and leaseholders for subsistence. Such patron-client type power relations sustain power asymmetries and inequalities among fishery users. A few occupy the fishery and its benefits. This indicates the violation of both formal and informal constitutional choice rules in fisheries management. The fishers' cooperative association works as a means to generate revenues for a few rich and powerful persons. Fishers fail to develop their resilience (the ability to continue activities to address disturbances).

The respondents report a steady increase in yearly revenues (from BDT 1100,000 in 2015 to BDT 1400,000 in 2019) but a gradual decrease in their earnings (from BDT 40,000 in 2015 to BDT 24,000 in 2019) from the fishery over the years. This trend may be depicted with the following bar charts (Fig. 2). The powerful leaseholders control the fishery and consolidate the maximum revenues. Fishers feel that the fishery provides them livelihood while leaseholders tend to take profits. Additionally, most fishers have no other sources of income. The lack of resources in additional to unequal power relations constrains fishers to develop their ability to continue activities to address disturbances in fisheries management.

Implications of power relations: Some fishery users make and implement decisions to manage the fishery. They overlook other fishers and their decisions in fisheries co-management. Fishers have no freedom to elect the fishery management committee. They are entirely excluded from the fishery management. The powerful leaseholders (neither fishers nor have fishing experience) select those fishers' cooperative members who are loyal to them. They tend to generate revenues instead of developing fisheries. Such attitude harms the effect of co-management. The tendency to obtain profits through overfishing may diminish the ecology of the fishery. The overfishing increases revenues but decreases fish variety. This situation suggests the split between CBFM's formal and fishers' informal constitutional choice rules. Co-management consolidates powerful leaseholders' access to fisheries; fishers assist them to manage those fisheries. Many local groups compete for the lease and not possible to get the lease without links with government officials and political back-up. The leasing process impedes fishers' and strengthens powerful leaseholders' access to fisheries. Fishers work for them as they lack alternative sources of income in the area. The existing leasing process eases powerful persons' and restrict fishers' access to fisheries. Fishers' dispossession may be related to their weak social and political representations in the society. Fishers possess no opportunity for developing

Table 2. Fishers' perception about power relations in comanagement

Scale components	Answers (%)						
	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree	Chi-square	p-value
I am consulted and informed about management decisions	0	15	7	50	28	90.77	0.00
All members are equally regarded in the fishery association	0	14	9	58	19	94.85	0.00
There is no conflict of interests among fishery association members	0	10	6	33	51	88.95	0.00
Benefits are equally distributed	7	0	0	63	30	88.84	0.00
Fishers have active participation in comanagement	11	0	0	61	28	90.87	0.00

Overall, power relations exclude fishers from decision-making and benefits in co-management

Table 3. Guidelines for building fishers' resilience in comanagement

Activities	Descriptions	Goals
Reformation of existing leasing policy	The existing leasing policy allows the rich and powerful persons to lease wetland fisheries by paying the highest revenue. The leasing policy needs to register local fishers with the department of fisheries, to allow only registered local fishers to participate in the bidding process, and to lease fisheries to local fishers for consecutive terms to improve fish production and fish habitats	Ensuring fishers' rights and access to fisheries
Participatory fisheries comanagement	Comanagement must emphasize fishers' active participation in decision-making and implementation, the definite and shared responsibilities among fishers, the equal distribution of benefits, and the freedom to form and administer the fishery management committee	Enabling fishers to manage fisheries
Development and maintenance of fisheries	The development includes initiatives to dig out fisheries and sanctuaries to increase water level and connect different parts of the fisheries to improve fish habitat and to stop overexploitation to maintain fish species diversity in the fishery	Improving fish habitat and catches
Collaboration	A collaboration between fishers, government bodies, and local people is crucial to protect fisheries. The government bodies can monitor fish habitats, overexploitation of resources, and conflict between and among fishers and with local people to control fisheries. The rights of fishers in fisheries cannot be established without the assistance of government bodies	Protecting fisheries and fishers' rights
Local knowledge	Local fishing practices and rules for managing fisheries should be incorporated into the management process with the scientific knowledge.	Integrating local practices into scientific knowledge
Alternative livelihood options	Alternative development interventions to generate livelihood options and incentives may decrease fishers' dependence on fishing for income and increase the sustainability of fisheries.	Generating income from other sources

their resilience to disturbances in wetland fisheries. Fishers are questioned to assess their perception about power relations in co-management (Table 2).

The results from Boishgoan fishery reveal that social relations between and among fishers and government officials have visible influence on fisheries management. The fishery-based social relations provide the rich and powerful leaseholders with a position to control fisheries. Then leaseholders employ fishers for fishing. Fishers participate in the fishery to make profit for their patrons because of their inability to obtain the lease, bear expenses, and exercise power to manage the fishery. The lack of resource and power dispossesses fishers from fisheries. Fishers engage with their leaseholders into patron-client relations.

To prevent wetland fisheries from ecological damage requires the elimination of the existing patron-client relations between fishers and leaseholders in fisheries management. Such unequal relations restrict fishers' adaptation to their social-ecological disturbances, skills to organize activities at different stages of disturbances, and ability to alternate activities to address disturbances in fisheries management. Fishers' continuous independent and active roles in managing the fishery may improve their resilience to social-ecological disturbances.

CONCLUSION

Co-management improves fishers' participation in decision-making and governing wetland fisheries. Fishers still face difficulties to ensure their livelihood and rights because of unequal power relations between stakeholders in managing fisheries. Co-management arrangements reinforce the control of powerful persons in fisheries that Njaya et al (2012) explain as co-management revives elite capture. Without reversing power asymmetries and inequalities, it is hardly possible to establish fishers' rights and resilience to their social-ecological disturbances in Bangladesh.

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Levels and Source of Aliphatic Hydrocarbons in Marine Fishes from Coast of Iraq Based on Biomarkers and Biogeochemical Indices

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Abstract: The total n-alkane concentrations in the fish tissue samples were 9.14 µg g^{-1} Dwt, and the Pr and Ph concentrations were 0.22 and 0.85 µg g^{-1} Dwt, respectively. The CPI (carbon preference index) values ranged from 0.76 to 2.01 and the Pr/Ph ratios were 0.16-1.40. The fraction of n-alkanes in the tissue samples from petroleum sources was estimated to be 83%, whereas the fraction from natural biogenic sources (marine algae, bacteria, and terrestrial plants) was 17%. The application of biomarker indices such CPI and Pr/Ph ratios indicated that AHs were mainly a mixture of anthropogenic and natural biogenic sources. The $CPI_{(o/e)}$ values signified that petroleum was a major sources of AHs in these fishes. The Pr/Ph ratios suggested different sources, including fossil fuel and petroleum by-products, as well as biological and chemical alteration under redox/anoxic conditions. The presence of a high fraction of n-alkanes from petroleum and crude oil sources in the tissues of these fishes indicated that their nursing habitats were critically contaminated by petroleum hydrocarbons. The results of this study suggest that further researches are needed to study the bioaccumulation of other organic pollutants, such as pesticides, plasticizers, and polycyclic aromatic hydrocarbons in the marine biota of the region.

Keywords: Aliphatic hydrocarbons, n-Alkanes, Isoprenoids, Marine fish, Iraq

Aliphatic hydrocarbons (AHs) and polycyclic aromatic hydrocarbons (PAHs) are among the most ubiquitous organic compounds in different environments (Hasanuzzaman et al 2007, Dach and Méjanelle 2010). AHs (i.e., n-alkanes, isoalkanes, cycloalkanes, terpenes, hopanes, and steranes) are derived from both biogenic and anthropogenic sources (Rushdi et al 2006, 2010, Duan et al 2011) and are the major constituents of crude oil and refined fossil fuel. AHs, mainly n-alkanes, are introduced to the aquatic environment by different natural (flora, fauna, and bacteria) and anthropogenic sources via atmospheric dust, runoff, spillages, industrial and sewage effluents, shipping activities, and natural oil seepage (Rushdi et al 2018, 2019, Huguet et al 2019, Appolinario et al 2020) as well as by organic matter biodegradation (Rushdi et al 2018). Contamination of the aquatic ecosystems by petroleum hydrocarbons is a widespread problem (Ite et al 2018). Petroleum hydrocarbons contain high amounts of n-alkanes with no predominance odd-to-even numbers of carbon atoms (Rushdi et al 2014, 2017), and a large amount of aromatic and heavy asphaltenic substances. The organisms mostly contain n-alkanes with odd numbers of carbon atoms (Jeng 2006, Nott et al 2000, Bush and McInerney 2013), least amounts of aromatic compounds, and no asphaltenic substances (Wang et al 2010, Ali et al 2013, Taheri-Shakib et al 2018).

Iraq is one of the major oil producers in the OPEC (Organization of the Petroleum Exporting Countries) after the Kingdom of Saudi Arabia, and 90% of its crude oil production is from onshore oil fields in the southern part of the country (USEIA 2019). The city of Basrah is located in the southern part of Iraq, where many oil operations were established after 2003 by many international oil companies. Consequently, certain concentration levels of petroleum hydrocarbons have been discharged into the environment as a result of these oil-related developmental activities such as industrial factories, electric power stations, and gas production plants (Al-Saad et al 2015). Recent studies have reported significant levels of petroleum hydrocarbons in water and sediment samples from the area (Rushdi et al 2018, Kadhim et al 2019). Few pieces of researches have studied the bioaccumulation of petroleum hydrocarbon (mainly, polycyclic aromatic hydrocarbons and organo-chlorinated compounds) in marine biota from the region (De Mora et al 2010, Ashraf and Mian 2010, Al-Khion et al 2016). Fish species can accumulate petroleum hydrocarbon compounds within their bodies with higher concentrations than in their outer surroundings, which may become a serious human health problem and thus, directly reach the human being (Ramalhosa et al 2012). Almost all studies reported the levels of hydrocarbon compounds in different aquatic species without investigating their other possible sources. Thus, the present work aims to measure the levels and determine the most important sources of aliphatic hydrocarbons in common commercial fishes from the Iraqi marine waters, based on the application of aliphatic hydrocarbon biomarkers and their geochemical indices.

MATERIAL AND METHODS

Collection of fish and tissue samples: Fourteen commercial marine fish species were collected from the Iraqi offshore water in 2016 (Table 1) and all were carnivore fishes except two filter feeders (*Pl. subviridis* and *T. ilisha*). Their living habitats varied from surface water (*Ch. dorab, S. commersonnianus, S. lysan, Tenualosa ilisha, T. ilisha, Ab. hians*, and *El. eleutheronema*) to bottom water (*Br. orientalis, Ac. arabicus, Ep. coioides, O. ruber, Al. diedaba, Pa. niger, Pa.* and *argentetus*). The tissues of the fish samples were pooled and macerated in a food liquidizer, from which at least three replicates of 15g each were freeze-dried, grounded, and sieved through a 63 µ metal sieve for chemical analyses.

Tissue extraction and separation*:* The procedure described by AL-Saad (1995) was used to extract hydrocarbons from the fishes tissues. Ten grams of each dried tissue were placed in a pre-extracted cellulose thimble and Soxhlet extracted with 150ml methanol: benzene (1:1 v:v) mixture for 24 hours. Each extract was then transferred into a storage flask and further extracted with a fresh solvent mixture. The combined extracts were reduced in volume to 10ml in a rotary vacuum evaporator. They were then saponified for 2 hours with a solution of 4N KOH in 1:1 methanol: benzene. After the extraction of the unsaponified matter with hexane, the extract was dried over anhydrous Na_2SO_4 and concentrated by a stream of N_2. Each concentrated extract was cleaned-up by column chromatography. A column filled with 8g of each of deactivated silica gel (100-200 mesh) at the bottom and alumina (100-200 mesh) on the top. The extract was then delivered at the top of the column and eluted with 50 ml of n-hexane to separate the aliphatic fraction. The fraction was reduced to a suitable volume (1ml) before analysis by capillary gas chromatography.

Samples analysis: An aliquot of 1 µl of each aliphatic hydrocarbon extract was subjected to analyses by an Agilent capillary gas chromatography with a flame ionization detector (FID). A column (model Agilent 19091J-101 HP-5 5% phenyl Methyl silicone; 50 m. x 200µm x 0.33 µm dimensions) was used for the aliphatic separation with helium as a gas carrier at a flow rate of 1.5 ml/minute. The operating temperatures were 280°C and 310°C for the injector and detector, respectively. The temperature of the column was held at 35°C for 10 minutes as initial temperature and then increased at 5°C minute^{-1} to 300°C for 17 minutes. The individual of aliphatic hydrocarbons was identified based on the retention time of an authentic mixed standard procured from Supelco, USA. The concentrations of aliphatic compounds were calculated based on the standard calibration curve of corresponding standard compounds. The range of recovery assays for standards compounds was 80

Table 1. Feeding habits, food sources, feeding habitats, total weight and total length of fish species from Iraqi marine offshore water

Species No.	Fish species	Common name	Feeding habits	Food sources	Feeding habitats	Total weight (g)	Total length (cm)
1	*Brachirus orientalis*	Lisan	Carnivores	Crustaceans	Bottom	480	30
2	*Acanthopagrus arabicus*	Shanak	Carnivores	Fish and Shrimp	Bottom	410	23
3	*Epinephelus coioides*	Hamur	Carnivores	Fish and Crustaceans	Bottom	1152	61
4	*Chirocentrus dorab*	Hiff	Carnivores	Fish and Shrimp	Water surface	819	75
5	*Scomberoides commersonnianus*	Dhala	Carnivores	Fish and Shrimp	Water surface	1214	80
6	*Scomberoides lysan*	Khubbat	Carnivores	Fish and Crustaceans	Water surface	408	25
7	*Otolithes ruber*	Nuwaiby	Carnivores	Fish and Shrimp	Bottom	517	33
8	*Alepes diedaba*	Hammam	Carnivores	Crustaceans	Bottom	219	22
9	*Tenualosa ilisha*	Sboor	Filter feeder	Zoo and Phytoplankton	Water surface	420	30
10	*Parastromateus niger*	Halwayuh	Carnivores	Phyto and Zooplankton	Bottom	333	23
11	*Pampus argentetus*	Zubaidy	Carnivores	Zoo benthos and Crustaceans	Bottom	310	22
12	*Ablennws hians*	Musaffaha	Carnivores	Fish	Water surface	1350	79
13	*Eleutheronema Eleutheronema*	Cheem	Carnivores	Fish and Crustaceans	Water surface	837	43
14	*Planiliza subviridis*	Biah	Filter feeder	Phyto- and Zooplankton	Water surface	112	18

to 92%. The standard deviation for the method was less than 10% based on the replicate analysis. Great care was taken to avoid contamination of the samples throughout the analytical procedure. All solvents were distilled twice before use; glassware was rinsed with distilled water and heated in an oven at 250°C for 24 hours. However, procedural blanks consisting of all reagents and glassware used during the analysis were periodically determined, which had shown no detectable interference.

Statistical analysis: The software SPSS 16.0 (IBM-Statistical Package for Social Sciences, version 16.0) was used to statistically analyze the data. The normal distribution of the data was utilized for all statistical analyses. Varimax rotation with Kaiser Normalization was applied for principal component analysis and Ward's method and Squared Euclidean distance for cluster analysis. The relationships between different variables were defined by Pearson's correlation.

RESULTS AND DISCUSSION

Aliphatic hydrocarbon levels, distribution, and characteristics: The concentrations of total n-alkanes compounds and isoprenoids, mainly pristane (Pr) and phytane (Ph), measured in the tissues of various marine fish species from Iraq (Table 2). The carbon chain length of n-alkanes in the fish tissues ranged from nC_{13} to $nC_{36,}$ as shown in (Fig. 1). The total concentrations of n-alkanes varied from 3.99 µg/g Dwt in the tissue of *Al. diedaba* to 17.95 µg/g Dwt in the *Pl. subviridis*. The maximum carbon number (C_{max}) of n-alkanes were at nC_{17} (*Ep. coioides*), nC_{24} (*Br. orientalis; Ch. dorab; Par. s niger, Pam. argentetus; El. eleutheronema*), nC_{26} (*Al. diedaba*), nC_{28} (*S. lysan*); and nC_{29} (*Ac. arabicus S. commersonnianus, O. ruber, Ab. hians, Pl. subviridis, T. ilisha*) (Table 1 and Fig. 1). The concentrations of Pr and Ph were ranging from 0.04 µg/g Dwt in *Eu. orientalis* to 0.483 µg/g Dwt in *Ep. coioides* and from 0.092 µg/g Dwt in *S. lysan* to 0.454µg/g Dwt in *T. ilisha*, respectively (Table 3).

The total concentrations of aliphatic hydrocarbons were slightly lower than the concentrations measured in different fish species from the same region (Al-Saad 1990). The total n-alkanes concentrations in these species tissues were fairly high compared to the concentrations reported in fishes from different parts of the Arabian Gulf and the Gulf of Oman (Tolosa et al 2005, De Mora et al 2010) and were relatively higher than the concentrations measured in marine sediments and bivalves from the region (Tolosa et al 2005, De Mora et al 2010, Bemanikharanagh et al 2017, Rushdi 2020). The n-alkanes concentrations of these fishes were similar to that from the coasts of Kuwait, Saudi Arabia, Bahrain, and Oman (De Mora et al 2010) and lower than the levels measured in coral reefs from the coast of Iran (Jafarabadi et al 2018). The isoprenoids (pristane and

Table 2. Different parameters and indices of aliphatic hydrocarbons, the concentrations, and fractions of their various sources measured in different marine fish species from Iraq

Compound	*Br. orientalis*	*Ac. arabicus*	*Ep. coioides*	*Ch. dorab*	*S. commers-onnianus*	*S. lysan*	*O. ruber*	*Al. diedaba*	*Par. niger*	*Pam. Argentetus*	*Ab. hians*	*El. eleutheronema*	*Pl. subviridis*	*T. ilisha*	Average	SD
	Carnivores												Filter feeder			
C_{max}	24	29	17	24	29	28	29	26	24	24	29	24	29	29		
CPI (o/e, 14)	0.61	0.71	1.11	0.63	0.81	1.54	0.70	1.10	0.76	0.69	0.54	0.74	2.21	0.69	0.92	0.46
CPI(o/e,25)	0.89	1.79	0.69	1.05	1.45	1.09	1.28	1.34	1.09	1.25	1.70	1.04	1.22	1.36	1.23	0.29
CPI (o/e, E)	0.76	1.25	0.87	0.80	1.05	1.24	0.98	1.24	0.88	0.92	1.16	0.87	2.01	1.02	1.08	0.32
HMW/LMW	0.75	0.61	0.91	1.18	1.21	0.60	0.77	0.64	1.50	1.06	0.49	1.14	5.68	0.73	1.23	1.31
Pr/Ph	0.16	1.40	1.36	0.63	1.27	1.39	0.76	0.86	1.13	0.85	0.73	0.35	0.38	0.56	0.85	0.41
Higher plant n-alkanes	0.042	1.375	0.000	0.012	0.802	1.452	0.812	0.595	0.000	0.432	1.081	0.042	0.149	0.978	0.56	0.53
Per cent	0.6	13.9	0.0	0.3	7.7	10.0	9.1	14.9	0.0	5.2	16.0	0.5	0.8	9.3	6.30	6.02
Microbial n-alkanes	0.471	0.385	0.150	0.425	0.675	0.276	0.574	0.031	0.455	0.547	0.522	0.492	0.396	0.576	0.43	0.17
Per cent	7.2	3.9	1.5	9.9	6.5	1.9	6.4	0.8	6.0	6.5	7.7	5.9	2.2	5.5	5.13	2.67
Algal n-alkanes	0.000	0.119	0.761	0.023	0.208	1.866	0.041	0.128	0.116	0.028	0.040	0.056	7.684	0.005	0.79	2.05
Per cent	0.0	1.2	7.8	0.5	2.0	12.8	0.5	3.2	1.5	0.3	0.6	0.7	42.8	0.0	5.3	11.4
Petroleum n-alkanes	6.033	8.025	8.882	3.836	8.757	10.987	7.517	3.235	7.058	7.376	5.105	7.680	9.725	8.961	7.37	2.19
Per cent	92.2	81.0	90.7	89.3	83.9	75.4	84.1	81.1	92.5	88.0	75.7	92.9	54.2	85.2	83.28	10.20

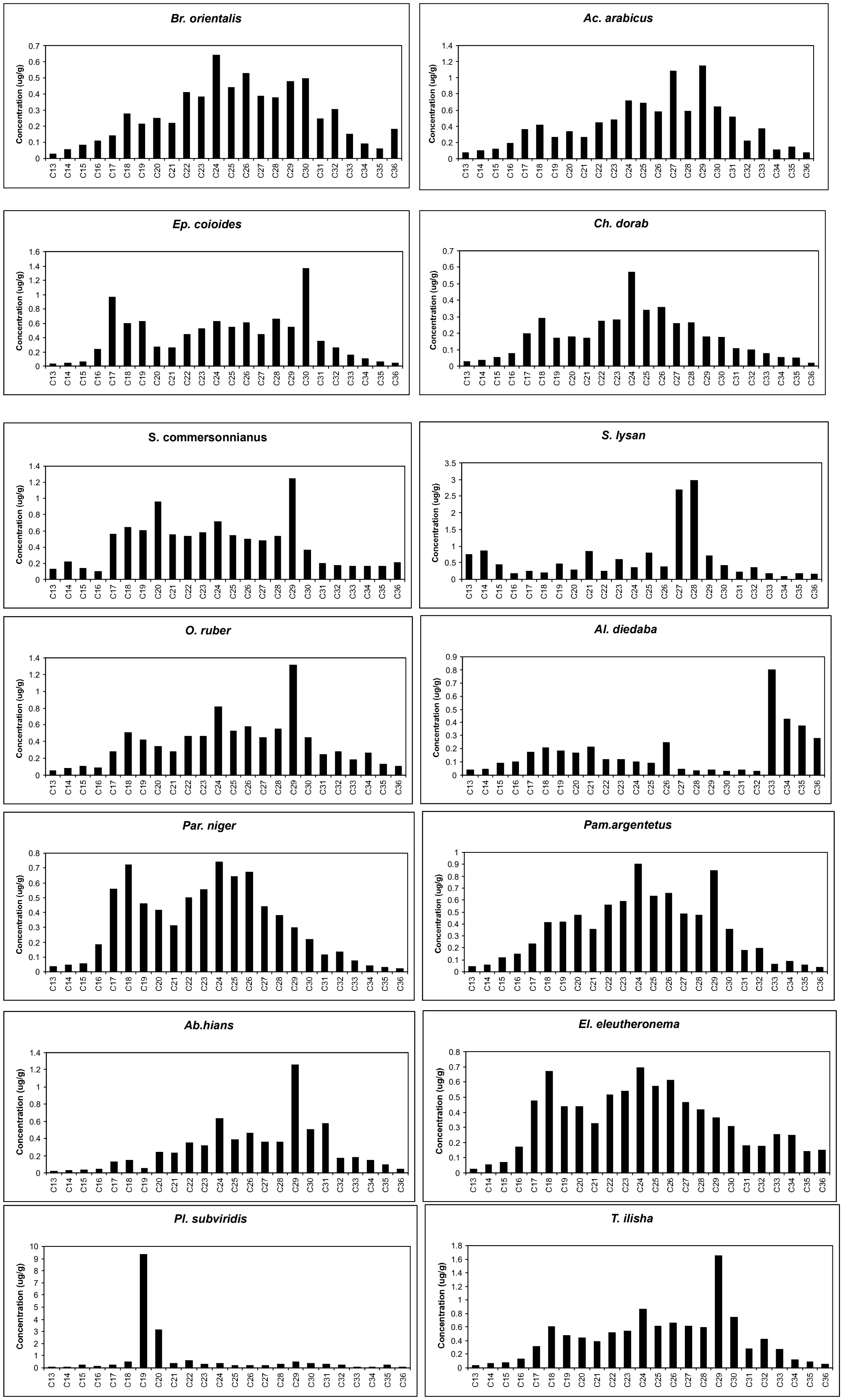

Fig. 1. Distribution and concentrations of n-alkanes in the tissue samples of the different marine fish species from Iraq

Table 3. Concentrations of n-alkanes and isopernoid pristans and phytanes (µg/g dry weight) in the tissues of marine fish species from Iraq

Composition	*M.W.*	*Br. Orientalis*	*Ac. arabicus*	*Ep. coioides*	*Ch. dorab*	*S. commers-onnianus*	*S. lysan*	*O. ruber*	*Al. diedaba*	*Par. niger*	*Pam. argentetus*	*Ab. hians*	*El. eleutheronema*	*Pl. subviridis*	*T. ilisha*
		Carnivores												Filter feeder	
$C_{13}H_{28}$	184	0.027	0.069	0.035	0.027	0.123	0.750	0.052	0.041	0.034	0.044	0.019	0.025	0.046	0.037
$C_{14}H_{30}$	198	0.055	0.098	0.044	0.037	0.214	0.867	0.075	0.046	0.044	0.056	0.024	0.051	0.061	0.065
$C_{15}H_{32}$	212	0.083	0.116	0.061	0.053	0.140	0.433	0.108	0.089	0.056	0.115	0.034	0.068	0.244	0.074
$C_{16}H_{34}$	226	0.111	0.188	0.236	0.075	0.101	0.187	0.089	0.099	0.183	0.150	0.043	0.170	0.137	0.130
$C_{17}H_{36}$	240	0.139	0.363	0.966	0.198	0.563	0.247	0.278	0.171	0.557	0.235	0.127	0.475	0.231	0.311
$C_{18}H_{38}$	256	0.278	0.414	0.593	0.292	0.641	0.201	0.510	0.208	0.723	0.412	0.146	0.667	0.485	0.606
$C_{19}H_{40}$	268	0.213	0.260	0.628	0.171	0.609	0.469	0.418	0.185	0.457	0.419	0.048	0.436	9.319	0.469
$C_{20}H_{42}$	282	0.249	0.337	0.271	0.179	0.959	0.296	0.337	0.168	0.414	0.474	0.240	0.437	3.106	0.437
$C_{21}H_{44}$	296	0.218	0.266	0.253	0.169	0.552	0.837	0.277	0.215	0.311	0.358	0.227	0.326	0.367	0.383
$C_{22}H_{46}$	310	0.407	0.439	0.443	0.272	0.531	0.253	0.460	0.120	0.498	0.559	0.354	0.513	0.628	0.514
$C_{23}H_{48}$	324	0.382	0.478	0.521	0.283	0.576	0.588	0.461	0.116	0.554	0.587	0.318	0.536	0.298	0.540
$C_{24}H_{50}$	338	0.640	0.716	0.625	0.5722	0.716	0.348	0.812	0.103	0.741	0.899	0.631	0.692	0.346	0.862
$C_{25}H_{52}$	352	0.442	0.682	0.541	0.337	0.539	0.787	0.522	0.088	0.642	0.631	0.386	0.573	0.193	0.611
$C_{26}H_{54}$	366	0.528	0.574	0.610	0.355	0.495	0.374	0.574	0.244	0.671	0.658	0.463	0.612	0.177	0.653
$C_{27}H_{56}$	380	0.387	1.087	0.438	0.259	0.482	2.695	0.444	0.044	0.439	0.487	0.361	0.466	0.200	0.616
$C_{28}H_{58}$	394	0.377	0.583	0.654	0.263	0.535	2.964	0.553	0.036	0.381	0.474	0.359	0.417	0.316	0.594
$C_{29}H_{60}$	408	0.478	1.151	0.543	0.179	1.248	0.712	1.311	0.039	0.295	0.848	1.253	0.362	0.467	1.645
$C_{30}H_{62}$	422	0.495	0.643	1.367	0.172	0.358	0.423	0.446	0.029	0.215	0.358	0.505	0.305	0.347	0.749
$C_{31}H_{64}$	436	0.247	0.513	0.347	0.106	0.197	0.211	0.248	0.041	0.116	0.180	0.574	0.181	0.321	0.275
$C_{32}H_{66}$	450	0.304	0.218	0.253	0.096	0.169	0.345	0.283	0.026	0.133	0.199	0.173	0.173	0.268	0.418
$C_{33}H_{68}$	464	0.152	0.374	0.157	0.077	0.163	0.179	0.180	0.800	0.073	0.061	0.182	0.250	0.075	0.272
$C_{34}H_{70}$	478	0.091	0.112	0.098	0.055	0.160	0.082	0.260	0.424	0.040	0.085	0.142	0.245	0.056	0.117
$C_{35}H_{72}$	492	0.060	0.149	0.063	0.048	0.159	0.174	0.135	0.376	0.032	0.057	0.097	0.140	0.220	0.087
$C_{36}H_{74}$	506	0.182	0.074	0.045	0.020	0.211	0.158	0.109	0.280	0.019	0.037	0.041	0.149	0.046	0.054
Total		6.545	9.904	9.792	4.295	10.441	14.580	8.942	3.988	7.628	8.383	6.747	8.269	17.954	10.519
Pristane		0.041	0.29	0.483	0.109	0.422	0.128	0.225	0.128	0.418	0.214	0.091	0.086	0.124	0.252
Phytane		0.25	0.207	0.356	0.172	0.333	0.092	0.296	0.149	0.369	0.251	0.124	0.246	0.33	0.454

phytane) were comparatively similar to the concentrations measured in fish species from the same coastal zone (Al-Saad, 1990) and higher than the values measured in sediments of the same area (Rushdi et al 2014), but lower than the levels measured in sediments from the coast of Saudi Arabia (De Oteyza and Grimalt 2006). A recent study on the lipid sources in sediments from the Iraqi and Saudi Arabian Gulf coasts showed that the aliphatic hydrocarbons from petroleum inputs in the coastal zone of Iraq were higher than the coast of Saudi Arabia (Rushdi 2020). This high input of hydrocarbons, as a result of petroleum product discharge in coastal water, would influence the feeding habitats of the aquatic biota of the area, including fish species, leading to some contribution of petroleum AH in their tissues. Therefore, the variations of AH concentrations and sources in these fish species could be attributed to the feeding habitats, locations (surface versus bottom water), the major sources of food, and their contamination conditions.

Aliphatic hydrocarbon sources: Biogenic and anthropogenic as well as biogeochemical processes, including alteration and diagenesis of organic matter in the water column and bottom sediments, are the main sources of aliphatic hydrocarbon in aquatic environments (Rushdi et al 2018). These hydrocarbons will, ultimately, accumulate in the tissues of marine organisms including, fish species, as long as they are present in their nursing habitats. The occurrence of nC_{17}, nC_{18}, and nC_{19} n-alkanes has been attributed to algal and bacterial sources. Talal (2008) pointed out that the high value of the odd carbon number chain nC_{17} was due to sulfuric reducer bacteria (*Desulfovibrio desulforicans*) presence in the sediments, while the high value of nC_{19} was attributed to the algal sources. The presence of odd carbon numbers of high molecular weight n-alkanes (e.g., nC_{25}, nC_{27}, and nC_{29}) in the environment is mainly a result of the higher plant tissue decomposition (Ficken et al 2000). Therefore, carbon preference index and pristane/phytane ratio (Pr/Ph) have been used to define the sources of n-alkane compounds in the environment. $CPI_{(o/e)} > 1$ indicates a biogenic origin of n-alkanes from plants (Rushdi et al 2006, 2019, Fagbot and Olanipekun 2013, Diefendorf et al 2014).

The C_{max} of the fish tissue n-alkanes, was mainly at nC_{17}, nC_{24}, nC_{26}, and nC_{28} and nC_{29} (Table 1), indicating that the sources were a mixture from marine biota including algae and bacteria, petroleum input, and higher plant waxes (Rushdi et al 2006; 2018). The $CPI_{(o/e)}$, which has been used to assess the contribution of biogenic versus anthropogenic inputs can be divided into $CPI_{(o/e,\ \leq 24)}$, (nC_{13}-nC_{24}, for marine inputs), and $CPI_{(o/e,\ \leq 25)}$ (C_{25}-C_{36}, for a higher plant wax contribution) as well as $CPI_{(o/e,\ E)}$, (for the entire range) (Rushdi et al 2017). The $CPI_{(o/e, \leq 24)}$ values varied from 0.54 to 2.21 with an average value of 0.92±0.46 (Table 1), indicating a mixture of both marine plants, bacterial residues, and major petroleum sources of these aliphatic hydrocarbons. The $CPI_{(o/e, \leq 25)}$ ranged from 0.69 to 1.79, demonstrating that the n-alkanes are derived from a small fraction of higher plant waxes with high contribution from petroleum sources. The $CPI_{(o/e,\ E)}$ values of these n-alkanes varied from 0.76 to 2.01, also confirm a mixture of minor natural and major anthropogenic sources. Another useful indicator of the n-alkanes origin in the environment is the ratio of pristane-to-phytane (Pr/Ph) isoprenoids (Commendatore and Esteves 2004, Peters et al 2005). When the Pr/Ph ratio is more than 1.0, then their major source is biogenic; and when the Pr/Ph ~1.0, then the source is of petroleum origin. If the ratio is 1.0-0.8 or < 0.8, then it is due to their alteration under depositional redox or anoxic conditions, respectively. The Pr/Ph ratios in the fish tissues ranged from 0.16 to 1.4 with an average e of 0.85 (Table 2.), indicating that they were from different sources, including biological and petroleum inputs as well as from the alteration process under redox/anoxic conditions. To estimate the relative input from different sources, method described by Simoneit et al (1991) for terrestrial plant wax n-alkanes (i.e., C_{27}, C_{29}, C_{31}, C_{33}) and applied it to estimate the n-alkane contribution of marine algae (C_{15}, C_{17}, and C_{19}) and bacteria (C_{16}, C_{18}, and C_{20}) (Rushdi et al 2017). The levels of higher plant, microbial, and algal n-alkanes were estimated to range from 0.00 to 1.081, 0.031 to 0.576 and 0.00 to 7.684 µg/g Dwt respectively (Table 2). The concentrations of n-alkanes from petroleum sources were dominant and ranged from 3.235 to 10.987 µg/g Dwt. The fractions of petroleum n-alkanes in the fish species tissues ranged from 54% to 93 with an average of 83 (Table 2), whereas the biogenic n-alkane percentages ranged from 0 to 43% from marine algae, 1 to 10% from bacteria, and from 0 to 16% from higher plants. This indicates that petroleum by-products are the major sources of n-alkanes in the tissues of these fishes, with minor contributions from natural terrestrial plants, marine algae and bacteria. The fractions of the main three n-alkane origins (e.g., marine biota, higher plants, and petroleum) determined in the fish species tissues of carnivores and filter feeders (Fig. 2).

The petroleum n-alkanes in the tissues of carnivores (67-93%) were slightly higher than in the tissues of the filter feeders (54-85%) The higher plant n-alkanes were slightly higher in carnivores (0-16%) than in filter feeders (1-9%), and the marine biogenic n-alkanes were higher in filter feeders (6-45%) than the carnivores (4-15%).This indicates that feeding habits may also influence the accumulation of aliphatic hydrocarbons in fish tissues. Other factors that affect the accumulation and depuration of hydrocarbons in fish tissues include route and duration of exposure, the lipid content of tissues, differences in species, age, and sex, and exposure to other xenobiotics (Johnson-Restrep et al 2008, Al-Ali et al 2016). The n-alkanes compounds were most likely added to the fish species tissues via the digestion processes of contaminated phytoplankton, zooplankton, crustacean, and higher plant or directly from solution or suspended particles, and eventually accumulated in the tissues of the species (Al-Saad et al 2011, Wang et al 2019).

Statistical analyses and AH similarity among different fish species*:* Principal component analysis (PCA) is generally applied to reveal the similarity and variation patterns among various parameters and variables in a group of samples. The PCA analysis of the aliphatic hydrocarbons in the fish tissues (Eigen value > 1.0) recognized two major components (Table 4).

Factor loadings of > 0.96 for variables were used for interpretation and, 98.54% of the total variance extracted two principal components (PC1 and PC2). PC1 revealed 96.99% of the variance with tissue samples of all fishes as major factors, except *P. subviridis*, (Fig. 3). Thus, PC1 represented an important source and mainly from anthropogenic inputs, was controlling the aliphatic hydrocarbons in all carnivore fish species and the filter feeder *T. ilisha*. This was shown by the high fractions of total n-alkanes (75.4-93.2%) from petroleum sources and low fractions (0.0-14.9%) from biogenic sources, including higher plants and marine algae and bacteria. PC2 explained only 1.63% of the total variance showing a significant factor loading for the filter feeder *P. subviridis* (surface water), and it was a result of different prevailing aliphatic hydrocarbon sources. The dominant contributors of n-alkanes in *P. subviridis* included petroleum (54.2%) and marine algae (42.8%) sources.

The cluster analysis (CA) results showed a similar outcome to the PCA, where generally two clusters (A and B) are shown in the dendrogram (Fig. 4). Cluster (A) included all the fish species, confirming that the dominant aliphatic hydrocarbons were of similar sources, which were mainly of petroleum origin. Cluster (B) included only *Pl. subviridis*, validating that other prevailing aliphatic hydrocarbons

Table 4. Principal component analysis (PCA) results illustrating the relative loadings of aliphatic hydrocarbons of the fish tissue samples

	CP1	CP2
Br. orientalis	.862	.504
Ac. arabicus	.869	.491
Ep. coioides	.840	.529
Ch. dorab	.856	.510
S. commers-onnianus	.837	.542
S. lysan	.846	.481
O. ruber	.857	.511
Al. diedaba	.804	.534
Par.s niger	.840	.533
Pam.argentetus	.852	.519
Ab.hians	.876	.467
El. Sextarius	.844	.532
Pl. subviridis	.501	.865
T. ilisha	.858	.507
Total variance explained (%)	96.991	1.626

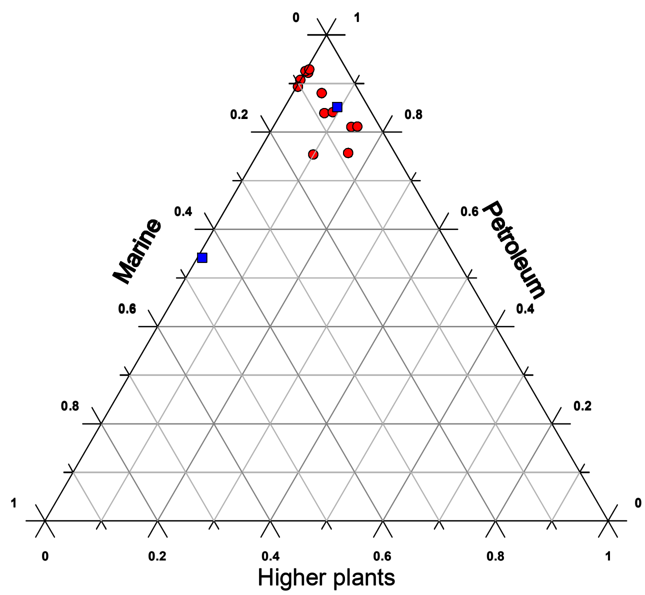

Fig. 2. A ternary diagram showing the aliphatic hydrocarbon n-alkanefractions from petroleum, marine and higher plant sources (circles = carnivores, rectangle = filter feeder)

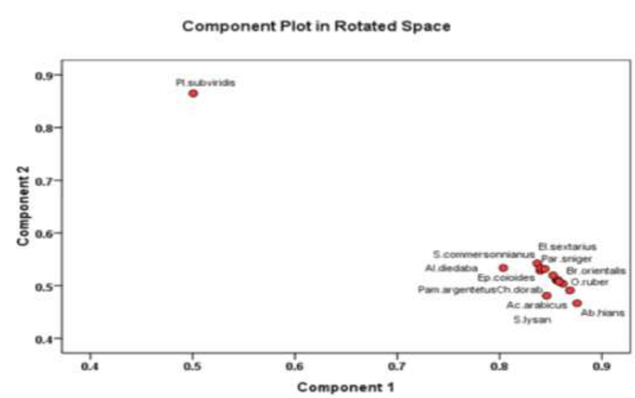

Fig. 3. A plot showing the principal component analysis (PCA) statistical outputs for the aliphatic hydrocarbon n-alkanes in the fish species tissues from Iraq

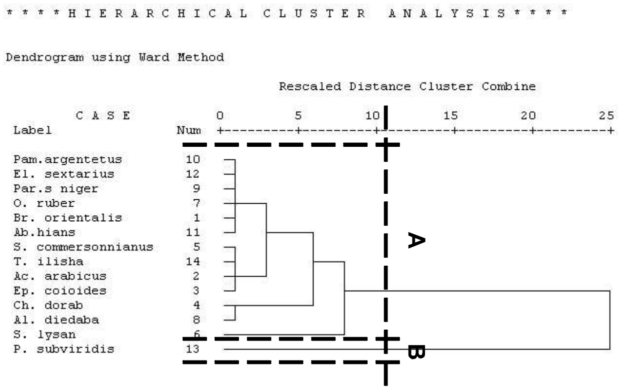

Fig. 4. A plot showing the cluster analysis statistical outputs of the aliphatic hydrocarbons in the tissues of fish species from Iraq

Table 5. Pearson's correlations of the different sources of n-alkanes in the various marine fish tissues from Iraq

	n-Alkanes	Higher plant	Algae	Bacteria	Petroleum
n-Alkanes	1	0.246	0.788**	0.085	0.885**
Higher plant		1	-0.127	0.089	0.284
Algae			1	-0.153	0.440
Bacteria				1	0.185
Petroleum					1

N = 14, **. Correlation is significant at the 0.01 level (2-tailed)., *. Correlation is significant at the 0.05 level (2-tailed)

(mainly biogenic) were significant sources of n-alkanes in its tissue.

Generally, the results showed that the major sources of n-alkanes in the tissues of these fish species were mainly from crude oil. Pearson's correlation coefficient (r), showed that there was a significant correlation (< 0.001) between total n-alkanes of the samples and both petroleum n-alkanes (r = 0.89) and algal n-alkanes (r = 0.79) (Table 5). The correlations were insignificant between higher plant and bacterial n-alkanes versus total n-alkanes (r = 0.25 and 0.09, respectively). These results confirmed that petroleum and algal sources were the main contributors to the n-alkanes in the tissues of the fish species, while both higher plant and bacterial n-alkanes had minor inputs.

CONCLUSION

The analyses of aliphatic hydrocarbons in the flesh of marine fish species from Iraq and their biomarker constituents and indices showed that petroleum hydrocarbons were predominant over the biogenic sources from marine and terrestrial higher plants. This is based on the n-alkane distribution pattern, C_{max}, $CPI_{(o/e)}$ values of ~1 (for entire, nC_{13} - nC_{24}, and nC_{25} - nC_{36} ranges) and Pr/Ph ~ 1. The joint biomarker approach and the biogeochemical index application are useful tools to differentiate between anthropogenic and biogenic sources of aliphatic hydrocarbons in aquatic biota. The fraction of n-alkanes from petroleum and related products in the tissues of the Iraqi marine fishes was relatively high, compared to natural biogenic sources from higher plant waxes, marine algae and bacteria. The contamination of the fishes by petroleum hydrocarbons is a serious health issue and is largely caused by oil-related activities in the area such as offshore oilfields, discharges from refineries and tanker traffic, and possible natural oil seeps. Further studies are needed to investigate the bioaccumulation of other anthropogenic and synthetic organic compounds such as polycyclic aromatic hydrocarbons, pesticides, and plasticizers in aquatic fauna and flora of the region as well as the environmental impacts of these organic compounds on the critical habitats coastal zone of Iraq.

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Study on Acute Toxicity of Bifenthrin to *Clarias batrachus* (Linn.)

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Abstract: The present investigation, acute toxicity of the fungicide, Bifenthrin, was carried out under experimental condition to adult *Clarias batrachus* (Linn.). The 96 h LC_{50} with 95% confidence limits of *Clarias batrachus* is 3.464 (3.032-3.779) µg l^{-1}. The LC50 values for 24, 48, 72 and 96 hours exposure to Bifenthrin are 5.093µg/l, 4.659 µg l^{-1}, 3.893 µg l^{-1} and 3.464 µg l^{-1}. None of the unexposed control fish died. Mortality rate between each concentration and mortality rate between 24-96 h depending on time was correlated. Significant relationship ($p<0.05$) was recorded between mortality rate and exposure times (24, 48, 72 and 96 h) at all concentrations. Similarly, significant variation was observed between mortality rate of fish at all the exposure doses at all the exposure times ($p<0.01$). The exposed fish showed abnormal behavioral responses depending on dose of bifenthrin and duration of exposure. The bifenthrin-based Marker pesticide was therefore classified as strongly toxic to fish.

***Keywords*:** Acute toxicity, Bifenthrin, *Clarias batrachus*, 96 h LC_{50}, Behavioral responses

Pesticides and related chemicals originate from human activity or agricultural farming and they are discharged directly or indirectly into the receiving waters (Bansode et al 2016). Though pesticides have contributed largely to human welfare, their adverse effects on non-target animals as well as ecosystem are significant (Hazarika et al 1998, John 2007). The movement of pesticides into surface and groundwater is well studied (Bansode et al 2016). Contamination of surface waters by pesticides used in agriculture field is a problem of worldwide importance (Sibley et al 1991). Pesticides reaching water bodies manifest their toxic effect in the aquatic organism as well as ultimately affect human beings through aquatic food source (Sahai 1992). The toxicity test is necessary to find out toxicant limit and safe concentration, so that there will be minimum harm to aquatic ecosystem in future (Bansode et al 2016). Bifenthrin is a third-generation synthetic pyrethroids insecticide which is characterized by very strong environmental persistence and high insecticidal activity (Bansode et al 2016). Bifenthrin is effective as a gut or contact insecticide and it affects the nervous system of vertebrates and invertebrates (Velisek et al 2009). It acts on sodium channels at the nerve cell endings to depolarize the pre synaptic terminals as well as affects cellular ATPase production (Roberts et al 1999).

The reports on the toxicity of bifenthrin on fish are scanty (Bansode et al 2016). No literature is available on the acute toxicity of bifenthrin on *Clarias batrachus*. *Clarias batrachus* has been chosen as a piscine model for this study because it is an air-breathing fish, having accessory respiratory organ and it is also a bottom dweller fish species. Being a bottom dweller species, *Clarias batrachus* usually highly exposes to different pesticides which come to the water via agricultural runoffs. The aims of the present study were to evaluate the acute toxicity and ethological responses of *C. batrachus* (Linn.) exposed to bifenthrin.

MATERIAL AND METHODS

Test organisms used in the bioassay comprised of adult *Clarias batrachus* (mean length 122.50±3.46 mm, mean weight 20.50±5.43g). The fish were collected from the fish farm located at Kazipara, near Barasat, 4 km away from the campus. The test organisms were brought to the laboratory and transferred to the rectangular cement tanks of 800 liters capacity containing unchlorinated, well aerated water. The fish were acclimatized to the food and laboratory conditions with 12 hr dark and 12 hr light cycles, pH range of 7.00 to 7.40 and temperature ranging from 22 to 28 °C for two weeks (APHA 2012).

For the determination of acute toxicity static replacement bioassays with fish were conducted in 15 liters glass aquaria each containing 10 liter of water. Each set of tests was accompanied by four replicates with sufficient control and was provided with five fish. Rough range finding tests were conducted initially to estimate the range of doses at which the mortality of fish may occur. Finally, the selected test concentrations of bifenthrin were used to *C. batrachus* for determination of the LC_{50} values at 24, 48, 72 and 96h of exposure were 3.0, 3.5, 4.0, 4.5, 5.0, 5.5, 6.0, 6.5, and 7.0 µg/l. Unchlorinated tap water stored in large glass aquaria (temperature 26 ± 0.28°C, pH 8.10 ± 0.24, free CO_2 10.7 ±

0.53 mg l^{-1}, DO 8.3 ± 0.34 mg l^{-1}, alkalinity 172 ± 5.11 mg l^{-1} as $CaCO_3$, hardness 125 ± 5.1 mg l^{-1} as $CaCO_3$) was used as a diluents medium. The bioassays and the tests on water quality parameters were performed following the methods outlined in APHA (2012). The required quantity of bifenthrin was weighed for the different test concentrations which were then added to the test medium. Uniform mixing of test chemical was done by stirring with the help of a magnetic stirrer (Sarkar et al 2018).

During the bioassay the dead organisms were removed quickly to avoid any microbial decomposition causing decrease in dissolved oxygen. The 10% of the test water was replaced by freshly prepared test water at every 24h interval to maintain a fixed concentration of diluents medium. Mortality rate at various doses and at various times of exposure (24, 48, 72, 96 h) was analyzed using the computer software R version 2.14.0 (US EPA, 1999) and probit analysis outlined by Finney (1971) for determining 96 h median lethal concentrations (LC_{50}) with 95% confidence limit of bifenthrin to *Clarias batrachus*. The lethal concentration (LC_{50}) was determined in MS Excel by plotting the test doses against the fish mortality within 24 hr, 48 hr, 72hr and 96h after the experiment (Finney 1971). The relation between mortality rate with exposure time and concentrations was evaluated using correlation analysis (Gomez et al 1984, US EPA 1999). The behavioral alterations (Restlessness, erratic swimming, and mucus secretion) of the exposed fish were also recorded during the experiment (Saha et al 2018).

RESULTS AND DISCUSSION

No test organism died during the acclimatization period. The acute toxicity of bifenthrin ($LC_{5,\ 10,\ 50,\ 90,\ 95}$) with 95% confidence limit to *Clarias batrachus* during the exposure period of 24, 48, 72 and 96h are given in Table 1 to 4 respectively. No mortality was observed in the control group during the experiment. Significant relationship ($p<0.05$) between mortality rate of *Clarias batrachus* and exposure times (24, 48, 72 and 96h) was recorded at all doses of the toxicant except 3.5 and 6.0 µg/l concentrations of the test chemical. The relation between concentration of bifenthrin and fish mortality at 24 hr. was, $y = 36.05\ln(x) - 5.169$, $R^2 = 0.971$; at 48 hr., it was $y = 29.22\ln(x) + 11.21$, $R^2 = 0.941$ (Fig. 1); at 72 hr. was, $y = 31.28\ln(x) + 22.71$, $R^2 = 0.889$; at 96 hr. was, $y = 28.67\ln(x) + 35.87$, $R^2 = 0.932$ (Fig. 2). The ethological alterations observed in the test organisms exposed to various lethal concentrations of bifenthrin are summarized in Table 2. The intensity of behavioral alterations increased with the increasing doses and progress of time of exposure (Table 2). At higher doses somersaulting of fish observed. Probably this was an early indication of their avoidance reaction from the test chemical (Saha et al 2018).

To control different pests indiscriminate and increased use of pesticides by human activities cause high risk to non-target organism's especially aquatic organisms (Bansode et al 2016). The surface water contamination by pesticides used in agriculture is a worldwide problem (Hill 1985, Sibley et al 1991). Estimation of LC_{50} value provides fundamental data to design more complex disposal model (Bansode et al 2016). Investigators from worldwide reported effects of pesticides on aquatic organism as well as ecosystem. (Cripe 1994, Shanmugam et al 2000). Though Pyrethroids have low toxicity for mammals and birds, they present a risk for aquatic organisms (Bradbury et al 1989). The present 96 h LC_{50} value of Bifenthrin to *Clarias batrachus* (3.464 µg l^{-1}) is much higher from the results of earlier workers (Velisek et al 200, Bansode et al 2016). Liu et al (2005), stated the 96h medial lethal toxic values of 2.08 and 0.80 µg l^{-1} for common carp and tilapia (*Tilapia* spp.) respectively. The differences in

Table 1. Acute lethal concentration ($LC_{5,10,50,90,95}$) values with 95% confidence limits of bifenthrin to *Clarias batrachus* at 24, 48, 72 and 96h (Control group theoretical spontaneous response rate = 0.000)

Lethal concentration parameters	Concentration values with 95% confidence limits (µg/l)			
	24h	48h	72h	96h
LC_5	2.809 (2.162-3.256)	2.090 (1.274-2.652)	2.049 (1.396-2.515)	1.994 (1.384-2.424)
LC_{10}	3.204 (2.599-3.616)	2.495 (1.677-3.031)	2.361 (1.713-2.809)	2.253 (1.651-2.665)
LC_{50}	5.093 (4.727-5.511)	4.659 (4.182-5.132)	3.893 (3.453-4.237)	3.464 (3.032-3.779)
LC_{90}	8.098 (7.115-10.148)	8.698 (7.287-12.433)	6.419 (5.753-7.731)	5.327 (4.874-6.121)
LC_{95}	9.235 (7.899-12.205)	10.383 (8.333-16.355)	7.397 (6.452-9.447)	6.019 (5.401-7.246)
Slope ± SE	6.364±0.98	4.726±0.88	5.899±0.95	6.857±1.11
Intercept ±SE	0.499±0.69	1.841±0.61	1.517±0.63	1.299±0.71

our result may be associated with differentness in limnological parameters of the test medium and also with age, size, health and species variation (Diedrich et al 2015, Capkin et al 2009, Patra et al 2015). As 96h LC_{50} for fish is below 30 µg l^{-1}, Bifenthrin belong to a group of chemicals highly toxic to fish and other aquatic organisms (Dobsikova et al 2006, Velisek et al 2007). This study reveals the toxicant concentrations (viz. LC_{50}) that can cause fish mortality at short-term exposure (Saha et al 2018). The observation on the ethological responses of the fish in the present study may be an indicative parameter for assessing the toxicity of bifenthrin in the ecosystem.

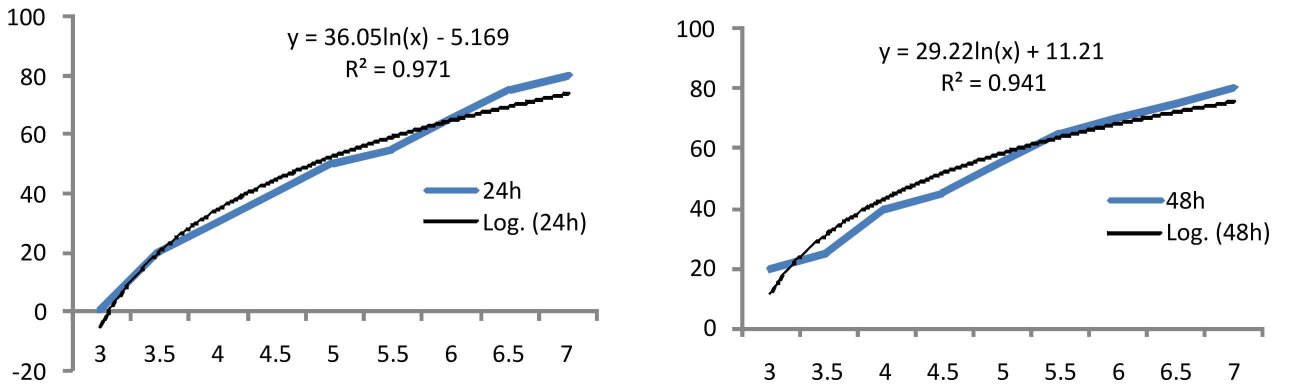

Fig. 1. Relationship between the concentrations of bifenthrin and mortality of *Clarias batrachu s*during 24h (left) and 48h (right)

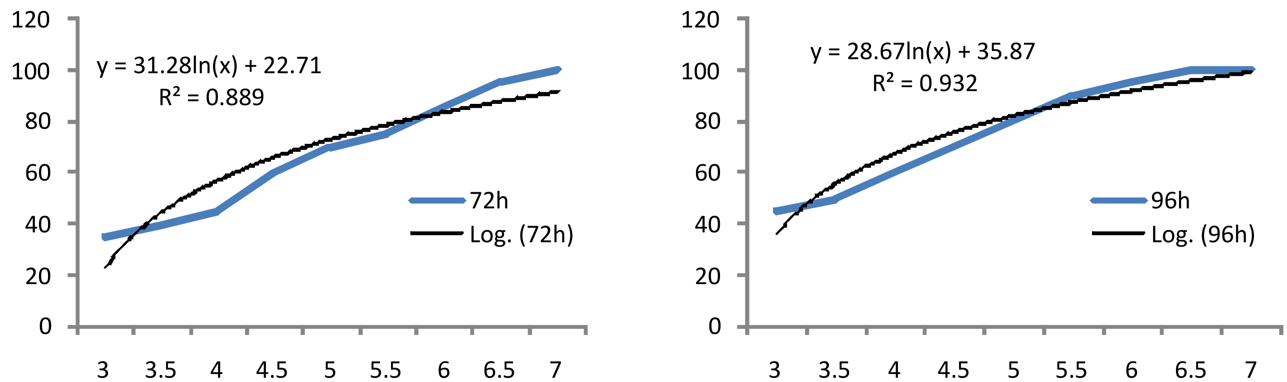

Fig. 2. Relationship between the concentrations of bifenthrin and mortality of *Clarias batrachus* during 72h (left) and 96h (right)

Table 2. Impact of bifenthrin on the behavioral parameters of different test organisms at various concentrations during different hours of exposure

	R	ES	MS	R	ES	MS	R	ES	MS	R	ES	MS
0.0	-	-	+	-	-	+	-	-	+	-	-	+
3.00	-	-	+	-	-	+	-	-	+	-	-	+
3.50	-	-	+	-	-	+	-	-	+	-	-	+
4.00	-	-	+	+	+	+	+	+	+	+	+	+
4.50	+	+	+	++	+	++	++	++	++	++	++	++
5.00	++	++	++	++	++	++	+++	++	++	++	+++	++
5.50	++	++	++	++	++	++	+++	++	+++	+++	+++	+++
6.00	++	++	++	+++	++	+++	+++	+++	+++	x	x	x
6.50	++	++	++	+++	+++	+++	x	x	x	x	x	x
7.00	++	+++	+++	X	X	x	x	x	x	x	x	x

R: restlessness; ES: erratic swimming; MS: mucus secretion; x: not recorded due to death; –: none; +: mild; ++: moderate; +++: strong

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Current Status of Rainbow Trout in Western Ghats, Southern India: A Fish Diversity and Water Quality Assessment Study

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Abstract: Rainbow Trout (*Oncorhynchus mykiss*) were introduced in the Western Ghats region of Munnar and Ooty in South India. After introduction, the population status had been declining greatly in many water bodies of these two geographical locations with no reports after 1970 from Munnar and after 1998 from Ooty. Therefore, this study was done to know the fish diversity, water quality and angling evidence in the following sites, namely Devikulam lake, Letchmi lake, Kaniamallay stream, Lakkam Stream, Madupatty and Kundale reservoirs of Munnar, Avalanche lake of Ooty and also to know the habitat suitability for the trout population in the sites mentioned. The water quality for all the water bodies was fair, good and marginal category according to the Canadian Council of Ministers of the Environment - Water Quality Index and two sites were suitable for trout life (Lakkam stream of Munnar and Avalanche lake of Ooty) while the others were not found suitable for trout and good catch records were collected by interviewing anglers and the population had vanished from maximum sites.

***Keywords*:** Angling, Rainbow trout, Western ghats, Ooty, Munnar

Rainbow trout (*Oncorhynchus mykiss*) are certainly the most important fish species in aquaculture and is native to North America, which was introduced in all continents except Antarctica. This fish species is capable of surviving at higher elevations and many anglers highly prefer this fish for sport and recreational fishery. With much significance towards aquaculture and angling in India, the European settlers began trout culture first in the Montane regions of Southern India, having trout introduced first in the Ooty region of Nilgiris in 1909. However, after years of establishment and stock improvement the population size of rainbow trout has been diminishing in this geographical location and has been limited to two waterbodies in the Avalanche Lake and Upper Bhavani reservoir. With the population stable in the Upper Bhavani reservoir, but the size and number of trout have been declining greatly in the Avalanche lake, though it was an angling and stocking site with excellent catches since introduction and there are no further reports after 1998 from this site. Similarly, Rainbow Trout were also introduced in the Munnar region in 1909 (Mackay 1945). Though the introduction in many streams and lakes in the High ranges of Munnar were successful, but in the years, the population size has been greatly vanishing in maximum sites, with no reports after 1970 (Sehgal 1999). Though good catches were made from all the sites of Munnar, but the size and number of trout kept diminishing and vanishing in a vast majority of sites and currently the trout population is stable only in the Rajamallay Stream of Munnar.

The water parameters for a majority of the sites were once studied (not in detail) during the 1970s (Sehgal 1971, 1999). But rainbow trout have been declining from a majority of the following waterbodies namely, Devikulam and Letchmi Lakes, Madupatty and Kundale Reservoirs, Lakkam and Kaniamallay Streams and from the Avalanche Lake of Ooty. In this study the water quality is studied for the first time for Lakkam and Kaniamallay Streams. Therefore, as a first step of investigation the fish diversity and water quality analysis were done in order to check the habitat suitability for rainbow trout and also to know the angling evidence after 1970 for Munnar and after 1998 for Ooty, since no reports are available for these sites after the mentioned time periods, in the mountainous regions of these geographical locations and to know the causative factors for the disappearance of trout.

Water-quality criteria refers to the maximum range of concentrations of elements, ions and water-quality parameters that need attention when selecting and treating trout waters and the test are based on studies carried out in laboratories. Temperature and dissolved oxygen are the important controls required for trout habitat (Elliot 1981). Rainbow trout require clear, cool and well oxygenated waters and instruction manuals along with government guides are available for trout fisheries and culture (Brannon 1991) but are in agreement with each other. However, the favorable conditions for the survival and growth of the trout not only depends on the required and satisfactory amount of water, but also on the temperature and excellent water quality (Yapo et al 2017). Trout requires specific chemical and biological conditions to live and thrive in its waters and without proper knowledge about the physicochemical parameters it is certainly difficult to understand the biological living of the fish because the chemical nature of water provides information on the ecosystem and other hydro biological relationships (Kiran 2010, Hlaváˇc et al 2014, Mohammed et al 2016). Therefore, trout waters do need all time conservation and protection since it's a very good indicator of water quality, especially serving its purpose in purification facilities (Randak and Pokorny 2001) thus proving the fish to be conserved in regards to its ecological and nutritional significance.

MATERIAL AND METHODS

Study areas: Water was collected from two different sampling points from the seven sites in the Munnar regions namely Devikulam Lake (10º04'56. 14” N 77º15'51. 41” E), Letchmi Lake, Kaniamallay Stream (10°06'34.1"N 77°03'27.3"E), Lakkam Stream (10°11'19.2"N 77°06'41.8"E), Madupatty (10°07'13.8"N 77°09'05.7"E) and Kundale (10°08'35.0"N 77°11'52.4"E) reservoirs and from the Avalanche reservoir (11º32'2” N 76º61'1” E) of Ooty were chosen for analysis in this study.

Sample collection: Fish sampling by using fishing nets of varying mesh sizes viz. gill nets and aquarium nets (40 cm size for small fishes) was done. After collection of fishes, examination and counting were done and was released back into the waters. All fishes were identified with the help of keys prescribed by Jayaram (1999).

Analysis of physio-chemical Parameters in water samples: Water samples were collected in sterile polypropylene bottles and the physical parameters such as the pH, temperature, total Dissolved Solids were done using a Eutech PC Testr 35. Chemical parameters were analyzed via Winkler's method, ethylene diamine tetra acetic acid and titrimetric method and other parameters were analyzed by argentometric, gravimetric, ultraviolet, spectrophotometric screening methods, respectively.

Catch data of rainbow trout population: Interview with Management officials (n = 10) of the Kanan Devan Hills Plantations Company, Munnar and Fisheries Department Officials of Ooty was done for angling information for trout sites with an aim to record the happenings after 1970 and 1998 since there are no records after this year. The total time taken for interviewing lasted for 30 minutes by oral interview and discussion (Table 1, 2). Data was collected by interview by using the following questions:

Table 1. Interview questions for anglers in Munnar, Kerala, South India

Q.1.	Have you angled in all sites of the Munnar region?
Q.2.	How long have you been angling and in which sites?
Q.3.	How many fishes have you caught in a site?
Q.4.	What were the primary reasons for trout to disappear from a site?
Q.5.	When was the last time you caught a trout and from which site?
Q.6.	Why did stop the stocking of trout fingerlings in the Devikulam and Letchmi Elephant Lake?
Q.7.	What were the issues you witnessed that were found disturbing trout life and in which sites?
Q.8.	What were the other fish species that you encountered while angling and in which site?

Table 2. Interview questions for fisheries officials, Ooty, Tamil Nadu, South India

Q.1.	Which are the current waterbodies where trout are stocked?
Q.2.	What conservation steps have been taken to restore trout in the Avalanche reservoir?
Q.3.	Why has angling been stopped?

Water quality index using the Canadian council of ministers of the environment: To evaluate the water quality, the Water Quality Index (WQI) was computed for water samples from each sampling site of all locations. In this study, a method developed by the Canadian Council of Ministers of the Environment (CCME) based on the following formula, The CCME Water Quality Index (CCME WQI):

$$CCME - WQI = 100 - \left(\frac{\sqrt{F1^2 + F2^2 + F3^2}}{1.732} \right)$$

To enable the CCME-WQI calculation, three physical and fourteen chemical parameters of water were used, following their limits which helps in determination of the water quality (Table 3), colonized by Salmonids which were formed or stipulated in the Regulation of the Minister of the Environment on the 4 October 2002, acting in accordance with the Council Directive 78/659/EEC on the quality index of fresh waters requiring protection, improvement, support of fish life (Directive Council, 1978).

Agglomerative hierarchical clustering: Agglomerative Hierarchical Clustering (AHC) was done based on Ward's method and Euclidean distance.

Statistical analysis: Statistical significance for the seasons, sites and parameters was done using Graph Pad Prism 6 software.

RESULTS AND DISCUSSION

Fish diversity and water quality assessment of waterbodies: The study was done for all the sites in the winter season (November and December) which is the breeding time for the fish to come to the shallow streams to spawn and was easy to make catches. While other fish species were found all around the sites studied.

CCME - WQI of Devikulam and Letchmi Lakes, Munnar: The CCME - WQI of Devikulam (57.77; Table 4) and Letchmi (54.22; Table 4) Lakes of Munnar was Marginal. Both these waterbodies had moderate amounts of dissolved oxygen with the temperature below range (12.7ºC and 11.5ºC; Table 5) at the surface level, but the ammonia (7.9 and 8.4 mg/l; Table 5) and nitrite levels (0.12 and 0.35 mg/l; Table 5) were approximate and above range when compared to the pristine levels (Table 5). The rest of the parameters were below the acceptable range, but does not hinder much for trout. The Devikulam Lake is not suitable for trout because of the toxic parameters beyond the range, species invasiveness and poaching, while in Letchmi Lake it was due to pollution and poaching.

Table 3. Standard values for water quality of trout waters

Physico – chemical parameters	Reference range (Standard values)	References
Temperature	6ºC-13ºC	MacIntyre et al 2008
Turbidity NT Units	2 - 12 NTU	Lisa Klein 2003
TDS	<200 mg l^{-1}	Wedemeyer 1996
pH	6.5-8.5	MacIntyre et al 2008
Total Alkalinity as $CaCO_3$	20 mg l^{-1}	MacIntyre et al 2008
Total Hardness as $CaCO_3$	75-150 mg l^{-1}	MacIntyre et al 2008
Calcium	4-160 mg l^{-1}	Heinen 1996
Magnesium	<15 mg l^{-1}	Heinen 1996
Iron	<0.5 mg l^{-1}	Industry Standard 1988
Ammonia	<0.02 mg l^{-1}	MacIntyre et al 2008
Nitrite	<0.1 mg l^{-1}	MacIntyre et al 2008
Nitrate	<1 mg l^{-1}	MacIntyre et al 2008
Fluoride	<1 mg l^{-1}	Camargo 2003
Sulphate	<50 mg l^{-1}	Heinen 1996
Phosphate	<0.3 mg l^{-1}	Industry Standard 1988
Dissolved Oxygen	≥9.0 mg l^{-1}	Industry Standard 1988
BOD (Biological Oxygen Demand)	5 ppm	Svo-bodova et al 1993

CCME - WQI of Kaniamallay Stream, Madupatty and Kundale Reservoirs, Munnar: The CCME - WQI of Kaniamallay Stream (78.08; Table 4), Madupatty and Kundale reservoirs (69.96, 73.42) reservoirs of Munnar was Fair. All three waterbodies had surface temperature within range (12.2ºC, 10.2ºC and 9.7ºC; Table 5) but low levels of dissolved oxygen (5.5, 5.9 and 6.2 mg l^{-1}) were observed with increased levels of ammonia (0.12, 0.25 and 0.15 mg l^{-1}) and other toxic parameters in the reservoir waters were seen in nitrite (0.1 and 0.15 mg l^{-1}) and nitrate (1.75 and 2.7 mg l^{-1}). The Madupatty and Kundale reservoirs are not suitable for trout because of the toxic parameters beyond the range, species invasiveness and poaching (tourists and locals), while in Kaniamallay Stream it was due to pollution and poaching.

CCME - WQI of Lakkam Stream, Munnar: The CCME - WQI of Lakkam Stream was good (84.45; Table 4) and can support trout life as certain parameters are within the pristine limit range and the mean observed temperature (11.25ºC; Table 5) and dissolved oxygen (8.75 mg l^{-1}), which was near the acceptable range and ammonia (0.12 mg l^{-1}) was above range but changes in time, while all other parameters were below range and did not interfere much for the living of trout. The Lakkam stream is not suitable for trout because of intense poaching (tourists and locals), but can be considered for reintroduction of trout because of water clarity.

CCME - WQI of Avalanche Reservoir, Ooty: The CCME - WQI of Avalanche Lake was good (84.83; Table 4) and trout life is supported in this location to an extent as a self-sustaining population with the mean observed surface temperature within limits (10.25ºC; Table 5) with dissolved oxygen levels (8.3 mg l^{-1}; Table 5) which is fair, and other parameters was within the acceptable range. But this site can be considered suitable for trout because of water clarity and conservative measure is taken by commercial fishing for common carp, even though poaching is prevalent at times.

Water quality assessments: The water quality of the all

Table 4. Water quality rating, specifically for trout waters or streams (Chen et al 1997)

WQI value	Water quality	Description
95-100	Excellent	Water quality is protected with a virtual absence of threat or impairment, conditions very close to natural or pristine levels.
80-94	Good	Water quality is protected with only a minor degree of threat or impairment, conditions rarely depart from natural or desirable levels.
65-79	Fair	Water quality is usually protected but occasionally threatened or impaired, conditions sometimes depart from natural or desirable levels.
45-64	Marginal	Water quality is frequently threatened or impaired, conditions often depart from natural or desirable levels.
0-44	Poor	Water quality is almost always threatened or impaired, conditions usually depart from natural or desirable levels.

Table 5. Physicochemical parameters of Avalanche Lake of Ooty, Kundale and Madupatty Reservoirs, Kaniamallay and Luckham Streams, Letchmi and Devikulam Lakes of Munnar during winter season

Physico – Chemical Parameters	Reference Range	Devikulam Lake	Letchmi Lake	Luckham Stream	Kaniamallay Stream	Madupatty Reservoir	Kundale Reservoir	Avalanche Lake
Temperature (ºC)	6ºC - 13ºC	12.75±0.95	11.5±1.29	11.25±0.64	12.25±0.64	10.25±0.64	9.75±0.64	12.5±2.64
Turbidity NT Units	5	1.5±0.57	0.5±0.57	0.5±0.57	1±0	3±0.8	2±0.81	1±0
TDS (mg L^{-1})	<200 mg L^{-1}	34.55±1.49^{abcd}	30.9±4.56^{abcd}	18.75±0.64^{abcd}	45±3.74^{abcd}	66.5±9.03^{abcd}	116.75±0.64^{abcd}	20.5±1.29^{abcd}
pH	6.5 - 8.5	7.05±0.05	7.3±0.27	6.8±0.17	7.1±1.03	6.9±0.12	7.45±0.12	6.7±0.32
Total Alkalinity as $CaCO_3$ (mg l^{-1})	20 mg L^{-1}	9.4±0.71^{abcd}	21.95±13.4^{abcd}	2.27±0.32^{abcd}	11.25±0.95^{abcd}	19.7±0.35^{abcd}	27.07±3.44^{abcd}	8.7±2.62^{abcd}
Total Hardness as $CaCO_3$ (mg l^{-1})	75 - 150 mg L^{-1}	7.5±2.88^{abcd}	26.5±11.47^{abcd}	4.4±0.71^{abcd}	18.75±0. 95^{abcd}	24.75±4.5^{abcd}	47.75±1.93^{abcd}	7±0.08^{abcd}
Calcium (mg L^{-1})	4 - 160 mg L^{-1}	3.5±0.57^{abcd}	12.6±2.56^{abcd}	1.75±0.64^{abcd}	4.4±0.7^{abcd}	11.75±3.22^{abcd}	15.25±1.93^{abcd}	2.7±1.7^{abcd}
Magnesium (mg L^{-1})	<15 mg L^{-1}	0.5±0.57^{a}	4.8±0.85	1.2±0.96	2.27±0.3	5.25±1.93^{a}	5.75±0.64a	1.75±0.95
Iron (mg L^{-1})	<0.5 mg L^{-1}	0.12±0	0.01±0	ND	ND	ND	ND	0.14±0.03
Ammonia (mg L^{-1})	<0.02 mg L^{-1}	0.38±0.13	0.47±0.05	0.12±0.05	0.12±0.05	0.25±0.12	0.15±0.05	0.01±0
Nitrite (mg L^{-1})	<0.1 mg L^{-1}	0.12±0.08	0.35±0.12	0.1±0	0.14±0.07	0.1±0	0.15±0.05	0.02±0.02
Nitrate (mg L^{-1})	<1 mg L^{-1}	0.55±0.51	0.33±0.44	1±0	0.65±0.23	1.75±0.64	2.7±0.35	0.75±0.33
Fluoride (mg L^{-1})	<1 mg L^{-1}	0.57±0.41	0.5±0.2	0.6±0	0.9±0.25	0.65±0.05	0.85±0.05	0.1±0
Sulphate (mg L^{-1})	<50 mg L^{-1}	2.25±0.5a	4.12±1.92	1±0ab	4.2±1.93	2.25±0.64	7.25±1.93^{a}	2.5±0.09^{ab}
Phosphate (mg L^{-1})	<0.3 mg L^{-1}	0.17±0.12	0.27±0.15	0.1±0	0.12±0.05	0.27±0.17	0.25±0.05	0.07±0.01
Dissolved Oxygen (mg l^{-1})	≥9.0 mg L^{-1}	7.92±0.86	8.4±0.37	8.75±0.64	5.2±0.64	5.9±0.38	6.25±0.38	8.3±0.57
BOD (ppm)	<5 ppm	1±0	1±0	1±0	2.6±0.47	3.2±1.93	2.37±0.94	0.75±0.5
CCME-WQI value and quality		57.77 (Marginal)	54.22 (Marginal)	84.45 (Good)	78.08 (Fair)	69.96 (Fair)	73.42 (Fair)	84.43 (Good)

^{abcd}Different superscript letters indicate significant difference between the seven water bodies and parameters ($p<0.0001$) (Mean ± SD)
ND=Not Detected

waterbodies in Munnar and Ooty of South India has been supporting trout life for many years but has vanished in maximum sites. All the waterbodies had surface temperatures within range and were proving ambient, but rainbow trout being poikilothermic withstand up to 30ºC and can adapt to high summer temperatures (Narum et al 2010, Narum and Campbell 2015) with capability of swimming performance up to 24°C (Rodnick et al 2004). But high-water temperatures increase stress that toxins exert on trout life (Heinen 1996). Certain toxic parameters in the case of ammonia, in all waterbodies of Munnar and was beyond the range (Table 5) and this happens initially when decomposition and death of living matter, biological wastes fall in the water can cause the release of ammonia, in which nitrogen is released and is organic. Bacteria or fungi convert the organic nitrogen into ammonium. The conversion of ammonium to nitrate (NO^-_2) is done by *Nitrosomonas* bacteria and *Nitrobacter* bacteria are responsible for the oxidation of nitrites (NO^-_2) into nitrates (NO^-_3). Ammonia conversion (NH_3) into nitrates or nitrites is highly essential because ammonia is toxic to fish (Smil 2000) like trout and compounds such as nitrite and nitrate was also found beyond range in both the lakes (Devikulam and Letchmi), the reservoirs (Madupatty and Devikulam) and the streams (Kaniamallay Stream). Nitrite is an intermediate of the transformation of ammonia into nitrate, and its surface concentration by chemical and biological redox processes is often kept low. The reasons for the presence of ammonia, nitrite in lake waters of Devikulam and Letchmi was the presence of frequent or constant surface run-off from animal excretory wastes from cattle grazing activities that has polluted the water and has also increased the organic load in the water, besides the presence of decaying plant matter caused by reeds in mass numbers, which has made the trout population to decline and vanish greatly. In the case of reservoirs waters of Madupatty and Devikulam, the toxic parameters (ammonia, nitrite and nitrate) were high because of regular tourist activities by horse and elephant riding with constant animal excretory run off from horse and elephant riding that has polluted the water and tourists litters the waters with food wastes and runoffs caused by soil erosion and dead plant matter by deforestation (releasing toxins) have caused the trout to disappear. In streams such as the Kaniamallay, the rise in ammonia was due to human activities (washing) and degraded tea waste from nearby tea factories and agricultural and animal waste runoff in this stream, which has caused the disappearance of trout from site to a great extent. Nitrate concentrations in trout waters of around 10mg can adversely affect salmon and trout fish species such as Rainbow trout (*Oncorhynchus mykiss*), Chinook salmon (*Oncorhynchus tshawytscha*), Cutthroat trout (*Oncorhynchus clarkii*), However, a maximum level of 2mg would be enough for the safe life of the most sensitive freshwater species (Camargo et al 2005). However, these minor concentrations observed in the waterbodies of Munnar can prove fatal for trout life.

Calcium concentrations are more desirable and also the magnesium levels were below the range (Table 5), showing that the water hardness was very much below normal. Calcium plays a very important role in various biological processes of fish which is necessarily required for bone formation, blood clotting and other metabolic reactions, fishes absorb calcium from the water or food directly for these biological needs. But the presence of free calcium ions at high concentrations (beyond required range) especially in culture water helps in the reduction of sodium and potassium loss from fish blood, vitally required for functioning of normal heart, nerve and muscle function. In low calcium water, the fish lose substantial quantities of these salts and the fish must use energy provided by their feed in order to re-absorb the lost salts (Wurts 1993). But the calcium levels observed in all waterbodies were below range, which makes the fish dependent on natural prey. Fluoride levels in all waterbodies were found less than normal range (Table 5) and be dangerous to fish when accumulated in the bones of fish, its toxicity inhibits enzyme activity, stopping glycolysis and protein synthesis (metabolic process) and increases depending on the concentration, exposure time and temperature and decreases with the increasing intraspecific body size along with calcium and chloride content in water and salmonids are more sensitive to fluoride toxicity than estuarine and marine creatures (Camargo 2003). Other heavy metals such as Iron were below normal level (Table 5), because intensified forestry increases the iron load in river ecosystems (Vuori 1995). Though all the waterbodies were in a forest environment, but the effect was little or none. Dissolved oxygen levels above 7 mg/L are the optimum for trout (Raleigh et al 1984). The amount of total dissolved solids can affect rainbow trout and an upper limit of 80 mg l^{-1} (Heinen 1996) is optimum and all sites were below range, thereby safe for trout. Though DO levels were above range in some waterbodies, but significant reduction in oxygen concentration was observed (Kaniamallay Stream, Madupatty and Kundale reservoirs) due to contamination by biodegradable organic substances, temperature, pH in few sites. The substances are decomposed by bacteria using oxygen from the water, which can be observed by BOD, which was below range (Svo-bodova et al 1993).

Significant difference between the seven water bodies and parameters (Table 5) was mainly due to climate conditions and geographical location and distance. While significant difference was not observed in a majority of the parameters, except in the case of TDS, Total Alkalinity and Hardness of $CaCO_3$ and Calcium which could be based on the amount of nutrient salts and chemical constituents present at each site. Some of the other adverse environmental conditions for all the sites studied arise when climatic conditions vary, the water in all the sites is received during the south-west monsoon which is the chief source of water and the water received during the monsoon season is maintained till the end of the post-monsoon season, while the water comparatively dries up during the pre-monsoon season, because of which all the fishes in the respective sites take refuge in deep pools and undercut banks. The presence of ammonia, which was beyond the range in a majority of the sites and should be a causative factor in the reduction on the abundance, since in natural environments the fish are often exposed to multiple contaminants that can interact with ammonia found externally to increase toxicity (Brinkman et al 2009). Rainbow trout are the most sensitive to ammonia and when exposed to low levels of ammonia over a period time are vulnerable to bacterial infections, poor growth and at higher concentrations, unexplained production losses can happen and when the un-ionized ammonia (UIA) is higher than 0.05 mg l^{-1}, damage can occur to the fish (Ruth Francis-Floyd 2009). The sources of ammonia in the environment of these sites are by natural processes, which include the decomposition and breakdown of organic waste matter, forest fires, animal waste, discharge by biota and other nitrogen fixation processes (Environment Canada 1997), which are happening in the six sites studied but significant difference was not observed between the sites studied.

Agglomerative Hierarchical Clustering (AHC) of the WQIs of all the waterbodies observed and was classified into 4 different clusters. In sites S1 (Devikulam Lake), S2 (Letchmi Lake) showed that the water quality is frequently threatened and conditions often depart from natural levels and sites S3 (Kaniamallay Stream), S4 (Madupatty reservoir), S5 (Kundale reservoir) showed the water quality is occasionally threatened and conditions sometimes depart from natural levels. While sites S6 (Lakkam Stream) and S7 (Avalanche Lake) showed that the water quality has minor degree of threats with conditions rarely departing from natural levels as shown in Figure 1. Comparatively the water quality for the trout was better in Lakkam Stream and Avalanche Lake.

The disappearance of trout from the water bodies in Munnar has been due to the contamination by biodegradable organic substances releasing toxic elements, temperature changes, depletion in oxygen levels besides other adverse conditions which were observed that did not suit the living of rainbow trout and have been discussed in this study.

Fish population assessments: The disappearance of trout in all waterbodies has not only been due to poaching and environmental conditions but also because of species invasiveness by common carp (*Cyprinus carpio*; Table 6) and by the koi carp (*Cyprinus rubrofuscus*; Table 6) these invasive aquatic pests which are a noxious fish are prevalent in the Devikulam Lake, while Avalanche lake has common carp, while common carp and catfish (*Clarias batrachus*) are prevalent in mass numbers in the Madupatty and Kundale reservoirs.

Table 6. Freshwater fish diversity recorded or caught from all seven study sites, (X) presence of species, (-) absence of species

Species	Study sites						
	Devikulam Lake	Letchmi Lake	Lakkam stream	Kaniamallay stream	Madupatty reservoir	Kundale reservoir	Avalanche Lake
Family: Cyprinidae; Genus: *Cyprinus*							
Cyprinus carpio	X	-	-	-	X	X	X
Cyprinus rubrofuscus	X	-	-	-	-	-	-
Garra hughi	-	-	X	-	-	-	-
Family: Poeciliidae; Genus: *Poecilia*							
Poecilia reticulata	-	X	-	-	-	-	-
Gambusia affinis	-	-	-	-	-	-	X
Family: Clariidae, Genus: *Clarias*							
Clarias batrachus	-	-	-	-	X	-	-
Family: Salmonidae; Genus: Oncorhynchus							
Oncorhynchus mykiss	X	-	-	-	-	-	X

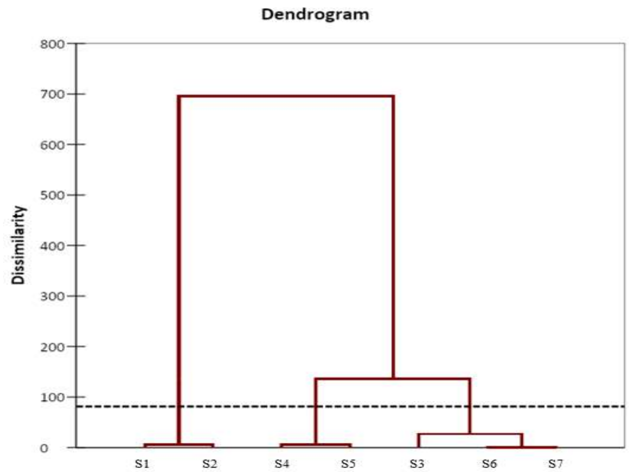

Fig. 1. The water quality index and agglomerative hierarchical clustering based on Ward's method and Euclidean distance

The presence of the cyprinids in the Devikulam Lake has completely changed the environment with the presence of overgrowth of tall water reeds which have become a spawning place and the carps on territorial expansion, increase turbidity causing reduction in the abundance of aquatic plants (macrophytes), leading to habitat change bringing the trout population to local or regional extinction. In absence of natural predators or commercial fishing the carp populations alter the environments (because of their reproductive rate) by feeding through bottom sediments and in the process, they destroy, disturb and consume submerged vegetation, causing serious damage to fish populations. The presence of macrophytes helps in removal of minerals from sediment pools and fights pollution, sheltering fish populations and also help in water conservation. Previous studies have proved that Devikulam and Letchmi Lakes are turbid and lacks macrophytes in the littoral zone (Sehgal 1999). Decimation of trout population has happened in the reservoirs of Madupatty and Kundale by carps and also by the catfish by predation pressure which has caused the decline of the salmonids. Studies have also been proved to show that the growth rates of fish can decline when a predator is present (Johnsson 1993), as invasive fish can may alter the habitat use under predation risk (Haddix 2005). Conservation strategies for trout can be done by establishing catchment management practices that aid in the reduction on the abundance and growth size of the carp where the nutrient process can be cut down (Weber et al 2010). The presence of common carp in Avalanche Lake has not proved detrimental to a vast extent since the fisheries department is taking conservative measures to eradicate the carp population by commercial fishing and necessary precautions are with protective measures to save the trout if accidentally caught, as an act of restoration and conservation. Similar strategies have been done in the Mediterranean streams for restoration of native brown trout by removing resident introgressed brown trout (Sabatini et al 2018). The presence of the mosquito fish (*Gambusia affinis*; Table 6) can significantly decrease the mosquito population but can also harm indigenous aquatic life and ecosystems (Rupp Henry 1995) where introduced, but depends on the range of introduction (Fryxell et al 2015). The Avalanche lake has many small streams emptying into the lake, making the site suitable for the living of rainbow trout. The guppies (*Poecilia reticulata*; Table 6) and are found in remnant populations in the Letchmi lake and the ray finned fish species (*Garra hughi*; Table 6) are found in the Lakkam stream, but these two indigenous species have not proved detrimental to trouts existence. But the trout population is scarce in the Devikulam and Avalanche Lakes. Stocking of rainbow trout fingerlings has been stopped in all these waterbodies. Species invasiveness has been another reason for the disappearance of trout in majority of sites or waterbodies.

Catch records (After 1970 from Munnar and after 1998 from Ooty): Though the water conditions were assessed and also the availability of the fish populations in the trout water bodies, the other reasons for the disappearance of the trout populations were overfishing or poaching, as good catch records were available till 1970 from Munnar and till 1998 from Ooty and which no records are available and interview (Table 1, 2) with the Management officials of the Kanan Devan Hills Plantations Company, Munnar and Fisheries Department Officials of Ooty had revealed the information. Previous studies from Devikulam and Letchmi Lake showed that the average catch/rod/hour was 233 g and 217 g in 1968-1969 (Sehgal 1999) when compared to catches done after 1970 for Devikulam Lake revealed catches weighing 500-750g measuring 24cm in 2000 and the largest catch after 2000 was 48 cm weighing 1700g showing an increase in size and a catch of 1100g measuring 63 cm in 2011 and the last catch was made in 2014 respectively, after which there were no catches recorded. In Letchmi Lake, after 1970 catches ranged around five to six fishes were caught in a year and the maximum size was 10-12 cm being the last in 2010 and after which no catches were recorded. Intense poaching by communities in both the lakes is also another cause for the disappearance of trout besides the environmental conditions and species invasiveness. Past catch records for Kaniamallay Stream showed catches with size from 207 to 398 g during the 1960s (Sehgal 1999) but the size and number of the catches done after 1970 were revealed with good catches in early 1980s (size and number of catches unknown). Past records for Madupatty reservoir revealed a catch weighing 141g in 1960s (Sehgal 1999) and after 1970 a catch weighing 1.3kg in 1981 was done followed by a catch weighing 2.72 kg and 55.8 cm in 1982. Similarly, for Kundale reservoir a catch weighing 151g was done in 1960s but after 1970, the catches were recorded in 1980's, with a catch haul of 38 fishes ranging from 400 g to 600 g measuring 30.4 cm and no catches were taken thereafter. Intense poaching by local communities in both the reservoirs and form the stream is also another cause for the disappearance of trout besides the environmental conditions and species invasiveness.

In 1944, a catch was recorded in Lakkam Stream measuring 24.75 inches weighing 3.17 kg (7 lbs) and 15.15 inches girth (Mackay 1945) and after 1970, the catches made by anglers in 1980 showed the average catch to be two to three fishes measuring 15.2 to 20.3 cm and weighing 300g to 400g. In 2003 it dropped to two fishes measuring 15 to 17 cm in length and 200 g to 300g. After this no catches were recorded or taken. Intense poaching by local communities in this stream is also another cause for the disappearance of trout. Angling activities in the Avalanche Lake of Ooty in the past had good records were fishes weighing from 545 g/rod/hr during 1966-1967 and was dropped to 212 g/rod/hr during 1969-1970. During 1997-1998 the catch rate was approximate at 86g/rod/hr, and the number of fish caught ranged at 4 fish/rod/day weighing 2kg and annually it was approximate at 75 fishes/rod/year (Gopalakrishnan et al 1999) and most of the catches were during January and February (during the breeding season). But angling activities after 1998 has been banned due to poaching by local communities and tribes and also because of the common carp. Though poaching is available in this lake, but necessary steps are being ensured towards safety and conservation of the trout besides the prevalence and species invasiveness, but commercial fishing is done for common carp. Therefore, Intense poaching has caused the disappearance of trout in the progressive years besides other causative factors discussed. Conservation of any fish species starts by conserving the habitat and environment followed by other remedial measures.

CONCLUSION

Rainbow Trout has disappeared from all waterbodies of Munnar and only two waterbodies have proved suitable (Lakkam Stream of Munnar, Avalanche Lake of Ooty). But remedial and conservative measures need to be taken for the long-term sustainable development of trout fisheries in the South Indian regions, currently existing rainbow trout population in Munnar is found in only one site namely, The Rajamallay Stream where stocking with angling activities take place, the population is self-sustaining and safe. While the in the Ooty region the population is currently found self-sustaining in the Upper Bhavani reservoir with stocking activities. Out of the seven sites studied restoration activities are currently underway in the Avalanche Lake. The water bodies in Munnar and Ooty were best suited for rainbow trout fisheries in early 1900s by the Englishmen but in time after years of introduction and establishment many adverse activities have caused the disappearance this fish population. But the environment hasn't been conducive for trout life in the progressive years as the health status of a fish can be influenced by many factors and the rate of mortality also depends on the elements that are connected with the water quality (Brown and Day, 2002). The disastrous impact of species invasiveness and intense poaching have also made the salmonids to disappear. Therefore, conservation of a fish species, starts with the conservation of its environment and its habitat.

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Seasonal Variation and Abundance of Zooplankton in Upper Manair Reservoir at Rajanna Sircilla,Telangana State, India

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Abstract: Assess the Seasonal variation of zooplankton in the Upper Manair reservoir were studied for various physico-chemical parameters with mainly focus on diversity and abundance of zooplankton. A total of 45 species of zooplankton were found, belonging to 24 species of rotifera, 08 species of cladocera, 08 species of copepoda, 02 species of ostracoda and 03 species of protozoa were screened. Rotifers were the dominant group of the zooplanktons and Ostracoda were lower group of zooplankton during the study period. The population of zooplankton was showed positively and negatively during the study period. The degree of difference of zooplankton groups showed variation seasonly. The present study is an attempt to Upper Manair reservoir qualitative and quantitative population of zooplankton and importance for successful aquaculture management.

***Keywords*:** Zooplanktons, Seasonal variation, Diversity, Abundance and Upper Manair reservoir

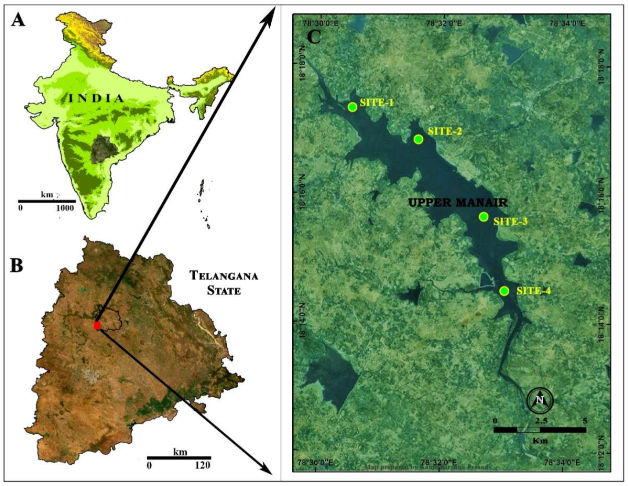
Zooplanktons are important biotic components influencing all the functional aspects of an aquatic ecosystem, examples as food chain, food web, energy flow and cycling of matter. Zooplankton depends on the following factors such as change of climatic conditions physical and chemical properties of water body and vegetation cover. The knowledge of zooplankton abundance, species diversity and specific distribution is helpful in understanding the tropodynamics and trophic progression of water bodies. Seasonal variations or fluctuations of zooplanktons somehow relation to certain physico-chemical parameters of water body. Planktons are considered as an index of fertility and the landings of fish are directly proportional to the quantity of plankton. Zooplankton diversity and abundance refers to variety within community and their diversity is one of the most important ecological parameter. The biomass abundance and species diversity of zooplankton are mainly used for the assessment the conditions of aquatic environment.

MATERIAL AND METHODS

The qualitative and quantitative variation have been considered very important for proper understanding of the factors influencing zooplankton population. The quantitative fluctuation of the planktonic diversity has a great effect on the ecology of reservoir. The present study will be helpful for the suitable, survival habitat and position of the species like such as rotifers, cladocerans, copepods, ostracods and protozoans etc. Zooplankton were collected monthly from four different station of the Upper Manair reservoir from June 2016 to May 2018. Samplings were made between 7.30 am to 8.30 am. Each sample was collected by filtering 20 litres of water through plankton net (size 25 micron). Filtrate was stored in 20 ml plastic bottles and 4% formalin was added for sample preservation. These samples were then brought to laboratory for further studies. One ml of sample was transferred to Sedgwick-Rafter cell with a pipette; identification and enumeration of zooplanktons were done by a Compound microscope (10X, 20X 40X magnification. All the zooplankton present in cell were counted the mean of five estimates were taken calculated for each component occurring in the total count. The systematic identification of plankton was made by using standard keys of Edmondson (1959), Adoni 1985), Sharma (1988), Dhanapathi (2000) and Altaff (2004). The identified zooplanktons were showed in percentage composition and population dynamics. The water quality parameters were analysed with standard procedures of APHA 2012.

Morphometric and hydrological details of the Upper Manair Dam: The Upper Manair Reservoir is a minor fresh water reservoir of the former Karimnagar district, located at Narmala,Gambhiraopet Mandal, Rajanna Sircilla district, which is 138 km away from the Hyderabad, which falls under1816'13''N and 78032'40''E longitude. Catchment area is 5.9 sq. km and live storage capacity 61,439,000 m^3 and grass storage of the reservoir is 62,387,000 m^3. The maximum depth of reservoir is 31 meters.

The climatic condition of study area was cool winter and



hot summer. Present study period temperature range a minimum 24ºC-December and a maximum of 38ºC-May. This region receive much rainfall from south west monsoon. The place receive more rainfall from June to September during the monsoon season. In October and November recorded less rainfall due to the north east monsoon. The water of this reservoir is used for drinking, agriculture and supports fish culture.

RESULTS AND DISCUSSION

In the present investigation 45 species of zooplankton belonging to 24 species of rotifer, 08 species of cladocera, 08 species of copepod, 02 species of ostracods and 03 species of protozoa were identified during 2016-2018. The rotifers were 1065 ml^{-1}, follwed by cladocera. copepods, ostracods and protozoa during 2016-2017. Seasonal wise population of zooplanktons indicated maximum population were post-monsoon 1504 ml^{-1}), during post moonson followed by pre-monsoon and monsoon season.The percentage of zooplankton population was 30, 24, 21, 14 and 11 for rotifers, cladocerans, copepods, ostracods and protozoa. Thes maximum percent of zooplanktons was in ipost monsoon (42%) follwed by pre-monsoon and monsoon. The variation of zooplankton population is positive correlation with the physical and chemical properties of water body. It is depends on the temperature, total alkalinity, DO, BOD and phophates.

During 2017-2018, Rotifers 1096, Cladocera 893, Copepods 791, Ostracods 542 and Protozoa 407 out of total number of zooplanktons 3729 (number of organisms ml^{-1} (2017-2018). Seasonal wise population of zooplanktons (in table 05) were post-monsoon 1561 (number of organisms ml^{-1}), Pre-monsoon 1390 (number of organisms ml^{-1}) and Monsoon season 778 (number of organisms ml^{-1}). The species composition of during monsoon indicates that the rotifers occur more predominate than cladocerans, copepods and ostaracods. The dominance of rotifers, because they utilize the nutrients and phytoplankton more rapidly to build up their population during the study period (2016-2018). The seasonal variations of zooplankton i.e. Rotifers were 29%, cladocerans 24%, copepods 21%, ostracods 15% and protozoa were 11%, seasonal wise

Table 1. Population of zooplanktons (number of organisms ml^{-1}) in 2016 -2017 and 2017-18

Months	Rotifers	Cladocera	Copepods	Ostracods	Protozoa	Total
June-2016	57 (60)	46 (49)	38 (40)	29 (32)	24 (26)	194 (207)
July-2016	50 (53)	41 (43)	35 (37)	30 (33)	26 (28)	182 (194)
August-2016	54 (56)	45 (47)	37 (39)	28 (30)	24 (25)	188 (197)
September-2016	53 (52)	39 (41)	34 (36)	21 (24)	25 (27)	172 (180)
Monsoon	214 (221)	171 (180)	144 (152)	108 (119)	99 (106)	736 (778)
October-2016	100 (105)	90 (93)	51 (53)	34 (38)	39 (42)	314 (331)
November-2016	133 (134)	109 (114)	66 (69)	43 (45)	41 (43)	392 (405)
December-2016	138 (141)	115 (118)	62 (64)	42 (47)	38 (40)	395 (412)
January-2017	140 (139)	117 (121)	63 (61)	38 (40)	45 (47)	403 (411)
Post-Monsoon	511 (522)	431 (450)	242 (247)	157 (170)	163 (172)	1504 (1561)
February-2017	97 (98)	75 (78)	78 (80)	46 (50)	28 (30)	324 (336)
March-2017	85 (87)	65 (68)	95 (98)	66 (68)	29 (31)	340 (352)
April-2017	80 (84)	62 (64)	100 (104)	62 (65)	30 (32)	334 (349)
May-2017	78 (80)	54 (57)	105 (110)	67 (70)	38 (36)	342 (353)
Pre-Monsoon	340 (349)	256 (267)	378 (392)	241 (253)	125 (129)	1340 (1390)
Total	1065 (1096)	858 (893)	764 (791)	506 (542)	387 (407)	3580 (3729)

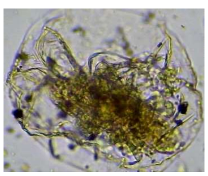
*2017-18 values in parentheses

Table 2. Physico-Chemical characteristics of water quality parameters during June 2016 to May 2017 (June 2017 to May 2018)

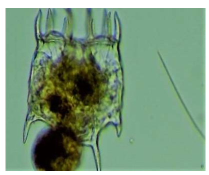
Water parameters	Monsoon	Post-Monsoon	Pre-Monsoon
Temp 0°C	29.25 ± 2.27 (25 ± 3.53)	23.5 ± 1.5 (29 ± 2.16)	30.75 ± 4.14 (31.25 ± 4.14)
Turbidity	4.2 ± 0 (5.8 ± 1.15)	8.65 ± 0.55 (5.97 ± 0.71)	8.2 ± 0.46 (6.4 ± 1.54)
pH	8 ± 0.4 (7.87 ± 0.34)	7.4 ± 0 (7.57 ± 0.17)	8.05 ± 0.33 (8.3 ± 0.49)
TDS	92.5 ± 0 (91.1 ± 1.10)	93.72 ± 0.77 (94.25 ± 2.48)	85.4 ± 0.2 (96.62 ± 3.02)
HCO_3^-	102.46 ± 3.30 (99.2 ± 3.14)	98.8 ± 2.62 (106.37 ± 1.08)	94.83 ± 1.83 (94.75 ± 3.88)
TH	96.67 ± 2.82 (93.05 ± 6.62)	104.27 ± 4.09 (103.65 ± 4.28)	102.92 ± 5.07 (97 ± 6.77)
NO_3^-	8.925 ± 3.79 (11.07 ± 1.58)	13 ± 3 (12.62 ± 1.08)	14.65 ± 2.10 (11.275 ± 1.03)
PO_4^{3-}	1.35 ± 0 (2.92 ± 0)	2.05 ±0 (2.12 ± 0)	2.75 ±0 (2.92 ± 0)
DO	6.50 ± 1.02 (6.6 ± 1.14)	5.40 ± 0.55 (5.50 ± 0.50)	6.30 ± 0.86 (6.92 ±0.54)
BOD	5.56 ± 0.26 (5.06 ± 1.06)	7.1 ± 0.76 (7.8 ± 1.4)	8.35 ± 0.05 (5.65± 1.39)
COD	5.63 ± 0.16 (5.8 ± 0.64)	6.6 ± 0.2 (6.975 ± 0.96)	8.6 ± 0.1 (7.87 ± 2.11)
TA	90.87 ± 1.08 (94.75 ± 4.31)	98.65 ± 3.24 (95.95 ± 2.49)	98.57 ± 1.35 (101.12 ± 7.35)
Cl^-	53.42 ± 1.26 (49.17 ± 6.72)	52.85 ± 0.15 (48.12 ± 4.53)	63 ± 3 (53.37 ± 4.54)
Ca^{+2}	26 ± 0 (28 ± 2.35)	29 ± 1 (32 ± 0.55)	33 ± 0 (29 ± 4.47)
Mg^{+2}	17 ± 0 (18 ±1.43)	19 ± 0 (19 ± 1.92)	22 ± 0 (17 ± 2.07)

(± Standard deviation); *Values of 2017-18 in parentheses

Zooplankton diagrams group wise


Ascomorpha saltans


Cephalodella forficula

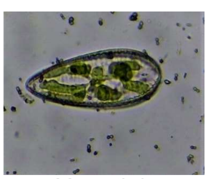

Brachinous bidentata

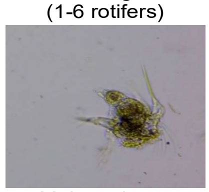

Philodina


Eosphora najas


Filinia longiseta (1-6 rotifers)


Alonella


Macrothrix


Moina micrura (7-9 cladocerans)

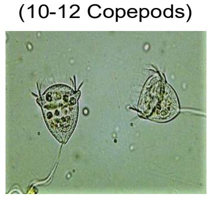

Canthocamptus longipes


Dicyclops thomasi


Leptodiaptomus siciloides (10-12 Copepods)


Cypris (ostracoda)


Euglena viridis


Vorticella (15-16 Protozoans)

percentage of zooplanktons were post monsoon were 42%, pre-monsoon 37% and monsoon 21% during 2017-2018 year. Kharwe (1993) observed that the plankton were maximum in the months of winter probably due to low temperature ,high content of dissolved oxygen, low transparency of water and other suitable conditions ,which are necessary for the growth of plankton diversity. The seasonal fluctuations of pH depend chiefly on amount of free carbon-dioxide. Free carbon dioxide and dissolved oxygen showed a negative relationship to one another. The plankton population is largely interrelated with temperature, turbidity, free carbon dioxide, dissolved oxygen, BOD and some other physico-chemical parameters. The ecological conditions of the Upper Manair Reservoir have a direct bearing upon the different producer to consumer level in aquatic life and physico-chemical parameters impart a major role in determination of the quality of any water body. The physico-chemical parameters, which influenced the zooplankton diversity adversely as well as positively. The quantative fluctuation of the zooplankton diversity has great effect on the ecology of reservoir.

Quantity of zooplanktons: The number of zooplanktons were identified in 2016-2017 were 3580 (Number of organisms ml^{-1}) and in 2017-2018 were 3729 (Number of organisms/mL. Total species identified 45 out of which 24 species of rotifers, 08 were cladocerans, 08 copepods, 02 were ostracods and 03 were protozoans. Rotifers having 08 families, Cladocera having 06 families, Copepods having 01, Ostracods 01 and protozoans having 03 families. Total 19 families of zooplankton species identified during the study period (2016-2018).

Table 5. Systematic position of zooplankton groups

Group	Family	Genus	Species
Rotifers (24)	1.Brachionidae (Ehrenberg 1838).	*Brachionus* (Pallas1776)	*B. calyciflorus,B.forficula* (Pallas1776) *B. diversicornis* (Daday1883), *B. falcatus* (Zacharias1898), *B. quadridentatus*, *B. bidentate* (Hermann 1783) and *Keratella quardata, K. tropica, K. crassavalga, K.cochlearis.*
	2. Notommatidae (O.F. Muller 1773)	Eosphora , Cephalodella (Boryde St.Vincent 1826)	*Cephalodella forficula , Eosphora najas* (Ehrenberg 1830)
	3. Trichoceridae (O.F Muller 1773)	Trichocera	*Trichocera*
	4. Dicranophoridae (O.F Muller 1773)	Dicranophorus	*D. forcipatus*
	5. Asplanchnidae (Harring, Myres 1933)	Asplanchna	*A. brightwelli* (Gosse 1850)
	6. Lecanidae	Lecane	*Ascomorpha saltans , L. abanica*
	7. Filinidae (Bartos 1959)	Filinia (Bory and Vincent 1824)	*F. longiseta* (Ehrenberg 18340)
	8. Philodinidae (Scopoli 1777)	Philodina ,Rotaria	*Philodina, Rotaria*
	9. Chydoridae (George Ossiansars 1862) (Baird 1850)	Alonella sars Alona	Alonella, Alona intermedia and Alona (W.Baird 1843).
Cladocerans (08)	1.Daphniidae (Stratus 1850)	Daphnia	*D. dubia* (Herrick 1883) , *D. parvula* (Fordyce 1901)
	2.Moinidae (Goulden 1968)	Moina (Baird 1850)	*M. brachiate* (Jurine 1820) *M. micrura* (Kurz 1874)
	3.Macrothricidae (JC Perez 1995)	Macrothrix	*M. mexicanus*
Copepods (08)	1.Canthocamptidae	Canthocamptus (Hamond,1887)	*C. longipes*
	2.Diaptomidae (Baird 1850)	Diaptomus (Westwood 1836) Skistodiaptomus (Light 1939) Leptodiaptomus (S.A.Forbes 1882)	*D. africanus* (Daday 1910) *Skistodiaptomus, Leptodiaptomus sicilis.*
	3.Cyclopoidae (Dana 1853)	Cyclops Mesocyclops (Claus 1892)	*C. bicuspidatus* (Claus 1857) *Dicyclops thomasi* (S.AForbes 1882) Mesocylops (G.O.Sars 1914)
Ostracods (02)	Cyprididae (Baird 1845)	Cypris (Muller 1776) Heterocypris (Claus 1892)	*C. protubera* (Muller 1776) *H. dentaomarginatus* (Baird 1859)
Protozoans (03)	Euglenaceae Paramecidae Vorticellidae (Ehrenberg 1831)	Euglena Paramecium Vorticella (O.F Muller,1776)	*E.virdis* *P.caudatum* *V.campanula*

CONCLUSION

The total 45 species of 19 families of zooplankton were recorded and maximum abundance of zooplankton was observed in the post monsoon season and minimum in monsoon during the study period. This is assumed that, due to some favourable conditions developed by their physico-chemical environment in the water. The physico-chemical parameters impart a major role in determination of the quality of any water body and influence the structure and function of aquatic ecosystem. In the present study water quality parameters were influenced the planktonic diversity adversely as well as positively. The turbidity is a very important structuring variable for zooplankton population. The high correlation between BOD and DO showed that, the lake was less polluted. High density of zooplankton population were observed during the post monsoon suggested that, both the dilution effect and the hydrodynamic characteristics of the Upper Manair dam water. The rotifer and particle feeder cladocera were higher in post monsoon season may be linked to favourable temperature and availability of more food in the form of bacteria and suspended detritius. The present study reveals that , no single factor is a strong determinant for planktonic abundance in water body. A community based monitoring is required and focus on natural variations, implications on water quality. The recorded data is valuable and increase awareness within the local population on water quality and findings from these studies are important tools for fishermen and determine future development possibilities of fish culture within the area.

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Medicinal uses of Edible Wild Fruits of Chenab Valley of Jammu, India

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Abstract: Data pertaining to ethno medicinal uses of edible wild fruits in treating various ailments were collected from the local people from Kishtwar, Ramban and Reasi districts of Jammu Division of Jammu & Kashmir. A total of 260 individual were interviewed by visiting the selected villages based on the pre-structured questionnaire through face-to-face interviews that comprised of traditional healers and people who had sufficient knowledge of local flora. The ethnomedicinal interview consisted of some targeted questions regarding the habit, local name of the plants, plant part used, method of crude drug preparation, mode of administration and method of collection and storage. Use value, relative frequency of citation, and family importance value were calculated to elaborate the EWFs, their families and ethnomedicinal uses. Results revealed that the fruits of 32 plant species (28 genera from 20 families) are being used for the treating various ailments by the inhabitants of Chenab valley. Almost all the formulations were administered orally. Relative frequency of citation values ranged from 0.01 to 0.17 and use value ranged from 0.04 to 2.0. EWFs are quite common in the area and are possess medicinal properties as well. The tradition of using EWFs in treating various ailments is a common practice among the inhabitants of the Chenab valley. The multiple uses of these fruits suggest further investigation regarding pharmaceutical applications.

Keywords: Ethnobotany, Wild edible fruits, Medicinal plants, Use value, Family importance value

Plant diversity is the life support of almost all terrestrial eco-systems, with both humans and animals being entirely dependent on plants directly or indirectly. Use of medicinal plants to treat various diseases have been a part of human culture since ancient times (Salmerón et al 2020, Lewis and Lewis 2003). The traditional system of health care in India is believed to be over two thousand years (Kala 2017). Medicinal properties of plants were mostly discerned through trial and error, but were also influenced by the belief systems of the people involved and often became entangled with religious and mythical practices (McCorkle et al 1996). Medicinal plant use evolved into an art and a science, practiced according to the experience, traditions and disease theory of the healer (van der Merwe et al 2001). Traditional use of medicinal plants is strongly related to the physiological and pharmacological activity of active plant ingredients (Fourie et al 1992, Sood et al 2010). The ethno botanical use of medicinal plants is of immense importance as about 85% of traditional medicines are plant derived (Farnsworth 1988). Increased popularity of medicinal plants in rural areas is due to their low cost, easier availability, compared to high cost of allopathic drugs and their potential side effects.

In India, tribal people depend on the forests for their livelihood. The tribal people are very close to nature and have hereditary traditional knowledge of consuming wild plants and plant parts like tubers, shoots, leaves, fruits etc. as a source of food and medicines. Wild fruits consumption reduces the risk of several diseases like diabetes, cancer, coronary heart diseases as well as various degenerative diseases. The wild edible plants play an important role in food and livelihood security by providing nutrient supplementary diet and generating side income to the poor people. The wild fruit plants are ruthlessly exploited for economical purposes and most of them are not cultivated or conserved (Arora and Pandey 1996) which have a considerable impact on conservation and sustainable development of regional biodiversity (Natcher et al 2017). The study aims to report the status of the indigenous knowledge on ethnomedicinal value of Edible Wild Fruits in the study area.

MATERIAL AND METHODS

The present study entitled, “Ethnomedicinal Uses of Edible Wild Fruits in Chenab Valley, Jammu, India” was carried out in the Union Territory of Jammu and Kashmir. Chenab Valley lies between the middle and outer Himalayan range in the Jammu region of Jammu and Kashmir, India. The present study was undertaken in Kishtwar, Ramban and Reasi districts of the Chenab valley. Kishtwar lies between 34° 10' North latitude and 75° 25' East longitude. It has an average elevation of 1,638 meters. It occupies an area of approximately 7824 square kilometers. Ramban lies in the lap of Pir Panjal range of the mighty Himalayas in Jammu and Kashmir. It falls between 33° 30' North latitude and 75° 20' East longitude with an elevation ranging from 662 meters to 1671 meters. It occupies an area of approximately 1329 square kilometers. Reasi is situated at the bank of River Chenab in Jammu and Kashmir. It falls between 33° 08' North latitude, 74° 82' East longitude. It has an average elevation of 466 meters and occupies an area of approximately 1719 square kilometers.

Field trips of the study areas were arranged in the fruiting and flowering season for the survey and to collect plant specimens. The sampling units for the study include the selected households, minor forest product collectors, local traditional health practitioners and local inhabitants. The sampling was carried out in several stages through multistage sampling technique. There are 12 blocks in Reasi, 4 blocks in Ramban and 9 blocks in Kishtwar. Out of the total number of blocks in each district, half of the blocks were undertaken for the survey. The blocks adjoining to the forest areas were selected purposively. Villages were selected based on random sampling method. Four villages were selected randomly from each block consisting of 52 villages in total from 13 blocks. Five respondents from each village were interviewed. In all, a total of two hundred sixty respondents were selected. In order to carry out the survey, a questionnaire was prepared after a literature review. The questionnaire was pre-tested using randomly selected informants from the study area to evaluate whether they were prepared in the way that clarify communication between interviewers and respondents. The necessary adjustments and modifications to the questionnaire were then made accordingly.

The data pertaining to ethnomedicinal survey was collected during the year 2017 and 2018 from individuals living in the study area. A total of 260 individual were interviewed by visiting the selected villages based on the pre-structured questionnaire through face-to-face interviews. The aim of the survey was to interact with maximum number of indigenous communities, particularly the tribes and people living in remote areas. During the survey, herbal healers, elder people were contacted and the objective of the study was explained to them, to conduct the personal interview to document the ethnomedicinal uses of edible wild fruits in the district Kishtwar, Ramban and Reasi. Only those who agreed were further interviewed. In ethnomedicinal interviews, some targeted questions were asked from the local people regarding the local name of the plants, medicinal use, plant part used, flowering and fruiting period, method of crude drug preparation, mode of consumption, method of collection and storage. The collected plants were pressed, dried and mounted on herbarium sheets and were identified accordingly. Identification of the specimens was done according to the field characters (already noted during collection) by comparison in the herbarium and consulting various floras for confirmation of identity. Inventory of entire edible wild fruit plants was prepared following the International Plant Names Index (http://www.ipni.org). The data obtained through questionnaire was put to statistical analysis using the following ethno botanical indices.

Relative frequency of citation (RFC): To know about the medicinal importance of individual plants, relative frequency of citation (RFC) is applied to give a quantitative form of its local importance to the informants neutrally. The relative frequency of citation reveals the local importance of each medicinal plant species as used by the people to the area (Vitalini et al 2013). Relative frequency of citation was calculated as:

RFC = FC/N, FC= number of informants who mentioned the species.

N = the total number of informants participating in the study.

High RFC value indicates high use reports for a plant implying its local importance to the people. The relative frequency of citation is helpful in determining the plants with highest use (most frequently indicated) in the treatment of ailment.

Family importance value (FIV): Family importance value determines the consensus between the informants on the use of medicinal plant species in the study area (Kayani et al 2014). Family importance value calculated as:

FIV = FC/N x 100, FC= number of informants mentioning the family.

N = the total number of informants participating in the study.

Use value (UV): Use value (UV) is calculated to assess all probable usage of plant species. UV indicates the relative importance of plant flora recognized locally (Tardio and Santayana 2008, Kayani et al 2015). UV was calculated as:

UV = Ui / N

where Ui is the number of uses mentioned by each informant for a given species.

N is the total number of informants.

RESULTS AND DISCUSSION

Socio-economic profile of the respondents: Out of 260 respondents, 65 per cent of the informants belonged to age group of 50-60 years, 24.61 per cent were in the age group of 60-70 years and the rest (10.3%) were more than 70 years old (Table 1). Informants with age more than 50 years were included in the survey. Gender wise, the majority of informants were male (85.7%) while female informants were only 14.3%. Majority (42%) of the respondents had education up to middle standard and agriculture (39%) was the major occupation of the respondents.

Growth habit: Most of the species were trees (53.12 %) followed by shrubs (21.87 %), herbs (18.75 %) and climbers (6.25%).

Plant part used Different parts of the plant of the Edible Wild Fruits were used for the treatment of various ailments**.** The most frequently used plant part was fruit (49%) followed by leaves (23%), seed (13 %), root (7%), bark (4%), latex (3%) and rhizome (1%) (Fig. 2).

Mode of consumption: There were various modes of consumption viz., ripe fruit, decoction, powder, juice, unripe, dry fruit, paste and infusion as far as the use of plants in the Chenab valley (Fig. 3). The most common mode of consumption was ripe fruit (41 %) followed by decoction, powder, juice, unripe fruit, paste and infusion.

Edible wild fruits in Chenab valley Jammu, India: A total of 32 edible wild fruits belonging to 28 genera from 20 families were being used for treating various diseases (Table 2). **Use value (UV):** Highest Use Value was observed in *Ficus carica* (2.00) followed by *Punica granatum* (0.92), *Hippophae rhamnoides* (0.67), *Juniperus communis* (0.56), *Berberis lycium* (0.53) (Table 2). Numerous studies have also reported the use of these species for treating various ailments (Brahma et al 2013, Khan et al 2015).

Relative frequency of citation (RFC): Highest relative frequency of citation was recorded for *Emblica officinalis* (0.17) followed by *Juglans regia*, *Prunus persica Syzygium cumini*, *Berberis aristata*, *Ficus palmata,* Solanum *lycopersicum* (Table 2). The highest relative frequency of citation for *Emblica officinalis* may be related to multiple uses of the species. Comparatively higher number of plant part such as fruit, seed, leaves and bark were reported for *Emblica officinalis*.

Family importance value (FIV): The family importance value (FIV) ranged from 0.38 to 3.08. Rosaceae was the most dominant family as maximum number of species mentioned by the respondents belonged to this family (Fig. 4).

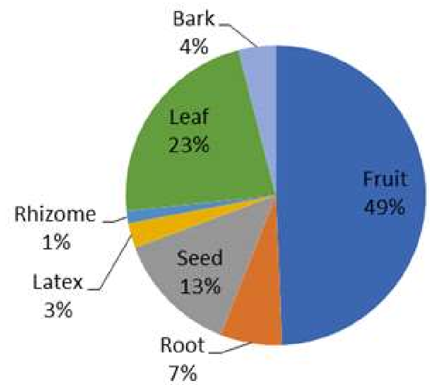

Fig. 2. Plant part used of edible wild fruits (%)

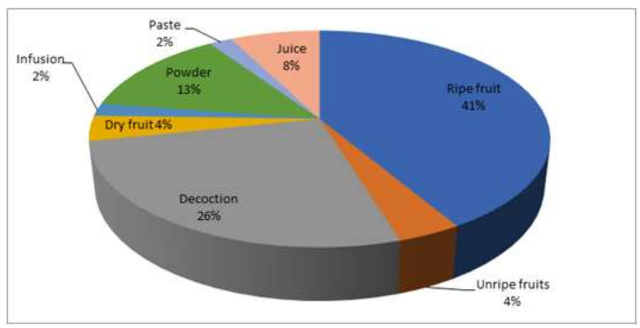

Fig. 3. Mode of consumption of edible wild fruits (%)

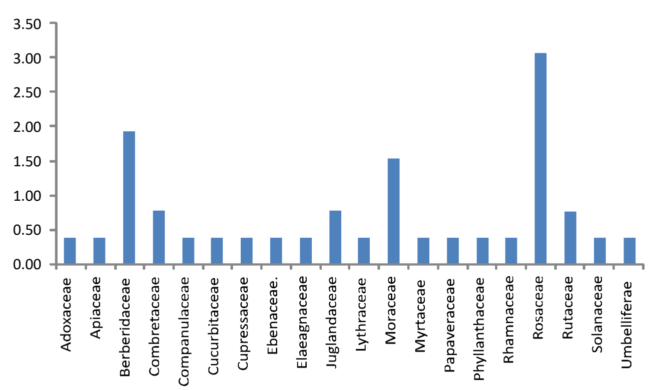

Fig. 4. Family importance value (FIV) of edible wild fruits

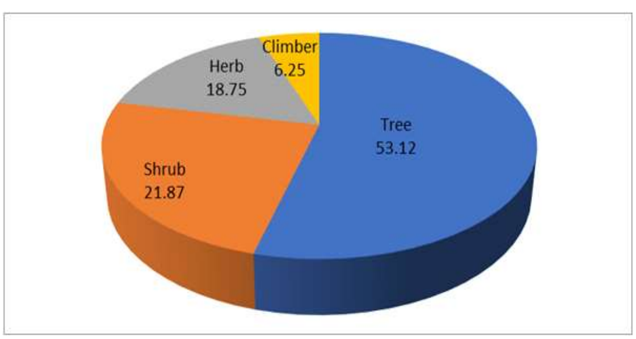

Fig. 1. Growth habit of edible wild fruits (%)

Table 1. Socio-economic profile of the respondents

Sex (%)		Age group (%)			Education (%)				Occupation (%)				
Male	Female	50-60	60-70	> 70	Llliterate	Upto middle	Upto matric	Above matric	Agriculture	Job	Herbal healers	Cattle rearing	Others
86	14	65	25	10	27	42	18	13	39	26	13	9	13

Table 2. Edible wild fruits in Chenab valley

Scientific name	Family	Growth habit	Status	Part used	Mode of consumption	Application	FC	UV	RFC
Syzygium cumini	Myrtaceae	Tree	W	Fruit, seed	Raw fruits	Diabetes, Diarrhoea	35	0.06	0.13
Aegle marmelos	Rutaceae	Tree	W	Fruit, leaves	Unripe Fruits	Stomach pain	12	0.08	0.05
Zanthoxylum armatum	Rutaceae	Tree	W	Fruit, leaves, seed	Powder	Asthma, Cholera, Fever, Indigestion.	15	0.13	0.06
Terminalia chebula	Combretaceae	Tree	W/C	Fruit	Powder, Unripe fruit	Dysentery, High cholesterol, Diarrhoea, Indigestion	21	0.19	0.08
Emblica officinalis	Phyllanthaceae	Tree	W/C	Fruit, seed, leaves, bark	Ripe Fruits	Liver toxins, high blood cholesterol, and age-related, diabetes and dysentery.	44	0.16	0.17
Terminalia bellirica	Combretaceae	Tree	W/C	Fruit, seed	Decoction	Digestive problems, Diarrhoea, Respiratory problems	17	0.18	0.07
Diospyros lotus	Ebenaceae	Tree	W/C	Fruit	Ripe fruits	Purgative, Laxative, Blood diseases, Gonorrhea, Leprosy and Chronic dysentery	19	0.32	0.07
Juniperus communis	Cupressaceae	Shrub	W/C	Fruit, Bark	Decoction, Ripe fruits, powder	Rheumatism and Painful swellings, kidney problems, stomachic.	9	0.56	0.03
Trachyspermum ammi	Apiaceae	Herb	W/C	Fruit, seed	Decoction	Diarrhoea, abdominal tumours, abdominal pains, piles	20	0.20	0.08
Codonopsis rotundifolia	Companulaceae	Climber	W	Fruit, root	Decoction	Boost Immune system, Weakness,Diarrhoea.	6	0.33	0.02
Prunus armeniaca	Rosaceae	Tree	C	Fruit	Ripe fruits	Respiratory, Digestive problems.	7	0.29	0.03
Berberis aristata	Berberidaceae	Shrub	W	Fruit	Ripe fruits, infusion	Skin Infection, jaundice, Diarrhoea	24	0.35	0.03
Berberis lycium	Berberidaceae	Shrub	W	Fruit, Bark, Leaves	Decoction	Back ache, Eye ache, Rheumatism, Tooth ache, Ulcers, Ear ache, Joints, Internal wounds, Jaundice	17	0.53	0.07
Ficus carica	Moraceae	Tree	W	Fruit, leaves, latex	Decoction, Ripe fruits	Eye vision problem, Piles, Laxative, Renal problem, Antispasmodic, Anti-platelet, Latex used in skin diseases, Latex smoothens bee sting	3	2.00	0.01
Prunus domestica	Rosaceae	Tree	W	Fruit, seed	Ripe fruits	Stomach inflammation, Constipation, Jaundice	17	0.18	0.07
Zizyphus vulgaris	Rhamnaceae	Tree	W	Fruit, leaves, roots	Raw fruits, Decoction	Blood purifier, digestive, fever	10	0.30	0.04
Rubus hoffmeisterianus	Rosaceae	Shrub	W	Fruit, leaves	Paste	Skin problems	5	0.20	0.02
Viburnum grandiflorum	Adoxaceae	Shrub	W/C	Fruit, leaves	Ripe fruits	Abdominal pain, constipation, eye problems	16	0.19	0.06
Ficus palmata	Moraceae	Tree	W	Fruit, latex	Ripe fruits	Eye vision problem, Skin pimples, lungs, bladder problems	29	0.18	0.12

Cont...

Table 2. Edible wild fruits in Chenab valley

Scientific name	Family	Growth habit	Status	Part used	Mode of consumption	Application	FC	UV	RFC
Juglans regia	Juglandaceae	Tree	C	Fruit, leaves, roots	Ripe fruits, dry fruits,	Hypertension, Sexual Stimulant, Anthelmintic, Carminative, Stomachic, Tonic, Blood purifier, Laxative, Jaundice, Weak legs, Eczema, Tooth cleaner	39	0.28	0.15
Punica granatum	Lythraceae	Tree	W/C	Fruit, leaves, seeds	Ripe fruits, juice, Powder, Decoction,	Piles, Intestinal, Liver and Bladder inflammation, Indigestion, Jaundice, Diarrhoea, Diuretic, Tonic, Cardiac, Cooling effect	12	0.92	0.05
Podophyllum hexandrum	Berberidaceae	Herb	W	Fruit, roots	Ripe fruits	Cancer, antirheumatic, purgative	15	0.20	0.06
Crataegus songarica	Rosaceae	Shrub	W	Fruit,	Ripe fruits	Heart and constipation problems	16	0.13	0.06
Hippophae rhamnoides	Elaeagnaceae	Shrub	w	Fruit	Ripe fruits, Decoction	Whooping cough, Skin eruptions	3	0.67	0.01
Coriandrum sativum	Apiaceae	Herb	W/C	Fruit	Decoction, Powder	Diarrhoea	27	0.04	0.10
Solanum lycopersicum	Solanaceae	Herb	W/C	Fruit, leaf	Juice, Ripe fruits	Skin, burn, Heart problems.	29	0.10	0.11
Prunus persica	Rosaceae	Tree	W/C	Fruit, leaves, seed	Ripe fruits, powder	Wounds, Fungal infection, to remove maggots from wounds, Demulcent, Lubricant	19	0.26	0.14
Momordica charantia	*Cucurbitaceae*	Climber	C	Fruit, leaves	Juice	Burn, abrasions, stomach problems, Diabetes	26	0.15	0.10
Morus serrata	Moraceae	Tree	W	Fruit, leaves	Juice	Hypertension, Arthritis, Tonic.	20	0.05	0.08
Cydonia oblonga	Rosaceae	Tree	W/C	Fruit, seeds, leaves	Ripe fruits	Digestive, tonic, respiratory diseases, blood pressure	28	0.33	0.05
Fragaria nubicola	Rosaceae	Herb	W	Fruit, Leaf, rhizome	Ripe fruits, juice	Menstruation, blemishes on tongue	7	0.43	0.03
Papaver somniferum	Papaveraceae	Herb	C	Fruit	Decoction	Diarrhoea, spasms, pain.	26	0.12	0.10

Cultivated=C, Wild=W, FC= Frequency of Citation, RFC= Relative Frequency Citation UV=Use Value

CONCLUSIONS

A total of thirty two edible wild fruits are consumed by local people for treating stomach disorders, cold and cough, wounds and cuts, skin diseases, fever, headache, nausea and vomiting, general debility and numerous other ailments. Most of the fruit species were trees. *Ficus carica* had the highest use value whereas, *Emblica officinalis* had the highest relative frequency of citation. The findings suggest the extent of traditional knowledge possessed by the communities living in the study area that needs to be documented and further studied.

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Inter-Regional Analysis of Indebtedness among Scheduled Caste Households in Rural Punjab

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Abstract: The highest proportion of households under debt is in Doaba followed by Majha and Malwa. The average amount of debt per indebted household and per sampled household increased from Malwa to Doaba, which is proportional to scheduled caste population. For an average scheduled caste household, the share of non-institutional agencies is 73.45 per cent in Majha, followed by Malwa and Doaba. Among the non-institutional agencies, the role of large farmers and landlords is relatively more in for the agricultural labour, non-agricultural labour, artisan and others categories in all the three regions. Among the institutional agencies, commercial banks are the largest contributor to debt for an average scheduled caste household in all the regions. An average scheduled caste household has incurred major proportion of the total debt for marriages and other socio-religious ceremonies and purchase of consumer goods in all the regions. The households under the agricultural labour, non-agricultural labour, artisan and others categories have to pay relatively higher rate of interest. These categories mostly incurred debt from non-institutional agencies. In the case of government and private employee categories, commercial banks are the largest contributor of debt to these categories in all the regions.

Keywords: SC households, Debt, Sources, Purpose, Rate of interest

The scheduled castes population comprised 201.4 million in 2011 as compared to 166.6 million in 2001 of total population in India showing a variation of 20.8 per cent (Census of India 2011). Majority of scheduled castes are landless, without any productive assets and sustainable employment opportunities (Mohanty 2001). The annual income level of scheduled castes was very less which further leads to their low standard of living (Sangral and Singha 2018). Many of the scheduled castes are suffering from deprivation in socio-economic and educational aspects. They are living below poverty line and are working still in unorganized sector or caste based occupations (Apparaya 2015). This group remained at the lowest end of the economic hierarchy as well (Sundram and Tendulkar 2003). Punjab is an agrarian rich state but there is an unequal distribution of land which is a major productive asset in the rural areas of Punjab. Majority of weaker sections mainly scheduled caste and backward caste households are landless (Singh and Singh 2017). Majority of the scheduled castes residing in the rural India are agricultural labourers owing to their large-scale illiteracy and landlessness. About three-fourths of agricultural labour households are under debt in rural Punjab. Agricultural labour households have to take loans at a high rate of interest from non-institutional agencies because they are not able to give adequate security or surety for getting loans from institutional agencies (Singh and Singh 2016). The debt taken by them is 'ancestral' in nature by large. The average amount of debt per scheduled caste household, at all-India level, increased from Rs. 1,283 during 1999-2000 to Rs. 3,767 during 2004-05 (Ministry of Labour and Employment 2010). These labour households did not use the debt to buy any luxuries but to arrange basic needs of consumption and medical treatment. About 40 per cent of Punjab's rural labour spend around 62 per cent of their total income on food (Bharti 2016). The income generated by scheduled caste households is not sufficient to meet their day-to-day expenses. In order to narrow down the expenditure-income gap, they have no other option than to avail debt from various institutional and non-institutional agencies. For providing loans to the scheduled caste households, the institutional agencies have not yielded the desired results. As a result, the scheduled caste households find no other way than to approach the non-institutional agencies for availing loans to meet their needs.

This study is a modest attempt to analyse the extent and magnitude of indebtedness among the different categories of sampled scheduled caste households across the regions in rural Punjab. The concentration of debt within the various categories of scheduled caste households has also been studied.

MATERIAL AND METHODS

The present study, based on a three-stage stratified random sampling technique, relates to 2012–2013. For the analysis of incidence of indebtedness among the scheduled caste households, namely agricultural labour, non-agricultural labour, government employees, private employees, artisans and others, the Punjab state has been divided into three zones on the basis of the highest, medium and lowest concentration zones of SC population. Keeping in mind, differences in the concentration, Jalandhar district was chosen for its highest concentration, Fatehgarh Sahib district for its medium concentration and Gurdaspur district for its lowest concentration (Census of India, 2011). The selected districts also represent three geographical regions of Punjab: Doaba, Malwa and Majha, respectively. One village has been selected from each development block of the selected districts. There are eleven development blocks in Jalandhar district, five development blocks in Fatehgarh Sahib district and eleven development blocks in Gurdaspur district. Thus, in all, a total of twenty seven villages have been selected for the survey from the three districts. Out of 27 villages, 543 SC households have been selected for the study. From each selected village, 10 per cent of the SC households have been selected for the survey on a random basis. Out of these 543 households, 303 from Doaba (Jalandhar district), 103 from Malwa (Fatehgarh Sahib district) and 137 from Majha (Gurdaspur district) are selected.

RESULTS AND DISCUSSION

Indebtedness: Extent and Magnitude: The region-wise analysis undertaken to assess the extent of debt among the different categories of scheduled caste households reveals that maximum number of households (82.51 per cent) are under debt in Doaba, followed by Majha (82.48 per cent) and Malwa (81.55 per cent).

The maximum number of agricultural labour households (86.84%) is under debt in Majha, followed by those in Doaba and Malwa. The highest proportion of non-agricultural labour households (89.90%) fall under debt in Doaba. In households representing the government and private employee categories, the maximum number of such households with the respective percentages of 77.78 and 80.00 are under debt in Malwa followed by those in Majha and Doaba. About 90 per cent of the artisan households are under debt in Majha followed by Malwa and Doaba. More than 92 per cent households of the others category are under debt in Doaba. The average amount of debt per indebted scheduled caste household is Rs. 36,924 in Doaba. Average amount of debt per sampled scheduled caste household is also highest in Doaba, followed by Majha and Malwa. The region-wise analysis shows that there has been more concentration of scheduled caste population in Doaba as compared to Malwa. The average amount of debt per indebted household and per sampled household has also been greater in Doaba. The indebtedness in both these terms is the highest for the households under the non-agricultural labour category in Doaba and Majha, while it is the highest for those representing the private employee category in Malwa.

Indebtedness according to source of credit: The inter-regional analysis reveals that an average sampled scheduled caste household is highly indebted to the non-institutional agencies in all the three regions. Among the non-institutional sources, the large farmers, cloth merchants and grocers, and money-lenders are the main agencies. However, among the institutional sources, commercial banks and PACS are the ones which have to make maximum recovery of debt from the scheduled caste households under the different categories in all the three regions.

Among the non-institutional agencies, the share of large farmers and landlords in the total debt of an average sampled household is the largest, i.e., 40.00 per cent in Majha, followed by Malwa and Doaba. The cloth merchants and grocers, money-lenders, and relatives and friends appear next in all the three regions. The share of institutional agencies in the total debt of an average scheduled caste household is about 29 per cent in Doaba, followed by Malwa and Majha. Most of the selected households are under debt due to the advances availed from commercial banks. In households under the agricultural labour category, the proportional share of non-institutional sources in lending is as high as 82.78 per cent in Doaba, followed by Majha and Malwa. The corresponding figures for those under the non-agricultural labour category in Malwa, Doaba and Majha are 82.44, 80.94 and 77.16 per cent, respectively. Amongst the institutional agencies, the agricultural labour households in Malwa owed the highest proportion of their total debt to commercial banks, followed by Primary Agricultural Co-operative Credit Societies (PACS), whereas the non-agricultural labour households in Majha are highly indebted to these credit societies. The households representing the government employee category owe 30.19 per cent of total debt to non-institutional agencies in Doaba followed by Malwa and Majha. However, the households under the government employee category owe maximum proportion of their total debt to commercial banks in Doaba and Majha. In Majha, the households under the private employee category owe maximum of their debt, 60.65 per cent to the non-institutional agencies, followed by those from Malwa and Doaba. The analysis shows that the role of institutional agencies in granting loans to these categories of households has been more significant in Majha and Doaba. For the households belonging to artisan and others categories, the ratio of indebtedness is the highest for the non-institutional agencies as compared to institutional agencies. The large farmers and landlords are the largest contributors for indebtedness to these categories in all the three regions.

The forgoing analysis brought out the fact that the scheduled caste households have taken the highest proportion of the total debt from non-institutional agencies in all the three regions. However, the role of credit agencies is different for the different categories of scheduled caste households in all the three regions. The role of large farmers and landlords is relatively more in the households belonging to the agricultural labour, non-agricultural labour, artisan and others categories in all the three regions. It reveals that these categories of scheduled caste households failed to get enough loans to meet their requirement from the institutional agencies, they mostly incurred it from non-institutional agencies. However, the situation is different households belonging to the government and private employee categories, where commercial banks are the largest contributor for the indebtedness to these categories in all the three regions. Most of the scheduled caste households have to get debt from non-institutional agencies because they have no securities and proper knowledge which institutional agencies often require at the time of availing debt and are left with no other option to get debt from non-institutional agencies at the exorbitant rate of interest.

Purpose of indebtedness: The purpose-wise distribution of debt among the different categories of scheduled caste households across the regions depicts that an average household has incurred major amount of the total debt for marriages and other socio-religious ceremonies, closely followed by purchase of consumer goods, house construction, addition of rooms and major repairs, and healthcare in Doaba and Malwa. A small amount of debt is incurred for the remaining items such as redemption of old debt, education, purchase of livestock and purchase of machines/tools. In Majha, an average household has incurred the maximum debt for marriages and other socio-religious ceremonies and the minimum tfor education.

The proportional share of debt incurred for different purposes across the three regions highlights that an average scheduled caste household of Doaba has incurred major proportion of the total debt for marriages and other socio-

Table 1. Extent of debt among scheduled caste households in rural Punjab

Regions	Scheduled caste household	No. of households		Indebted households as percentage of sampled households	Average amount of debt (Rs.)	
		Sampled	Indebted		Per sampled households	Per indebted households
Doaba	Agricultural labour	19	16	84.21	32105	38125
	Non-agricultural labour	99	89	89.90	36040	40089
	Government employee	35	24	68.57	21485	31333
	Private employee	37	27	72.97	24243	33222
	Artisan	75	59	78.67	27026	34355
	Others	38	35	92.11	36236	39324
	All sampled households	303	250	82.51	30465	36924
Malwa	Agricultural labour	29	24	82.76	26379	31875
	Non-agricultural labour	24	18	79.17	27291	34473
	Government employee	9	7	77.78	27222	35000
	Private employee	10	8	80.00	29500	36875
	Artisan	14	12	85.71	31071	36250
	Others	17	15	88.24	32058	36333
	All sampled households	103	84	81.55	28543	35000
Majha	Agricultural labour	38	33	86.84	33342	38394
	Non-agricultural labour	24	21	87.50	33750	38571
	Government employee	17	12	70.59	23000	32583
	Private employee	12	9	75.00	25416	33889
	Artisan	20	18	90.00	32750	36388
	Others	26	20	76.92	27500	35750
	All sampled households	137	113	82.48	30240	36663

Source: Field Survey, 2012-13
AL-Agricultural labour; NAL- Non-agricultural labour; GOVT. - Government employee; PVT. - Private employee; ART-Artisan. (ii) OTHERS- Others include small traders, farmers, domestic labour, rickshaw pullers, vegetable vendors, etc

Table 2. Debt incurred from different credit agencies

(Mean values, in Rs.)

Agencies	AL	NAL	Services		ART	Others	All
			Government	Privatte			
Non-institutional				Doaba			
Large farmers and landlords	13947 (43.44)	13636 (37.84)	2485 (11.57)	6216 (25.64)	8960 (33.15)	19079 (52.65)	10987 (36.06)
Money-lenders	4210 (13.11)	6041 (16.76)	1572 (7.31)	1540 (6.35)	3333 (12.33)	3684 (10.17)	3895 (12.78)
Relatives and friends	1316 (4.10)	1111 (3.08)	428 (2.00)	1081 (4.46)	933 (3.46)	1053 (2.90)	990 (3.25)
Cloth merchants and grocers	7106 (22.13)	8383 (23.26)	2000 (9.3)1	3379 (13.94)	5333 (19.73)	5578 (15.40)	5848 (19.20)
Sub-total	26579 (82.78)	29171 (80.94)	6485 (30.19)	12216 (50.39)	18559 (68.67)	29394 (81.12)	21720 (71.29)
Institutional							
Primary Agricultural Co-operative Credit Societies	1579 (4.92)	2575 (7.15)	5285 (24.60)	4054 (16.72)	3267 (12.09)	2237 (6.17)	3135 (10.29)
Commercial banks	3947 (12.30)	4294 (11.91)	9715 (45.21)	7973 (32.89)	5200 (19.24)	4605 (12.71)	5610 (18.42)
Sub-total	5526 (17.22)	6869 (19.06)	15000 (69.81)	12027 (49.61)	8467 (31.33)	6842 (18.88)	8745 (28.71)
Grand-total	32105 (100)	36040 (100)	21485 (100)	24243 (100)	27026 (100)	36236 (100)	30465 (100)
				Malwa			
Non-institutional							
Large farmers and landlords	11552 (43.79)	13125.00 (48.09)	7222 (26.53)	7500 (25.42)	10357 (33.33)	12353 (38.53)	11117 (38.95)
Money-lenders	2069 (7.84)	1458 (5.34)	5000 (18.37)	3500 (11.87)	2500 (8.05)	3529 (11.01)	2621 (9.18)
Relatives and friends	1724 (6.54)	1042 (3.82)	- -	- -	714 (2.30)	1176 (3.67)	1019 (3.57)
Cloth merchants and grocers	4310 (16.34)	6875 (25.19)	6111 (22.45)	6000 (20.3)4	5714 (18.39)	6765 (21.10)	5825 (20.41)
Sub-total	19655 (74.51)	22500 (82.44)	18333 (67.35)	17000 (57.63)	19285 (62.07)	23823 (74.31)	20582 (72.11)
Institutional							
Primary Agricultural Co-operative Credit Societies	2586 (9.80)	1666 (6.11)	3333 (12.24)	2500 (8.47)	7500 (24.14)	2941 (9.18)	2718 (9.52)
Commercial banks	4138 (15.69)	3125 (11.45)	5556 (20.41)	10000 (33.90)	4286 (13.79)	5294 (16.51)	5243 (18.37)
Sub-total	6724 (25.49)	4791 (17.56)	8889 (32.65)	12500 (42.37)	11786 (37.93)	8235 (25.69)	7961 (27.89)
Grand-total	26379 (100)	27291 (100)	27222 (100)	29500 (100)	31071 (100)	32058 (100)	28543 (100)
				Majha			
Non-institutional							
Large farmers and landlords	16763 (50.28)	13542 (40.12)	5588 (24.30)	5833 (22.95)	13250 (40.46)	10192 (37.06)	12095 (40.00)
Money-lenders	3553 (10.66)	3333 (9.88)	2706 (11.76)	3750 (14.75)	2250 (6.87)	2885 (10.49)	3109 (10.28)
Relatives and friends	789 (2.37)	1459 (4.32)	882 (3.84)	1667 (6.56)	750 (2.29)	962 (3.50)	1022 (3.38)
Cloth merchants and grocers	5000 (14.99)	7708 (22.84)	3530 (15.35)	4166 (16.39)	6750 (20.61)	7692 (27.97)	5985 (19.79)
Sub-total	26105 (78.30)	26042 (77.16)	12706 (55.25)	15416 (60.65)	23000 (70.23)	21731 (79.02)	22211 (73.45)
Institutional							
Primary Agricultural Co-operative Credit Societies	2500 (7.49)	5208 (15.43)	3823 (16.62)	2500 (9.84)	3750 (11.45)	2308 (8.39)	2810 (9.29)
Commercial banks	4737 (14.21)	2500 (7.41)	6471 (28.13)	7500 (29.51)	6000 (18.32)	3461 (12.59)	5219 (17.26)
Sub-total	7237 (21.70)	7708 (22.84)	10294 (44.75)	10000 (39.35)	9750 (29.77)	5769 (20.98)	8029 (26.55)
Grand-total	33342 (100)	33750 (100)	23000 (100)	25416 (100)	32750 (100)	27500 (100)	30240 (100)

Source: Field Survey, 2012-13 ;Figures in parentheses are column-wise percentages

Table 3. Distribution of debt according to different purposes

(Mean values, in Rs.)

Categories	AL	NAL	Services		ART	Others	All
			Government	Privatte			
Purpose of loan				Doaba			
Purchase of machines/tools	1842 (5.74)	404 (1.12)	914 (4.26)	1351 (5.57)	2200 (8.14)	4474 (12.35)	1624 (5.33)
Purchase of livestock	4474 (13.93)	1616 (4.49)	-	541 (2.23)	1293 (4.79)	3026 (8.35)	1574 (5.17)
Household construction, addition of rooms and major repairs	6579 (20.49)	5485 (15.22)	4714 (21.94)	2297 (9.48)	4200 (15.54)	5395 (14.89)	4746 (15.58)
Purchase of consumer goods	5263 (16.39)	12576 (34.89)	2000 (9.31)	5270 (21.74)	6067 (22.45)	7105 (19.61)	7706 (25.29)
Education	1053 (3.28)	1717 (4.76)	2143 (9.97)	1351 (5.57)	933 (3.45)	1052 (2.90)	1403 (4.60)
Healthcare	1579 (4.92)	3030 (8.41)	6143 (28.59)	3514 (14.49)	4133 (15.29)	6184 (17.07)	4026 (13.22)
Marriages and other socio-religious ceremonies	7368 (22.95)	10101 (28.03)	4429 (20.61)	9108 (37.58)	6933 (25.65)	8605 (23.75)	8181 (26.86)
Redemption of old debt	3947 (12.30)	1111 (3.08)	1142 (5.32)	811 (3.34)	1267 (4.69)	395 (1.08)	1205 (3.95)
Total	32105 (100)	36040 (100)	21485 (100)	24243 (100)	27026 (100)	36236 (100)	30465 (100)
Malwa							
Purpose of loan							
Purchase of machines/tools	1207 (4.57)	-	-	-	3214 (10.34)	4412 (13.76)	1505 (5.27)
Purchase of livestock	862 (3.27)	1041 (3.82)	-	4000 (13.56)	2500 (8.05)	5882 (18.34)	2184 (7.65)
Household construction, addition of rooms and major repairs	3621 (13.73)	1667 (6.11)	5000 (18.37)	6500 (22.03)	6786 (21.84)	4118 (12.84)	4078 (14.29)
Purchase of consumer goods	6552 (24.84)	7083 (25.95)	4444 (16.33)	2500 (8.48)	5357 (17.24)	5000 (15.60)	5680 (19.90)
Education	1034 (3.92)	-	3333 (12.24)	3500 (11.86)	2143 (6.90)	1470 (4.59)	1456 (5.10)
Healthcare	2414 (9.15)	5000 (18.32)	3889 (14.29)	2000 (6.78)	1429 (4.60)	2353 (7.34)	2961 (10.38)
Marriages and other socio-religious ceremonies	7241 (27.45)	10625 (39.93)	8334 (30.61)	9500 (32.20)	8571 (27.59)	6176 (19.27)	8349 (29.25)
Redemption of old debt	3448 (13.07)	1875 (6.87)	2222 (8.16)	1500 (5.09)	1071 (3.44)	2647 (8.26)	2330 (8.16)
Total	26379 (100)	27291 (100)	27222 (100)	29500 (100)	31071 (100)	32058 (100)	28543 (100)
Majha							
Purpose of loan							
Purchase of machines/tools	-	2917 (8.64)	-	2083 (8.20)	4750 (14.50)	2885 (10.49)	1934 (6.40)
Purchase of livestock	3026 (9.08)	2083 (6.17)	-	-	1500 (4.58)	4615 (16.78)	2299 (7.60)
Household construction, addition of rooms and major repairs	7105 (21.31)	3542 (10.50)	-	3750 (14.75)	5500 (16.79)	2308 (8.39)	4161 (13.76)
Purchase of consumer goods	6184 (18.55)	8958 (26.55)	5000 (21.74)	6250 (24.59)	6250 (19.09)	7500 (27.27)	6788 (22.45)
Education	1184 (3.55)	625 (1.85)	4412 (19.18)	1667 (6.55)	1500 (4.58)	1538 (5.59)	1642 (5.43)
Healthcare	3948 (11.84)	5208 (15.43)	882 (3.84)	2500 (9.84)	3250 (9.92)	2885 (10.49)	3358 (11.10)
Marriages and other socio-religious ceremonies	7816 (23.44)	8333 (24.69)	10353 (45.01)	7916 (31.15)	7000 (21.38)	4038 (14.69)	7394 (24.45)
Redemption of old debt	4075 (12.23)	2084 (6.17)	2353 (10.23)	1250 (4.92)	3000 (9.16)	1731 (6.30)	2664 (8.81)
Total	33342 (100)	33750 (100)	23000 (100)	25416 (100)	32750 (100)	27500 (100)	30240.88 (100)

Source: Field Survey, 2012-13 ;Figures in parentheses are column-wise percentages

religious ceremonies, followed by purchase of consumer goods, house construction, addition of rooms and major repairs and health care, etc. An average household in Malwa has incurred the highest share of total debt for marriages and other socio-religious ceremonies followed by purchase of consumer goods, house construction, addition of rooms and major repairs, health care, redemption of old debt and purchase of livestock, respectively. In Majha, the highest proportion of the total debt has been taken for marriages and other socio-religious ceremonies, closely followed by the purchase of consumer goods and the lowest for the expenditure on education.

The households belonging to the agricultural labour category have incurred the highest proportion of debt for marriages and other socio-religious ceremonies closely, followed by the house construction, addition of rooms and major repairs and the lowest for the expenditure on education in Doaba and Majha. However, the situation is slightly different in Malwa, where purchase of consumer goods appears at the second rank and the lowest proportion of total debt is taken for the purchase of livestock. The non-agricultural labour households of Doaba and Majha have incurred the highest proportion of the total debt for the purchase of consumer goods. In Malwa, this proportional share is the highest for marriages and other socio-religious ceremonies and the lowest for the purchase of machines/tools for this category. The income of agricultural and non-agricultural labour households is very low (Kumar et al 2020). To fulfil basic needs and maintain minimum cultural level, these households borrow money for the purchase of consumer goods and celebration of marriages and other socio-religious ceremonies

The households belonging to government employee category have incurred the highest share of debt for marriages and other socio-religious ceremonies in Malwa and Majha except Doaba, where the highest share of debt is incurred for expenditure on healthcare. The private employee households have incurred the highest amount of debt for marriages and other socio-religious ceremonies in all the three regions. In Doaba, the second and third rank goes to purchase of consumer goods and health care. In Malwa, the second and third rank goes to the house construction, addition of rooms and major repairs and purchase of consumer goods. In Majha, the same rank goes to purchase of consumer goods and house construction, addition of rooms and major repairs.

The households under the private employee category have incurred the highest proportion of total debt for marriages and other socio-religious ceremonies, followed by the purchase of consumer goods and the lowest for the purchase of livestock in Doaba and Majha. It has been found that not even a single household of private employee category has incurred debt for the purchase of livestock and purchase of machines/tools in Majha and Malwa. The households under the private employee and artisan categories have incurred the maximum proportion of total debt for marriages and other socio-religious ceremonies, followed by house construction, addition of rooms and major repairs and the lowest for the redemption of old debt in Malwa. However, the artisan households have incurred the major proportion of debt for marriages and other socio-religious ceremonies, closely followed by the purchase of consumer goods, and house construction, addition of rooms and major repairs in Doaba and Majha. In households under others category, the proportional share of total debt incurred for different purposes increases from redemption of old debt to marriages and other socio-religious ceremonies in Doaba. In Malwa, this proportion increases from expenditure on education to marriages and other socio-religious ceremonies. The situation is slightly different in Majha, where the proportional share increases from the expenditure on education to the purchase of consumer goods. The foregoing analysis provides that to maintain a minimum level of consumption and to bridge the consumption expenditure-income gap, these households have to borrow either from non-institutional or institutional agencies. However, the situation of households under the non-agricultural labour category is found to be the worst on this account.

Indebtedness according to rate of interest: The average scheduled caste household has borrowed Rs. 4,901 at the rate of interest ranging between 0-10 per cent in Doaba, followed by Malwa and Majha. This amount is the lowest for the households under the others category and the highest for the private employee category in Majha.An average household of Doaba has incurred the maximum debt amount at the rate of interest ranging between 10 to 20 per cent followed by Majha and Malwa. This amount increases from agricultural labour households to the other category households in Doaba. An average household of Malwa availed Rs. 12,136 at the rate of interest ranging between 20 to 30 per cent, followed by Majha and Doaba. This amount is the lowest for the private employee households of Majha and the highest for the non-agricultural labour households of Doaba. A very small amount of debt has been incurred by an average scheduled caste household at the rate of interest ranging between 30 to 40 per cent per annum. It has been found that not even a single household of government and private employee categories has incurred debt at 30 to 40 per cent range of rate of interest in all the three regions.

The relative shares of total amount of debt with respect to the different ranges of rate of interest depicts that an average scheduled caste household has incurred the highest share of total debt at the rate of interest ranging between 10 to 20 per cent per annum in Doaba and Majha. This proportion is 9.80 per cent in Malwa. This proportion ranges between 26.14 per cent for the households under the agricultural labour category in Malwa to 64.89 per cent for the artisan category in Majha. The household belonging to the government employee, private employee, artisans and other category has incurred the highest share of total debt at the rate of interest ranging between 10 to 20 per cent per annum in all the regions. An average scheduled caste household has incurred the highest share of total debt at the rate of interest ranging between 20 to 30 per cent per annum in the Malwa. This proportional share is 42.52 per cent in Malwa and followed by Majha and Doaba. This proportion is the highest for the households under the non-agricultural labour category in Malwa and the lowest for the government employee category in Doaba. The household belonging to agricultural labour and non-agricultural labour categories has incurred the highest share of total debt at the rate of interest ranging between 20-30 per cent per annum in all the regions. Another substantial proportion of the total debt appears in the range of 0 to 10 per cent interest rate. An average scheduled caste household has incurred 16.15 per cent of the total debt at the rate of interest ranging between 0-10 per cent in Malwa, followed by Doaba and Majha. This proportion is as high as about 36 per cent for the households under the government employee category in Doaba, and 34.43 per cent for the private employee category in Majha.

A meagre amount of debt has been incurred at the rate of interest ranging between 30 to 40 per cent in all the regions. In Malwa, only agricultural labour households have incurred debt

Table 4. Distribution of debt according to rate of interest

(Mean values, in Rs.)

Categories	AL	NAL	Services		ART	Others	All
			Government	Privatte			
Rate of Interest (per cent, per annum)↓							
Doaba							
0-10	4474 (13.93)	4646 (12.89)	7714 (35.90)	5135 (21.18)	4400 (16.28)	3947 (10.89)	4901 (16.09)
10-20	9210 (28.69)	11970 (33.21)	12200 (56.78)	12162 (50.17)	15400 (56.98)	23474 (64.78)	14138 (46.41)
20-30	15526 (48.36)	16263 (45.12)	1571 (7.32)	6946 (28.65)	6800 (25.16)	7368 (20.34)	9924 (32.58)
30-40	2895 (9.02)	3161 (8.78)	-	-	426 (1.58)	1447 (3.99)	1502 (4.92)
Total	32105 (100)	36040 (100)	21485 (100)	24243 (100)	27026 (100)	36236 (100)	30465 (100)
Malwa							
0-10	5517 (20.92)	2708 (9.92)	6667 (24.49)	7000 (23.73)	5000 (16.09)	2941 (9.17)	4611 (16.15)
10-20	6896 (26.14)	8541 (31.30)	12222 (44.90)	14000 (47.46)	14643 (47.13)	18235 (56.88)	11359 (39.80)
20-30	12414 (47.50)	16042 (58.78)	8333 (30.61)	8500 (28.81)	11428 (36.78)	10882 (33.95)	12136 (42.52)
30-40	1552 (5.88)	-	-	-	-	-	437 (1.53)
Total	26379 (100)	27291 (100)	27222 (100)	29500 (100)	31071 (100)	32058 (100)	28543 (100)
Majha							
0-10	3290 (9.86)	5000 (14.82)	6471 (28.13)	8750 (34.43)	5500 (16.79)	2308 (8.39)	4599 (15.21)
10-20	11842 (35.52)	11250 (33.33)	10941 (47.57)	12916 (50.82)	21250 (64.89)	11731 (42.66)	13071 (43.23)
20-30	16184 (48.54)	15417 (45.68)	5588 (24.30)	3750 (14.75)	6000 (18.32)	11538 (41.96)	11278 (37.29)
30-40	2026 (6.08)	2083 (6.17)	-	-	-	1923 (6.99)	1292 (4.27)
Total	33342.11 (100)	33750 (100)	23000.00 (100)	25416 (100)	32750 (100)	27500 (100)	30240.88 (100)

Source: Field Survey, 2012-13 ;Figures in parentheses are column-wise percentages

at the high rate of interest ranging between 30 to 40 per cent per annum. However, the households belonging to the agricultural labour, non-agricultural labour and other categories are indebted at this range of rate of interest in Doaba and Majha. The households belonging to the agricultural labour category have incurred 9.02, 6.08 and 5.88 per cent of the total debt in Doaba, Majha and Malwa respectively at the rate of interest ranging between 30 to 40 per cent. On the other hand, the households under the non-agricultural labour category have incurred about 9 per cent and 6.17 per cent of the total debt at this range of rate of interest in Doaba and Majha. However, the remaining households belonging to the artisan and others categories have incurred very small proportion of total debt at the high rate of interest in all the three regions. Not even a single household of government and private employee categories has incurred debt at this exorbitant of rate of interest in all the three regions.

The foregoing analysis highlights that the households under the government employee, private employee, artisan and other categories have incurred the highest proportion of the total debt at the rate of interest ranging between 10 to 20 per cent per annum in all the regions. However, the situation is different for the agricultural labour and non-agricultural labour categories. These households have incurred the highest proportion of the total debt at the rate of interest ranging between 20 to 30 per cent per annum in all the regions. The field survey revealed the fact that the average propensity to consume is greater than unity for the different categories of the scheduled caste households except government employees in all the three regions of rural Punjab. This gap in income and expenditure compels the scheduled caste households to borrow from different sources to meet the both ends meals.

CONCLUSIONS

The foregoing analysis shows that more than four-fifths of scheduled caste households are under debt in all the three regions. The highest proportion of households under debt is in Doaba followed by Majha and Malwa. The indebtedness is the highest for the non-agricultural labour households in Doaba and Majha, while it is the highest for the private employee households in Malwa. The share of non-institutional agencies is the highest in Majha, followed by Malwa and Doaba. The role of large farmers and landlords is relatively more in the case of the agricultural labour, non-agricultural labour, artisan and others categories in all the three regions. The scheduled caste households incurred major proportion of the total debt for marriages and other socio-religious ceremonies in all the regions. The purchase of consumer goods, house construction, addition of rooms and major repairs, health care and redemption of old debts are the other purposes of loans. The government employee, private employee, artisans and other category households incurred the maximum debt at lower rates of interest and the agricultural labour and non-agricultural labour households incurred the maximum debt at higher rates of interest in all the regions. The institutional credit agencies should come forward with new credit schemes for the scheduled castes enabling them to avail the required loans at concessional rats of interest. The functioning of money-lenders should be regulated and monitored properly. Sincere efforts need to be done by the state government to provide more job opportunities to the unemployed and low paid rural scheduled caste population. The government should start special training programmes for the rural scheduled caste people to upgrade their skills and capabilities. The establishment of agro-based industries in the rural areas and proper implementation of MGNREGS would go a long way to overcome the problems of scheduled caste population.

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Economic Analysis of Carnation Cultivation under Polyhouse Conditions in Bilaspur District of Himachal Pradesh

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Abstract: Flower cultivation under polyhouse is a fast emerging, money spinning component in the agricultural sector and has become the potential agricultural activity especially for the hilly states like Himachal Pradesh. Present study was conducted in Bilaspur district of Himachal Pradesh to assess the cost and return structure for flower cultivation under polyhouse conditions. A sample of 60 polyhouse farmers 34 small (<500 m^2) and 26 large (>500 m^2) was selected by proportional allocation method from two development blocks of the district. Cost A1 for carnation cultivation was Rs.1,64,307 and Rs.3,53,669 on small and large polyhouse units, respectively. Expenses on human labour formed the major component of the total cost followed by planting material. The average price received per box (1000 sticks) was Rs.3,050 and Rs.3071 for small and large polyhouse units, respectively. The NPV of the carnation cultivation under small and large poly house units at 8 per cent discount rate was Rs 2.69 lakh and Rs 16.49 lakh, respectively. The BC ratio for small and large units confined to 1.18 and 1.56, respectively with an IRR 44.1 per cent and 229 per cent for small and large category polyhouse units.

Keywords: Carnation cultivation, Polyhouse conditions, Cost of cultivation, NPV, IRR and BCR

In the present era of diminishing land holdings accompanied by a significant change in weather and climate, protected cultivation has come up as the best alternative for using land and other resources efficiently. It has the capability to enhance the productivity of scarce resources like land, water, energy, etc. It has come as a bonanza to marginal and small farmers who can earn a decent livelihood from their small landholdings and limited resources. The major advantage of protected cultivation is that it provides self-employment opportunities to the youth and the rural population. The concept has empowered farmers to grow exotic vegetables and flowers throughout the year.

Himachal Pradesh government has made Rs.150 crore aspiring plan to support floriculture in the state. Under the plan, different motivations are being given to the dynamic and progressive farmers to urge them to adopt this worthwhile cash crop adventure under the recently propelled 'Himachal Pushp Kranti Yojna'. As per authorities of state Department of Horticulture, the area under floriculture in Himachal Pradesh was about 705.77 hectare during the year 2018-19. Many districts *viz.,* Bilaspur, Solan, Kangra, Kullu and Mandi have come up as the major flower producing districts under polyhouse conditions. However, there is urgent need to create more infrastructure for protected flower cultivation, marketing and value addition and to bridge the technological gaps at farm level. During the year 2018-19 in Bilaspur district of Himachal Pradesh, 20.83 hectare area was under flower cultivation out which 7.73 hectare area was under carnation. Therefore, the study was undertaken with the specific objectives to study the cost & return structure and financial feasibility of carnation under polyhouse cultivation in Bilaspur district of Himachal Pradesh.

MATERIAL AND METHODS

Nature and source of data: Bilaspur district of Himachal Pradesh was purposively selected for the study. Two-stage random sampling technique was used. There are four community development blocks in district Bilaspur, of which two namely Jhandutta and Bilaspur Sadar were selected randomly. A list of polyhouse owners cultivating carnation was obtained and the farmers were divided into two categories *viz.,* small (upto 500 m^2) and large (more than 500 m^2). Then a sample of 60 polyhouse units was drawn randomly through proportional allocation method from the two selected blocks. The secondary data were collected from the relevant sources mainly Departments of Agriculture and Horticulture, Bilaspur. Primary data from the producers on different aspects of flower production were collected through personal interview method during the month of October, 2019.

Analytical framework: To meet out the objectives of the present study, different mathematical and statistical tools were employed for the analysis of data. The tabular analysis was extensively used to study the social-economic characteristics and economic analysis. Literacy rate and dependency ratio were calculated using the following formulae:

Literacy rate

$$\text{Literacy rate (\%)} = \frac{\text{Total number of literate persons}}{\text{Total population – non school going population}} \times 100$$

Dependency ratio

$$\text{Dependency Ratio} = \frac{\text{Number of dependents}}{\text{Total workers}}$$

To evaluate the financial feasibility of investment in polyhouse economic indicators, viz., net present value, benefit cost ratio and internal rate of return were used, with the following equation/formulae-

Net Present Value

$$NPV = \sum_{t=1}^{n} \frac{R_t}{(1+i)^t}$$

Where,

R_t = Net cash inflow or outflow during a single period t

i = Discount rate or return that could be earned in alternative investments

t = Time period

Benefit Cost Ratio

BCR = Gross returns /Total costs

While doing investment analysis, BCR is worked out by using the following formula.

Benefit-Cost Ratio = PV of benefit expected from the project / PV of the cost of the project

Internal Rate of Return (IRR)

IRR = Lower discount rate + (Difference between the two discount rates)

$$\times \frac{\text{Present worth of cash flows at lower discount rate}}{\text{Absolute difference between present worth of cash flows at the two discount rates}}$$

RESULTS AND DISCUSSION

Demographic profile: Demographic features viz., size and structure of the family, available work force, occupation pattern and literacy status etc. are major indicators determining the social and economic setup of the selected families. These characteristics affect the organisation and management of farms as well as the adoption of improved and modern technologies. It was observed that the average family size on sample polyhouse units was 4.41 persons, out of which 52.42 per cent were males and 47.58 per cent females (Table 1). Family size on large units was higher than the smaller ones. On an average, only 2.27 per cent of the family members were illiterate resulting in a literacy rate of as high as 97.71 per cent. About 83.33 per cent of the total population was educated upto matric level and above. More than 54 per cent family members were educated up to senior secondary and graduation level.

This highlights the fact that literacy rate in the study area was quite high. It can be noted from the table that agriculture was the main occupation of the selected farmers as 81.67 per cent of work force practiced farming. About 13.33 per cent of workers population was government pensioners. Dependency ratio estimated for the selected sample was only 0.28.

Land inventory and land use pattern: Land use pattern indicates the utilization of the available land resource by the farmers. Land use pattern of sample farmers is summarized in Table 2. It may be seen from the table that the average size of land holding on small and, large farms was 1.12 and 0.99 ha, respectively. The area under pasture and grazing land

Table 1. Demographic profile of farmers

Particulars	Particulars		
	Small	Large	Overall
Average size of family (No)	4.32	4.5	4.41
Number of males (%)	54.42	50.42	52.42
Number of females (%)	45.58	49.58	47.58
Structure of family			
Joint families (%)	41.18	38.56	39.87
Nuclear families (%)	58.82	61.54	60.18
Educational status			
Illiterate (%)	2.05	2.54	2.27
Non school going (%)	1.37	1.45	0.76
Primary (%)	13.01	16.10	14.39
Matric (%)	30.14	27.12	28.79
Senior secondary (%)	36.99	21.19	30.68
Graduate and above (%)	16.44	33.05	23.86
Literacy rate (%)	97.92	97.46	97.71
Occupational status			
Agriculture (%)	97.06	61.54	81.67
Private Jobs (%)	0.00	3.85	1.67
Govt. job (%)	0.00	7.69	3.33
Govt. pensioner (%)	2.94	26.92	13.33
Dependency ratio	0.23	0.34	0.28

Table 2. Land inventory and utilization pattern (ha farm^{-1})

Particulars	Small	Large	Overall
Total owned land	1.12	0.99	1.06
Pastures/grassland	0.34	0.34	0.34
Cultivable waste land	0.34	0.24	0.29
Land under non-agricultural uses	0.01	0.02	0.01
Net cultivated area	0.43	0.39	0.41

was estimated as 0.34 ha, whereas 0.29 ha of land holding was cultivable wasteland. The net cultivated area was 0.43 ha on small and 0.39 ha on large farms. Average size of polyhouse was 481.65m^2 on small and 947.04 m^2 on large category.

Input use pattern: Carnation cultivation under protected conditions is a capital intensive avocation. Along with the higher installation cost of polyhouse, the cost of planting material was also quite high for carnation. It was found that for planting carnation in small polyhouse units farmers on an average invested Rs. 1,07,350 on planting material and for large units farmer invested Rs. 2,19,318. Cost of fertilizers was very high, it was found that on average farmers spent Rs. 35,937 on fertigation on small polyhouse units and Rs. 69,762 on large polyhouse units. The expenditure on pesticides was also high, it was Rs. 36,792 for small polyhouse units and Rs. 60,281 for large polyhouse units. Waghmare and Shendage (2013) also realised that hired human labour, planting material, fertilizers, plant protection chemicals, rental value and interest on fixed capital due to heavy investment were the major items of cost of high-tech cultivation of rose.

Labour utilization pattern: Protected cultivation of flowers is both the capital as well as labour intensive avocation. Since carnation is a three-year-long crop and requires high skill for cultivation, skilled and trained labour is required for different operations. Table 4 gives an overview of labour utilisation pattern for small and large polyhouse units. It was found that total labour requirement was 409 and 667 man-days for small and large polyhouse units, respectively. Carnation remains in

Table 3. Input use pattern

Inputs	Small				Large			
	Quantity required per m^2	Total quantity required	Price per unit (Rs.)	Total cost of inputs (Rs.)	Quantity required per m^2	Total quantity required	Price per unit (Rs.)	Total cost of inputs (Rs.)
Planting material (No. of rooted cuttings)	21.47	10735	10.37	107350 (214.70)	19.94	19938	11	21931 (219.32)
FYM (q)	0.07	33.00	800.00	26400 (52.80)	0.05	50	805	40250 (40.25)
Fertilizers				35937 (71.87)				69761 (69.76)
Pesticides				36792 (73.58)				60281 (60.28)
Electricity				5423 (10.85)				5773 (5.77)

Note: Figures in parentheses indicate the cost per metre square

Table 4. Labour utilization pattern

Operations	Small polyhouse unit				Large polyhouse unit			
	Labour requirement (man days)			Share of labour (per cent)	Labour requirement (man days)			Share of labour (per cent)
	F	H	T		F	H	T	
Preparatory tillage	1	0	1	0.25	2	0	2	0.26
Ridging and bed preparation	4	5	9	2.32	6	10	16	2.40
Sowing/ transplanting	4	4	8	1.99	5	6	11	1.65
Gap filling	2	3	5	1.25	4	2	6	0.84
Fertilizer application	20	2	22	5.34	24	4	28	4.32
Pesticide application	20	2	22	5.32	23	4	27	4.06
Stopping/ pinching/disbudding	4	4	8	2.00	4	3	6	0.97
Staking	2	1	3	0.65	5	4	9	1.30
Weeding /hoeing	75	119	194	47.37	88	237	324	48.65
Harvesting	33	35	68	16.68	50	58	108	16.28
Packaging & boarding on buses	29	40	69	16.80	48	81	129	19.30
Total man-days	194	215	409	100	259	408	667	100

Note: F-family labour; H-Hired labour; T-Total labour polyhouse for three years and needs intercultural operations regularly and has very long harvesting period which requires more labour for harvesting and packaging. Thus, weeding, harvesting and packaging were the most labour intensive operations for the carnation crop. Almost 49 per cent and 47 per cent of the total labour was required for weeding and 19 per cent and 17 per cent for packaging on large and small polyhouse units, respectively. After weeding and packaging, harvesting was the next labour consuming operation and required 16 and 17 per cent of the total on large and small polyhouse units, respectively.

Cost of cultivation: Average cost of cultivation for carnation under different sizes of polyhouses is presented in Table 5. The total cost of cultivation varied between Rs.2,09,126 to Rs.4,33,339 under different sizes of polyhouses. Among all expenses, expenditure on planting material, hired labour,

Table 5. Cost of cultivation

Costs	Particulars	Categories	
		Small (Rs.)	Large (Rs.)
COSTA1	Depreciation on polyhouse structure for a life span of 10 years (excluding cladding material)	5000	8000
	Depreciation on cladding material with shade net for a life span of 5 years	5000	16000
	Depreciation on supporting material for Carnation plants for a life span of 10years	1000	2000
	Depreciation on major and minor implements for a time period of 10 years	2500	3000
	Planting materials	35780	73106
	Farm yard manure	8800	13419
	Fertilizers	11979	23254
	Pesticide	12264	20094
	Electricity charges	1808	1924
	Hired labour	25200	50750
	Packaging material	11700	28712
	Transportation cost	15525	42680
	Commission charges	22570	59577
	Land revenue	10	20
	Interest on working capital @3.25%	5172	11132
	Total	164307	353669
COST A2	Rent paid to leased in land	0	0
	COST A1	164307	353669
	Total	164307	353669
COST B1	Imputed interest on owned fixed capital (excluding land) @10%	1537	3275
	COST A1	164307	353669
	Total	165844	356944
COST B2	Imputed rental value of owned land (less land revenue) + rent paid for leased-in land	1870	3750
	COST B1	165844	356944
	Total	167714	360694
COST C1	Imputed value of family labour	22400	33250
	COST B1	165844	356944
	Total	188244	390194
COST C2	Imputed value of family labour	22400	33250
	COST B2	167714	360694
	Total	190114	393944
COST D	Management charges (10 percent of Cost C2)	19011	39394
	COST C2	190114	393944
	Total	209126	433339

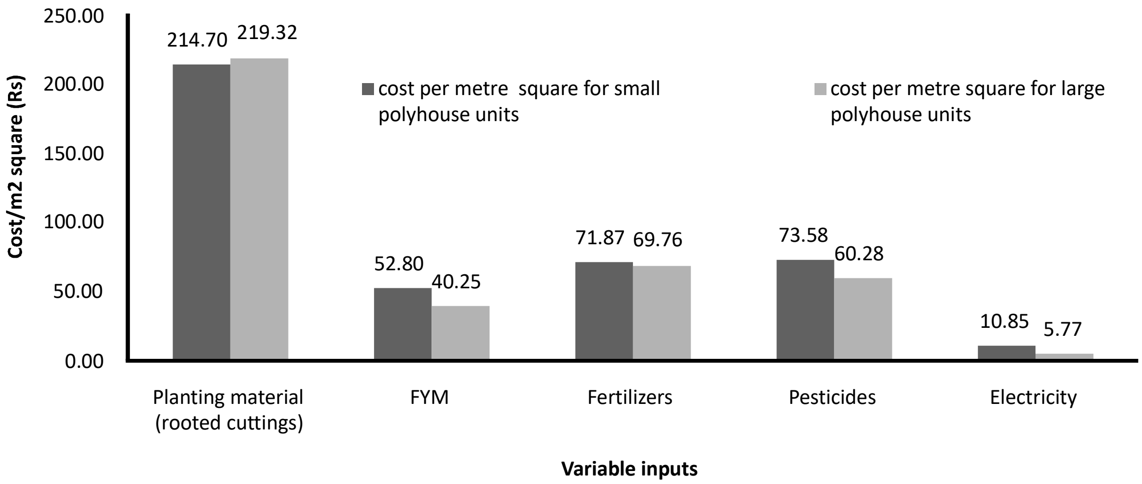

Fig 1. Cost of inputs per square metre

marketing fee and transportation cost were the major expenses made by a farmer in carnation cultivation. Farmers were totally dependent on commission agents for marketing and it was also found that commission agents used to keep 10 per cent of the total sale amount out of which 7 per cent was charged as market fee and 3 per cent was kept by commission agents for collecting the produce at Delhi bus stand and taking it to Ghazipur flower market.

As high as up to 45 per cent commission charges were reported by Bagade et al. (2018), when they analysed the marketing costs for gerbera through commission agents in Maharashtra.

Economic feasibility of carnation: Net income was computed by deducting cost C2 from gross income. This measure of income is obtained after the imputation of all expenses including the family labour. Here, the net income from small and large polyhouse units for the time period of three years was, Rs. 1,15,907 and Rs. 6,05,489, respectively (Table 6). The details of economic indicators for carnation under subsidized polyhouses of both the categories are given in Table 7. The net present value of carnation was found to vary between Rs. 2,69,189 to Rs.16,49,816 under both categories for 10 years life span. Similarly, benefit cost ratio for both the categories of polyhouse units i.e. small and large units confined to 1.18 and 1.56, with an internal rate of 44.12 and 229 per cent, respectively at a discount rate of 8 per cent. The economic indicators remained in the acceptable limits. Hence, polyhouse cultivation of carnation is an economically viable option. Punera et al (2017) also reported IRR for carnation grown under 1000m^2 (large category) polyhouses of carnation to be 117 per cent for export oriented carnation, but in 2017 there was no subsidy on polysheet replacement. Therefore, cultivation of carnation with subsidy on polysheet replacement will provide more returns (IRR 229%).

Table 6. Return structure of carnation cultivation (3 years period)

Return structure of cultivation (Rs.)	Small polyhouse units	Large polyhouse units
Gross income	686250	1787322
Farm business income	193328	726314
Own farm business income	193328	726314
Family labour income	183107	705239
Net income	115907	605489

Table 7. Investment analysis parameters

Particulars	Units	Small polyhouse units (500 m^2)	Large polyhouse units (1000 m^2)
NPV	Rupees	2,69,189	16,49,816
Benefit-cost ratio		1.18	1.56
IRR	Percentage	44.12	229

CONCLUSION

The net returns from the production of carnation cut stems were Rs. 1,15,907 under small polyhouse units, whereas, under large category net returns were Rs.6,05,489. Benefit cost ratio for both the categories of polyhouse units i.e. small and large units confined to 1.18 and 1.56, respectively at 8 per cent discount rate. The Internal Rate of Return being 44.12 per cent and 229 per cent for small and large category polyhouse units was higher than the interest rate at which the farmers could borrow from lending agencies and invest on these units. Therefore, production of carnation under polyhouses is feasible and profitable. Carnation cultivation can be made more remunerative if the planting material (rooted carnation cuttings) are supplied by the Government agencies at reasonable prices. So far, the farmers are dependent on private companies for quality planting material. There is a dire need to develop procurement facilities and post-harvest infrastructure for flowers in the state. There is a need of cold storage and refrigerated transportation facilities at district levels. There is also a need to devise a method for the selection of genuine farmers. For this prior training should be made pre requisite and the Horticultural or Agricultural officials should also monitor the performance on regular basis.

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Climate Influence on Abscission Pattern and Efficacy of Chemical Thinners in Nectarine cv. May Fire

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Abstract: The present investigations were subjected to nine different treatments viz. at Naphthaleneacetic acid40 and 60 ppm; Ethrel at 200 and 300 ppm applied one and two week after petal fall and controlon 12-year old trees of nectarine cultivar May Fire, At both locations, treatment with NAA at 40 ppm when applied two weeks after petal fall resulted insignificantly higher thinning percentage.NAA and ethrel when applied two week after petal fall induced early fruit than applied one week after petal fall.NAA at 40 ppm and Ethrel at 300 ppm when applied two weeks after petal fall caused complete degeneration of cells in pith, vascular and cortex regionson the 3rd day (at 20.5°C/13°C maximum and minimum temp. and 60.3% RH).In control stimulation of cell disintegration could not be examined in any region during the 15days of observing period.

***Keywords*:** Thinning, Abscission zone formation, May Fire, NAA, Ethrel

Nectarines (*Prunuspersica* (L.) Batsch var. *nucipersica)* are the group of peaches having a smooth skin, often referred as "fuzzy-less peaches" or "shaven peaches" due to lack of fuzz or short hair on the fruit surface. The absence of fuzz (pubescence) on the nectarine fruit surface fundamentally is the only difference between peach and nectarine, though fuzzy peaches and nectarines are regarded commercially as different fruits. Several genetic studies have concluded that nectarines are created due to a recessive gene, whereas in peach fuzziness is controlled by the dominant gene. On an average, nectarines are slightly smaller, but with much overlap. The lack of skin fuzz make nectarine skins appear more reddish than those of peaches, contributing to the fruit's plum-like appearance. May Fire is one of the most important among the different cultivars of nectarine grown in the state. Its fruit is an early maturing, attractive coloured, medium sized; having smooth skin of green to white with deep red over colour. Area under this cultivar is increasing rapidly due to higher price in the market. For profitable nectarine production, some quality parameters are very important and foremost being the large sized fruit which has strong market demand. However, nectarines invariably bear excessively, resulting in the production of small sized fruits, which are relatively less remunerative.

Fruit thinning is an important cultural practice to remove excessive fruit-lets from trees and one of the most effective measures to improve fruit size, and next season's flower bud initiation, colour and quality at harvest, and increases return bloom the following year, thereby reducing alternate bearing. Chemical thinners, such as naphthalene acetic acid (NAA) and ethephon can effectively thin fruits when applied at a fruit diameter of 14-15 mm. However, chemical thinning results are extremely variable and very difficult to predict or control because of an incomplete understanding of the modes of action of chemical thinners as well as their interactions (e.g. concentration, environmental condition, cultivar response) that affect thinning effectiveness. Environmental conditions, particularly temperature and light intensity, may impact the efficacy of chemical thinners. Low temperature following application results in a poor fruit abscission response whereas; high temperature may lead to over-thinning or excessive leaf abscission (Pandita and Jindal 2004). In view of these points, the proposed study were undertaken using different chemical thinning agents on “May Fire” nectarine at different locations to derive detailed recommendation of fruit thinning in nectarine based on environmental condition of the particular area.

MATERIAL AND METHODS

The present investigations were undertaken on bearing trees of nectarine cultivar May Fire raised on wild peach seedling rootstocks at Horticulture Research Station, Kandaghat, Solan and Farmer's orchard at Kotla-Barog, Sirmour during the 2014 and 2015.Kandaghatand Kotla Barog are located at the altitude of 1425 m amsl and 1245 m amsl, respectively and trees at these sites were planted at a spacing of 3×3 meters and trained as open centres. Twenty seven trees were selected at each location on the basis of uniform vigour and kept under uniform cultural practices during the entire course of investigation. There were nine treatments in (Table 1). Observations on maximum and minimum temperatures and average relative humidity were recorded starting from one week after petal fall i.e. time of first application of different treatments (1 WAPF) for 14 days i.e. up to 7 days after second application of different treatments (2 WAPF) with the pre-installed EL-USB self-recording data loggers at both the sites. Light illumination was recorded by luxmeterat 9.00 AM, 1.00 PM and 5.00 PM under and outside the tree canopy at selected orchard sites for 14 days from one week after petal fall and the value of solar influx in percentage was calculated (Rao1998) as under.

$$\text{Solar Influx (\%)} = \frac{\text{Total solar radiation beneath the canopy}}{\text{Total solar radiation in open}} \times 100$$

Collection of samples: Fruits along with pedicel were collected in the morning hour every day starting from one day after petal fall till 15 days or the formation of abscission zone, which ever was earlier.

Microscopy of material: The abscission zone segments were immediately killed and fixed in a Formalin-Aceto-Alcohal (FAA) solution containing 90 ml of 70 per cent ethyl alcohol, 5 ml of glacial acetic acid and 5 ml of formaldehyde. After 24 hr, the abscission zone were transferred from FAA solution to 70 percent ethyl alcohol and preserved till microtomy. The tertiary butyl alcohol (TBA) method for dehydration of sample was used. The concentrations of TBA used for dehydration were in ascending order of 50,70,85,95 and 100 per cent. The following series of solution of water, ethyl alcohol and tertiary butyl alcohol were prepared.

Total percent of alcohol	50	70	85	95	100
Distilled water	50	30	15	-	-
95% ethyl alcohol	40	50	50	45	-
Tertiary butyl alcohol	10	20	35	55	75
Absolute ethyl alcohol	-	-	-	-	25

The materials were kept in each series successively for six hours. Finally, the material was passed through three changes of pure TBA for overnight and again later for about 24 hrs in TBA and finally in liquid paraffin in the ratio of 1:1. Paraffin method of infiltration was used and the material was embedded in paraffin blocks. Safranin and Fast Green are used for staining the section and DPX mountant is used for mounting. The sections of 10μ and 20μ thickness were cut with Nippon manual plant microtome Model MTH-1.

RESULTS AND DISCUSSION

Abscission zone formation: In this study, NAA and Ethrel when applied two week after petal fall induced early fruit abscission at both locations compared to when these treatments were applied one week after petal fall. At Kandaghat, during the year 2014, treatments with NAA at 40 ppm and Ethrel at 300 ppm when applied two weeks after petal fall caused complete degeneration of cells in pith, vascular and cortex regions (Plates 2 & 5) on the 3rd day (at 20.5°C/13°C maximum and minimum temp. and 60.3% RH), however, these plant growth regulators at above dozes when

Table 1. Effect of different treatments on fruit thinning in nectarine cv. May Fire at two different locations

Treatment		Fruit thinning (%)					
		Kandaghat			KotlaBarog		
		2014	2015	Pooled	2014	2015	Pooled
T_1	NAA 40 ppm, 1 week after PF	42.04 (40.42)	31.86 (34.34)	36.95 (37.44)	38.24 (38.20)	30.53 (33.49)	34.38 (35.88)
T_2	NAA 60 ppm, 1 week after PF	39.86 (39.14)	30.59 (33.53)	35.22 (36.39)	35.29 (36.43)	27.80 (31.80)	31.55 (34.16)
T_3	Ethrel 200 ppm, 1 week after PF	37.39 (37.69)	27.68 (31.72)	32.53 (34.76)	30.20 (33.29)	25.63 (30.39)	27.91 (31.86)
T_4	Ethrel 300 ppm, 1 week after PF	40.07 (39.25)	26.55 (30.97)	33.31 (35.22)	35.79 (36.71)	25.63 (30.39)	30.71 (33.62)
T_5	NAA 40 ppm, 2 week after PF	59.33 (50.40)	42.37 (40.61)	50.85 (45.49)	50.95 (45.55)	40.27 (41.70)	45.61 (43.63)
T_6	NAA 60 ppm, 2 week after PF	52.26 (46.30)	38.18 (38.16)	45.22 (42.26)	43.42 (41.22)	37.42 (37.71)	40.42 (39.47)
T_7	Ethrel 200 ppm, 2 week after PF	50.94 (45.54)	35.88 (36.77)	43.41 (41.20)	41.29 (39.97)	32.79 (34.93)	37.04 (37.48)
T_8	Ethrel 300 ppm, 2 week after PF	54.39 (47.53)	40.59 (39.56)	47.89 (43.56)	46.25 (42.85)	39.03 (38.66)	42.64 (40.77)
T_9	Control(No thinning)	15.51 (23.01)	12.49 (20.61)	14.00 (21.84)	16.58 (24.00)	15.20 (22.88)	15.89 (23.45)
	CD (p=0.05)	2.49	1.12	1.44	3.09	1.81	1.64

applied one week after petal fall (T_1 & T_4) caused complete degeneration cells in pith, vascular region and cortex only on the 7th day after application. In control trees, stimulation of cell disintegration could not be examined in any region during the 15days of observing period i.e. 15 days following one week after petal fall (Plate 1). In the year 2015, complete disintegration of cells in pith, vascular and cortex regions was observed on the 5th day (at 15°C/12.5°C maximum and minimum temp. and average 80.5% RH) in the treatments T_5 and T_8, on 7th day in T_6 and $T_7$and on 9th day in T_1 and T_4 (Plate X). In control trees, there was no disintegration of cell in any region during the 15 days of observation (Plate 1).

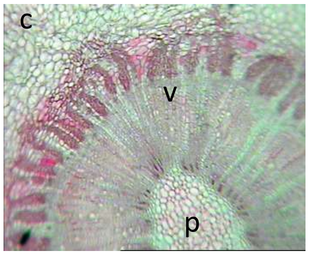
At Kotla Barog, during the year 2014, the treatments T_5 (NAA at 40 ppm, applied 2 weeks after PF) and T_8 (Ethrel at 300 ppm applied 2 weeks after PF) resulted in complete degeneration cells in pith, vascular region and cortexon the 5th day (at 25.5°C/14°C maximum and minimum temp. and average 47.8% RH), however, when NAA at 40 ppm and Ethrel at 300 ppm were applied one week after petal fall, degeneration of cells in these region completed on the 7th day after application. In control trees, however, disintegration of cell in any region could not be observed during the 15 days of observing period (Plate 1). During the year 2015 at this location, complete disintegration of cells in pith, vascular region and cortex in the abscission zone of fruit pedicel was observed in the treatments T_5 andT_8 on 7th day (at maximum and minimum temp 23°C/12°C and 81.0% RH), however, in T_1 and T_4 complete degeneration cells of pith, vascular region and cortex region was noticed on the 9th day. In control trees, however, disintegration of cell in any region of could be noticed during the entire 15 days of observing period.

In the study, disintegration of cells in pith, vascular and cortex regions in the pedicel end was hastened at both locations with the application of NAA at 40 ppm and Ethrel at 300 ppm two weeks after petal fall, which explicit their greater effectiveness in stimulating fruit abscission (Table 1). Yearly variation in the time taken to complete the disintegration of cells in these tissues can be attributed to observed differences in environmental condition among locations and years. Present results indicate that disintegration of cells was advanced at Kandaghat in the year 2014 at 20.5- 24.5°C/ 13.5-14°C maximum and minimum temperature and 47.3-60.3% average relative humidity following the chemical treatments. However, in the year 2015, prevalence of much lower temperature (15.0-19.5°C/11.0- 12.5°C max.& min. temp.), higher relative humidity (73-85%RH) and lower light intensity after application of chemical thinners at this location and higher temperature (25.5- 28°C/12.5- 14.0°C & 23.5-26.0°C/11.5- 13.5°C, in 2014 & 2015, respectively) after application of treatments at KotlaBarog during both the years of investigation delayed the disintegration of cells at the pedicel end. Pandita and Jindal (2004) observed that cell wall degradation and subsequently the separation of cells in vascular region occurred due to dissolution of middle lamella on the third day after NAA application. Hong Zhu (2008) observed that NAA enhanced expression of genes related to ethylene biosynthesis, abscission zone formation and cell wall degradation on 1st, 3rd, and 5th day after treatment. Formation of fruit abscission zone (FAZ) occurred 3rd, and 5th days after treatment with NAA, but decreased to control level by 7th and 13th days after treatment (Zhu et al 2011).

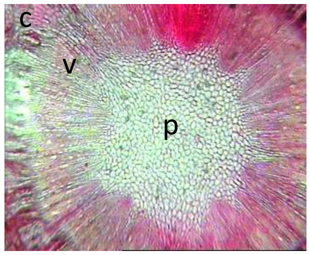
Fruit thinning: The pooled values of fruit thinning at location revealed significantly higher thinning percentage (50.85%) in the treatment T_5 (NAA 40 ppm) in comparison to all other treatments. Conversely, the fruit thinning level was significantly lowest (14.00%) in control. The pooled values of fruit thinning at KotlaBarogindicated that the treatment T_5 (NAA 40 ppm) was most effective in stimulating thinning (45.61%), which in this respect was found significantly superior to all other treatments. The fruit thinning level was however, significantly lowest (15.89%) in control.

Data clearly reveal that different plant growth regulator treatments were more effective in inducing fruit abscission in the year 2014 as compared to 2015.Moreover, variability in the extent of thinning was also observed among the locations, which was higher at Kandaghat compared to KotlaBarog. During the study, chemical thinners were more effective when applied 2 weeks after petal fall instead of 1 week after petal fall. Fruit thinning effect of NAA is predictable (Sharma et al 2003, Rimpika et al 2015). However, inconsistency in thinning level at two locations during study period may be attributed to weather conditions at the time of application and immediately thereafter. Environmental conditions, particularly temperature and relative humidity, may have impacted the efficacy of chemical thinners. During the year 2015, poor fruit abscission response under different plant growth treatments can be attributed to a sharp drop in average temperature after application (from 19.5 to 13.7°C at Kandaghat and 20.5 to 15°C at KotlaBarog). Under warm weather conditions, NAA (Robinson and Lakso 2004) and ethephon (Clever 2007) seems to be successful thinning agents, however, results were not always consistent (Webster and Spencer 2000). The results are in agreement with the earlier findings (Widmer et al 2008) that post bloom application of ethephon induced higher thinning when temperature ranged between 18 to 22°C. Present study reveal that the effects of plant growth regulator on fruit abscission were more pronounced at Kandaghat where day temperatures (Annex. average I) were lower (24.0 and 20.4°C in 2014 & 2015, respectively) and average RH higher

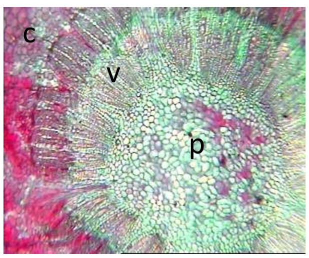
(53.3 and 66 % in 2014 and 2015, respectively) in comparison to KotlaBarog (27.8 and 25.0°C day temperature in 2014 and 2015, respectively; 54.1 and 57.3% RH in 2014 & 2015, respectively). These results demonstrate that chemical thinners seem to be more effective at optimum temperature range; too low or too high temperature lessened



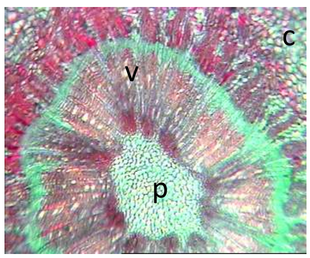
No sign of disintegration of cells (1st day)



No sign of disintegration of cells(3rd day)



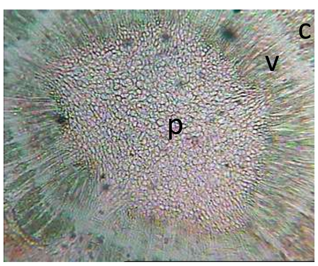
No sign of disintegration of cells (5thday)



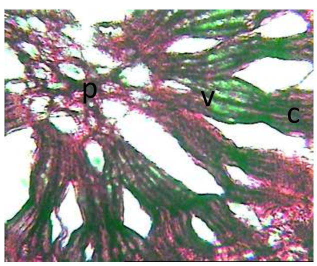
No sign of disintegration of cells (15th day)

P –pith, V -vascular region, C- cortex

Plate 1. Control



No sign of disintegration of cells (1st day)



Almost completely degenerated cells in pith, vascular region and cortex (3rd day)

Plate 2. NAA 40 ppm applied 2 WAPF, Kandaghat (2014)

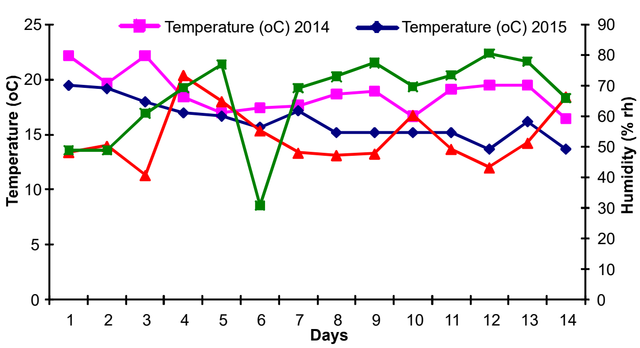
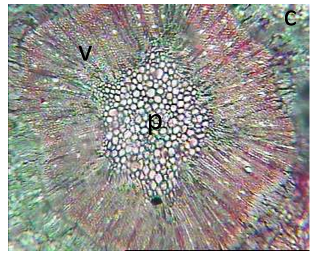
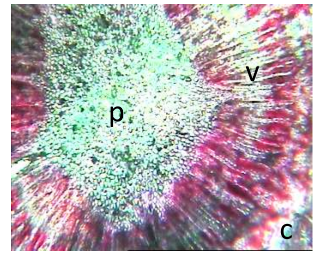


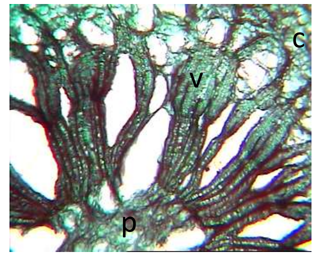
Fig. 1. Observations on temperature and relative humidity for 14 days starting from 1 week after petal fall to the end of 2nd week of petal fall in nectarine at Kandaghat



No disintegration of cells in any region(1st day)

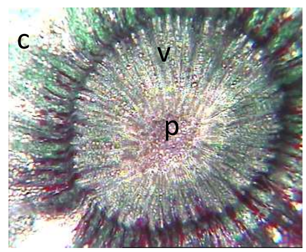


No disintegration of cells (3rd day)

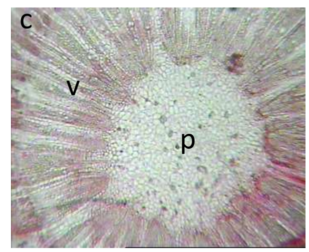


Disintegration of cell in pith, vascular region and cortex (5th day)

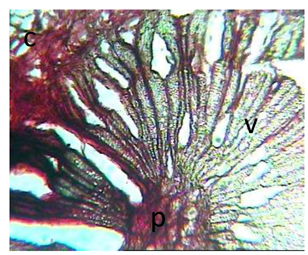
Plate 3. NAA 40 ppm applied 2 WAPF Kotla Barog (2014)



No disintegration of cells in pith, vascular region and cortex region(1st day)



No disintegration of cells in pith, vascular region and cortex region (3rd day)



Disintegration of cells in pith, vascular region and cortex (5th day)

Plate 4. NAA 40 ppm applied 2 WAPF Kandaghat (2015)

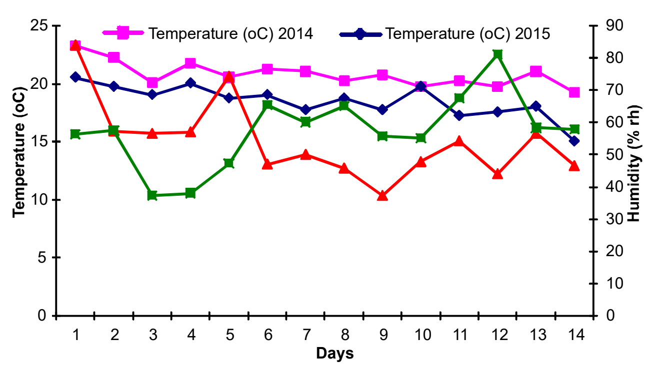


Fig. 2. Observation on temperature and relative humidity for 14 days starting from 1 week after petal fall to the end of 2nd week after petal fall in nectarine at Kotla Barog

effectiveness. Present results are also in conformity with earlier findings (Cline and Bijl 2002) that NAA induced greater abscission at temperature between 20-25°C and higher relative humidity.

CONCLUSION

The foliar spray of NAA at 40 ppm when applied two weeks after petal fall judiciously thinned nectarine fruits and improved fruit size and fruit quality. However, variability in the extent of thinning was observed among the locations, which was higher at Kandaghat compared to KotlaBarog. Chemical thinners were more effective in the year 2014 than 2015 and when applied 2 weeks after petal fall instead of 1 week after petal fall. Environmental conditions, particularly temperature and relative humidity, may have impacted the efficacy of chemical thinners. Present results indicate that disintegration of cells was advanced at Kandaghat in the year 2014 at 20.5-24.5°C/ 13-14°C maximum and minimum temperature and 47.3-60.3% average relative humidity after application chemical thinners. These results demonstrate that chemical thinners seem to be more effective at optimum temperature range; too low or too high temperature lessened effectiveness.

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Comparative study on Crop Water Requirement Using CROPWAT Model for Different Vegetable Crops Grown Under Protected and Open Field Cultivation

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Abstract: The result revealed that the values of average daily reference evapotranspiration (ETo) under polyhouse were found less than, values of ETo under open field for all months. It is because of the green-house effect and the low radiation. The values of ET_0 during both seasons were lower under polyhouse cultivation compared to open field condition. The estimated results, related to total crop water requirement indicates that significant irrigation water saving occurs through cultivation of vegetable crops under polyhouse as compared to open field cultivation. The operating time of drip under polyhouse was less than open field cultivation for all vegetable crop which, results reduction in electricity consumption for irrigating the vegetable crop. It also found that all vegetable crops requires approximately 27% less water under polyhouse cultivation comparing to total water required under open field cultivation. The polyhouse cultivation technique enhance water saving and reduction in electricity consumed, for climatic condition of Udaipur.

***Keywords*:** Evapotranspiration, Protected cultivation, Water saving, Irrigation scheduling, Crop water requirement

Vegetables are the major source of food and nutrition. In India availability of water are limited, farmer needs to adopt various types of water saving irrigation techniques like growing crop under protected cultivation. In world scenario India is the second largest country as producer of vegetable crops in the world. Their production is much less than the requirement of present time, if specific and balanced diet is provided to every individual. The present production of 125.74 million tonnes (NHB 2014) is to be raised to 250 million tons by 2024-2025. It is very essential to promote the protected cultivation of vegetables (Sanwal et al 2004). Surface irrigation (Pipe irrigation), Drip irrigation &Sprinkler irrigation and mini sprinkler irrigation are the different types of irrigation methods commonly adopted by the Indian farmers. To date, there is not much research work available on irrigation scheduling and corresponding water saving for vegetables under drip irrigation for open and green house condition. There is an urgent need to assess the cultivation and suitability of different vegetables under different water saving irrigation methods to meet the growing demand of the vegetables. Thus, the investigation was aimed to development of Irrigation scheduling on the basis of water requirements of different vegetables crops under polyhouse and open field condition for Udaipur, Rajasthan.

MATERIAL AND METHODS

Study area and data collection: A comparative study on crop water requirements using CROPWAT model for different vegetables crops (Tomato, Capsicum and Cucumber) grown under protected (polyhouse) and open field condition was carried out during the *rabi* season of 2016-17 and 2017-18 (Nov-Feb) for Udaipur district of Rajasthan. The study area (Udaipur) is located between 24°35'31.5"to 24°35'31.3" N latitude 73°44'18.2" to 73°44'21.1" E longitude and at an altitude of 582.17 m above mean sea level (MSL). It comes under dry, sub-humid agro-climatic region. The average annual rainfall of Udaipur is 637.3 mm, most of the rain received during the period of July to Sep. May is the hottest and December is the coolest month of the year. The daily meteorological data during the year 2016-17 and 2017-18 were collected from meteorological observatory of CTAE, Udaipur.

Methods*:* CROPWAT model is basically a decision support system for Windows, developed by the Land and Water Development Division of FAO, Italy with the help of the Institute of Irrigation and Development Studies of Southampton, UK and National Water Research Center, Egypt. This model carries out calculations for reference evapotranspiration, irrigation requirements and crop water requirements in order to develop irrigation schedules under various management conditions. CROPWAT uses the FAO Penman- Monteith method for calculation of reference crop evapotranspiration. The daily meteorological data recorded during the year 2016-17 and 2017-18 were used to compute reference evapotranspiration (ETo). The modified Penman-Monteith method suggested by Allen et al(1998) was used to compute reference evapotranspiration (ETO). In this model, most of the equation parameters are directly measured or can be readily calculated from weather data. The equation can be utilized for the direct calculation of any crop evapotranspiration (ETc). The FAO Penman-Monteith method to estimate ETo is:

$$ET_0 = \frac{0.408\ \Delta.4\ _n - G) + y\dfrac{900}{T+273}U_2(e_s - e_a)}{\Delta + y(1 + 0.34U_2)}$$

where,

ET_o = reference evapotranspiration [mm/day],

R_n = net radiation at the crop surface [MJ/ m^2 day],

G = soil heat flux density [MJ/ m^2day],

T = air temperature at 2 m height [°C],

u_2 = wind speed at 2 m height [m s^{-1}],

e_a = actual vapour pressure[k Pa],

e_s = saturation vapour pressure [k Pa],

e_s - e_a = saturation vapour pressure deficit [k Pa],

Δ = slope vapour pressure curve [k Pa°C^{-1}],

Y = psychrometric constant [k Pa°C^{-1}].

In this study different vegetable crops grown under protected (polyhouse)and open field condition under drip irrigation were taken for comparing crop water requirement and developing irrigation scheduling (including number of irrigation and operating time of standard size of drip system for vegetables crop). Major vegetables are considered for this present study which includes tomato, capsicum and cucumber. The daily crop water requirement for the vegetable crops were estimated by using the following relationship:

WR = ETo × Kc × Wp × A

Where, WR = Crop water requirement (L d-1), ETo = Reference evapotranspiration (mm d^{-1})

Kc = Crop coefficient (Table 1 lists values for Kc ini, Kc mid, and Kc end for various vegetable crops) .Wp = Wetting fraction (taken as 1 for most cases in close growing crops)

A = Plant area, m2 (i.e. spacing between rows, m x spacing between plants, m)

The values of crop coffecient (Allen et al 1998) and canopy area of plant for estimating crop evapotranspiration (ET_C) and crop water requirement (l/day/plant) are presented in Table 1.

RESULTS AND DISCUSSION

The simulated values of average daily reference evapotranspiration (ETo) at different months through CROPWAT model using Penman-Monteith equation, under protected (polyhouse) and open field condition for Udapur district of Rajasthan is shown in the Figure 1 along with the mean value of average daily reference evapotranspiration (ETo) from both season (2016-17 and 2017-18) under polyhouse and open field condition separately. The average daily reference evapotranspiration (ETo) under polyhouse were found lower than values of ETo under open field condition for all months (Table 2). It is probably because of the green-house effect and the low radiation under polyhose. In this study open field recorded the maximum evapotranspiration during the whole season, which agreed with the results reported by Abdrabbo (2001). The values of ET_0during both season (2016-17 & 2017-18) for the month of Nov (1.725 & 1.728 mm/day), Dec (1.4925 & 1.368 mm/day), Jan (1.485 & 1.44 mm/day)and Feb (2.25 & 1.44 mm/day) were estimated lower for polyhouse cultivation compares to open field condition. outside Fernandez et al (2010) observed that the reference evapotranspiration (ETo) inside greenhouses was always lower, ranging on 45 to 77% of that verified.

Table 1. Crop coefficients, Kc (Allen et al 1998), and plant area, $m^2$of various vegetables crops

Crop name	Kc initial	Kc mid	Kc end	Plant area, m^2
Tomato	0.6	1.15	0.80	0.5 × 0.5 = 0.25
Capsicum	0.6	1.05	0.90	0.45 × 0. 5 = 0.23
Cucumber	0.6	1.00	0.75	0.5 × 0.25 = 0.13

Crop water requirement under poly house and open field cultivation*:* Tomatoes require a high water potential for optimal vegetative and reproductive development (Table 3). The total water requirement (during whole growing period) of Tomato crop estimated 43 litre/plant (152.7 mm) for polyhouse which is less than total water requirement of tomato grown under open field condition (59.2 litre/plant). The local weather parameters not only affect the crop water requirement, but also it depends upon variety of crop, season and the method of tomato cultivation. While, for capsicum crop total water requirement was also found minimum in polyhouse cultivation (39 litre/plant) as compared to open field (53.6 litre/plant). Similarly, total water requirement of cucumber crop was found to be minimum under polyhouse cultivation (20.7 litre/plant & 159 mm) and maximum in open field condition (28.1 litre/plant & 216.7 mm). The overall results, related to total crop water requirement indicates that significant irrigation water saving occurs through cultivation of vegetable crops under protected (polyhouse) as compared to open field cultivation. The similar finding was reported by Santosh et al (2017).

Development of irrigation scheduling under poly house and open field cultivation for different vegetable crop: The irrigation scheduling for different vegetables crop under polyhouse and open field cultivation was developed for standard size of drip irrigation system which, characterized by lateral to lateral spacing (50×50 cm), dripper to dripper spacing (30×30 cm) and having drippers of 2 litre per hour discharge rate. In this study it found that, if irrigation takes place on alternate day (60 irrigation for crop period of 120 days), then the operating time of drip system under poly house cultivation was less than operating time for open field cultivation for all vegetable crop which, results reduction in electricity consumption for irrigating the vegetable crop (Table 4). The amount irrigation water saving under polyhouse cultivation was observed 648000, liters/ha for tomato crop, 634783, liters/ha for capsicum crop and 569230, litres/ha for cucumber crop as compared to open field cultivation. The vegetable crops grown under polyhouse gives batter results regarding water saving and crop water use efficiency for climatic condition of Udaipur district of Rajasthan. Similar results were reported by Lorenzo et al(2006) and Moller and Assouline (2007).

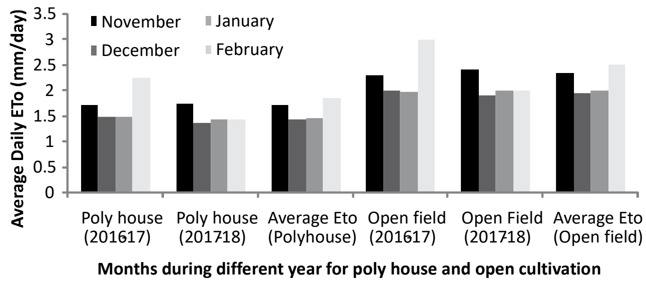

Fig. 1. Average daily value of reference evapotranspiration (mm/day) for different months by using CROPWAT Model in both season under poly house and open field condition

Table 2. Average daily value of evapotranspiration for different months under polyhouse and open field condition

Months	Average daily value of Evapotranspiration (ETo) (mm/day)					
	Poly house (2016-17)	Poly house (2017-18)	Average ETo (Polyhouse)	Open field (2016-17)	Open Field (2017-18)	Average ETo (Open field)
November	1.725	1.728	1.7265	2.3	2.4	2.35
December	1.4925	1.368	1.43025	1.99	1.9	1.945
January	1.485	1.44	1.4625	1.98	2	1.99
February	2.25	1.44	1.845	3	2	2.5

Table 3. Crop water requirement of vegetable crop under poly house and open field condition

Months	Crop evapotranspiration (ET_c) (mm/day)		Water requirement (litre/plant/day)	
	Open field	Polyhouse	Open field	Polyhouse
Tomato				
November	0.376	0.27624	0.35	0.25
December	2.23675	1.644788	0.55	0.41
January	2.2885	1.681875	0.57	0.42
February	2	1.476	0.5	0.369
Total	207.5628	152.7	59.2	43
Capsicum				
November	1.41	1.0359	0.3243	0.238257
December	2.04225	1.501763	0.469718	0.345405
January	2.0895	1.535625	0.480585	0.353194
February	2.25	1.6605	0.5175	0.381915
Total	233	171	53.6	39
Cucumber				
November	1.41	1.0359	0.1833	0.134667
December	1.945	1.43025	0.25285	0.185933
January	1.99	1.4625	0.2587	0.190125
February	1.875	1.38375	0.24375	0.179888
Total	216.785	159.4973	28.1	20.7

Table 4. Irrigation scheduling of tomato, capsicum and cucumber crop for polyhouse and open field cultivation under standard size of drip system

Parameter for drip system	Protected (Polyhouse) cultivation	Open field condition
Crop name: Tomato (spacing of crop - 0.5 m × 0.5 m)		
Total water requirement (l/ha)	1720000	2368000
Total Water requirement (l/plant)	43	59.2
Lateral to lateral spacing (CM)	50	50
Dripper to dripper spacing (30)	30	39
Dripper discharge	2 lph	2lph
Number of irrigation provided	60	60
Operating time of drip per irrigation	13 min	18 min
Crop name: Capsicum (spacing of crop - 0.45 m × 0.5 m)		
Total Water Requirement (l/hac)	1695652	2330435
Total Water requirement (l/plant)	43	59.2
Lateral to lateral spacing (CM)	50	50
Dripper to dripper spacing (30)	30	39
Dripper discharge	2 lph	2lph
Number of irrigation provided	60	60
Operating time of drip per irrigation	12.6 min	17 min
Crop name: Cucumber (spacing of crop - 0.5 m × 0.25 m)		
Total Water Requirement (l/hac)	1592308	2161538
Total Water requirement (l/plant)	43	59.2
Lateral to lateral spacing (CM)	50	50
Dripper to dripper spacing (30)	30	39
Dripper discharge	2 lph	2lph
Number of irrigation provided	60	60
Operating time of drip per irrigation	11 min	16 min

CONCLUSION

The average daily reference evapotranspiration (ETo) under polyhouse were found lower than values of ETo under open field condition for all months. It is probably because of the green-house effect and the low radiation under polyhouse. In this study open field recorded the maximum reference evapotranspiration during the whole growing period of vegetable crops. From the above data it shows that, vegetable production in open field condition requires higher crop water requirement for all the vegetables crops as compared to other Protected (polyhouse) cultivation. It also shows that all vegetable crops requires approximately 27% less water under polyhouse cultivation as compared to total water required under open field cultivation. The polyhouse cultivation technique enhance water saving and reduction in amount of electricity consumed for irrigation over open field cultivation for climatic condition of Udaipur district of Rajasthan. The farmer can utilized this save water for irrigating additional area of crop in order to enhance their income.

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Effect of Ash from different Agricultural Wastes on Soil Properties and Grain Yield of Maize (*Zea Mays* L) in Degraded Ultisol

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Abstract: Maize (*Zea mays* L) is an important cereal crop in southeast Nigeria but few data exist on appropriate organic amendments for its high production. A field study was conducted in 2016 and 2017 planting seasons to compare the effect of ash from burnt saw dust (BSD), burnt rice mill waste (BMW) and wood (WO) on soil properties and grain yield of maize. The BSD, WO and BMW were applied at 4 t ha-^{1}, respectively. There was significant increase in soil Ca, Mg, Na, K and cation exchange capacity in burnt agricultural waste amended plots relative to the control. The significant high difference in soil pH, organic matter, aggregate stability, available P, total N and total porosity were observed in amended plots compared to the control. Bulk density was significantly reduced in amended plots while the effect on dispersion ratio was not-significant. Similarly, significantly higher plant height and maize grain yield were observed in amended plots relative to the control. On the average WO gave the maximum improvement in soil and agronomic parameters. This resulted in WA being a better amendment than BMW and BSD for use in maize production.

Keywords: Ash, Soil properties, Crop production, Grain yield

The soils of the tropical region are inherently low in fertility. This however, is naturally made up of rapid formation and accumulation of organic matter (OM). Amusan and Ojeniyi (2011) reported that organic matter (OM) which play important role in the fertility of tropical soils is either removed in the course of inevitable mechanical land clearing or rapidly depleted as a result of continuous cultivation. The fertility of the soil is improved by addition of soil amendment (Alu et al 2018, Njoku and Okoro 2019). The changes associated with addition are important in planning cultural operations and developing appropriate management systems (Azzez et al 2007). Thus research interest in tropical countries has recently shifted to utilization of organic amendments as nutrient source in crop production (Njoku and Mbah 2012).

Maize (*Zea mays* L) belongs to family graminae and class cereal that thrive under a wide range of environmental conditions. Mbah et al (2010) reported that maize perform well with pH of 5.5-5-7 while strongly acidic soil (pH <5.0) is unsuitable for good yield. Liming of acidic soil makes it possible for greater number of crops to be grown. The most commonly used limes are oxides, carbonates and silicates of calcium and magnesium. Scarce information is available on the effect of ash from burning of different organic materials. Mbah and Njoku (2019) reported that application of wood ash as amendment in the tillage resulted to the improvement in soil physical and chemical properties. There is need to evaluate the effects of these locally available ashes from burning of waste from different materials on soil properties. The aim of this study was to find out the effects of ashes from burnt wood (WO), rice husk dust (BMW) and saw dust (BSD) on the properties of a degraded ultisol and maize grain yield.

MATERIAL AND METHODS

The study was conducted at Ebonyi State University, Abakaliki in 2016 and 2017 cropping seasons. The area lies between latitude of $09^{0}19^{1}$N and longitude of $08^{0}6^{1}$E with mean elevation of 450 m above sea level. It has an annual rainfall of 1700-1800mmand rainfall pattern is bimodal between April and October, while the dry season is between November and March. The soil is an Ultisol and classified as Typic-Haplustult (Federal Department of Agriculture and Land Resources 1985).

Field methods: The site was cleared of grasses in May 2016. A total land area of 19 m and 13.5 m (256.5m^{2}) was mapped out for the study which was carried out on the same area in the 2016 and 2017 seasons. The field was divided into five blocks with each block having four experimental units giving a total of twenty plots. The experimental units were demarcated by 1 m alleys and each plot measured 3m x 3m (9m^{2}). The experimental design was a randomized complete block design and treatments were 4 t ha-^{1}of burnt wood ash (WO), burned rice husk dustash (BMW) , burned saw dust ash(BSD) and control. The BMW and BSD were collected from Abakaliki rice mill and timber shade, respectively. The wood-ash was obtained from the burning of Agba (*Carpolobia alata*) tree. The ashes were spread evenly on appropriate plots and incorporated into the soil during tillage with hoe. The maize variety used was Oba super 11 and was planted two seeds per hole at intra and inter row spacing of 50 cm and 50 cm, respectively. The maize seedlings were thinned down to 1 plant per stand 2 weeks after germination. Weeding was carried out at 3 weeks interval until maturity using hoe. The study was repeated in 2017 planting season but without application of the ash to test their residual effects.

Observation and data collection: Four undisturbed soil core samples (for analysis of bulk density) and four auger samples were randomly collected from a depth of 0-30 cm in each plot for laboratory analysis. The soil core samples collected using 98.2m^2 open-filled cores (area 19.5m^2 and height 5 cm) were analyzed separately and mean results used whereas auger samples were mixed and composite sub-samples used for analysis. Measurement of dry bulk density was carried out at 45 and 90 days after planting (DAP) while plant height was measured at 4, 8 and 12 weeks after planting. For plant height and maize grain yield measurements 10 plants were randomly selected per plot, tagged and sampled. At maturity the maize grains were harvested, dried, threshed, weighed and yield data adjusted to 14 % moisture content.

Laboratory methods: A composite soil sample was collected from ten points in the entire plots before the study started in 2016. The composite sample and the auger samples collected after the study were analyzed in the laboratory for total N, K, Mg, pH, Ca, organic carbon (OC), Na, available P and cation exchange capacity (CEC). Total N was determined by the macro-kjeldahl method (Bremner 1982) and available P by using Bray 11 method as outlined by Olsen (1982). The organic carbon was estimated by method of Mclean (1982). The exchangeable bases and CEC were determined by the method described by Thomas (1982). Particle size distribution was calculated by hydrometer method (Gee and Bauder 1986). Soil pH was estimated by pH meter and bulk density was by the core method (Blake and Hartge 1986). Total porosity (Tp) was obtained from bulk density(db) value with assumed particle density (dp) of 2.65 g cm^{-3} as follows:

$$Tp= 100\{1-db/dp\} \text{ ------------Equation 1}$$

Where Tp=total porosity, db=bulk density, dp=particle density.

The distribution of aggregates was estimated at the macro level (WSA > 0.5mm) and micro-level (dispersion ratio, DR=%silt +clay dispersed in calgon) using the wet sieving technique described by Kemper and Rosenau (1986).

Data analysis: The data collected from the study was subjected to Statistical Analysis System (Statistical Analysis System 1999) using Duncan Multiple Range Test (DMRT).

RESULTS AND DISCUSSIONS

Initial properties of soil and ash from different agricultural wastes: The soil is strongly acidic and has low available P. The highest Mg content of 9.60 Cmol kg^{-1} was observed in ash from burnt wood and was 88, 34 and 24% higher than Mg contents of C, BMW and BSD, respectively. The order of increase in Ca content was WO>BDS>BMW>C. In general the soil has low nutrient content compared to the ashes.

Effect of ash from different agricultural wastes on maize plant: Application of ash from burnt agricultural wastes significantly increased maize plant height relative to the control at different sampling times in both cropping seasons (Table 2). The maximum plant height of 88 cm at 4 WAP was observed at BSD plots which was 1, 3 and 33% higher in WO, BMW and C, respectively. The order of plant height increase at 12 weeks after planting in 2016 was WO>BSD>BMW>C.

Significantly taller plants relative to the control were observed in ash amended plots in 2017 cropping season. The highest plant heights at 8 and 12 weeks after planting were in WO amended plots. In both planting seasons non-significant plant height were observed among the treatments at 4 WAP. The result of this study showed that ash enhanced the growth of maize plants. This may be because of the increase in nutrient availability following the addition of ash (Table 1). Mbah et al (2010) and Mbah et al (2018) also reported similar trend. Ayeni et al (2008a) also reported increase in height of seedlings amended with ash relative to the control in cocoa seedling.

Effect of the ash from different agricultural wastes on soil bulk density (bd gcm^{-3}) and total porosity (Tp %): At 45 DAP in 2016 planting season bd was significantly reduced (1.35 gcm^{-3}) in ash amended plots relative to the control (Table 3). and was lower than in BSD, BMW and control by 5,3 and 14%, respectively. In 2017 planting season) lower soil bd was observed in amended plots relative to the control at 45 and 90 DAP. For both years soil bd among treatments were not-significantly different from each other at 90 DAP. Observed soil bd values in 2016 planting season was lower than bd values in 2017 planting season. The significantly higher total porosity (Tp) was in amended plots relative to the control in both planting seasons. At 45 DAP in 2016 planting season Tp values ranged between 45-49% in amended plots. At both periods of measurement (45 and 90 DAP) Tp values were lowest and highest in WO-amended and control plots, respectively. At 90 DAP soil Tp in the treatments were significantly higher than the control, however, there was no significance difference among the plot amended with ash.

Application of ash reduced soil bd with the reduction being more pronounced at the early stages of maize growth. The higher bd observed at 90 DAP could be probably due to the breakdown of some of the organic amendments in the matrix or because of increase in soil compaction at this stage. The reduction in soil bd led to corresponding increase in soil total porosity. Low bd and high Tp may have increased root proliferation and hence growth of the maize plant (Table 1). Mbah et al (2010) earlier reported reduced soil bd and increased maize plant height in ash amended plots relative to the control.

Table 1. Initial properties of the soil and ash from different wood, burnt saw dust and burnt rice mill waste

Parameters (unit)	Soil	Burnt wood	Burnt rice mill waste ash	Burnt saw dust ash
K Cmol kg^{-1}	0.15	0.29	0.73	0.36
Mg Cmol kg^{-1}	1.20	9.60	6.37	7.25
Ca Cmol kg^{-1}	2.10	48.6	18.84	20.82
Na Cmol kg^{-1}	0.13	0.38	0.65	0.41
Avail P mg kg^{-1}	15.6	260.8	58.2	39.2
Total N g kg^{-1}	0.09	0.04	0.10	0.06
0rganic C %	1.08	0.66	0.61	10.58
pH	5.1	11.60	10.	89.30

Table 2. Effect of ash from different agricultural wastes on maize plant height at 4, 8 and 12 weeks after planting

Treatment	2016			2017		
	4	8	12	4	8	12
C	59^a	66^a	68^a	57^a	60^a	65^a
BSD	88^b	132^b	175^b	83^b	98^b	152^b
WO	87^b	150^c	176^b	84^b	122^c	168^c
BMW	85^b	163^d	169^b	80^b	119^c	140^d

C= Control, BSD= 4 t ha^{-1} burnt saw dust ash, WO=4 t ha^{-1} wood-ash, BMW=4 t ha^{-1} burnt rice mill waste ash

Values followed by different lettering in a column for control and ash-amended plots are statistically different

Table 3. Effect of ash from different agricultural wastes on soil bulk density and total porosity at 45 and 90 days after planting

Treatment	Bulk density (Bd gcm^{-3})				Total porosity (%)			
	2016		2017		2016		2017	
	45	90	45	90	45	90	45	90
C	1.58a	1.70a	1.54a	1.72a	40a	36a	42a	35a
BSD	1.47b	1.61b	1.48b	1.64b	44b	39b	44b	38b
WO	1.35c	1.60b	1.40c	1.63b	49c	40b	47c	38b
BMW	1.42b	1.62b	1.45b	1.62b	46d	38b	45b	39b

See Table 2 for details

Effect of ash from different agricultural wastes on soil aggregate stability(AS %) and dispersion ratio (DR): There was significantly higher aggregate stability (AS) in ash amended plots relative to the control (Table 4). In 2016 planting season AS values ranged from 33.3-47% with the lowest (33.3%) in the control. The order of increase in AS in 2017 cropping season was WO>BMW>BSD>C. There was no significant effect on soil DR in both cropping seasons. The observed increase in AS in ash amended plots could be attributed to higher OM added to the soil following ash application (Table 1).

Effect of ash from different agricultural wastes on soil pH, total N, available P and organic carbon (%): There was significant difference in soil pH, total nitrogen (TN), available P and organic carbon (OC%) relative to the control (Table 5). Addition of ash significantly increased soil pH with highest increase observed in WO amended plots in 2016 planting season. In this season OC% values ranged from 1.20-3.33% while the order of increase in total N and available P was BSD>BMW>WO>C and WO>BMW>BSD>C, respectively. In 2017 planting season the values of pH ranged between 4.58-5.70 with the lowest value of 4.58 observed in the control. Similarly, available P and TN ranged between 2.31-6.31and 0.12-0.33with highest value observed in WO and BSD, respectively. Highest OC value of 1.11% was observed on BSD amended plots. The value 1.11% observed in BSD amended plots was 20%,8% and 1% higher than observed values in C, WO and BMW, respectively. Increase in available P in the amended plots could be attributed to higher levels of P released from the ash (Table 1).

Ayeni et al (2008b) reported increased in soil pH and organic carbon following addition of 10 t ha-[1] of cocoa pod ash while Awodun et al (2009) showed that the liming effect of

Table 4. Effect of ash from different agricultural wastes on soil aggregate stability (AS%) and dispersion ratio (DR)

Treatment	AS 2016	AS 2017	DR 2016	DR 2017
C	33.3^a	30.0^a	0.75^a	0.68^a
BSD	42.3^b	40.8^b	0.77^a	0.76^a
WO	47.0^c	44.9^c	0.78^a	0.70^a
BMW	44.6^d	42.8^d	0.78^a	0.71^a

See Table 2 for details

ash create favorable pH that increase soil nutrient content. In a study on the physicochemical properties of an acid Ultisol subjected to different tillage practices and wooash application. Nnadi et al (2019) reported increased total N, available P, organic carbon and pH in wood ash amended tillage practices relative to non-wood ash amended tillage practices. Ayeni et al (2008a) and Mbah et al (2010) also reported increased soil pH in ash amended soil relative to non-ash treated soil.

Effect of ash from different agricultural wastes on soil exchangeable bases and cation exchange capacity (Cmol+kg^{-1}): The addition of ash from different wastes significantly increased soil exchangeable bases and CEC in both planting seasons (Table 6). In 2016 planting season increase in Ca and Mg were in the order W>BSD>BRM>C and BMW>BSD>WO>C, respectively. In the same planting season Na and K values ranged between 0.11-0.16 and 0.11-0.19 Cmol+kg-^{1}, respectively. Highest CEC value of 2.60 Cmol+kg-^{1} was observed in WA amended plots. This value 2.6 (cmol+kg-^{1})was higher than CEC values in control, BSDA and BMWA by 62, 50 and 30%, respectively. In 2017 planting season highest Ca, Mg and Na values were observed in WA amended plots. The order of increase in Ca and Mg in 2017 cropping season was WO>BMW>BSD>C and BMW>WO>BSD>C, respectively. In both planting seasons application of ash did not have significant effect on Na content of the soil among the treatments.

In the same planting season highest K and CEC values were observed in WA amended plots. The lowest values in all parameters studied in this planting season were observed in the control. Observed Increase in exchangeable bases in this study could be attributed partly to higher content of exchangeable bases in the ashes (Table 1) and partly to microbial activities in the soil and breakdown of OM Studies by Smith et al (2001) and Owolabi et al (2003) showed that plant derived ash such as sawdust, wood and oil palm bunch increased macronutrient content of the soil and nutrient uptake of crops.

Effect of ash from different agricultural wastes on maize grain yield (t ha^{-1}): The application of the amendments significantly increased maize grain yield relative to the control in both planting seasons (Table 7). In 2016 planting season maize grain yield ranged between 0.98-2.0 t ha^{-1}. The highest grain yield of 2.0 t ha^{-1} was observed in WA-amended plot. The grain yield value of 2.0 t ha^{-1} in WO amended plot was higher than maize grain yield values in BSDA, BMWA and control by 16, 15 and 95%, respectively. Similarly, higher grain yield in ash amended plots relative to the control was observed in 2017 planting season. The order of grain yield increase in this planting season was WO>BSD>BMW>C. In both cropping seasons non-significant treatment effect was observed between BSD and BWM. The higher maize grain yield in ash amended plots could be attributed to the reduction in bulk density, increased total porosity, aggregate stability and consequently increased nutrient availability to the maize plant. The higher yield observed in ash amended plots relative to the control could also be as a result of addition of OM in the soil following application of the ash

Table 5. Effect of ash on soil pH, Total N, Available P and Organic carbon(%)

Treatment	2016				2017			
	Ph	Av.	PTN	OC%	pH	Av.	PTN	OC%
C	4.60a	4.2a	0.26a	1.20a	4.58a	2.31a	0.12a	0.90a
BSDA	5. 60b	6.6b	0.38b	2.90b	5.61b	5.20b	0.33b	1.11b
WO	5.69c	8.2c	0.26c	3.32c	5.70c	6.31c	0.22c	1.02c
BMW	5.52d	6.7d	0.30d	2.60d	5.53d	5.36d	0.27d	1.10b

See Table 2 for details

Table 7. Effect of ash from different agricultural wastes on maize grain yield (t ha^{-1})

Treatment	2016	2017	Mean
C	0.98^{a}	0.70^{a}	0.84
BSD	1.68^{b}	1.47^{b}	1.58
WO	2.00^{c}	1.58^{c}	1.79
BMW	1.70^{b}	1.43^{b}	1.57

See Table 2 for details

Table 6. Effect of ash from different agricultural wastes on soil exchangeable bases and cation exchange capacity (CEC - Cmol+kg^{-1})

Treatment	2016					2017				
	Ca	Mg	K	Na	CEC	Ca	Mg	K	Na	CEC
C	0.78a	0.62a	0.10a	0.11a	0.98a	0.68a	0.41a	0.08a	0.09a	0.07a
BSD	3.60b	2.00b	0.14b	0.16b	1.30b	1.06b	1.38b	0.12b	0.14b	1.01b
WO	4.21c	1.80c	0.19c	0.15b	2.60c	2.11c	1.56c	0.15c	0.13b	1.50c
BMW	2.60d	3.60d	0.14b	0.16 b	1.82d	2.02d	2.20d	0.11b	0.11b	1.28d

See Table 2 for details

(Table 1). Nweke et al (2017) also reported increased in soil pH, available P and castor yield in tillage practice amended with woodash Mbah et al (2004) observed that continuous cultivation without addition of amendments reduce crop yield. The results of this study confirm earlier report by Mbah et al (2010) and Okoye (2018) when they used ash as soil amendment.

CONCLUSION

The application of ash from different sources significantly improved soil physical and chemical properties relative to the control. Similarly, maize plant height and grain yield were increased relative to the control following the addition of the ash. The improvement in soil properties and increase in agronomic parameters varied among the treatments due to their sources. On the average WA gave the highest improvement in the soil properties and agronomic parameters studied. This placed WO as a better amendment than BSD and BMW for use in the study area. Thus more researches on ash from different sources and crops adaptability to their use as soil amendment in the tropics is recommended.

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Profitability and Economic Efficiency of Input Use in Vegetable Cultivation in Himachal Pradesh

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Abstract: The present study was conducted to examine the resource use efficiency of organic and inorganic vegetable crops in low hill zone of Himachal Pradesh. Simple random sampling technique was used to select a sample of 100 farmers. Cost incurred was higher for the cultivation of inorganic vegetable crops whereas, returns and output-input ratio was higher in organic cultivation. Cultivation of vegetable crops revealed that majority of inputs is being underutilized. Thus there is need for proper reallocation of the resources which will result in enhanced production. Major problems in the cultivation of vegetable crops were high wage rate, lack of organic certification, shortage of skilled labour and lack of technical knowledge.

***Keywords*:** Organic, Inorganic, Simple random sampling, Resource use efficiency

Organic agriculture is developing rapidly and is now practiced in more than 120 countries of the world. According to the latest survey on organic farming worldwide, a total of 71.5 million hectares were organically managed at the end of 2018, representing a growth of 2.90 percent or 2 million hectares compared to 2017. Australia has the largest organic agricultural area (35.7 million hectares), followed by Argentina (3.6 million hectares), and China (3.1 million hectares). In India, organic farming is in a nascent stage and about 2.78 million hectare of farmland was under organic cultivation as of March 2020. (FiBL survey, 2019).India holds the world's second largest agricultural land and accounts for 13 per cent of global vegetable output (National Horticulture Board, 2018) with an area of 10.26 MH with a annual production of 184.4 MT and productivity of 17.97 t/ha. Over the last few years, India has witnessed massive growth in vegetable production. India is home to 30 per cent of the world's total organic farmers, but accounts for only 2.59 per cent (1.5 million hectares) of the global organic cultivation area of 57.8 million hectares (FiBL survey, 2019). According to statistics, India ranks 8th in terms of World's organic Agricultural land and 1st in terms of organic producers in 2020. The majority of Indian population depends on vegetables and thus it is necessary to focus on the production of vegetables. The leading vegetable producing states are Uttar Pradesh, West Bengal, Bihar, Madhya Pradesh, Gujarat, Odisha and Karnataka. Himachal Pradesh is in the 2nd place for the largest area under organic certification. In Himachal Pradesh, the total area under vegetables is 75.23 thousand hectares with a total production of 1608.55 thousand MT. The State's farmers have shown growing interest in organic farming in the recent past and aims to increase the area under organic farming in its policy document on organic agriculture. Thus keeping in view the above facts the present study was conducted in low hill zone of Himachal Pradesh to estimate the profitability and resource use efficiency in organic and inorganic vegetable production.

MATERIAL AND METHODS

Profitability analysis: The study was conducted in the low hill areas of Himachal Pradesh and Bilaspur and Una districts were selected randomly on the basis of area under vegetables crops. Two blocks each from selected districts were selected randomly for the collection of primary data. Simple random sampling technique was used to select respondents. A list of organic and inorganic vegetable growers was prepared with the help of agriculture and horticulture departments and other agencies from the selected blocks and a sample of 100 vegetable growers comprising of 50 each from selected blocks was selected for collecting the requisite data. The data were collected and analysed for the reference year 2019-20. Regression analysis using Cobb – Douglas function was used to determine resource use efficiency. To estimate the cost and returns from organic and inorganic vegetable cultivation, CACP cost concepts were used framed by the Estimation Committee on Cost of Cultivation, 1981, Directorate of Economics and Statistics, Government of India..

Cost A_1 = Seed/Seedling cost **+** Value of manures, fertilizers and plant protection chemicals **+** Owned and hired machinery **+** Irrigation charges **+** Depreciation on implements, farm buildings and irrigation structures **+** Interest on working capital **+** Other miscellaneous charges.

Cost A_2: Cost A_1 + rent paid for leased in land

Cost B_1: Cost A_1+ interest on the fixed capital

Cost B_2: Cost B_1 + rental value of owned land

Cost C_1: Cost B_1 + imputed value of family labour

Cost C_2: Cost B_2 + imputed value of family labour

Cost C_3: Cost C_2 + value of management input (10% of Cost C_2)

Income measure: Following income measures were estimated:

Farm business income **=** Gross income – Cost A_1

Family labour income **=** Gross income – Cost B_2

Farm investment income **=** Farm business income – farm labour wages

Net income **=** Gross income – Total cost (C_3)

Output input ratio = Gross income ÷Total cost (C_3)

Estimation of resource use efficiency

Regression analysis using a non – linear Cobb – Douglas function was used to determine resource use efficiency in inorganic and organic cauliflower and potato mentioned by Rahman and Lawal (2003).

$Y = \beta_0 X_1^{\beta 1}\ X_2^{\beta 2}\ X_3^{\beta 3}\ X_4^{\beta 4}\ U_t$

For the analysis of above model, it is converted into the linear form by taking the logs on both sides:

$\text{Log } Y = \text{Log } \beta_0+\beta_1 \log X_1+\beta_2 \log X_2+\beta_3 \log X_3+\beta_4 \log X_4$

Where,

Y = Gross Returns per hectare, X_1 = Expenditure on seeds (Rs.) per hectare, X_2 = Expenditure on FYM (Rs.) per hectare, X_3= Expenditure on fertilisers (Rs.) per hectare, X_4= Expenditure on plant protection (Rs.) per hectare, β_0 = Intercept, U_t= The error term, β_i = The elasticity coefficient (i =1, 2, 3.....)

The marginal value product of a particular resource represents the expected addition to the gross returns by using an additional unit of a resource, while other inputs are kept constant. The marginal value products (MVPs) of the resources employed in organic / inorganic vegetables production were estimated by multiplying the marginal physical product (MPP) by the unit price of the output(y).

$MVP_{xi} = MPP_{xi}.Py$

Where, MVP_{xi}= Marginal value product of i^{th} input**,** MPP_x = Marginal physical product of the i^{th} input**,** $\mathbf{P_y}$ = Price of unit output

Estimation of MVP-Factor Cost Ratio (r):

$r = MVP_{xi}/MFC$

Where, r = Allocative Efficiency, MVP_{xi}= Marginal value product, MFC = Marginal factor cost

If, r = 1 resource efficiently used, r > 1 resource underutilized, r < 1 resource over utilized

Estimation of D Value: Relative percentage change in MVP was calculated by using following formula:

$$D = \left(\frac{1 - MFC}{MVP}\right) * 100$$

Where, D is absolute value percentage change in MVP of each resource (Mijindadi 1980).

RESULTS AND DISCUSSION

Profitability analysis of major vegetable crops: The costs A_1, B_2, C_3 were Rs. 75, 106.12, Rs. 85, 455.44 and Rs. 1.22 lakh per hectare for inorganic cauliflower production. Net income estimated was Rs. 1.06 lakh per hectare.

Table 1. Costs and returns estimate of cauliflower and potato

(Rs ha^{-1})

Particulars	Inorganic		Organic	
	Cauliflower	Potato	Cauliflower	Potato
Cost A_1	75106.00	72214.00	55588.98	75528.25
Cost B_2	85455.44	108046.45	110952.65	130300.00
Cost C_3	121964.15	155143.64	138045.19	162402.08
Yield (q ha^{-1})	151.96	283.41	140.55	274.51
Gross Income	227940.38	340086.36	281100.20	411762.80
FBI	152834.25	267871.47	256678.32	387340.93
FLI	118063.06	265033.13	266557.22	394424.54
FII	20573.95	20573.95	20573.95	20573.95
Net Income	105976.22	184942.72	143055.01	249360.72
Output-Input Ratio	1.89	2.20	2.15	2.55

FBI= Farm business income, FLI= Farm labour income, FII= Farm Investment Income

However, in case of organic cauliflower total cost incurred for the cultivation was Rs 1.38 lakh on per hectare basis. Net income was estimated as Rs. 1.43 lakh per hectare. Thus the output-input ratio in organic cultivation of cauliflower (2.15) was higher than inorganic one (1.89). For inorganic potato production total cost incurred was Rs.1.55 lakh per hectare and net income was estimated to be Rs.1.84 lakh per hectare with an output-input ratio of 2.20.In organic potato, total cost was Rs.1.62 lakh per hectare incurred for production of the crop and net income was estimated to be Rs.2.49 lakh per hectare with an output-input ratio of 2.55.

Production function analysis and resource use efficiency in vegetable crops: In inorganic cauliflower, the estimated Cobb-Douglas production function was statistically significant and explained 87 per cent of variation in cauliflower production. The sum of the elasticity coefficients ($\Sigma\ b_i$= 0.66) was less than unity, indicating a decreasing return to scale. For organic cauliflower, the estimated function was statistically significant and explained 80 per cent of variation in organic cauliflower production. The sum of the elasticity coefficients (Σb_i= 1.11) was more than unity, indicating a increasing return to scale. Seed (0.39), plant protection (0.30) and labour (0.42) were the significant factors in organic cauliflower production. In inorganic potato, the estimated function was found statistically significant and explained 97 per cent of variation in potato production. The inputs such as fertilizer, plant protection and labour were significantly contributing to production. The sum of the elasticity coefficients (Σb_i= 0.42) was found less than unity, indicating a decreasing return to scale in potato production. For organic potato, the estimated function was found statistically significant and explained 98 per cent of variation in organic potato production. The sum of the elasticity coefficients (Σbi= 0.87) was less than unit, indicating a decreasing return to scale in organic potato cultivation. Seed (0.44) and fertilizer (0.43) are the two significant factors in organic potato.

Table 2. Regression coefficients of different production variables of major vegetable crops in the study area

Particulars	Inorganic		Organic	
	Cauliflower	Potato	Cauliflower	Potato
Seeds	0.30*** (0.18)	0.56 (0.11)	0.39* (0.10)	0.44** (0.14)
Fertilizers	0.36** (0.15)	0.27** (0.11)	-0.04 (0.05)	0.43** (0.17)
Plant protection	0.19 (0.25)	0.03*** (0.01)	0.30* (0.11)	-0.02 (0.10)
Labour	0.09 (0.14)	0.12** (0.05)	0.42* (0.11)	0.20 (0.16)
Σbi	0.66	0.42	1.11	0.87
R square	0.88	0.97	0.81	0.99
Adjusted R square	0.87	0.97	0.80	0.98
F cal	129.08	709.06	47.95	748.76

*, **, *** denotes significance at 1%, 5% and10%
Figures in the parenthesis are the standard errors

Marginal value product (MVPs) and factor price ratio of vegetable crops: The efficiency ratio i.e. 5.78 for seed and 7.55 for fertilizer were greater than unity indicating the underutilization of the resources in the production of inorganic cauliflower (Table 3). The use of seed and fertilizer was at optimum economic advantage. Thus, there is need for adjustment in the MVP of these resources by 82.69 per cent in seed and 86.75 per cent in fertilizer. In organic cauliflower efficiency ratio i.e. 13.93 for seed, 8.97 for plant protection and 12.69 for labour showed their underutilization in the production need to increase the use of seed, plant protection and labour by 92.82, 88.85 and 92.12 per cent, respectively. The efficiency ratio was 12.89 for fertilizer, 0.36 for plant

Table 3. Estimated marginal value product (MVPs) and factor price ratio of vegetable crops

	Inputs	Coefficients	APP	MFC	r	D-value
Inorganic cauliflower	Seed	0.30***	19.01	5.78	5.78	82.69
	Fertilizer	0.36**	20.82	7.55	7.55	86.75
Organic cauliflower	Seed	0.39*	36.02	13.93	13.93	92.82
	Plant protection	0.30*	29.67	8.97	8.97	88.85
	Labour	0.42*	30.17	12.69	12.69	92.12
Inorganic potato	Fertilizer	0.27**	47.09	12.89	12.89	92.24
	Plant protection	0.03***	13.72	0.36	0.36	-177.14
	Labour	0.12**	12.88	1.49	1.49	32.88
Organic potato	Seed	0.44*	40.83	18.04	18.04	94.46
	Fertilizer	0.43**	33.34	14.44	14.44	93.08

*, **, *** denotes significance at 1, 5 and 10%.
MIC = P_y=1

protection and 1.49 for labour showed that fertilizers and labour were underutilised whereas plant protection measures were over utilised during the production of inorganic potato. It was further found that use of fertilizers and labour should be increased. In organic potato the efficiency ratio i.e. 18.04 for seed and 14.44 for fertilizer implied their underutilization in the production. It was estimated that the use of these two inputs should be increased by more than 90 per cent to produce at optimum level.

CONCLUSION

Organic farming is a key to sustainable agriculture and serves as an alternate way of achieving the aim of economic and social development as well as solving the food security problems. The study revealed the cost differential between organic and inorganic cultivation and indicate that all the farms located in the study area were financially viable .i.e. they were capable of generating income in excess of cost of cultivation of different crops. Hence, it is advised that the farmers should switch over to organic farming which also minimizes the environmental degradation and helps the farmers for doubling their farm income. However, there is pertinent need for development of extension services, irrigation facilities, storage and marketing facilities etc. Government should focus on provision of certification of organic produce and demonstration practices to encourage the organic cultivation in the low hills of Himachal Pradesh.

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Comparative Study of Earthworm Population and Depth Distribution in Two Different Land Use Systems of Kumaun Himalaya, Uttarakhand, India

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Abstract: The present study deals with the population and depth distribution of earthworms (Annelida: Oligochaeta) in two different land-use systems (Orchards and cultivated lands) of Uttarakhand, India (Altitude 1400 m. a. s. l. Latitude 29°.29' 41" N Longitude 79° 31' 07" E). The present study was conducted to comprehend Earthworm diversity and land management in selected study sites of Kumaun Region, Uttarakhand India. The earthworms are well-known soil ecosystem engineers and very docile soil dwellers. They play a vital role in various pedological activities including soil health improvement, decomposition of organic matter, changes in porosity, water infiltration; soil microbial activity, and soil reclamation. The earthworms were collected by hand sorting method inducting catch and release practice, few mature worms were processed and preserved for the Morphometric identification and segregated based on soil depth and their maturity. Soil pH, temperature and earthworm weight was measured on-site; worms were washed and preserved in 10% formalin. Density and biomass recorded during the investigation ranged from 0.1 m^2 to 91.0 m^2 and 5 gm^2 to 15 gm^2 respectively. In Agriculture, land worm density ranged from 1.0 m^2 to 91.0 m^2 and in the Orchards worm density range was 5.0 m^2 to 37 m^2. In Cultivated land Maximum worm density was recorded at Padampuri and in Orchards at Pahadpani. Minimum worm density was recorded at Churigarh. In 0-10 cm minimum biomass, the range is 5 gm^2 in July and February, and in 10-20 cm maximum biomass, the range is 15 gm^2 in July.

Keywords: Earthworms, Population dynamics, Land use system, Soil Ecosystem

Earthworms, the terrestrial Oligochaetes are popularly known as ecosystem engineers distributed throughout the world (Suthar 2011) and are of great importance in various soil activities like the decomposition of organic matter and nutrient dynamics in various soil ecosystems.Four thousand species are present globally and India represents more than 418 species referable to 67 genera and 10 families (Mohan et al 2013). Earthworms are the most important soil organisms as they influence organic matter breakdown, soil structural development, and nutrient cycling, especially in productive ecosystems (Kooch et al 2007). Population structures of earthworms depend on several bio-geographical, physiological, and pedo-biological factors of a terrestrial ecosystem (Persuad 2009). Earthworms are the most important part of soil macrofauna contributing significantly to nutrient dynamics and soil fertility (Goswami et al 2015, Mani et al 2017). Anthropogenic activities adversely affect the diversity and population of earthworms; it can be managed by restoring soil health using varied techniques (Ribeino et al 2018).The earthworms efficiently act as an aerator, crusher and mixer of the soil and actively participate in decomposition and stimulate the soil ecosystem (Joseph et al 2020). Many natural and man made factors affect the density, biomass, cast production of earthworms in the native grassland ecosystem (Arnone 2014) and other habitats across the world's biodiversity hotspots and agro-ecosystems. Conservation of agriculture is an approach to growing crops that strives to achieve high and sustainable productivity, quality and economic viability, while also respecting the environment. (Bitew et al 2019). Research on the diversity of earthworm species in different states of India has been carried out by several workers in various ecosystems. There are many reports on earthworms from various parts of the world on their ecology and their inter-relationship with soil ecosystems and nutrient dynamics (Kangmin et al 2010, Najar et al 2011, Fuiji et al 2012, Dacaens et al 2013, Sathiavelu 2014, Sauza et al 2019, Stroud 2019). The present work is an attempt to understand the fluctuations in the population during various seasons in two different land-use systems of Indian mountain regions.

MATERIAL AND METHODS

Description of study site: Study site Dhari, Nainital is located at the altitude of 1400 m. a. s. l., latitude 29°.29' 41" N, longitude 79° 31' 07" E and was extensively surveyed and sampled the main crops grown in the area are *Solanum tuberosum, Zea mays, Brassica oleracea, Phaseolus vulgaris, Pisum sativum,*and orchards are rich in *Malus* *domestica, Prunus persica, Malus domestica, Citrus limon*. Earthworms were collected monthly during all seasons by hand sorting method using a quadrate of 50×50 cm up to the depth of 20 cm. Morpho-metrically different earthworms were collected, rinsed, dried on blotting paper, weighted, anesthetized in 70% alcohol followed by preservation in 10% rest of the worms were documented and released. Soil pH was determined by a pH meter (HI208). Soil temperature was measured at various depths 0-10cm and 10-20 cm using a soil probe thermometer, from April 2019 to February 2020.

RESULTS AND DISCUSSION

The maximum number of earthworms recorded was129 at Padampuri during July. The maximum Number of clitellate worms was found at the village Padampuri (Table 1). The maximum soil moisture was 37 and 34% in 0-10cm and 10-20cm soil layers, at Managhair, maximum soil moisture was 37% in 0-10cm depth and Okhalkanda 34% in 10-20cm soil layers in cultivated land. In the Orchards maximum soil moisture was at Okhalkanda i.e 28% and 32% at 0-10 and 10-20cm respectively. Soil pH was near neutral in all study sites. (Table 2). Carbon content was between 0.94 to 4.56%in the soil samplesDhari. Nitrogen content recorded between 0.09% to 0.38% (Table 3). The phosphorus range was 0.0018 to 0.0115% in cultivated land and Orchards. The maximum phosphorus was in the soil of Nadgal i.e. 0.0115 and 0.0101%. The potassium range was 0.0070 to 0.0862%. in cultivated land. Maximum potassium was at Churigarhin Orchards was 0.0446% at Nadgal (Table 4).

Density and biomass: In the year 2019-2020at the site

Table 1. Earthworms recorded in various study sites of Dhari region

Month (2019)	Study site	Total no of earthworms observed/collected	Earthworms in agriculture land (%)	Earthworms in orchards (%)	Clitellate worms (%)	Aclitellate worms (%)
April	Dhanachuli	47	13	87	26	74
May	Sasbani	77	47	51	46	53
June	Managhair	88	49	51	45	55
July	Padampuri	129	84	16	81	19
August	Okhalkanda	65	29	71	45	55
September	Nadgal	73	11	89	56	44
October	Pahadpani	114	56	44	79	21
November	Sarna	117	59	41	49	50
December	Matiyar	78	69	30	38	61
January	Churigarh	0	0	0	0	0
February	Chaukhuta	18	83	16	72	16

Table 2. Soil Moisture and pH of agricultural land and orchards

2019			Agriculture land				Orchard			
Months	Sites	Temperature	Moisture (%)		pH		Moisture (%)		pH	
			Soil Depth (cm)							
			0-10	10-20	0-10	10-20	0-10	10-20	0-10	10-20
April	Dhanachuli	11°C	25	8	6.1	6.1	12	22	5.7	5.7
May	Sasbani	9°C	34	24	6.5	6.6	15	19	6.2	6.2
June	Managair	9°C	37	25	6.8	6.9	6	2	6.5	6.2
July	Padampuri	14°C	20	24	5.9	5.8	17	21	5.8	5.8
August	Okhalkanda	17.5°C	30	34	7.1	7.0	28	32	7.3	7.9
September	Nadgal	13.5°C	22	22	7.1	6.9	26	24	7.8	8.0
October	Pahadpani	12°C	25	26	6.5	6.4	24	26	6.4	6.5
November	Sarna	7.5°C	20	20	6.5	5.9	16	18	4.6	5.9
December	Matiyar	3.1°C	20	19	5.7	5.6	16	11	7.0	6.7
January	Churigarh	1°C	31	30	7.5	7.5	18	16	6.8	7.2
February	Chaukhuta	4°C	18.3	18	6.5	6.3	14	12	6.5	6.6

Table 3. Status of soil nutrients in agriculture land and orchards (2019)

2019		Agriculture land				Orchard			
Months	Sites	Carbon (%)		Nitrogen (%)		Carbon (%)		Nitrogen (%)	
		Soil Depth (cm)							
		0-10	10-20	0-10	10-20	0-10	10-20	0-10	10-20
April	Dhanachuli	1.25	0.94	0.13	0.10	3.04	2.34	0.13	0.09
May	Sasbani	2.90	2.88	0.13	0.11	2.60	2.24	0.13	0.09
June	Managair	2.93	2.80	0.15	0.13	2.61	2.26	0.14	0.10
July	Padampuri	4.52	4.45	0.25	0.23	3.94	3.43	0.24	0.22
August	Okhalkanda	3.92	4.56	0.26	0.31	2.15	4.52	0.18	0.29
September	Nadgal	3.98	3.82	0.32	0.29	1.60	1.44	0.25	0.24
October	Pahadpani	1.32	1.22	0.15	0.09	2.54	2.32	0.15	0.13
November	Sarna	3.51	3.00	0.15	0.12	2.46	2.07	0.18	0.16
December	Matiyar	1.76	2.22	0.38	0.24	2.34	1.87	0.33	0.35
January	Churigarh	3.16	2.85	0.44	0.51	2.42	2.03	0.32	0.18
February	Chaukhuta	1.68	1.60	0.19	0.19	2.42	2.15	0.29	0.16

Table 4. Soil nutrients in agriculture land and orchards

2019		Agriculture land				Orchard			
Months	Sites	Phosphours (%)		Potassium (%)		Phosphours (%)		Potassium (%)	
		Soil Depth (cm)							
		0-10	10-20	0-10	10-20	0-10	10-20	0-10	10-20
April	Dhanachuli	0.0058	0.0023	0.0376	0.0222	0.0072	0.0036	0.0231	0.0075
May	Sasbani	0.0078	0.0072	0.0382	0.0365	0.0071	0.0052	0.0220	0.0149
June	Managair	0.0081	0.0061	0.0437	0.0373	0.0072	0.0051	0.0191	0.0159
July	Padampuri	0.0080	0.0068	0.0332	0.0367	0.0082	0.0057	0.0151	0.0098
August	Okhalkanda	0.0089	0.0077	0.0448	0.0327	0.0073	0.0087	0.0234	0.0429
September	Nadgal	0.0115	0.0112	0.0461	0.0428	0.0095	0.0101	0.0446	0.0441
October	Pahadpani	0.0062	0.0028	0.0326	0.0242	0.0075	0.0045	0.0202	0.0142
November	Sarna	0.0023	0.0030	0.0438	0.0454	0.0039	0.0032	0.0094	0.0079
December	Matiyar	0.0037	0.0032	0.0224	0.0196	0.0064	0.0028	0.0075	0.0070
January	Churigarh	0.0064	0.0037	0.0862	0.0653	0.0032	0.0018	0.0192	0.0132
February	Chaukhuta	0.0105	0.0055	0.0328	0.0228	0.0059	0.0078	0.0091	0.0082

Table 5. Earthworm density (m^2) in land-use systems at different depth

		Agriculture land		Orchard	
		0-10 cm	10-20 cm	0-10 cm	10-20 cm
April	Dhanachuli	5.0	1.0	35.0	6.0
May	Sasbani	24.0	34.0	35.0	19.0
June	Managair	24.0	19.0	27.0	18.0
July	Padampuri	91.0	18.0	15.0	5.0
August	Okhalkanda	12.0	7.0	34.0	12.0
September	Nadgal	8.0	0	34.0	31.0
October	Pahadpani	30.0	34.0	35.0	15.0
November	Sarna	32.0	37.0	30.0	18.0
December	Matiyar	41.0	13.0	10.0	14.0
January	Churigarh	0	0	0	0
February	Chaukhuta	5.0	10.0	3.0	0

Table 6. Earthworm biomass (gm²) in land-use systems at different depth

Months	Study area	Total number of earthworms	Biomass of earthworms in 0- 10 cm	Biomass of earthworm in 10-20 cm
April	Dhanachuli	47	15	6
May	Sasbani	77	10	14
June	Managhair	88	10	15
July	Padampuri	129	5	15
August	Okhalkanda	65	15	5
September	Nadgal	73	10	5
October	Pahadpani	114	10	5
November	Sarna	117	10	6
December	Matiyar	78	6	3
January	Churigarh	0	0	0
February	Chaukhuta	18	5	5

Table 7. Correlation between earthworm density (cultivated land and orchards) and biomass

Density (Cultivated land)	Density (Orchard)	Biomass
0-10 cm,10-20 cm	0-10 cm,10-20 cm	0-10 cm,10-20 cm
0.4796	0.6760	0.191

Table 8. Correlation between earthworm density and biomass, pH, moisture, carbon, nitrogen, phosphorus and potassium of cultivated land and orchard

Biomass	Biomass	pH		Moisture		Carbon		Nitrogen		Phosphorus		Potassium	
0-10	10-20	0-10	10-20	0-10	10-20	0-10	10-20	0-10	10-20	0-10	10-20	0-10	10-20
Density cultivated land (0-10 cm)													
0.8857	0.3091	0.0741	0.0577	0.1163	0.0291	0.1729	0.1535	-0.5016	-0.4679	0.0904	0.288	-0.4143	-0.3121
Density Ccultivated land (10-20 cm)													
0.446	0.2024	0.0643	0.0169	-0.0155	-0.1602	0.0322	0.3109	-0.1127	-0.2562	-0.1213	-0.5473	-0.0893	-0.0728
Density orchard (0-10 cm)													
0.8857	0.3091	-0.0405	0.0442	0.4086	0.649	-0.143	0.1824	-0.8155	-0.2547	0.5523	0.2737	0.3903	0.3806
Density orchards (10-20)													
0.446	0.2024	0.2243	0.2798	0.3741	0.3026	-0.5191	-0.2857	-0.3242	0.0914	0.4768	0.3605	0.5118	0.5107
Correlation Between Density(0-10) Cultivated Land													
Cultivated land													
0-10	10-20	0-10	10-20	0-10	10-20	0-10	10-20	0-10	10-20	0-10	10-20	0-10	10-20
Density cultivated land (0-10 cm)													
-0.1743	0.6057	-0.564	-0.5788	-0.2421	-0.1479	0.4126	0.4187	-0.0653	-0.2243	-0.1992	-0.0367	-0.2536	-0.0292
Density cultivated land (10-20 cm)													
0.0958	0.3659	-0.178	-0.3185	-0.2266	-0.3664	0.1251	0.0475	-0.3623	-0.4262	-0.3476	-0.2272	-0.2673	-0.0813
Density Orchards (0-10 cm)													
-0.1743	0.6057	0.0741	-0.4427	0.1163	0.0291	0.1729	0.1535	-0.5016	-0.4679	0.0904	0.288	-0.4143	-0.3121
Density Orchards (10-20 cm)													
0.446	0.2024	0.0643	0.0169	-0.0155	-0.1602	0.0322	0.3109	-0.1127	-0.2562	0.1213	0.5473	-0.0893	0.0728

Significant at = P> 0.01 or P <0.01, Significant at = P> 0.05 or P <0.05

Table 9. Correlation between earthworm biomass at variable depths with pH , moisture, carbon, nitrogen, phosphorus and potassium of both the land use system

pH		Moisture		Carbon		Nitrogen		Phosphorus		Potassium	
Biomass cultivated land (0-10 cm)											
0-10	10-20	0-10	10-20	0-10	10-20	0-10	10-20	0-10	10-20	0-10	10-20
-0.0788	-0.0827	0.0244	0.0566	-0.0589	0.0012	-0.5784	-0.742	0.0508	0.1439	-0.5378	-0.5232
Biomass orchard (0-10 cm)											
-0.0538	0.0099	0.4418	0.6723	-0.1395	0.3429	-0.783	-0.1563	0.4607	0.333	0.2973	0.3753
Biomass cultivated land (10-20 cm)											
-0.5109	-0.3673	-0.0299	-0.1015	0.2951	0.2623	-0.6287	-0.6004	0.1555	0.3043	-0.2016	-0.0294
Biomass orchards (10-20 cm)											
-0.3705	-0.5639	-0.2792	0.1852	0.5513	0.2057	-0.591	-0.4333	0.3659	0.1519	0.0475	-0.0926

Significant at = P> 0.01 or P <0.01, Significant at = P> 0.05 or P <0.05

Dhari worm density recorded in Agriculture land was 1.0 m^{-2} to 91.0 m^{-2} and in Orchards, it ranged 5.0 m^{-2} to 37 m^{-2} respectively (Table 5). Similarly, earthworm biomass ranged from 5 gm^{-2} to 15 gm^{-2}. In the depth 0-10cm,the minimum biomass was 5 gm^{-2} in July and February and at 10-20 cm depth biomass was maximum i.e15 g m^{-2} in July (Table .6)

During the entire course of study the earthworms collected and identified were the representatives of the Family Lumbricidae: *Aporrectodea trapezoides, Eisenia fetida, Octolasion cyaneum* Family Megascolecidae*: Amynthas morrisi, Amynthas alexandri, Amynthas corticis, Metaphire anomala, Amynthas gracilis, Metaphire houlleti, Metaphire birmanica* (Julka 1988). It indicates the entire area is having a very good diversity of mountain earthworms and well acclimatized with the local environment of earthworms. The temperature, pH and moisture correlated with the minimum and the maximum number of earthworms indicates that the best-suited temperature was 14 to 18 C, pH 6 to 8 and moisture content 15-25%. It is a well-known fact that neutral pH is ideal for earthworms but it was observed these earthworms in the mountain region can adjust themselves to acidic soils too .Earthworms are very sensitive bio-indicator their density and abundance increase with the presence of available nutrients, less tillage and less plowing, therefore, it is evident with the present findings i.e. that the numbers of earthworms found more in orchards in comparison to agricultural land as less mechanical tillage is practiced in orchards.

CONCLUSION

The present study deciphered information on the diversity of earthworms in two different land-use systems and their correlation with various environmental conditions, soil pH, moisture content temperature along with the soil nutrients like carbon, nitrogen, phosphorus and potassium. The study yielded information on vertical distribution on clitellate and aclitellate earthworms. It is assumed that the selected site both agriculture and orchards are a rich and diverse repository of earthworms therefore more extensive faunistic survey is needed to uncover earthworm diversity in the mountains of the State of Uttarakhand.

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Monitoring and Evaluation of Tropospheric NO2 Columns Density and Ultraviolet Aerosol Index (UVAI) over Iraq during the Outbreak of COVID-19 Using Remote Sensing and GIS

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Abstract: Since the discovery of COVID 19 coronavirus in January 2020 and the researchers everywhere try to find a reason behind spreading of coronavirus over the world. The important question here is, does air pollution can be a good medium to increase the infection rate and spread of COVID-19. In present work, ESA remote sensing data, specifically, Sentinel 5p Level 2 data to study the air pollutants with high spatial-temporal resolution was analyzed. We used the tropospheric NO2 vertical column density, along with UV Aerosol Index (UVAI) were used to investigate the role of changing in the air pollutants on the spread of COVID-19. The continuous decrease in the in tropospheric nitrogen dioxide NO_2 amounts in all cities in Iraq during the lockdown measures. At the same time, the results illustrate a significant increase in UV Aerosol Index in all cities in Iraq. More specifically, the cities that have the highest levels of air pollution are Baghdad and Basra. The maximum declination in NO2 was 43% lower than that from 1-31 January 2020. On the other hand, we found a significantly large increase ratio in UVAI and the largest increase is 239.8 and 221.2% in June and July respectively. In the end, we concluded that the implementation control actions in Iraq have been effectively contributed to reducing the current air pollution situation and increasing the air quality but unfortunately, the effectiveness of the actions didn't help to reduce the spread of the COVID-19 pandemic and decrease the number of cases of coronavirus in Iraq.

Keywords: COVID-19, UVAI, NO_2, Sentinel 5P, GIS

Air pollution become a major problem, especially in the major industrialized countries, which contribute to the emission of a high percentage of polluting gases and particulate matter (WHO, 2000). Some of these air pollutants absorbs solar radiation, changes cloud properties, atmospheric stability and dynamics of circulation and the water cycle (Jing et al 2019). It also affects the climate system through the detection of incoming shortwave radiation and operates as radiation scatters, decreasing surface irradiance (Samset et al 2018). Oxidation of NO from natural forest fires and lightning is one of the main causes of this air pollution (Morton and George 2020). Nitrogen oxides are a collection of seven gases and compounds mainly consisting of nitrogen and oxygen. NO2 pollution is emitted from automobile exhaust and from coal, oil, diesel and natural gas combustion, particularly from power plants. When it combines with sunlight and other chemicals to form smog it can create environmental health hazards. It's not only promotes the formation of ozone, but also has adverse human health effects. The tropospheric NO2 obtained from the satellite Sentinel-5P can be used to clarify the spatial variation effects of this gas on the spread of COVID-19 and to demonstrate the impact of continuous gas exposure on the exacerbation of the disease and an increase in deaths (Yaron O 2020). COVID-19 pandemic is a continuing global pandemic coronavirus disease 2019 (COVID 19), caused by severe acute coronavirus syndrome 2 (Mikalai et al 2020). The outbreak initially started in December, 2019 in Wuhan, China. The epidemic was declared a public health emergency of international concern by the World Health Organization (WHO) on 30 January 2020, and a pandemic on 11 March 2020 [WHO, 2020]. For Iraq which has a population of 40335690, the total cases up to 19 August, 2020 is about (188802), total death (6206) and total recovered (134369) (Worldometer 2020). Another factor which's affect the spreading of COVID-19 is the Ultra-Violet Aerosol Index (UVAI). This term can be defined by means of the aerosol index (AI), a qualitative index that indicates the existence of elevated aerosol layers with substantial absorption. The main types of aerosols that cause signals detected in the AI are desert dust, biomass burning and volcanic ash plumes (Omar et al 2007). The Sentinel-5P aerosol index is referred to as the Ultraviolet Aerosol Index (UVAI) (TROPOMI 2020). Then, The UVAI describes as a functional parameter for the identification of UV-absorbing aerosols (Sujung et al 2017). The objectives of the present study is to analyze Sentinel-5P satellite dataset of the atmospheric nitrogen dioxide (NO2) pollution and (UVAI) in the period of the outbreak of the COVID-19 in Iraq.

MATERIAL AND METHODS

In this study, Iraq was chosen as the area of interest is located in the south-West of Asia between latitudes of (29° and 38°) North, and longitudes of (39° and 49°) East (Fig. 1). Iraq has the form of a valley, consisting of the great Tigris and Euphrates alluvial plains of Mesopotamia. The plain is surrounded by northern and eastern mountains (the highest point being at 3,611 m), and southern and western desert regions, which account for over 40 percent of the land area, also upland rolling between the upper Euphrates and the river Tigris (Sabah 2015). Iraq has a semi-dry climate. The climate is influenced by the location of Iraq between the subtropical aridity of the Arabian desert regions and the subtropical humidity of the Arabian Gulf. The monthly average temperatures range from higher than (48°C) in summer, to about (0°C) in winter. Most of the precipitation occurs between December and April, the mean annual precipitation is about (100-180 mm) (Yaseen 2020). Northern mountainous region has a higher precipitation than the central and southern regions.

DATA ANALYSIS

Data access: Sentinel 5-P data (TROPOM) Level 2 products are accessible via Copernicus Open Access Hub and are free to access on the Sentinel-5P Pre-Operations Data Hub. The data can be downloaded using the open Hub in: https://scihub.copernicus.eu/ and open the search menu to specify the product types, sending period, check mission, processing level, and timelines. Table 1.

To target a product of a global map, kept the accepted entries for the timeliness to be "Offline". The available Sentinel-5p products was be delivered in form as the Network Common Data (NetCDF files) (NetCDF 2020). The file format is very flexible and is an interface to a library of data access functions for storing and retrieving data in the form of an N-dimensional array (Fabian 2020). The output product contains two groups: “PRODUCT” and “METADATA”.

The first group "PRODUCT" contains the main data parameters of the product; latitude, longitude, and variable to determine the observation time and the dimensions needed for the other required data, in addition to the “qa_value” parameters. The second group "METADATA" aims to facilitate dataset discovery and stored the metadata items, such as the header file (Mill 2012). We downloaded (29 - 31) files from the Sentinel 5p, for each day, and then processed the data using The Basic ENVISAT Atmospheric Toolbox (BEAT).

Data analysis: In this work, we use VISAN application to map the global monthly average tropospheric L2__NO_2 column number density and UV Aerosol Index. We first processed the data into daily average files using specific codes for both products to manipulate and visualize the data. Then we measured the daily averages of the import products to make a monthly average. Next, we exporting these monthly average maps to panoply and ArcGIS10.8 to design the geo-gridded final map.

In order to find the daily average of the products and create a map of the import products, processed the Sentinel-5p data _ Level 2 and keep a single grid per orbit (level 3). The conversion was done by combining several operators in one step. The first step here is to map all time samples in the product onto a spatial (latitude, and longitude) grid and then concatenate all the output files to create an average map between latitudes [29°, 38°] N, and longitudes [39°, 49°] E. Sentinel-5p data are available with latitude/longitude bounds variable. The latitude, longitude, pixel corner coordinates, and related angles and satellite position in the level 2 files are copied from the level 1B input data [RD34, chapters 26 and 27]. The latitude and longitude are given at the intersection of the line of sight with the WGS84 ellipsoid. The geo-coordinates of the pixel corners show in Figure 2. (Christoph 2020).

In the next step, derived the monthly averaged map of the tropospheric vertical column of NO2 and for UV Aerosol Index in the interesting area for latitudes using a list of operations applied to all products every month to combine multiple products from the input files by appending them across the time dimension and storing the output results into a single output file.

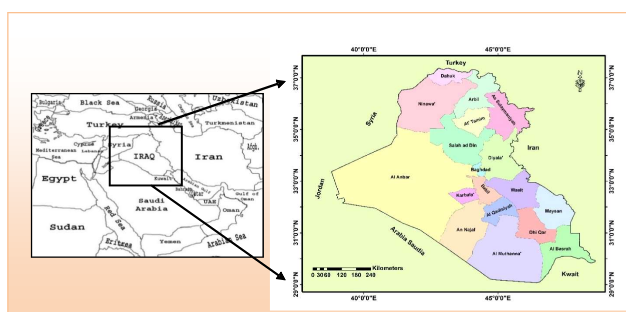


Fig. 1. Region of interest

Table 1. The parameters of the dataset

Parameters	Specifications
Check mission	Processing level
Sensing period	2020-01-01 - 2020-06-31
Product type	L2__NO2, L2__AER_AI
Processing level	L2

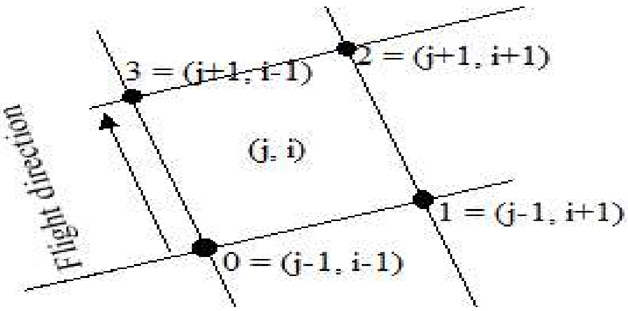


Fig. 2. Pixel corner coordinates. The sequence {0,1,2,3} refers to the elements in the corner dimension

RESULTS AND DISCUSSION

Abrupt reduction in tropospheric NO2 during the lockdown measures due to COVID-19: The evolution of NO2 column in the troposphere at the Iraq scale before and after the adoption 25% of the lockdown measures is shown in Figure 3. The variation in NO2 columns changes from one city to another. The highest NO2 emission represented in red, while those areas with a low reduction are represented in yellow and cyan. On the other hand, the lowest NO2 emission is represented in blue. The slowing of economic activity during the period from the first of January until the end of July

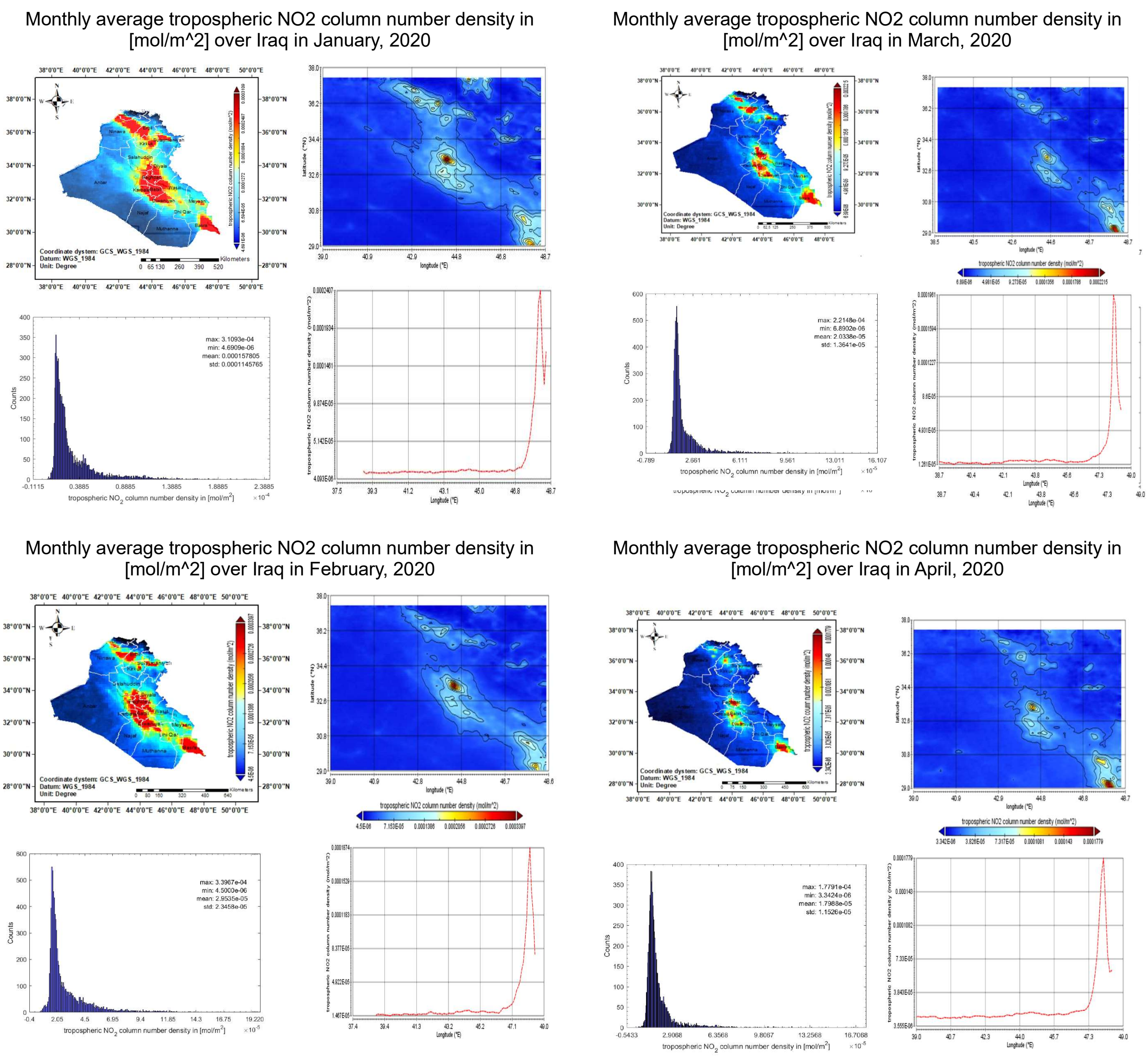
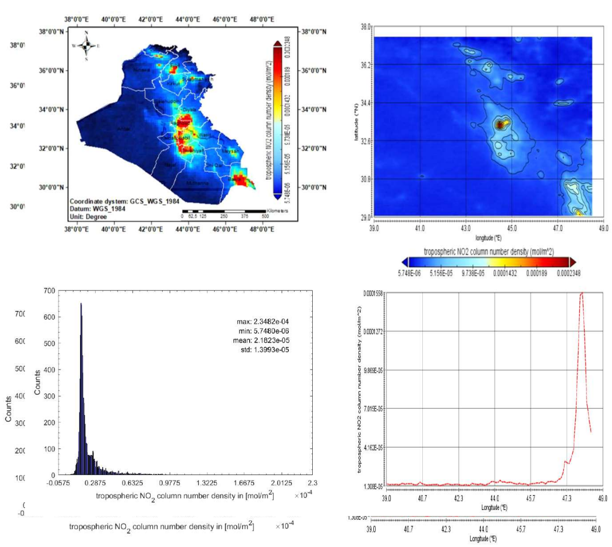


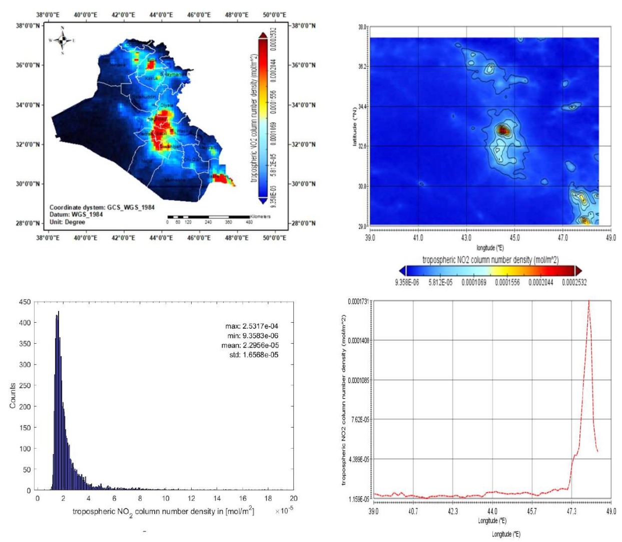
Fig. 3. Tropospheric vertical column of NO2 in (mol/ m^2) over Iraq for each month from January to December. Upper panel: (left) Monthly maps of average values of NO2, (right) lat/log 2D maps display the elevation of NO2 columns over the study area. Lower panel: (left) a graphical display of NO2 data using bars of different heights, and (right) a graphical display of NO2 data over the study area at the longitude [39° and 48°. 7′] N

2020 has led to marked decreases in emissions of the tropospheric nitrogen dioxide vertical column densities and the amounts of NO2 have dropped with the coincided of coronavirus outbreak. It can be also seen that the air pollution in Iraq seems to be higher in January and this is the usual result due to the lower humidity and the lower global solar irradiance during the winter. The highest value in NO2 was in January (> 0.0003 mol / m^2), meanwhile, the extreme values of NO2 greatly declined and reflected lower emissions (0.00017791 mol / m^2) in April and then the NO2 columns recovered progressively but to levels lower compared to the January. The maximum reduction of 43% in NO2 in April - with a decrease 18.2% in the standard deviation, while the minimum reduction in the values of NO2 and standard deviation observed in July was 10.2% and 18% respectively (Fig. 4). The spatial distribution of the averaged tropospheric NO2 pollution in Iraq was significant, and the distribution is inhomogeneous around cities of Iraq. The largest abundance of No2 distribution appears in central Iraq at longitude 44.3661° E in Baghdad, the capital of Iraq, and some areas of

Monthly average tropospheric NO2 column number density in [mol/m^2] over Iraq in May, 2020



Monthly average tropospheric NO2 column number density in [mol/m^2] over Iraq in June, 2020



Monthly average tropospheric NO2 column number density in [mol/m^2] over Iraq in July, 2020

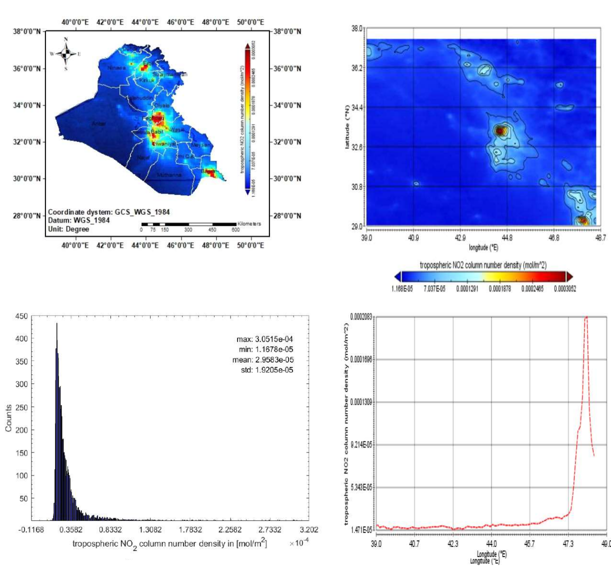


Fig. 3. Continued

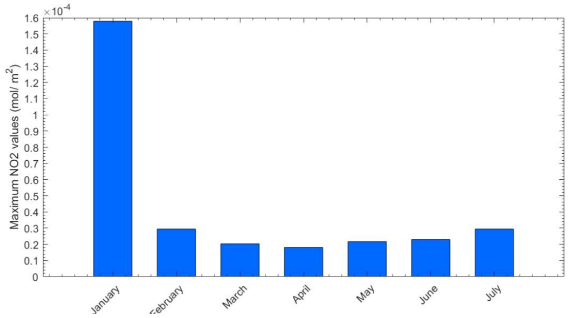


Fig. 4. Maximum distribution of tropospheric vertical column of NO2 in (mol/ m^2) over Iraq form January-July in 2020

southern Iraq and the maximum distribution was in Basrah at longitude 47.7738° E. We found a significant increase of approximately (50%) in the NO2 column abundance in Basrah compared to rest of the country. The average NO2 column in Basrah during the last period is found to be 0.000195 mol/ m^2. Substantial decreases were also recorded in other cities as Salah al-Din, Anbar, and Muthanna and the spatial distribution of NO2 over these three cities remain very low in the January–July.

Tracking the variation of UV Aerosol Absorbing Index (UVAI) in Iraq during the lockdown measures due to COVID-19: The UV index (L3 AER_AI product) is derived

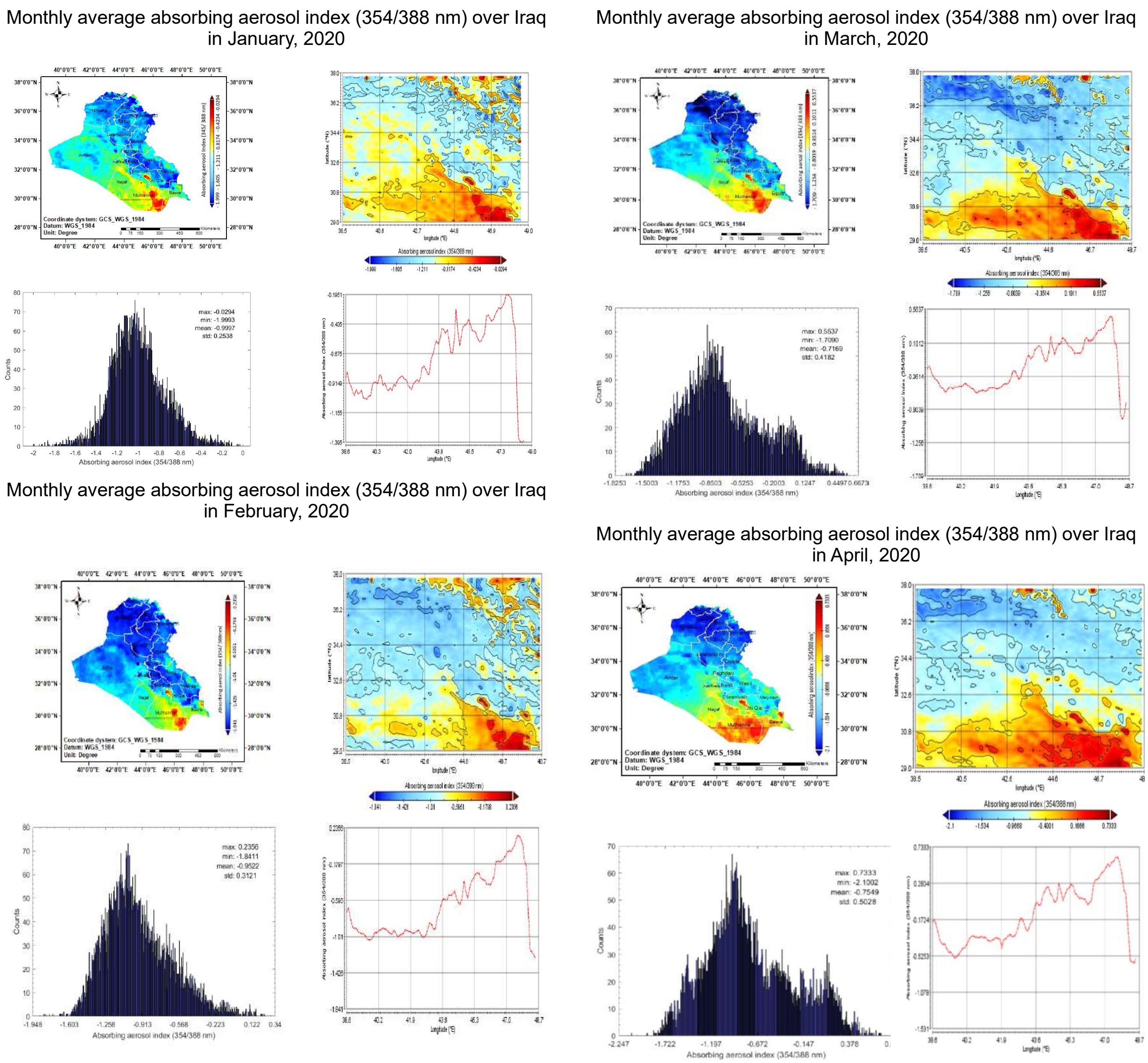
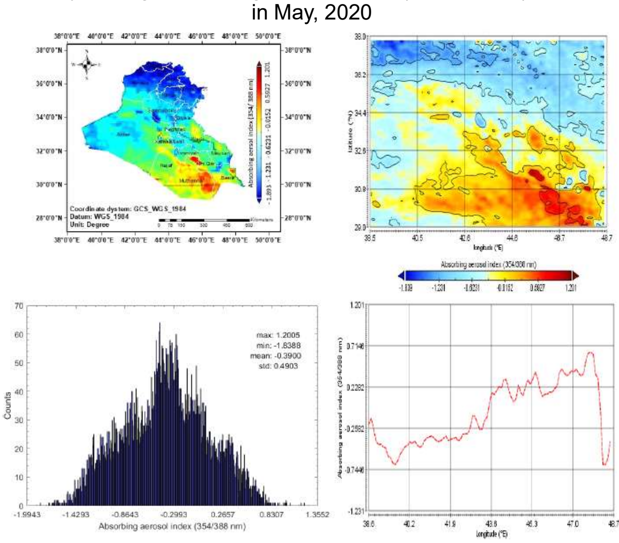


Fig. 5. UVAI irradiances over Iraq during January – July, 2020. Upper panel: (left) Monthly maps of average UVAI, (right) lat/log 2D maps display the elevation of UVAI over Iraq. Lower panel: (left) a graphical display of UVAI using bars of different heights, and (right) a graphical display of UVAI data over the study area at the longitude [39° and 48°. 7'] N

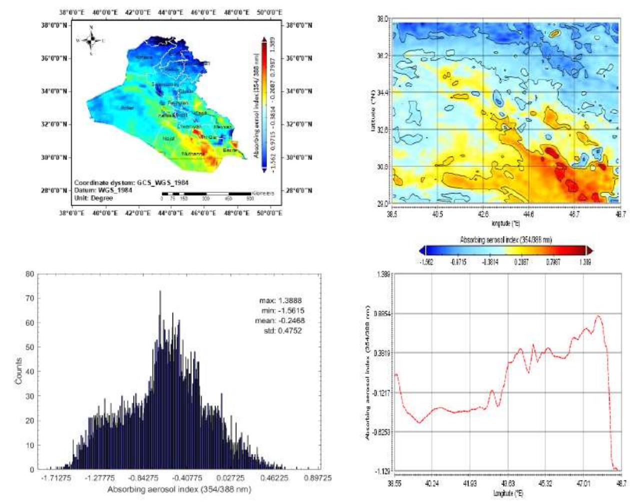
from the measured solar radiation in the UV spectra with a pair of measurements at the 354 nm and 388 nm wavelengths. [24]. The spatial variation of UVAI obtained from the Sentinel-5P products is depicted in Figure 5. The general changing in UVAI and pollutant levels over the whole of Iraq during the COVID-19 period. The UVAI during January – July ranged between 2.0284 and 3.3589. In general, the comparison shows a notable increase in the values of UVAI indices over the whole studying area in Iraq. More specifically, minimum absorbing aerosol index (- 0.9997) at wavelengths (354 - 388) nm was observed in January 2020, one month before the lockdown measures in Iraq, while the maximum increases in the values of UVAI for that period were in June and July and approaches 239.8 and 221.2% . (Fig. 6).

Based on Figures 5, and Figure 6, the UV index grows significantly in all cities in Iraq, but the higher UV index appears in the southern cities at longitude [45.2994°-47.7738°] E and latitude [29.9133°-30.5258°]N, especially in Basrah city. Interestingly, the northern cities have the lowest UV index compared to others cities in east and middle of the country. Lockdown measures due to COVID-19 affected strongly the air pollution over the regions with high levels of

Monthly average absorbing aerosol index (354/388 nm) over Iraq in May, 2020



Monthly average absorbing aerosol index (354/388 nm) over Iraq in June, 2020



Monthly average absorbing aerosol index (354/388 nm) over Iraq in July, 2020

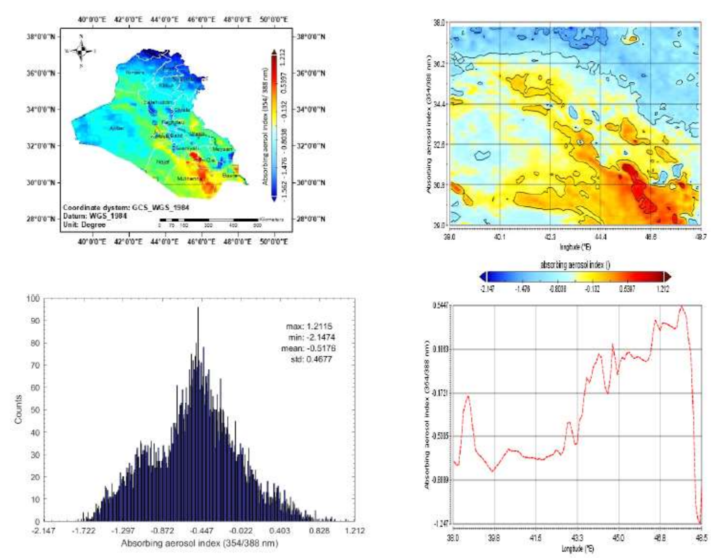


Fig. 5. Continued

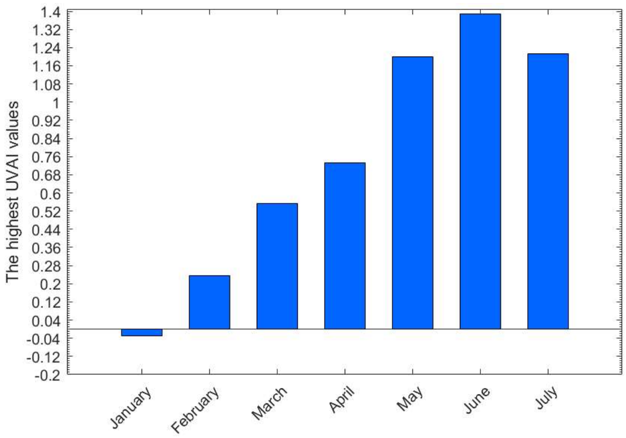


Fig. 6. The highest UVAI over Iraq in January to July, 2020

aerosols. This indicate that UV aerosol index played a major role in the spreading of COVID-19.

Impact of Lockdown Measure on Air Quality Levels and the Spread of the Coronavirus in Iraq

Air quality and public health affected directly by the amounts and levels of air pollutant emissions into atmospheric. Minimizing contact between people and reduce economic activities in Iraq due to the Covid-19 lockdown had successfully shown marked effects on air pollution in the studying region. The nitrogen dioxide (NO2) and UV aerosol index shows highly variable in time and space within the series of lockdown measures that implemented in Iraq to prevent the disease spreading. NO2 seem to be decreasing regularly during this period, whereas the percentage increase in the UVAI was very large compared with that before one month before the lockdown in January (Fig. 7). The upper and middle panel in this figure presents the change in the pattern of variation in air quality in Iraq during the lockdown period. Looking at the six months from February to July and comparing with the January. The variation in the amounts of NO2 levels and UVAI irradiances change continuously from one month to another, NO2 levels show a sharp continuous decline from 1st February to ending April 30, 2020 and then very slight increase in NO2 levels in May, June, and July. In the same time, the averaged UVAI seems to be increasing by large amounts, pointing to the high production of scattering aerosols indices form February to July.

For the purpose of visible the COVID-19 growth rate ratio in Iraq, used data from the WHO's reports and sketched the monthly mean values of the confirmed cases in Iraq (Fig. 7). The first confirmed case of COVID-19 in Iraq has been reported on 24 February 2020 in Najaf for an Iranian student (Adil 2020). During the first three months of the pandemic, the confirmed cases were very low and much better than anticipated. The mean values of confirmed cases were 1 in February, 304 in March, 1404 in April, and 3454 in May. Moreover, in June and July, the coronavirus has spread at an alarming rate and the mean values of confirmed cases exceeded 46000 in both June and July.

This huge increase in the mean values of the confirmed

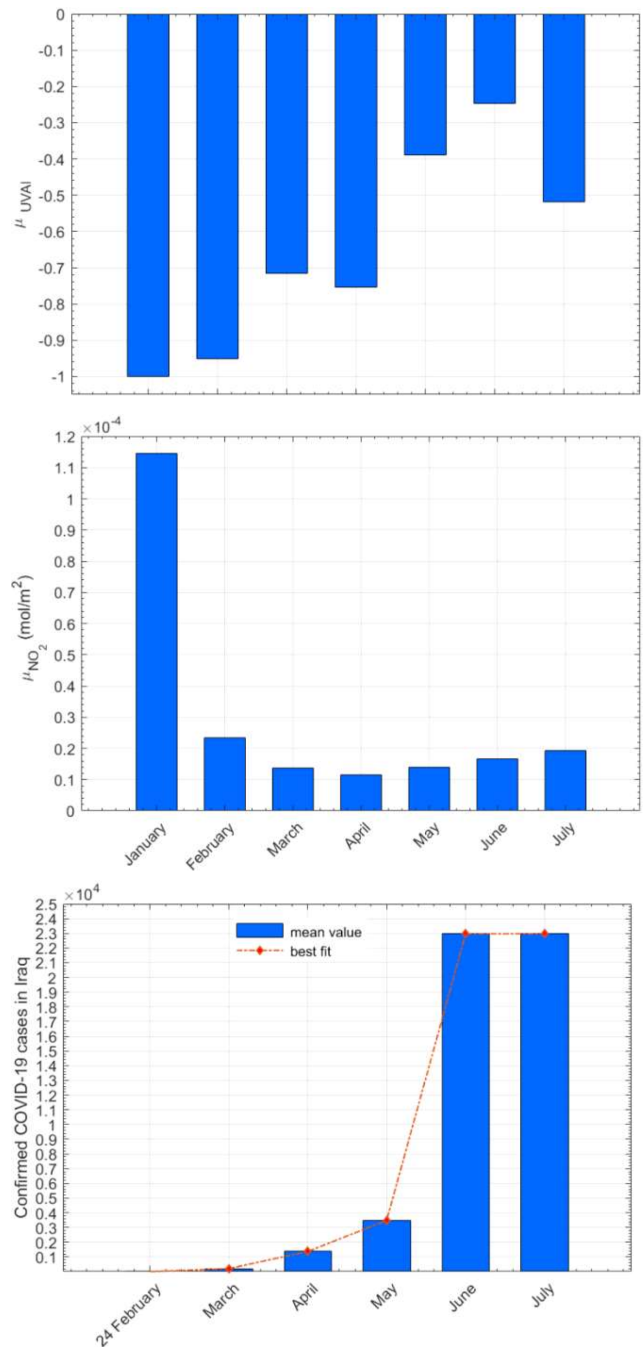


Fig. 7. Upper panel and middle panel shows the variation in the mean values in NO2 and UVAI respectively in Iraq. The lower panel illustrates the confirmed COVID-19 cases in Iraq.

cases of COVID-19 is directly consistent with the variation of UV Aerosol Index (UVAI) and is inconsistent with the abrupt reduction in tropospheric NO2 during in Iraq in June and July. According to the WHO's reports, the total number of confirmed cases in June and July has risen more than 80% (WHO 2020).

CONCLUSIONS

The tropospheric NO2 column, the major air pollutant, is largely influenced by human activities and the reduction in industrial productions and vehicle emissions during the implementation control actions due to this pandemic was good evidence to visible this change. Furthermore, substantial reductions in the NO2 emissions across Iraq within that period. The averaged NO2 pollution dropped by 43 % and is higher in the central and southern parts of Iraq specifically in Baghdad and Basrah, and lower in the other parts of the country. On the other hand huge increase in UV aerosol index in the all cities in Iraq. The maximum rate of increase for the UVAI is 239.8 and 221.2% in June and July respectively. In addition, the higher UV index also appears in the southern parts of Iraq. The higher emission levels of NO2 and UVAI were distributed over cities with a large number of inhabitants in the center and south of Iraq in Baghdad and Basrah. According to these marked results, can conclude that NO2 has no significant effect on the coronavirus outbreak, while UV aerosol index may have strongly affected the spreading of the COVID-19. The results of this study may have a role in supporting the activities of environmental institutions in improving air quality to reduce the number of infections with Coronavirus.

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Water Quality Assessment of the Cauvery and Vaigai River at Upstream and Downstream Locations: Impact of Domestic and Industrial Effluents

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Abstract: The study aimed to investigate the impact of urbanization and industrialization on the two major rivers of south India, River Vaigai and River Cauvery. The water samples from the river were collected from upstream side and downstream side of two towns that lies in the confluences of the river watershed. The water sample collected during post-monsoon season was subjected to various physico-chemical analysis including the heavy metal analysis. In the Cauvery River, the sample collected at upstream causeway of Mayanur showed a pH, total dissolved solids, turbidity, hardness, alkalinity, chlorides and sulphates concentrations as 7.56, 1825 mg l^{-1}, 23 NTU, 515 mg l^{-1}, 305 mg l^{-1}, 1885 mg l^{-1}, and 512 mg l^{-1} respectively. In the downstream side of the Mayanur causeway the concentrations were 7.72, 2830 mg l^{-1}, 52 NTU, 625 mg l^{-1}, 620 mg l^{-1}, 2255 mg l^{-1}, and 588 mg l^{-1} respectively. Similarly, the water sample collected from the Vaigai River upstream and downstream causeways of Madurai and Manamadurai also showed the higher concentration of pollutants more than the permissible standards prescribed by the Bureau of Indian Standards (BIS). The study concludes that the river water needs to be treated with filtration, coagulation and advanced membrane process before supplied for drinking, irrigation and industrial applications.

***Keywords*:** Cauvery basin, Chlorides, Heavy metals, Urbanization, Vaigai basin, Water quality

India is a country which is blessed with a large network of rivers and predominant of the population highly depends on the river water for agriculture, domestic needs and small scale industries (Balakrishna et al 2017, Gaur 2018). Both perennial and non-perennial rivers contribute in fulfilling the water requirements of the sub-continent. The sub-continent has been blessed with enough water resource; due to negligence, exploitation and poor infrastructure and maintenance only a small fraction of it has been accessed and used. Industries and companies are exploiting the rivers by discharging liquid wastes into the rivers increase the level of contaminants in the river water and make it unsuitable for ready usage (Patel et al 2018). In this research, the main area of concern was to analysis the various physicochemical parameters of rivers Cauvery and Vaigai for water quality and interpreting the effects of the industries and cities of Mettur and Mayanur for the river Cauvery and the cities Madurai and Manamadurai on the river Vaigai. There are much literature evidence showing the contamination level of Cauvery and Vaigai Rivers at various other locations, but no research were carried out in the above selected locations. Additionally, there were no research articles comparing the quality of both the rivers. In the present study, river water samples were taken from both upstream and downstream of the selected cities. The objective of the present study was to analyze the water samples for various physic-chemical parameters and heavy metals from both upstream and downstream.

MATERIAL AND METHODS

Study area: The study was carried out in SASTRA University water analysis laboratory after collecting the water samples from Cauvery River and Vaigai River which is considered as the major peninsular rivers in South India. The Cauvery River catchment area is a widespread one and lies between latitude 10°7' N to 13°28' N and longitude 75°28' E to 79°52' E starts at Thala cauvery and drains in Bay of Bengal. The river water samples were collected from two places Mettur and Mayanur towns that lie in the Cauvery basin during the post monsoon season (Fig. 1). The Vaigai River is considered as one of the most vital river that provides water for irrigation and drinking purpose for three districts of Tamil Nadu. The catchment area of Vaigai River is widespread and lies between the GPS coordinates of 09°39'15.0” N to 09°20'52.7” N in latitude and 77°29'42.3'' E to 78°59'53.4” E in longitude. It originates in Varusanadu Hills, the Periyar Plateau of the Western Ghats range, and flows northeast through the Kambam Valley and drains near the Palk Strait near Uchipuli, close to Pamban bridge in Ramanathapuram District. The Vaigai River is 258 Km long and has a drainage basin of 7031 sq. km in Tamil Nadu (Chandran et al 2016). In the present study, the water samples were collected in two distinct locations say, Madurai and Manamaduari located on the course of the river (Fig. 2).

Physic-chemical analysis: The water samples from the rivers were collected in fresh polystyrene bottles of 2 L. Another set of samples were collected in a 500 mL polystyrene bottles and were preserved with boric acid and hydrochloric acid (1:1 ratio) for the estimation of trace elements. The physic chemical parameters were analyzed by the standard methods for water and wastewater (APHA 2012). The trace elements like sodium, calcium, iron, manganese, zinc etc., were estimated. The water samples were first lyophilized and were measured using X-ray fluorescence diffraction and elemental analyzer (XRF, Bruker S8 Tiger, USA).

RESULTS AND DISCUSSION

Cauvery River

The Cauvery river water was comparatively pure in the upstream side of Mettur and as it approaches the human settlements the contamination levels gradually increased. The turbidity level in the Mettur upstream was 12.0 NTU and 38.0 NTU in the downstream of (Table 1).This may be due unsewered domestic discharges as well as industrial effluents mixing with the river. As the river further progressed down into the denser cities/town the contamination level further increased. The turbidity level of Mayanur town, in the upstream side was 23NTU and in the downstream it was 52 NTU. A slight decrease in the turbidity from Mettur downstream to Mayanur upstream may be due to natural process of river bed filtration happening (Ghani et al 2017, Ding et al 2018, Sahu et al 2019). Removal of the contamination load from the river water during infiltration is linked to numerous processes such as filtration, sedimentation, coagulation, ion exchange, sorption, occur in the river bed sediments and then in the aquifer (Przybylek et al 2017). Sahu et al (2019) showed the turbidity removal depends on the hydro geological conditions. As the detention time and porosity increased the removal efficiency also increased. Generally, the river beds are effective in removing the contaminants but unfortunately the beds are clogged with many inorganic chemicals discharge from domestic and industrial effluents. In order to have a safe and secure life the water from the river needs to undergo several treatment steps including, coagulation/ flocculation, filtration, aeration, and disinfection process.

In the Cauvery River the water quality parameters like hardness, alkalinity, chlorides and sulphates indicated that in

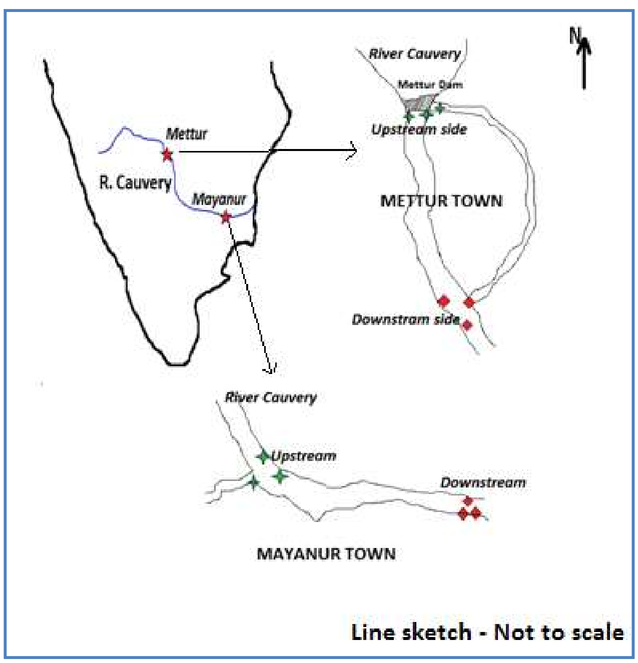

Fig. 1. Geographic line sketch of the study area in Cauvery River (a) Mettur and (b) Mayanur

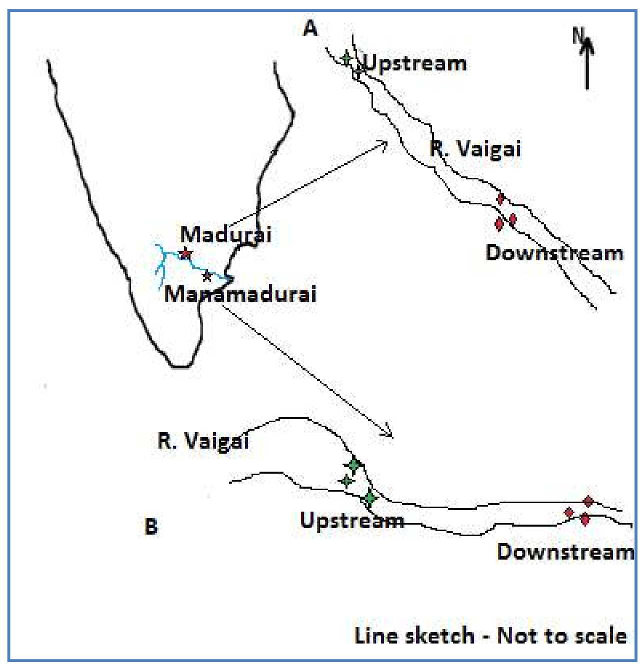

Fig. 2. Geographic line sketch of the study area in Vaigai River (a) Madurai (b) Manamadurai

all the places the river water was more than the Bureau of Indian Standards (BIS: 10500 – 2012) for drinking water. In all the four sampling points the chlorides concentrations were much higher than the permissible value of 1000 mg/L (Table 1). It may be due to the rock formations in the upstream of Cauvery River and a little contribution may be from the anthropogenic sources like domestic sewage discharges (Bhat et al 2016, Gdara et al 2017). Water containing calcium carbonate at concentrations below 60 mg/L is generally considered as soft; 60- 120 mg/L, moderately hard; 120-180 mg/L, hard; and more than 180 mg/L, very hard (Akram and Rehman 2018). Cauvery river water is under the moderately hard to very hard category, so a proper treatment is required before consumption to avoid the diseases. The concentrations of sulphate and hardness were also towards the higher range.

The solids concentrations and electrical conductivity of the Cauvery River were also above the acceptable standard limits (Table 1). The standard total dissolved solids (TDS) concentrations were 500 – 2000 mg/L, only in Mayanur downstream and the TDS crossed the permissible limit. Total dissolved solids are measure of the combined content of all inorganic and organic matters or salts which are in water. The main ingredients are usually the cations such as calcium, magnesium and potassium and the anions such as carbonate bicarbonate, nitrate, chloride sulphate etc., (Islam et al 2016). This may be due to the dissolved salts present and from anthropogenic discharges (Przybylek et al 2017, Akram and Rehman 2018). According to World Health Organization, the dissolved minerals specifically calcium and magnesium hardness are an essential commodity in the drinking water, if they are absent leads to many health risks. The low mineral drinking water increases the dieresis and the elimination of calcium, magnesium, sodium, potassium, nitrate and chloride ions from the body.

The aluminium concentrations were higher than the standard (0.2 mg/L) in the Mettur downstream side (0.38 mg/L) from the upstream side (0.04 mg/L). The copper and manganese in the Mayanur sites were higher than the standard (1.5 mg/L), may be due to the discharge from the small and medium scale copper and manganese smelters in and around Mayanur (Table 2). Similarly, the silver and zinc values were also much higher in the river course due to lot of solid waste dumping including batteries, tube lights, e-waste and anthropogenic discharges. The obtained results were in agreement with Kumar et al 2013, Sankhla et al 2016).

Table 2. Concentrations of heavy metals (Al, Cu, M , Ag, Zn) in the Cauvery River

Location / Parameter	Mettur U/S	Mettur D/S	Mayanur U/S	Mayanur D/S
Aluminium	0.042	0.38	0.27	0.55
Copper	0.72	2.25	21.88	37.17
Manganese	0.58	3.79	15.22	37.48
Silver	0.01	0.86	1.56	2.49
Zinc	2.69	42.5	38.26	47.8

Table 1. Physic-chemical characteristics of the Cauvery River at upstream and downstream of Mettur and Mayanur

Parameter	Unit	Mettur		Mayanur		BIS: 10500 – 2012 drinking water standard
		Upstream side	Downstream side	Upstream side	Downstream side	
pH	No unit	7.97	8.16	7.56	7.72	6.5 – 8.5
Dissolved oxygen	mg l^{-1}	7.5	7.2	4.2	3.8	>4.0
Turbidity	NTU	12	38	23	52	<5.0
Electrical conductivity	mS cm^{-1}	0.822	1.24	1.53	2.18	<0.5
Total hardness	mg l^{-1}	475	565	515	625	200 – 600
Total alkalinity	mg l^{-1}	425	520	305	620	200 – 600
Chlorides	mg l^{-1}	1631	2111.5	1885	2255	250 – 1000
Sulphates	mg l^{-1}	394	512.8	512	588	200 – 400
Total suspended solids	mg l^{-1}	72	155	125	205	NA
Total dissolved solids	mg l^{-1}	1250	1550	1825	2830	500 – 2000
Total solids	mg l^{-1}	1322	1705	1950	3035	NA
Calcium	mg l^{-1}	7.2	12.8	72.4	89.5	75 – 200
Sodium	mg l^{-1}	27.33	35.2	39.1	40.4	NA
Magnesium	mg l^{-1}	3.79	3.98	179.2	188.7	30 – 100
Potassium	mg l^{-1}	4.24	8.12	12.2	18.72	NA

Vaigai River

The River Vaigai is a non-perennial river and the water were taken for drinking, industrial and other applications from various intake structures in the course of river. During the sampling period, it was observed that the Vaigai River upstream of Madurai is comparatively cleaner than the downstream side. There are many solid waste humps, domestic wastewater discharges and some industrial effluents found in the river course. The values of pH, turbidity and electrical conductivity in upstream and downstream are much higher than the BIS drinking standards. The dissolved oxygen level of the river was < 1.0 mg/L in the downstream side of Madurai (Table 3). This clearly indicates that there is high chance of wastewater discharges in the river bodies; the result also correlates our visual inspection as abundance of zooplankton's and phytoplanktons. The results are in agreement with Ramprasad et al. (2017) and Joshua et al. (2018). The other parameters such as solids, alkalinity and hardness concentrations were much higher than the standard prescribed values. It denotes that there is high possibility of risk to human life. Sengupta (2013) explained that drinking hard water causes cardiovascular diseases, growth and reproductive retardation due to high amount of calcium and magnesium deposits either from anthropogenic or natural ways. The similar kind of results was obtained by Cheng et al (2018) and Duncan et al (2018), as the water enters the human settlements the concentration in the river exceeds the standard values.

Similar to Cauvery River, Vaigai River also showed higher concentrations of chlorides, sulphates and alkalinity (Table 3). The total hardness was in the range of 512-705 mg/L, total alkalinity in 715-864 mg/L. Chlorides were in the range of 1727-2577 mg/L. The present results were in agreement with Jesu et al (2013) and Mallika et al (2017). The higher concentrations of chlorides may be due to industrial discharges and natural rock formations that can be harmful for irrigation and domestic consumption. During the period of July – September 2016, five regions of Vaigai basin showed a phyisc-chemical characteristic higher than the BIS standard limits. The total alkalinity, hardness and chlorides were in the range of 285-870, 242-1750 and 185-385 mg/L respectively. The suspended and dissolved solids concentrations in the Vaigai River at 4 different locations were higher than the BIS standards (2012) for drinking water. The dissolved solids concentrations were in the range of 1765-2755 mg/L which was much higher than the 500-2000

Table 4. Concentrations of heavy metals (Al, Cu, Mn, Ag, Zn) in the Vaigai River

Location / Parameter	Madurai U/S	Madurai D/S	Manamadurai U/S	Manamadurai D/S
Aluminium	0.112	0.24	0.272	0.311
Copper	2.77	4.08	8.38	9.72
Manganese	0.177	0.202	0.288	0.351
Silver	0.644	1.211	0.522	1.748
Zinc	22.78	38.04	52.11	74.8

Table 3: Physic-chemical characteristics of the Vaigai River at upstream and downstream of Madurai and Manamadurai

Parameter	Unit	Madurai		Manamadurai		BIS: 10500 – 2012 drinking water standard
		Upstream side	Downstream side	Upstream side	Downstream side	
pH	No unit	8.32	8.77	8.72	8.94	6.5 – 8.5
Dissolved oxygen	mg l^{-1}	2.5	1.2	0.9	0.2	>4.0
Turbidity	NTU	32	107	74	235	<5.0
Electrical conductivity	mS cm^{-1}	1.122	1.884	1.414	1.955	<0.5
Total hardness	mg l^{-1}	512	705	650	695	200 – 600
Total alkalinity	mg l^{-1}	715	720	822	864	200 – 600
Chlorides	mg l^{-1}	1727	1988.5	2172.77	2577.5	250 – 1000
Sulphates	mg l^{-1}	404	515	475	522.5	200 – 400
Total suspended solids	mg l^{-1}	138	305	313	555	NA
Total dissolved solids	mg l^{-1}	1765	2180	2110	2755	500 – 2000
Total solids	mg l^{-1}	1903	2485	2423	3310	NA
Calcium	mg l^{-1}	15.8	19.7	21.8	29.7	75 – 200
Sodium	mg l^{-1}	33.5	38.1	55.8	68.9	NA
Magnesium	mg l^{-1}	7.29	9.38	11.8	19.7	30 – 100
Potassium	mg l^{-1}	3.14	5.99	6.08	6.43	NA

mg/L standard prescribed by BIS, 2012.

The heavy metals like aluminum, copper, manganese, silver and zinc in four locations in the Vaigai River were higher than the BIS standard limits (2012) (Table 4). The heavy metals were higher than estimated by Paramasivam et al (2015) and Chandaran et al (2016). The reason may be due to the sampling period (done during the post monsoon season) where the quantity of flow in river is less and many untreated industrial, and domestic effluents were discharged

CONCLUSION

The water quality in most of the assessed location along the Cauvery River and Vaigai River basins was found to be deteriorated and not meeting the Bureau of Indian standard for drinking water (BIS-10500: 2012). The bases for the deterioration are pollution (domestic urban and industrial discharges) and non-point source discharges (agricultural and solid waste dumps).The dissolved oxygen levels in downstream of rivers was indicates the higher percentage of domestic and industrial effluents mixed with river. The concentrations of heavy metals in the rivers are alarming and with such continuous practice of discharging the untreated domestic and industrial waste will affect the ecosystem and public health. Hence, there is an urgent need to ban the discharge of untreated wastewater both from domestic and industrial clusters and treat the river water before supplying to the public.

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Dam Break Analysis using HEC-RAS and Flood Inundation Modelling for Pulichinatala Dam in Andhra Pradesh, India

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Abstract: Dams have been playing a significant role in enhancing socio-economic status of people and environmental benefits in arid and semi-arid region of world. However, they cause a huge damage to the life and property when dam breaches. To minimise the effect of dam breaches, it is important to identify potential areas which likely get affected by using through modelling analysis. The aim of modelling is to simulate the movement of dam break flood wave along a river valley and to provide a solution in form of warning to the cities living downstream of dam. The present study analyse the breach of Pulichitnala dam located at Guntur district of Andhra Pradesh upto Prakasam barrage using HEC-RAS. The data required for analysis such as cross-sections elevation, dam structure, flow hydrograph, rating curve were collected from different line department of the State. The result obtained through the simulation of dam breach indicates a discharge of 121368.90 $m^3 sec^{-1}$ at dam site and 84042.91 $m^3 sec^{-1}$ at about 85km away from dam. A sensitivity analysis has been carried out changing Manning's roughness, changing PMF, breach time and breach width.

Keywords: Dam break, HEC-RAS, Flood, Flood inundation

Dam is constructed for various domestic, agricultural and industrial purposes across the river. But, sometimes dam failure can cause high level of flood disaster to its nearby areas. Floods cannot be fully prevented in advance but the hazard can be minimized by previously knowing the flood prone areas. Therefore, to reduce the loss of life, loss of economy in the flood prone areas, estimation of water levels of flood and velocity vector is possible by performing dam break analysis (Balaji and Kumar 2018). It is evident that the flood cannot be prevented but by adopting proper methods in evacuation, the losses can be minimized and dam break analysis is one of the tools for minimization of flood causalities. U.S. Army Corps of Engineers develops HEC-RAS which is capable to model the dam break with one-dimensional and two-dimensional steady and unsteady conditions. For preparedness of this disaster, flood analysis plays very important role, so that downstream flood wave propagation can be estimated and inundation map is prepared for further use (Joshi and Shahapure 2017). Failure of dam can be of various reasons but mainly overtopping and piping failures modes are considered. Any failure pattern starts with an initiation process of breach. Breach can be defined as a small cut or crack in a dam body that can initiate a dam failure process and leads the reservoir water to move downstream of dam with its full velocity. It causes high level of devastation to the human life, environment and also leads the economic loss (Yi Frank Xiong 2011). Dam breach parameters generally classified into two groups (a) geometrical parameters and (b) time related parameters (Goel 2017). Breach parameters affect the flood discharge values and also the other flow parameters, so the proper calculation of these is very necessary. Chandrabose and Thulasidharan (2014) have developed a dam break model using HEC-RAS with the help of DEM generated geometry for Malankara dam constructed across Thodupuzhariver in Kerala and for the determination of Probable Maximum Flood they used the GIUH based Clark's method. Sharma and Mujumdar (2016) performed the Ajwa dam break modelling using HEC-RAS software. Anjana et al (2016) reported dam break analysis of Idukki dam using HEC-RAS. Goel et al (2017) described the usefulness of HEC-RAS model, dam breach parameters, data required for modelling and model setup. Joshi and Shahapure (2017) studied the Vir dam break analysis using two-dimensional modelling using HEC-RAS. Abhijith et al (2017) considered the overtopping mode of failure for the Idukki dam and modelling is performed with the help of HEC-RAS. Balaji and Kumar (2018) reported study on dam break analysis of Kalyani dam in Andhra Pradesh using HEC-RAS model. In the current investigation Pulichintala dam constructed on Krishna River has been selected for dam break flow analysis study. It is a major dam which covers about 50 lakh population downstream of the dam. One dimensional unsteady simulation is preferred for this study. The objectives of the study are to investigate dam break analysis for Pulichintala dam in Andhra Pradesh is to be carried out using HEC-RAS model. The study includes the sensitivity analysis of dam failure parameters and will provide the computation of hydrographs and water level at various downstream sections.

MATERIAL AND METHODS

Study area and data availability: it's a combination of earthen dam (355.00m) and concrete dam (934.00m) falls between latitude 16°46'14" N and longitude of 80°03'33" E. Dam is having a length of 1289.00m with its top elevation 58.24m. It has 24 radial gates with a discharge capacity of 57,700 $m^3 sec^{-1}$.

Methodology: HEC-RAS is capable of doing one dimensional, two dimensional modelling. The data requirement and modelling procedure is different for both. In this work one-dimensional (1-D) modelling is performed. Procedure of 1-D modelling gives the hydrograph at every previously plotted cross-section on the river. In this modelling 1-D Saint Venant's Equation is used as described below. The equation of Saint Venant expressed in conservation form with additional terms for the effect of expansion/contraction, channel sinuosity and non- Newtonian flow consist of mass equations (subramanya). These equations are:

Conservation of mass equation

$$\frac{\partial Q}{\partial x} + \frac{\partial S_c (A + A_0)}{\partial t} - q = 0 \qquad (1)$$

Conservation of momentum equation

$$\frac{\partial (S_m Q)}{\partial t} + \frac{\partial (\beta Q^2 / A)}{\partial x} + gA\left(\frac{\partial h}{\partial x} + S_f + S_e + S_i\right) = 0 \quad (2)$$

Data used: The data required for dam break flow analysis and modelling is provided by Water Resources Department (WRD) Govt of Andhra Pradesh and breach data is taken according to the agency guidelines given in CWC report (CWC 2018). The required data includes salient features and detail of hydraulic structure, Manning's roughness value of river bed and its flood plain, cross-sections elevation on river reach, elevation-volume curve of reservoir, rating curve or normal depth at downstream side of dam, probable maximum flood (PMF) hydrograph of dam and breach parameters.

Breach parameters: Dam breach parameters are useful for flood analysis. Change in those parameters effect the flood discharge values. After processing the sensitivity analysis by varying PMF hydrograph values, Manning's roughness values, breach time and breach width, an inundation map is plotted for worst case scenario. According to the National Weather Services (NWS) guidelines, earthen dams take 0.1 to 1.0 hour failure time and concrete dam take 0.1 to 0.2 hour failure time. Details on dam break parameters are available with the UK Dam Break Guidelines and U.S Federal Energy Regulatory Commission (FERC) Guidelines (FERC 1988). Data used for Pulichintala dam break analysis is given in Table 1.

For the whole river course a constant Manning's Roughness Coefficient is assumed. As the dam breach flood levels far exceed the normal flood level marks and the flood spreads beyond the normal river course so the Manning's roughness coefficient is assumed to be little more than usually used in other hydrodynamic model. Manning's coefficients are estimated for active and off channel portions of the stream based on standard references (Chow 1959). For active channel and off channel portions values of Manning's roughness η are taken as 0.035 and 0.045, respectively. Breach parameters such as: breach width, breach depth, breach side slope, breach formation time, breach initiation time. Below shown breach parameters are calculated according to the guidelines given in government report (CWC 2018).

Dam break modelling: Pulichintala dam break modelling is performed using HEC-RAS one-dimensional model. In order to simulate the model, the necessary details are provided in different windows named as RasMapper, view/edit geometric data, view/edit unsteady data, unsteady flow analysis and finally the model is simulated to perform an unsteady flow simulation in HEC-RAS model (Fig. 1).

After preparing the geometric shape of model (Fig. 2), Probable Maximum Flood hydrograph is considered as upstream boundary condition and rating curve of Prakasam barrage is taken as downstream boundary condition. The probable maximum flood (PMF) is of 411 hours, and taken at 1hour interval. The initial condition plays important role in 1-D modelling, for this initial flow is taken as initial value of PMF hydrograph and initial elevation is taken as initial elevation of reservoir. After plotting all necessary information the unsteady simulation processed and results are generated.

Table 1. Data used for dam break analysis

Parameters used for dam break	Unit and measurement
Pulichintala dam (concrete and earthen dam) length (L)	1289.00 m
Dam height (H_d)	36.34 m
Breach height (H_b)	36.34 m (entire dam height)
Approach flow width (L_a)	902.3 m (70% of dam length)
Height of water at FRL (H_w)	53.34 m
Volume of water at FRL (V_w)	1026.00 M.Cum
$B_{avg} = 0.12 \times 1.5^{type} \times (V_w/H_b^3)^{(1/4)} \times (L_a/H_b)^{(2/3)} \times H_b$	672.99m

RESULTS AND DISCUSSION

Flood hydrograph at locations: TBL of the dam is 58.24m and full reservoir level, FRL is 53.34m. Assumption is made that elevation of the dam when dam failure starts is 58.24m which is TBL of the dam. Therefore, for simulating dam break flood, it has been assumed that initial reservoir level is at 58.24m when PMF inflows into the reservoir. In this situation, if water level increases and reaches the level of 58.24m or above the height of the dam, dam will fail by overtopping. In the analysis breach width (675m), breach time (0.3hour) and Manning's roughness η are taken as 0.035 and 0.045 for active and off channel section respectively. Employing the above described data as input to HEC-RAS model, outflow hydrographs two different sections are computed (Fig. 3). Details on outflow hydrographs coordinates at different locations are presented in Table 2.

The result of combined flow hydrographs at Pulichintala dam and Prakasam barrage cross-sections are presented (Fig. 3). In peak flow travel time from Pulichintala dam site to Prakasam barrage is 8 hour. From the analysis it is observed that the peak value of the discharge decreases and travel time increases as the flood wave propagates downstream. The falling limb of the hydrograph goes on smooth and smoother as the wave travels farther downstream. It may be noted that the maximum flow at dam site is 121368.9 $m^3 sec^{-1}$ with the water surface elevation of 51.96 m. The water surface elevation of 29.60m is observed at Prakasham barrage with flow of 84042.91 $m^3 sec^{-1}$ with a travel time of 8 hours.

Sensitivity analysis of the model parameters: Different sensitivities analysis is carried out to study the effects of the most influencing parameters on the flood wave propagation. Initially, PMF is increased by 50% and its results are analyzed. Secondly, sensitivity analysis for three model parameters namely; breach width, time of breach and

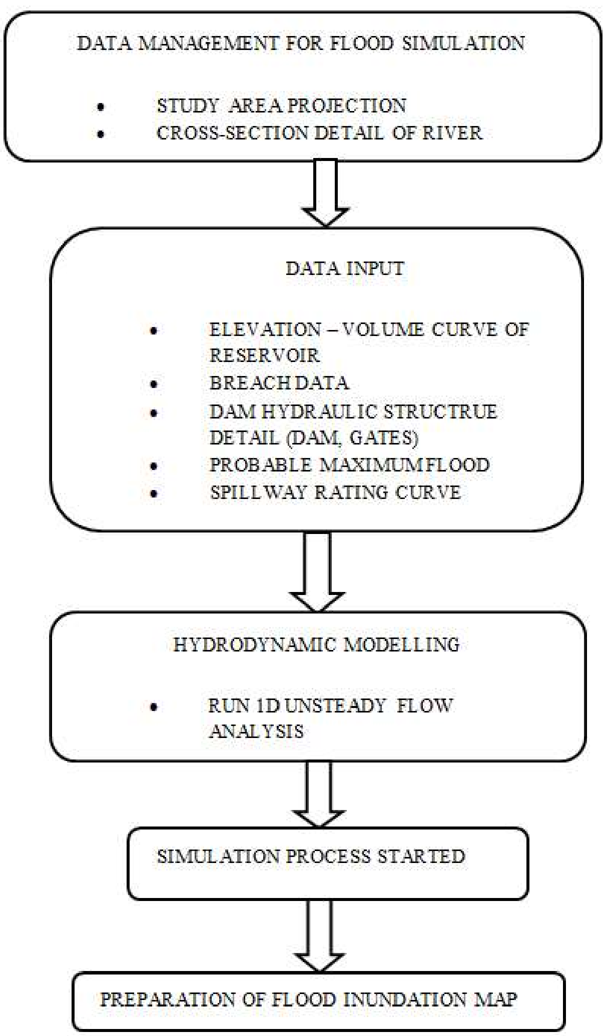

Fig. 1. Dam break modelling chart

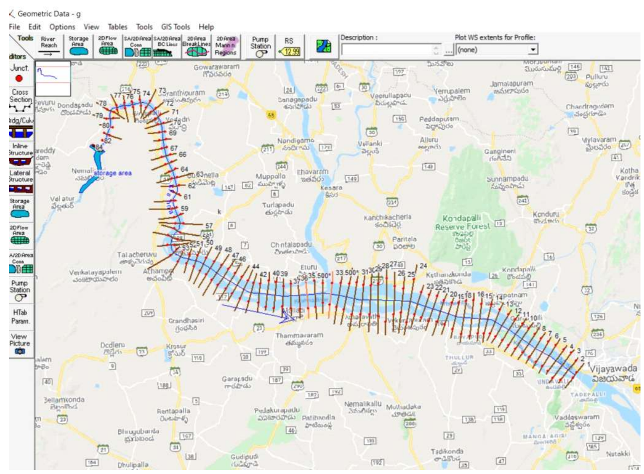

Fig. 2. One-dimensional Pulichintala dam break modelling

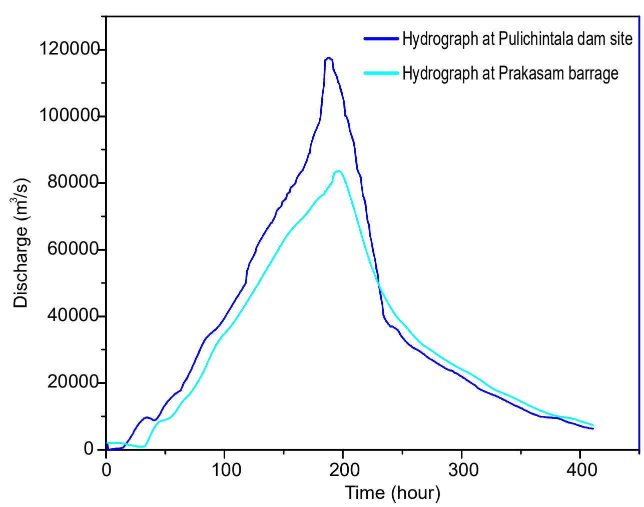

Fig. 3. Flow Hydrograph at Pulichintala Dam and at Prakasam barrage

Manning's roughness constant have been performed. The input parameters and their variations for the above cases are presented in Table 3. The comparative results for maximum discharge and maximum water surface elevation in the study area are presented in Figure 8 to 11 for PMF, breach length, time of breach and bed roughness, respectively.

Sensitivity of PMF: In the analysis, PMF is increased by 1.5 times while keeping other parameters constant and used for dam break analysis and propagation of flood wave is studied. It is observed that there is only 3.97 m increase in discharge at the dam section due to increase in PMF 1.5 times (Fig. 4). Similarly water level is increased by 4.3 m, 2.89 m, 5.96 m and 6.62 m at 3, 25, 61 and 85 km respectively (Table 4). While analyzing peak flow, the peak flow was increased when PMF is increased by 1.5 times. As the PMF values increases by 1.5 times of initial values, the outflow discharge values increases by 34.8% and water surface elevation increases by 7.6% correspondingly at the dam section.

Sensitivity of time of failure: The sensitivity of the breaching time has been studied by changing the time of breach to 0.1, 0.3, 0.5 and 1 hour. This parameter has a marginal effect on maximum water level when time of failure increased from 0.1 hr to 1.0 hour (Table 5). It is evident that water level observed 51.93m at dam section and 29.59 m at Prakasam barrage for the breach time of 1.0 hour. Change in failure time moderately affects the discharge and water surface elevation results and as the breach time increases from 0.1 hour to 1.0 hour, the discharge decreases by 7.83% and the decrease in water surface elevation is about 0.04% at the dame site. It shows that breach time has very less impact on maximum water surface elevation.

Sensitivity of breach width: In order to study the effect of

Table 2. Peak discharge and water surface elevation at different location

Distance from dam (km)	Peak discharge (m^3/sec)	Peak water surface elevation (m)
0	121368.90	51.96
3	121485.00	52.11
7	121047.40	51.64
15	113955.20	48.83
20	104045.50	48.02
25	103650.50	41.22
35	99446.64	36.36
50	93977.67	33.98
61	89307.70	32.07
70	85905.43	30.92
85	84042.91	29.60

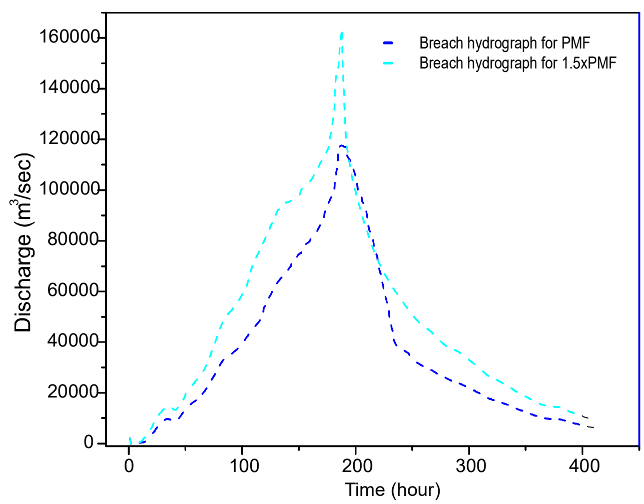

Fig. 4. Peak Hydrograph at dam site for PMF and 1.5 times PMF

Table 3. Variation of input parameters for sensitivity analysis

Sensitivity analysis – I Effect of PMF	Case – 1(a)	PMF= 1.5 X PMF	
Sensitivity analysis – II Effect of breach time	Case – 2(a)	Time of breach = 0.1hour	
	Case – 2(b)	Time of breach = 0.3hour	
	Case – 2(c)	Time of breach = 0.5hour	
	Case – 2(d)	Time of breach = 1.0hour	
Sensitivity analysis – III Effect of breach width	Case – 3(a)	Breach width = 500m	
	Case – 3(b)	Breach width = 675m	
	Case – 3(c)	Breach width = 850m	
	Case – 3(d)	Breach width = 1000m	
Sensitivity analysis – IV Effect of roughness	Case – 4(a)	Flood plain =0.045	Main channel=0.035
	Case – 4(b)	Flood plain=0.050	Main channel=0.035
	Case – 4(c)	Flood plain =0.050	Main channel=0.050
	Case – 4(d)	Flood plain=0.050	Main channel=0.040

breach length, the model is simulated with changing breach width of 500, 675, 850 and 1000m. The effect of breach width on the maximum water surface elevation at various downstream sections (Fig. 5). It has been observed that when breach width increases, maximum discharge at any section also increases. The peak flow observed was 121336.2 $m^3 sec^{-1}$ (breach width of 500 m), 121368.9 $m^3 sec^{-1}$ (breach width of 675 m), and 121695.4 $m^3 sec^{-1}$ (breach width of 850 m), compared to 121696.7 $m^3 sec^{-1}$ (breach width of 1000 m) at the dam site. There is increase in 0.27 % in peak flow when breach width increased to 850m, similarly peak flow decreased by 0.03 % when breach width reduced to 500m at dam site. This analysis indicates that increase in breach width may increase water level and peak flow, but it is not significant as variations are very less (Table 6). It may be noted that width of the river is very large, it is varying from 1.4m (dam site) to 3.9 km (Prakasam barrage), and therefore significant variation is not observed by increasing or decreasing breach width.

Sensitivity of roughness: Manning's, coefficient is also a sensitive and important parameter which affect the flow computation in open channel flow. Further, it is very difficult to estimate the coefficient value particularly for flood plain region for which generally no historical flow records are available. The effect of roughness corresponding to river bed and flood plains are considered in the present study. In this study the model has been simulated with 4 sets of Manning's coefficient (Table 3). When roughness coefficient is increased by 0.005 for flood plain (Case 4a and b), water level increase by 0.14 m 0.080 m at dam section and barrage respectively. Similarly, when roughness coefficient is increased by 0.005 for flood plain and 0.015 for main channel (Case 4(c)) water level increase by 2.72 m and 0.37 m at dam section and barrage, respectively. It is also observed that maximum water level reaches to 29.97 m at Prakasam barrage (Fig. 6).

As the river roughness increases from 0.035, 0.40, 0.045, 0.050 the discharge value decreases and water depth increases. As the main channel roughness increases from 0.035 to 0.050 the decrease in discharge is 12.95% and

Table 4. Sensitivity analysis for PMF

Location from Dam (Km)	Peak discharge (m^3/s)		Peak water surface elevation (m)	
	PMF	1.5 x PMF	PMF	1.5 x PMF
0	121368.90	163534.30	51.96	55.93
3	121485.00	163308.80	52.11	56.41
25	103650.50	143383.80	41.22	44.11
61	89307.70	125946.90	32.07	38.03
85	84042.91	119204.90	29.60	36.22

Table 5. Sensitivity analysis for time of failure

Location from Dam (Km)	Peak discharge (m^3/s)				Peak water surface elevation (m)			
	1 hr	0.5 hr	0.3 hr	0.1 hr	1 hr	0.5 hr	0.3 hr	0.1 hr
0	119594.30	121368.90	123285.80	128955.00	51.93	51.96	51.96	51.95
3	119751.60	121485.00	123290.50	128338.80	51.98	52.09	52.11	52.12
25	103526.60	103650.50	103763.80	103886.30	41.17	41.21	41.22	41.23
61	89295.24	89307.70	89315.34	89312.48	32.06	32.07	32.07	32.08
85	83975.75	84024.14	84042.91	84060.72	29.59	29.59	29.60	29.60

Table 6. Sensitivity analysis for breach width

Location from Dam (Km)	Peak discharge (m^3/s)				Peak water surface elevation (m)			
	500 m	675 m	850 m	1000 m	500 m	675 m	850 m	1000 m
0	121336.2	121368.9	121695.4	121696.7	51.90	51.96	52.00	52.03
3	121401.6	121485.0	121834.9	121846.6	52.03	52.11	52.16	52.19
25	103120.3	103650.5	103996.8	104072.9	41.19	41.26	41.25	41.28
61	89041.55	89307.7	89402.92	89446.34	32.05	32.07	32.08	32.09
85	83877.59	84042.91	84098.66	84129.94	29.57	29.60	29.61	29.61

increase in water depth is 5.24% at the dam section (Fig. 7).

Inundation map: Final step of dam break analysis is to plot an inundation map for the study area. Inundation map is plotted for breach width of 675m, in which at the dam site the water level is about 51.96m and at 85km downstream of dam the water level is 29.60m *i.e.* at Prakasam barrage. The flood inundation map shows the detail of flood affected areas nearby dam and downstream of dam so that in any critical situation it can help to prevent the locals from flooded water. There are about 390 numbers of villages that can be inundated due to this dam breach flood and all the villages location is visible in the map (Fig. 8). It can also be useful to

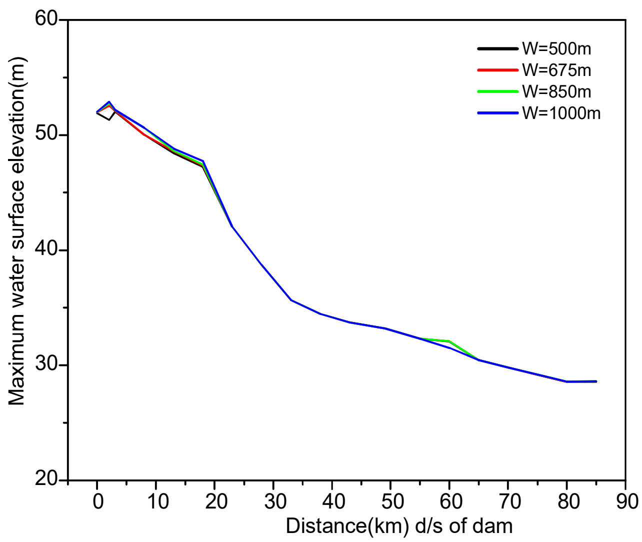

Fig. 5. Effect of breach width on maximum water surface elevation

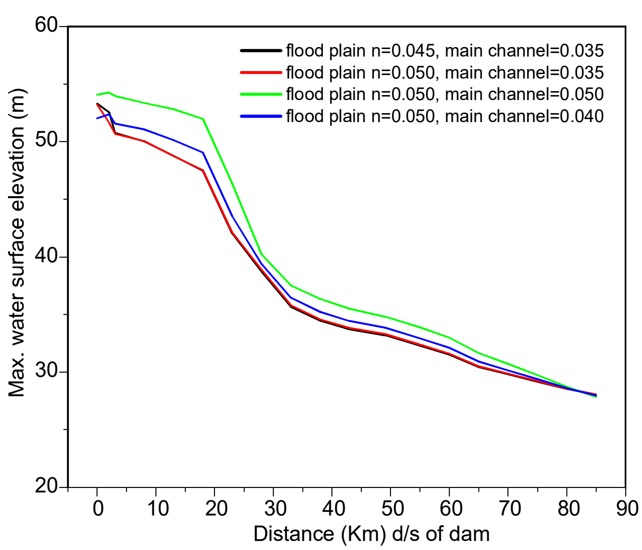

Fig. 6. Effect of bed roughness on maximum water surface elevation

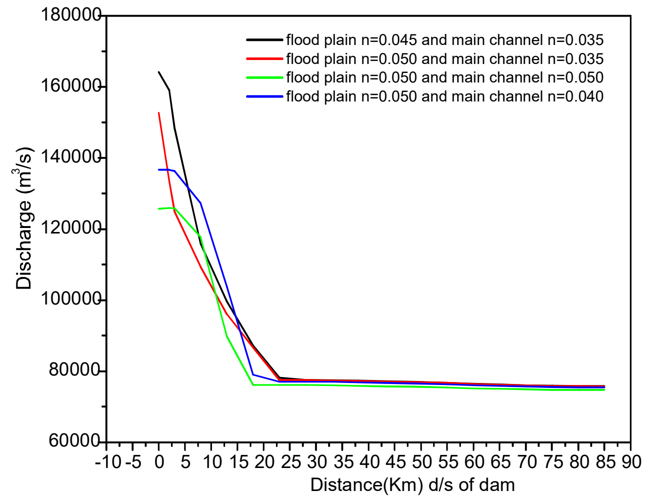

Fig. 7. Effect of roughness on outflow discharge

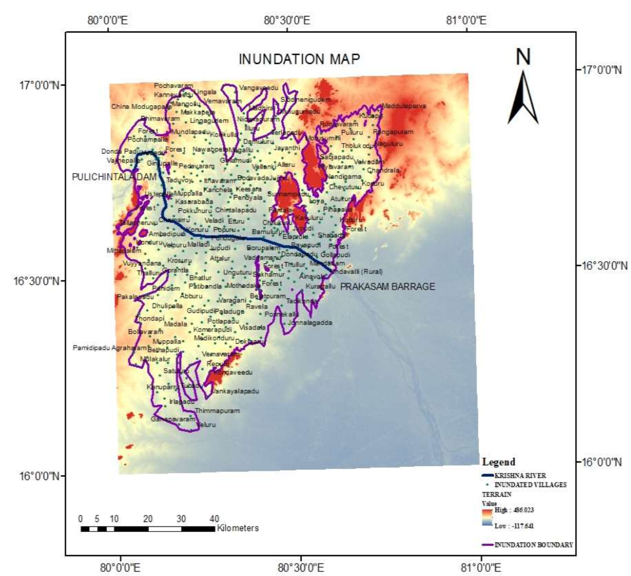

Fig. 8. Pulichintala Dam Inundation map

develop an emergency action plan by the respective revenue department/concern office of that area.

CONCLUSIONS

The study was carried out using a widely used HEC-RAS model developed. The outflow hydrographs of the hypothetical dam break flood at different locations have been studied. For active channel and off channel portions values of η have been considered as 0.035 and 0.045 respectively. As the PMF values increases, the results of discharge and water surface elevation also increases. Increase in breach formation time decreases discharge and water surface elevation values. Increase in breach width also increases the discharge and water surface elevation values. As the Manning's roughness values (η) increase, the discharge and subsequently the water surface elevation increases also, the river bed roughness has more impact on flood values than flood plain roughness values.

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