Use of *Hissopus officinalis* L. Culture for Phytoamelioration of Carbonate Outcrops of Anthropogenic Origin the South of European Russia

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Abstract: Eurasian-African species of the *Lamiaceae* family – *Hissopus officinalis* (L.) gradually enters the culture of the South of European Russia. This semi-shrub has high resistance to carbonate soils, overground productivity, and longevity. Field experiments were conducted including the study of *H. officinalis* value to phytomeliorate cretaceous exposures in comparison with standard *Agropyron cristatum* Gaertn. crops and natural succession on the chalk outcrop of anthropogenic origin in the Belgorod region in 2008-2016. During nine years the *H. officinalis* crops were significantly higher than those of *A. Cristatum* Gaertn. and options with natural succession for the accumulation of overground and underground phytomass. It has been established that over an average nine-year period the *H. officinalis* crops generated 370.5 $g \cdot (m^2)^{-1}$ of absolutely dry substance of aboveground organic mass per year in comparison with the *A. cristatum* ($213.6 \ g \cdot (m^2)^{-1}$ per year) crops and natural substrate overgrowth ($59.7 \ g \cdot (m^2)^{-1}$ per year). On a chalk outcrop, the total carbon tends to increases by 1.971% in absolute terms as compared to the initial state for nine years of life in fine-grained soil under the *H. officinalis* crops. The content of humic acids increases by 1.109% in absolute terms, including an increase in the content of fulvic acids by 0.793%.It is concluded that the *H. officinalis* crops have greater environmental and technological value for phytomelioration of cretaceous exposures as compared with standard grass stands and natural vegetation communities.

Keywords: Agropyron cristatum, Carbonate exposures, Phyto melioration, Hissopus officinalis, Soil-forming process

It is typical for carbonate soils and outcrops that are related both to natural soil-forming process and in most cases to anthropogenic effect to be spread in the geographical coverage of many Russian and world's regions. According to estimates, they occupy 800 million ha in the world (The State… 2011) and more than 800 thousand ha in the Central Black Earth Region of Russia and it is expected to increase up to >3 million ha the future. Carbonate soils and carbonate outcrops have extremely low productivity, low recovery potential, and adverse effects on vegetation (Degtyar and Chernyavskikh 2006). An ecological and cenotic approach for generation of sustainable phytocenoses using different plant species (Sysuyev and Ustuzhanin 2009) that are most adapted to specific cultivation conditions is an important component of measures aimed at recovery of low-yielding soil productivity (Trofimov et al 2009,Kosolapov et al 2013, Savchenko et al 2014). In this regard, it is of great importance to solve the problem of increased organic substance entering carbonate soils subject to within the soil-plant system (Dumacheva et al 2015).

Issues of preservation of plants (Khapugin 2018, Senchugova and Khapugin 2018), their habitats (Erdős et al 2018, Bakhshi et al 2018) under conditions of vegetation mosaicity in forest-steppe belt are discussed in many aspects. Anthropogenic impacts have led to the transformation of both plant cover (Lisetskii 1998, Smirnova et al 2016, Terekhin and Chendev 2018) and soilcover (Goleusov and Lisetskii 2008, Nekhodimova and Fomina 2013, Chendev et al 2018).Particular calcium landscapes can expand the area during the slope development in the forest-steppe system along with the transformation of forests and steppe vegetation (Kudryavtsev 2007, Erdős et al 2018, Shuaibova et al 2018). The southern landscapes of the Central Russian Upland with shallow chalk deposit, marls, and cretaceous outcrops occupy a unique position in the regional biotope structure (Gorbunov and Bykovskaya 2012) due to the presence of calciphilous flora (Gusev et al 2016, Dumacheva et al 2018), including its endemic component (Snegin et al 2017, Dorofeeva et al 2018). For phytoameliorative measures on cretaceous outcrops and for

the generation of sustainable grass stands, it is common to use drought-resistant grasses of the *Poaceae* family and it is most often to involve *A. cristatum* of Eurasian species, which is undemanding to soils and can grow on sandy, carbonate, and rocky soils with low moisture and nutrients. The role of *A. cristatum* in the formation of natural and transformed communities is discussed in a number of works (Ambrose and Wilson 2003, Wang 2005, MacDougall and Wilson 2011, Blank et al 2015). This species has been observed on such anthropogenic landforms as earthen mounds during hundreds of years of renaturation (Lisetskii et al 2014, 2016, Deak et al 2018).

Recently, the culture of the region has gained the Eurasian-African species of the *Lamiaceae– H. officinalis* family as a melliferous crop. This semi-shrub has a very high resistance to carbonate soils, high over ground productivity and longevity (Degtyar' and Chernyavskikh 2006). There are selection varieties created with the use of local source material; the system of commercial seed production has been deployed (Titovskiy et al 2017, Dumacheva et al 2018). Inside the territory of the region, it is represented by two main types of *H. Officinalis* (L.) and *H. cretaceous* Dub., which is sometimes ranked as a subspecies of the main *H. officinalis subsp. Montanus* (Jord. & Fourr.) Briq. species. In addition to its medicinal value (Rota et al 2004,Tanova and Petrova 2008) and its importance for the formation of apiculture food reserve under harsh conditions of carbonate outcrops on widely occurring ravine systems, it is possible to use this species for phytoamelioration of carbonate substrates and improvement of their humus condition. The main purpose of research was to assess the phytoameliorative role of *H. officinalis* varieties during the restoration of anthropogenic cretaceous outcrops in comparison with the use of standard *A. cristatum* crops and with natural succession. The research tasks included an analysis of accumulation dynamics for underground and aboveground organic substances and their influence on changes in humus group composition, as well as an assessment of the total nitrogen production and reclaimable land nitrification capacity.

MATERIAL AND METHODS

The research covers the southern macro slope of the Central Russian Upland (50°29′ N, 37°52′ E). Economic, natural, climatic, and geological characteristics of the region are determined by high-degree development and topographic features with predominant slope-type terrain and with the significant development of a ravine network from0.8 to 1.5 km·(km^2)$^{-1}$ dense. The duration of sunshine is 1800 hours. The average annual air temperature ranges up from 5.4 to 6.7°C. The average frost-free period from 154 to

157 days. The average annual precipitation can vary from 465 to 530 mm. There has been observed annual drought and dry winds of varying intensity within the territory of the region. The probability of semi-arid and arid years is 50%. In 2008-2016, they conducted field studies on the use of *H.officinalis* for phyto melioration of cretaceous out crops in comparison to *A. cristatum* and natural succession on the chalk exposure of anthropogenic origin, which has formed at the site of excavation during the construction of a motor road in the Volokonovka district of the Belgorod region. The substrate is represented by chalk outcrop (residual chalk deposit). The initial soil is residual-carbonate black soil. The slope has south-western exposure. The experiment is based on the streamlined repetition method. The total area of the plot is 4 m^2; the replication rate is 6 times. The used method is early winter, solid, and broadcast planting.

Experiment options:

1. Natural succession of vegetation.
2. *A. cristatum* crop, Pavlovsky variety, with the seeding rate of 5 g·(m^2)$^{-1}$ of germinating seeds.
3. *H. officinalis* crop, Volokonovsky variety, with the seeding rate of 3 g·(m^2)$^{-1}$ of germinating seeds.

The value of above-ground phytomass productivity was determined by mowing method 1 time per season during heavy bearing. An area of the registration plot was 2 m^2. The phytomass was weighed, when it was green. To determine the content of absolutely dry substance a 1.5-2 kg assay sample was taken for analysis from the total mass and then brought to air-dried condition in gauze bags. The air-dry mass was completely crushed to powder in the mill. From the mass obtained, samples were taken out of 50-60 on a four-time repeated basis and dried completely in a thermostat at a temperature of 105-106°C for 8 hours. As a result, the dry substance content (%) was calculated for each repetition. The average value of four repetitions was taken as dry substance content in the experiments. The value of absolutely dry substance (a.d.s.) accumulation in the underground phytomass was determined three times for all years of research. The method of selection of monolith samples of 25x25 in size to a depth of 0-20 cm with subsequent roots washing 6 times using 3 non-adjacent repetitions was applied. The samples were dried to an air-dried condition and then dried completely in a thermostat. Mixed samples for soil analyses were taken by a sampler from the 0-10 cm horizon at 10 places on the plot and then prepared a combined sample. By sifting through round-cell sieves (d=1 mm), fine earth (mechanical substrate separates of < 1 mm in size) and the skeletal part (mechanical substrate separates of > 1 mm in size) were isolated. Fine earth and skeletal parts were analysed separately. Mixed samples

were prepared from each of the six plots. After the preparation of mixed samples, the soil was brought to air-dried condition, ground down, and analysed. The biological repetition for all indicators is 2-fold and the total one is 12-fold.The group analysis of humus was fulfilled by Tyurin's method modified by Ponomareva and Plotnikova (Arinushkina 1970). The humus composition (carbon content of humic acid (C_{HA}) and fulvic acid (C_{FA})) was determined before the experiment in 2008 and after its completion in 2016.

The results were statistically processed using formulas to calculate the simple average and the error of mean. The variation proportion for resulting characteristics under the study, which is due to the action of the investigated organized factors, was estimated by the method of total variance decomposition of statistical systems (analysis of variance). To identify the level of close relations between characteristic under study, a pair correlation coefficient was applied (Lakin 1990).

RESULTS AND DISCUSSION

The dynamics of the above-ground mass accumulation is an integral complex indicator showing stability level of both individual species and communities as a whole.The rate of organic substance accumulation is the result of the function of photosynthesis and respiration in the above-ground sphere and the partial transfer of photosynthesis products to the underground. The amount of organic substance generated by phytocenos is per unit time is an essential component of the ecosystem. The higher the speed is, the more efficient the environmental resources are used and the more intensive is the process of soil formation and stabilization of the entire ecosystem (Semenov et al 2004).In both crops high above-ground phytomass capacity in the seeding year was within 1.3-21.3 $g \cdot (m^2)^{-1}$. Significant differences became evident starting from the second year of life (Fig. 1).

As compared to other options, the wheat grass seeds ensured faster grass stand formation with an absolutely dry substance being accumulated in the average amount of more than 213.6 $g \cdot м^{-2}$ (a.d.s.) per year. In the first 3 years of the entire nine-year period of the studies, the common hyssop crops accumulated the above-ground mass by 57.6% more with its average annual yielding capacity of 370.5 $g \cdot м^{-2}$a.d.s. When being used for crops of both wheat grass and hyssop, it showed general tendency related to the stable formation of the above-ground mass starting from the third year of the grass stand use. The process of significant phytomass formation was reported to have place in natural succession areas only in five years after the trial establishment. The

higher plant communities only became to form starting from the sixth year. At the initial stage of development of soil-plant groups, lichens and especially *Nostoc cyanobacteria* played the most significant role. During the first five years of the studies, cyanobacteria were 79.3-89.2% of the total phytomass, which had been formed in the overgrowing areas. It was previously mentioned (Nekhodimova and Fomina 2013, Zimonina 2016) that different types of *Nostoc* cyanobacteria are among the most stable ones in natural, anthropogenically disturbed and urban areas. They are highly tolerant to adverse conditions and prefer substrates without higher plants.

According to the trial results, the time (t, years) dynamics of aboveground mass accumulation (F_a, $g \cdot m^{-2}$) is well described by polynomials of different orders for all options: for *A. cristatum*– $F_a=2.44t^3–42.92$ $t^2+238.42t+169.12$, $R^2=0.93$; for *H. officinalis*– $F_a=–18.334t^2–251.57t–306.71$, $R^2=0.93$; for natural succession – $F_a=4.54t^2–20.89t+20.19$, $R^2=0.987$.A variance analysis of the single-factor experiment, which was carried out by the method of streamlined repetitions, showed that the share of the "crop" factor in the total variation of the resulting "formation of above-ground phytomass" characteristic made up 61% for the entire period of the studies; that of annual climatic conditions was 26% and that of random factors was 13%.For nine years of the studies, the *H.officinalis* crop) exceeded the *A. cristatum* crops and natural vegetation succession areas in terms of aboveground capacity on the cretaceous exposures of the Southern Russia. The main source of organic substance accumulation in the soil, related turnover of nutrients, and soil formation process is the inflow of underground vegetable matter entering the soil. It is of particular importance to have roots and rhizosphere microflora interacted in the conditions of carbonate outcrops, which is primarily due to the environment-forming role of vegetation and especially individual species that are most stable on any outcrops (Fig. 2).

It has been established that the underground mass accumulation (F_r, $g \cdot m^{-2}$) generally shows an increasing time-related dynamics (t, years) in a soil layer of 0-20 cm with the age of plant groups being incremented; this is described by polynomials of different orders: for *A. cristatum*– $F_r=28.25t^2–38.25t+439.1$, $R^2=0.99$; for *H. officinalis*– $F_r=–430.65t^2–2490.7t–1811.6$, $R^2=0.986$; for natural succession – $F_r=122.9t^2–343.5t+221.7$, $R^2=0.997$.The underground to aboveground mass ratio from 2010-2016 increased to from 1.6 to 2.1 in the wheat grass crops, from 2.1 to 3.6 in the hyssop crops, and from 0.2 to 1.5 in the natural overgrowing areas. The share of the "crop" factor in the total variation of the resulting "formation of underground

phytomass" characteristic made up 76% for the entire period of the studies; that of annual climatic conditions was 14% and that of random factors was 10%.In general, by the ninth year of life, the accumulations under an artificially created hyssop crops were 3.1 times higher than those under the wheat grass crops and 6 times higher than for the natural succession.

The main role of the biomass in the soil formation is reduced to the process of transition of relatively simple
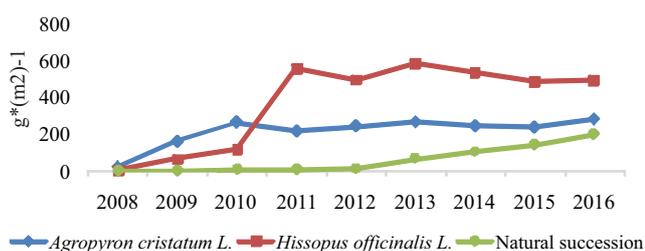

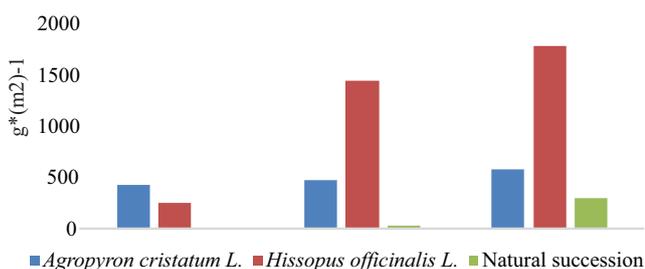**Fig. 1.** Dynamics of accumulation of aboveground phytomass

Fig. 2. Dynamics of accumulation of underground phytomass

organic substances into the form of complex organic substances and organo-mineral systems. The content of carbon compounds with different degrees of lability increases in the substrate at a time. The most important indicator is an analysis of carbon accumulation in the composition of various humus substances, which can show the direction of humification processes development and the rate of soil formation process depending on the crops to be grown (Semenov et al 2005). Chalk is a porous material with high adsorption capacity. The skeletal part in the cretaceous substrate was 92.7% at the beginning of the experiment. Therefore, it is very important to assess humus condition, both in the fine-grained soil and skeletal part. According to the analysis of the humus group composition (Table 1), it can be seen that it is primarily increased total carbon content (C_{org}) that caused changes, which have occurred in the humus fractional composition of the chalk outcrop both in the skeletal part and in the fine-grained soil.

As compared to the initial condition, the maximum increase in the C_{org} content was both in the skeletal part and in the fine-grained soil under *H. officinalis* and it was 36.9% in the skeletal part and 197% in the fine-grained soil. The lowest rate of accumulation was typical for water-soluble humus carbon, which was associated with a high content of soil solution calcium ions forming poorly soluble systems during chemical reactions both with minerals and with organic substances. In general, the skeletal part was characterized by a high content of fulvic acids by weight as compared with humic acids both at the beginning and by the end of the experiment. The humic (C_{HA}) to fulvic acid (C_{FA}) carbon ratio is

Table 1. Dynamics of the group composition of humus carbonate outcrop when sowing various crops and natural succession (mean ±standard error)

Indicators (%)	Phytoamelioration options			Initial state
	A. cristatum (L.) crops	*H. officinalis* (L.) crops	Natural succession	
Skeletal part (mechanical substrate separates of > 1 mm in size)				
C_{total}[1]	0.423±0.029	0.511±0.030	0.280±0.023	0.142±0.008
C_{WSH}[2]	0.006±0.001	0.007±0.001	0.008±0.001	0.005±0.001
C_{HA}[3]	0.082±0.009	0.114±0.011	0.076±0.009	0.018±0.001
C_{FA}[4]	0.129±0.013	0.198±0.020	0.104±0.012	0.087±0.004
C_{HA}: C_{FA}[5]	0.636±0.014	0.576±0.021	0.731±0.016	0.207±0.004
Fine earth (mechanical substrate separates of < 1 mm in size)				
C_{total}	1.981±0.171	2.833±0.306	1.621±0.162	0.862±0.062
C_{WSH}	0.027±0.003	0.088±0.306	0.052±0.162	0.006±0.062
C_{HA}	0.493±0.052	1.193±0.116	0.214±0.027	0.084±0.005
C_{FA}	0.338±0.035	0.836±078	0.298±0.027	0.043±0.005
C_{HA}: C_{FA}	1.459±0.033	1.427±0.045	0.718±0.051	1.953±0.025

Note: [1]C_{total} – total carbon content; [2]C_{WSH} – carbon content of water soluble humus; [3]C_{HA} – carbon content of humic acids; [4]C_{FA} – carbon content of fulvic acids; [5]C_{HA}: C_{FA} – the ratio of humic and fulvic acids

significantly less than one. At the same time, an opposite tendency was noted for fine-grained soils. The greatest gross accumulation of humic acid carbon was reported in the area with *H. officinalis.* By the end of the experiment, its quantity in the fine-grained soil increased by 79% as compared to the initial condition, which is more than twice higher against the *A. cristatum* crops and the natural succession area. A more favourable ratio $C_{HA}:C_{FA}$ was reported for the areas with artificially sowed grass, while in the naturally overgrowing areas there was noted the ratio, which was shifted towards the fulvic-humate humus. The results of the variance analyses of the single-factor study showed the share of the "crop" factor in the total variation of the resulting "total carbon content" characteristic was 73% in fine-grained soils and that of other factors was 27%. The share of the resulting "content of humic acid carbon" characteristic is 87% in fine-grained soils and that of other factors is 13%; the share of the resulting "content of fulvic acid carbon" characteristic is 82% in fine-grained soils and that of other factors is 17%.

CONCLUSION

When developing sustainable crops on the carbonate outcrops in the southern part of European Russia, *H. officinalis* (L.) crops can generate productive plant aggregations to form larger amounts of aboveground and underground phytomass as compared to grass crops (for example *A. cristatum* (L.)) that are widely used in the region. For an average nine-year period of the studies the *H. officinalis* (L.) crops used to generate 370.5 g·(m²)⁻¹ of an absolutely dry substance of aboveground organic mass per year, while the *A. cristatum* crops formed 213.6 g·(m²)⁻¹ per year and the communities produced 59.7 g·(m²)⁻¹ per year in case of natural substrate overgrowth. To increase the gross content of total carbon, fulvic acid carbon, and humic acid carbon in the soil substrate, both in fine-grained soils and in the skeletal part of the soil, the *H. officinalis*(L.) crops significantly superior to the other two examined options. On a chalk outcrop, the total carbon tends to increases by 1.971% (or 197.1% in relative terms) in absolute terms as compared to the initial state for nine years of life in fine-grained soil under the *H. officinalis* (L.) crops. The content of humic acids increases by 1.109% in relative terms (110.9% relative) and the content of fulvic acids-by 0.793% in absolute terms (79.3% relative). Thus, *H. officinalis* (L.) crops have more significant environmental and technological value for the phytoamelioration of cretaceous exposures as compared to standard grass stands and natural vegetation succession.

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Assessment of Physicochemistry, Periphyton Species Composition, Diversity and Biomass of Asu River Southeast, Nigeria

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Abstract: : The physicochemistry, periphyton species composition, diversity and biomass of river Asu were assessed for nine months from October, 2013 to June, 2014. The study was to determine seasonal variability in the water quality and periphyton of the river due to the ecological and domestic role to the riparian communities. The parameters measured showed that air (36.60^{0}C) and water temperatures (33.70^{0}C) were higher in the dry season at stations A and B. Total dissolved solids (49.00 mg l^{-1}) and conductivity (96.00 µS cm^{-1}) were higher in the wet season at station B. pH ranged from 5.00 to 7.00. Dissolved oxygen, carbon (iv) oxide, transparency, depth and flow rate varied from 3.60-8.70 mg l^{-1}, 5.20-19.08 mg l^{-1}, 0.10-0.80 m, 0.29-7.90 m and 0.50-3.00 m s^{-1}, respectively. Nitrate ranged from 0.10 mg l^{-1} to 0.70 mg l^{-1}. Phosphate was higher (0.40 mg l^{-1}) at station A in the wet season. Ammonia nitrogen varied from 0.40 mg l^{-1} to 0.75 mg l^{-1}. Carotenoid (2.90 mg g^{-1}) and chlorophyll a (2.30 mg g^{-1}) were higher at stations B and A in the dry and wet season, respectively while percentage ash content ranged from 1.00-15.00. Ninety (90) species of periphyton belonging to six (6) divisions and forty eighty (48) families were identified. Bacillariophyta was the most abundant (68 %) and diverse group in bothwet and dry season. Chlorophyta had the highest biomass accumulation with Cladophora contributing the highest biomass. Seasonal variation in periphyton abundance and diversity were significant). Canonical correspondence analysis (CCA) showed that nitrate, phosphate, flow rate, water temperature, ammonia nitrogen, transparency, depth and pH influenced the abundance, diversity and biomass of periphyton in Asu River most. Hence, regular monitoring of anthropogenic activities around the river is recommended to maintain the water quality.

Keywords: Asu River, Nigeria, Periphyton, Water quality

Periphyton are complex mixture of algae, cyanobacteria, heterotrophic microbes and detritus that are attached to submerged surfaces in most aquatic ecosystem (Osagie 2010). They are phytoplankton attached on stones, logs and aquatic macrophytes in lentic and lotic ecosystem. Their sessile nature and photosynthetic ability make them the major producers and constitute more than 50% of the primary production in some freshwater ecosystems (Childer et al 2008). However, the resident time/accumulation ability of periphyton in the aquatic ecosystem is influenced by human and natural factors. In lakes or rivers, temperature, substrate type, invertebrate grazing, current or water velocity, physical disturbance and nutrient are factors that determine the establishment, growth and survival of periphyton in natural aquatic ecosystem (Peterson et al 2001, Murdock and Dodds 2002, He 2010, Tarkowska-Kukuryk and Mieczan 2012, Chang et al 2013). The relationship between nutrient concentrations and periphyton production have shown that nutrient enrichment enhance periphyton productivity (Vadeboncoeur et al 2006), which in turn increases the biomass or primary production of the aquatic ecosystem. Shallow littoral areas, substratum surface availability, high potential growth and proximity to anthropogenic activities contribute to the proliferation and productivity of periphyton production in aquatic ecosystem (Nandakumar and Sreekumari 2013).

River water quality is of great environmental concern because of its importance to human and aquatic organism (Simeonov et al 2004). However, man has been identified as the major contributor to pollution of river water through number of activities such as urbanization, sewage/industrial disposal and agriculture. Natural processes like erosion, rock weathering and precipitation also affects river water quality. Naturally, river system has recovery ability especially when it recovering capacity has not being exceeded by pollution (Nouri et al 2008). The periphytonare important in water quality monitoring because they are highly sensitive to even slight changes inwater quality in addition to it toxicant sequestering ability (Montuelle et al 2010).

This study is aimed at assessing the dynamics of periphyton species composition, diversity, and biomass in relation to environmental variables in Asu River. It also intends to ascertain the water quality (pollution) level. There is no information on the periphyton of Asu River although such information will be essential in water quality assessment of the River. Therefore, there is need for proper

assessment of the water quality of this river to provide information to government agencies and water managers for the proper and sustainable management of this very important resource.

MATERIAL AND METHODS

Study site: The study was carried out at Asu River which lies between latitude 6º 03' 44".00N and longitude 8'00" 36.38"E. The river connects to the Atlantic Ocean through the Cross River. The depth, width, flow velocity, water volume and size of the shoreline of river vary with season, with the highest values during the rainy season. The river supports agricultural activities such as fishing, cultivation of vegetables along the river bank, cereal and root crops within the water shed. Two sampling stations were selected for the study. Station A (downstream) located at the point where surface runoffs from nearby Akpoha market and quarry industry by the road side empty into it content. Cultivations of vegetable and cereal crops with NPK fertilizer are common within this station. Station B (upstream) was I km away from station A which was selected to represent the areas with less human activities.

Physicochemical variables: Water samples were collected from a depth of 0.5m below the surface water while temperature, total dissolved solid, pH and conductivity were determined *in situ* using Hanna digital multimeter (Model HI 98801). Transparency and depth were measured using secchi disc and a calibrated pole, respectively. Dissolved oxygen was fixed *in situ* and determined in the laboratory using Winkler's method. Carbon (vi) oxide was obtained by titration method while ammonia nitrogen was determined using spectronic 20D machine (Solorzano 1996).

Periphyton samples: Periphyton samples were collected monthly from two designated stations (up and down stream) from October, 2013 to June, 2014 between 10 -15 hours of the day from a fix area of $0.5m^2$ from substrata (floating logs, aquatic vegetation and riparian stones) at the sites and preserved in 4% buffered formalin (Nwonumara et al 2016). The preserved periphyton were identified and quantified under light microscope (model: XSZ-107E; 100X and 400X magnifications) using standard identification guides according (Biggs and Kilroy 2000, Nwankwo 2004). Periphyton sample for carotenoid and chlorophyll A were collected in dark bottles, nitrate and phosphate also collected in a sample bottle were determined using spectronic 20D machines while percentage ash was determined by dry ash method (AOAC 2003).

Data analysis: Physicochemical variables were analysed using descriptive statistics. Periphyton abundance was represented by number of individuals of each species per area (expressed as number of individuals per metre square (ind/m^2). Species richness was calculated using Margalef's index, d = s – 1/ln (N). Species diversity was calculated using Shannon-Weiner index, H = - Σpilogpi and evenness calculated as E = H/Log S. Periphyton biomass was calculated from biovolume using geometric model for calculating cell biovolume (Jun and Dongyan 2003). Periphyton-environment relation was determined using with Canonical Correspondence Analysis (CCA). Temporal and spatial variation in physicochemical variables and periphyton data were determined using analysis of variance. All statistical analyses were carried out using statistical package for social science (SPSS) Version 20 and PC ORD version 5.

RESULTS AND DISCUSSION

Physicochemical variables: Air (36.60^0C) and water temperatures (33.70^0C) were higher in the dry season at stations A and B. Temperature responds rapidly to seasonal variability and tend to be higher in the dry season when rainfall is lower. The earlier researchers also recorded higher temperature in the dry season (Nwonumara et al 2016, Nwinymagu et al 2018). Total dissolved solids (49 mg l^{-1}) and conductivity (96 μS cm^{-1}) were higher in the wet season at station B. This could be due to increase in the amount of dissolved ions washed into the river by moving water. The result is contrary to other researchers where higher TDS and conductivity were in the dry season (Nwinymagu et al 2018). pH ranged from 5.00 to7.00 with a higher value in the wet season. This could be due to the dilution of the water column thereby reducing the organic acid content that could have arisen from the decomposition of organic matter in the substratum. Dissolved oxygen was lower (3.60 mg l^{-1}) at station A in the dry season and higher (8.70 mg l^{-1}) at station B in the wet season. High turbulence in the wet season could have promoted air-water mixing thus elevating the oxygen content (Muhibbu-Din et al 2011, Okogwu et al 2013). Carbon dioxide varied from 5.20 mg l^{-1} to 19.08 mg l^{-1} being higher in the dry season. Increased solar irradiation during dry season probably caused an increase in biodegradation of organic matter leading to the release of more CO_2 into the water column. Transparency ranged from 0.10 m to 0.80 m in both stations. Depth (7.90 m) was higher in the wet season at station A. In the same vein, flow rate (3.00 m s^{-1}) was also higher in the wet season in both stations. Depth and flow rate increased with water volume. Nitrate ranged from 0.1 mg l^{-1} to 0.7 mg l^{-1}. Phosphate was higher (0.40 mg l^{-1}) at station A in the wet season. Higher nitrate and phosphate recorded in the wet season could be due to the inflow of nutrients from the riparian farmlands. Ammonia nitrogen varied from 0.40 mg l^{-1} to 0.80 mg l^{-1}. Carotenoid (2.90 mg g^{-1}) and chlorophyll A (2.30

mg g^{-1}) were higher at stations B and A in the dry and wet season, respectively while percentage ash content ranged from 1.00-15.00. Seasonal difference in air and water temperature, TDS, conductivity, dissolved oxygen, dissolved carbon dioxide, transparency, depth, flow rate, nitrate, carotenoid and percentage ash content of the periphyton were significant at both stations (Table 1). However, temporal variations in most of the physicochemical variables measured were not significant.

Periphyton taxonomic composition: A total of 90 species of periphyton belonging to 48 families and 6 divisions (Bacillariophyta, Chlorophtyta, Xanthophyta, Dinophyta, Rhodophyta and Cyanophyta) were identified in Asu River (Table 2). Bacillariophyta was more abundant in the dry season than wet season, with total percentage abundance of 67.70% with *Diatoma* spp being the most abundant. Xanthophyta and Rhodophyta had the least abundance and contributed 2% each Periphyton was generally more abundant during the dry season (Fig. 1 and 2) than the wet season. The spatial and temporal variations in Bacillariophyta and Xanthophyta abundance were significant.

Chlorophyta had the highest biomass accumulation (7.79) among the 6 divisions of periphyton (Table 2) with total percentage biomass of 68%. The species that contributed most to the Chlorophyta biomass and to all other species was
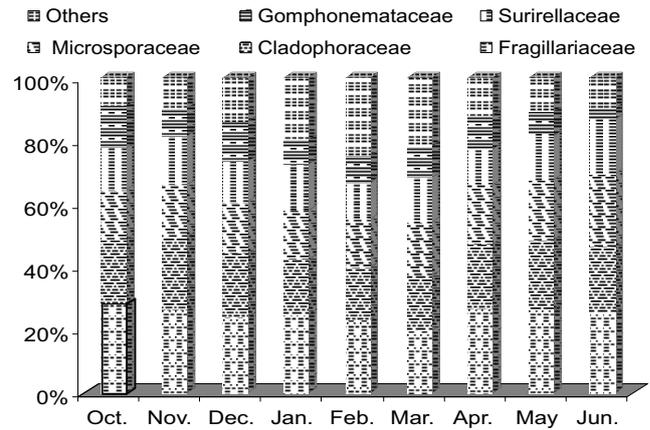
Fig. 1. Percentage composition of the dominant periphyton families in station A

Cladophora glomerata with 66.00% contributions to the total biomass accumulation of Chlorophyta. Dinophyta was the least (0.01%) contributor to the periphyton biomass (0.28 %). The difference in the spatial variation of Chlorophyta biomass was significant. The most abundance and diverse periphyton taxon was Bacillariophyta while Dinophyta was the least among the periphyton taxa in both wet and dry season. The total periphyton abundance and diversity of Asu River were significant.

Fragillariaceae was the most dominant among the families of periphyton identified with percentage of 28.40 and

Table 1. Mean values and seasonal variation in the major physicochemistry during wet and dry seasons in Asu River

Stations	Station A						Station B					
	Wet season			Dry season			Wet season			Dry season		
Water parameters	Mean	Min.	Max.	Mean	Min.	Max.	Mean	Min.	Max.	Mean	Min.	Max.
Air temperature (^{0}C)	32.20[a]	30.20	34.00	33.10[b]	27.20	36.60	32.10[a]	30.50	34.00	32.7[b]	27.00	35.50
Water temperature (^{0}C)	30.20[a]	28.50	32.00	30.70[b]	26.80	32.10	29.50[a]	28.90	30.50	30.9[b]	26.90	33.70
Total dissolved solid (mg l^{-1})	46.00[a]	31.00	45.00	41.20[b]	32.00	46.00	35.30[a]	25.00	49.00	31.8[b]	33.00	47.00
Conductivity (µs cm^{-1})	86.00[a]	36.00	79.60	93.50[b]	69.00	94.00	71.70[a]	50.00	96.00	84.3[b]	68.00	89.00
pH	6.30[a]	6.00	7.00	5.80[b]	5.20	5.80	6.30[c]	5.60	7.40	6.00[c]	5.00	7.00
Dissolved oxygen (mg l^{-1})	8.10[a]	4.00	8.30	5.50[b]	3.60	6.00	6.90[a]	4.00	8.70	3.40[b]	3.70	5.80
Carbon (iv) oxide (mg l^{-1})	7.10[a]	5.20	8.80	10.70[b]	6.30	19.00	7.10[a]	5.30	8.80	10.60[b]	5.30	19.10
Transparency (m)	0.50[a]	0.10	0.80	0.20[b]	0.10	0.30	0.40[a]	0.10	0.80	0.20[b]	0.10	0.30
Depth (m)	4.90[a]	0.90	7.90	0.50[b]	0.30	0.90	4.60[a]	0.90	6.20	0.60[b]	0.30	0.90
Flow rate (m s^{-1})	1.70[a]	0.90	3.00	0.6 0[b]	0.90	2.80	2.10[c]	0.50	3.00	1.10[d]	0.60	1.80
Nitrate (mg l^{-1})	0.30[a]	0.10	0.70	0.20[b]	0.10	0.20	0.10[c]	0.10	0.20	0.10[d]	0.10	0.30
Phosphate (mg l^{-1})	0.40[a]	0.10	0.40	0.20[a]	0.10	0.20	0.10[a]	0.10	0.10	0.10[a]	0.10	0.20
Ammonia nitrogen (mg l^{-1})	0.70[a]	0.60	0.80	0.60[a]	0.40	0.70	0.70[a]	0.60	0.70	0.50[a]	0.10	0.40
Carotenoid (mg g^{-1})	1.50[a]	0.90	1.90	1.80[b]	1.00	2.90	1.40[a]	0.60	1.90	1.60[b]	0.90	2.90
Chlorophyll a (mg g^{-1})	1.60[a]	1.00	2.30	1.50[a]	0.90	2.00	1.50[a]	1.00	2.00	1.40[a]	0.80	1.90
Percentage Ash (%)	2.30[a]	1.00	4.00	7.50[b]	3.00	15.00	2.00[a]	1.00	4.00	7.50[b]	3.00	15.00

Mean with different superscript in a row are significant (p < 0.05)

Table 2. Periphyton species abundance (ind l^{-1}) and percentage relative abundance during the study

Taxa	Wet season		Dry season	
	SITE A	SITE B	SITE A	SITE B
Bacillariophyta	1860 (52.99%)	1300 (59.91%)	5240 (55.86%)	4510 (57.53%)
Achnanthes oblongella Ostrup 1902	-	20 (0.92%)	20 (0.21%)	40 (0.51%)
A. inflate Grunow 1867	20 (0.57%)	-	10 (0.11%)	20 (0.26%)
Achnanthidium lanceolata Gronuw1880	20 (0.57%)	10 (0.46%)	90 (0.96%)	50 (0.61%)
Actinella punctata Lewis 1864	30 (0.85%)	50 (2.30%)	50 (0.53%)	30 (0.38%)
Amphora ovalis Kutzing 1844	30 (0.85%)	40 (1.84%)	70 (0.75%)	30 (0.38%)
Asterionella formosa Hassall 1850	40 (1.41%)	-	130 (1.39%)	110 (1.40%)
Aulacoseira spp Thwaites 1848	-	-	60 (0.64%)	40 (0.51%)
Brachysira vitrea Ross 1986	50 (1.42%)	-	80 (0.85%)	60 (0.77%)
Cocconeis pediculus Ehrenberg 1838	10 (0.28%)	10 (0.46%)	30 (0.32%)	40 (0.51%)
Cylotella stalligera Cleve and Grunow 1882	30 (0.85%)	-	20 (0.21%)	30 (0.38%)
C. kapii Agardh 1830	10 (0.28%)	10 (0.46%)	80 (0.85%)	60 (0.77%)
C. placentula Ehrenberg 1838	20 (0.57%)	30 (1.38%)	40 (0.43%)	30 (0.38%)
C. tumida Gronuw 1880	40 (1.14%)	10 (0.46%)	70 (0.75%)	20 (0.26%)
Cymbella aspera Cleve 1894	60 (1.71%)	20 (0.92%)	100 (1.07%)	50 (0.64%)
Diatoma spp Vincen 1842	250 (7.12%)	190 (8.76%)	810 (8.64%)	720 (9.18%)
Diatomella parva Manguin 1962	10 (0.28%)	30 (1.38%)	50 (0.53%)	60 (0.77%)
Encyonema minutum Mann et al 1990	10 (0.28%)	10 (0.46%)	80 (0.85%	100 (1.28%)
Epithemia sorex Kutzing 1844	40 (1.14%)	-	110 (1.17%)	20 (0.26%)
Eunotia arcus Ehrenberg 1837	50 (1.42%)	30 (1.38%)	100 (1.07%)	80 (1.02%)
F. rhomboides De Toni 1891	10 (0.28%)	20 (0.92%)	140 (1.49%)	90 (1.15%)
Fragelaria pectinalis (Muller) Lyngbye 1819	40 (1.41%)	10 (0.46%)	100 (1.07%)	210 (2.68%)
Frustulia vulgaris De Toni 1891	10 (0.28%)	-	40 (0.43%)	40 (0.51%)
Gomphanema trucatum Ehrenberg 1832	90 (2.56%)	30 (1.38%)	110 (1.17%)	140 (1.79%)
G. angustum Rabenhorst 1864	40 (1.14%)	-	140 (1.49%)	30 (0.85%)
G. clavatum Ehrenberg 1832	10 (0.28%)	10 (0.46%)	30 (0.32%)	40 (0.51%)
G. minutum Aardh 1831	20 90.57%)	60 (2.76%)	-	30 (0.38%)
G. parvalum Kutzing 1839	20 (0.57%)	40 (1.84%)	100 (1.07%)	100 (1.28%)
Gyrosigma scalproides Cleve 1894	10 (0.28%)	10 (0.46%)	20 (0.21%)	10 (0.13%)
Hemidiscus cuneiformis Wallich 1860	30 (0.85%)	40 (1.84%)	70 (0.75%)	90 (1.15%)
Melosira varians Agardh 1827	40 (1.14%)	20 (0.92%)	10 (0.11%)	-
Meridion circulare (Graville) Agardh 1831	-	-	150 (1.59%)	60 (0.77%)
Nitszchia dissipata Rabenhorst 1860	60 (1.71%)	10 (90.46%)	60 (0.46%)	70 (0.87%)
N. amphibian Grunow 1862	10 (0.28%)	30 (1.38%)	100 (1.07%)	90 (1.15%)
N. gracilis Hantzsch 1860	30 (0.85%)	20 (0.92%)	110 (1.92%)	110 (1.40%)
N. intermidia Cleve and Grunow 1880	-	-	20 (0.21%)	20 (0.26%)
N. sigmoidea Smith 1853	-	-	70 (0.75%)	40 (0.51%)
Navicula radiosa Kutzing 1844	30 (0.85%)	20 (0.92%)	50 (0.53%)	50 (0.64%)
Neidum affine Pfizer 1871	10 (0.28%)	20 (0.92%)	30 (0.32%)	30 (0.38%)
Pinnularia gibba Ehrenberg 1843	10 (0.57%)	10 (6.46%)	40 (0.43%)	40 (0.51%)
P. microstauron Cleve 1891	30 (0.57%)	-	40 (0.43%)	20 (0.26%)
P. subcapitata Gregory 1856	10 (0.28%)	20 (0.92%)	40 (0.43%)	50 (0.64%)
P. viridis Ehrenberg 1843	20 (0.57%)	-	20 (0.21%)	20 90.26%)
Placoneis placentula Mereschkowsky 1903	-	20 (0.92%)	40 (0.43%)	10 (0.13%)
Rhoicosphenia abriviata Agardh 1831	40 (1.14%)	30 (1.38%)	30 (0.32%)	10 (0.13%)
R. operculata Hakanasson 1979	10 (0.28%)	-	40 (0.43%)	40 (0.51%)
Surirella angusta Kutzing 1844	10 (0.28%)	50 (2.30%)	30 (0.32%)	20 (0.26%)
S. brebissonii Krammer and Lange-Bertalot 1987	20 (0.57%)	20 (0.92%)	10 (0.11%)	10 (0.13%)
S. linearis Smith 1853	-	10 (0.46%)	100 (1.07%)	40 (0.51%)
S. minuta Kutzing 1949	30 (0.85%)	10 (0.46%)	280 (2.99%)	200 (2.55%)
Synedra acus Kutzing 1844	30 (0.85%)	30 (1.38%)	20 (0.21%)	20 (0.26%)
S. biceps Kutzing 1844	-	20 (0.92%)	50 (0.53%)	40 (0.51%)
S. delicatissima Smith 1853	30 (0.85%)	30 (1.38%)	30 (0.32%)	50 (0.64%)
S. rumpens Kutzing 1844	-	-	110 (1.17%)	110 (1.40%)
S. ulna var-biceps Kirchner1878	40 (1.14%)	30 (1.38%)	10 (0.11%)	70 (0.89%)

S. ulna var-biceps Kirchner 1878	40 (1.14%)	30 (1.38%)	10 (0.11%)	70 (0.89%)
S. ulna var-ramesi Hustedt 1903	40 (1.14%)	30 (1.38%)	20 (0.21%	10 (0.13%)
S. ulna. Ehrenberg 1832	190 (5.41%)	60 (2.76%)	580 (6.18%)	510 (6.51%)
Stauroneis anceps Ehrenberg 1843	10 (0.28%)	-	60 (0.64%)	50 (0.64%)
Stenopterobia delicatissima Heurck 1869	20 (0.57%)	20 (0.92%)	100 (1.07%)	90 (1.15%)
Tabellaria fenestrata Kutzing 1844	90 (2.56%)	60 (2.76%)	200 (2.13%)	170 (2.17%)
Chlorophyta (Green algae)	870 (24.79%)	550 (25.35%)	2380 (25.37%)	2090 (26.66%)
Apatococcus vulgaris Brand 1925	20 (0.57%)	10 (0.46%)	30 (0.32%)	30 (0.38%)
Cheatophora pisiformis (Roth) Agardh 1812	10 (0.28%)	20 (0.92%)	30 (0.32%)	10 (0.13%)
Cladophora glomerata (Linnaeus) Kutzing 1843	100 (2.85%)	130 (5.99%)	170 (1.81%)	190 (2.42%)
Clostarium acerosum Ehrenberg and ex Raifs 1848	50 (1.42%)	40 (1.84%)	-	50 (0.64%)
Coleocheate disc Brebisson 1844	-	-	40 (0.43%)	30 (0.38%)
Cosmarium reniforme (Ralfs) Archer 1874	10 (0.28%)	30 (1.38%)	20 (0.21%)	40 (0.51%)
Dinophyta	70 (2.56%)	20 (0.92%)	170 (1.81%)	120 (1.53%)
Klebsormidium nitens (Kutzing) Lokhorst 1996	30 (0.85%)	10 (0.46%)	230 (2.45%)	70 (0.89%)
Lingulodinium polyedrum (Stein) Dodge 1989	50 (1.42%)	-	60 (0.64%)	60 (0.77%)
Microspora abbreviate (Rabenhorst) Lagerheim1887	210 (5.98%)	70 (3.23%)	610 (6.50%)	520 (6.63%)
Oedogonium grande Kutzing ex Hirn 1900	10 (0.28%)	10 (0.46%)	100 (1.07%)	90 (1.15%)
Preperidinium meunieri (Pavillard) Elbrachter 1993	20 (0.57%)	-	50 (0.53%)	50 (0.64%)
Rhizoclonium africanum Kutzing 1853	210 (5.98%)	80 (3.69%)	640 (6.82%)	450 (5.74%)
Scrippsiella trochoidea (Stein) Loeblich III 1976	20 (0.57%)	20 (0.92%)	60 (0.64%)	10 (0.13%)
Staurostrum gracile Ralfs ex Ralfs 1848	30 (0.85%)	10 (0.46%)	70 (0.75%)	80 (1.62%)
Stigeoclonium tenue (Agardh) Kutzing 1843	50 (1.42%)	70 (3.23%)	70 (0.75%)	120 (1.53%)
Tribonema vulgare Pascher 1925	170 (4.84%)	70 (3.23%)	650 (6.93%)	450 (5.74%)
Ulothrix sp Kutzing 1833	60 (1.71%)	40 (1.84%)	240 (2.56%)	290 (3.69%)
Vaucheria schleicheri De Wilderman 1895	100 (2.85%)	40 (1.84%)	70 (0.75%)	50 (0.64%)
Xanthophyta (Yellow algae)	270 (7.69%)	110 (5.01%)	720 (7.68%)	500 (6.38%)
Zygnema sp	80 (2.28%)	10 (0.46%)	70 (0.75%)	70 (0.89%)
Rhodophyta (Red algae)	180 (5.13%)	80 (3.69%)	460 (4.90%)	290 (3.69%)
Audouinella hermanii (Roth) Dudy 1830	160 (4.56%)	50 (2.30%)	440 (4.69%)	260 (3.32%)
Batrachospermum virgato-decaisneanum Sirodot 1884	20 (0.57%)	30 (1.38%)	20 (0.21%)	30 (0.38%)
Cyanophyta (Blue-green algae)	240 (6.84%)	110 (5.07%)	410 (4.37%)	330 (4.21%)
Anabaena fuellebornii Schmidle 1902	80 (2.28%)	50 (2.30%)	60 (0.64%)	70 (0.89%)
Aphanocapsa parasitica (Kutzing) Komarek & Anagnostis 1995	100 (2.85%)	20 (0.92%)	80 (0.85%)	60 (0.77%)
Chroococcus turgidus (Kuzting) Nageli 1849	30 (0.85%)	-	120 (1.28%)	40 (0.51%)
Geitlerinema splendium (Greville ex Gomont) Anagnostidis 1989		-	20 (0.21%)	20 (0.26%)
Lyngbya confervoides Agardh ex Gomont 1892	10 (0.28%)	-	40 (0.43%)	70 (0.89%)
L. intermedia Treub ex Hansgirg 1892	20 (0.57%)	20 (0.92%)	70 (0.57%)	30 (0.38%)
Oscillatoria obtusa Gardner 1927	-	20 (0.92%)	60 (0.64%)	40 (0.51%)

35.60% in stations A and B, respectively (Fig. 1 and 2). *Diatoma* from fragillariaceae was the most abundant species during the study. Cladophoraceae and microsporaceae were the next most dominant families while the least family among the most dominant families was gomphonemataceae having as low as 3.50and 8.10% in station A and B, respectively. The three most dominant families (Fragilleriaceae, Cladophoraceae and Microsporaceae) contributed 50-60% (depending on the month) of periphyton composition in both stations during the study period.

The periphyton families identified during the study period were consistent with the works of other researchers (Montuelle et al 2010, Ingrida 2013, Kurma et al 2013). The periphyton was dominated by fragillariaceae while the most abundant species was *Diatoma*. Abundance and diversity of dominant families were highest during dry season and in station A. Increased solar radiation during dry season also contributed to the species abundance and diversity of these groups. Fragiliaraceae have ability to successfully colonize a substrate and persist in the community as an adaptive strategies used in competing for resources thereby enhancing their abundance (Ferragut and Bicudo 2010). The ability of *Diatoma* species to tolerate harsh environmental conditions and adapt to a wide range of ecological conditions could have enhanced its proliferation and abundance in Asu River. However, low abundance of some families/species could be attributed to the influence of water velocity that causes stress on periphyton species thereby reducing the abundance and diversity (Chang et al 2013).
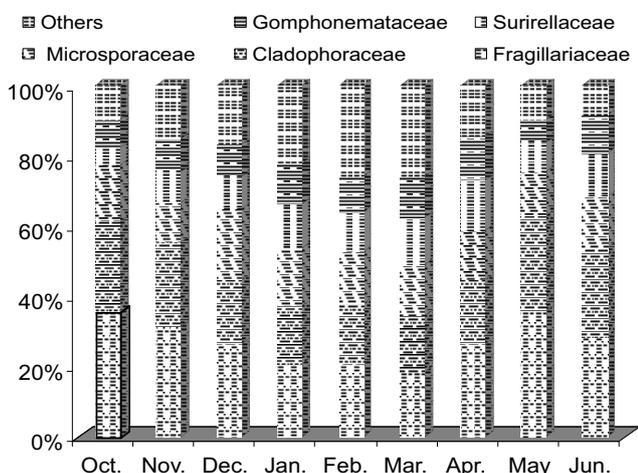
Biological Indices of periphyton: The species richness was highest during March in both stations and least in of October (Table 3). In the same vein, species diversity increased in March, but the biomass showed highest accumulation in June and October (wet season) in station A while in station B highest values of biomass was in May and June. As species richness increased, diversity also increased. However, low biomass at the period of high diversity could be due to the sizes of the species that make up the periphyton community at the period. Evenness value showed that periphyton species in Asu River were not evenly distributed during the period of the study.

Periphyton-environment relation: The ordination analysis, indicating that periphyton-environment relation was significant for Axis 1 ($r = 0.89$) and Axis 2 ($r = 0.77$) (Fig. 3). Axis 1 explained 40.50% of periphyton-environment
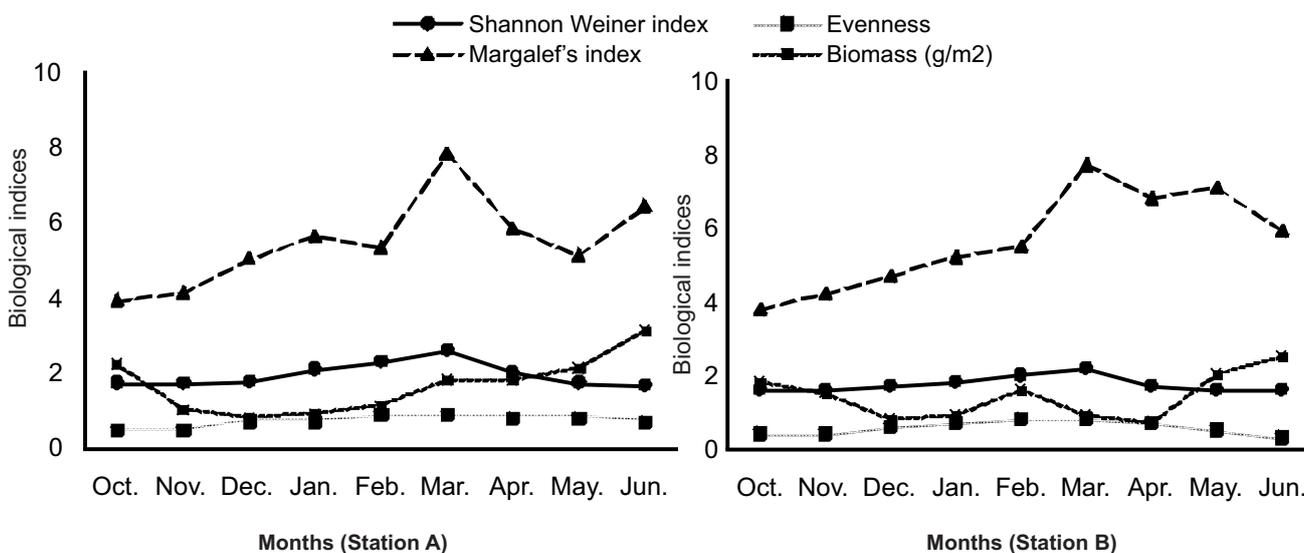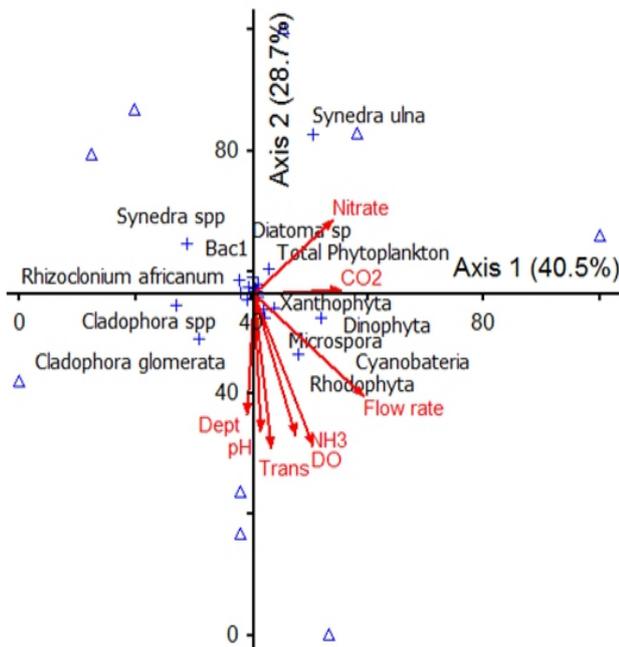

Fig. 2. Percentage composition of the dominant periphyton families in station B

Fig. 3. Diversity indices and periphyton biomass of Asu River at the sample stations

Key: Station A (closed circle) and Station B (open circle). NH_3 = Ammonia, CO_2 = Carbon dioxide, DO = Dissolved oxygen, Flow rate = Water flow rate (velocity)

Fig. 4. Canonical Correspondence Analysis (CCA) of periphyton environment relation of Asu River during the study

relationship and was mostly attributed to water flow rate (0.72), carbon dioxide (0.57) and nutrient (0.52). Axis 2 contributed 28.7% to the association and temperature (-0.78), dissolved oxygen (0.76), ammonia nitrogen (0.71), pH (0.69) and depth (0.56) were the dominant variables. Monte Carlo test performed along with canonical correspondence analysis (CCA) showed that the first axis was significant (eigenvalue=0.89, p=0.002), this axis was mainly related to flow rate and nitrate, while axis 2 was attributed to physical and chemical variables. The major that influences periphyton abundance, diversity and biomass were water velocity, depth, temperature and nutrient. The water velocity, nutrient availability and substrate type are the major controllers of periphyton abundance and diversity. Other factors include ammonia-nitrogen, temperature, pH, CO_2 and water depth. The regulating nutrient input through human activities will help to maintain the water quality for sustainable uses.

CONCLUSION

The water quality of a aquatic ecosystem determines the ecological integrity of the water body, hence the efficiency of its role to the environment and man. The water quality of Asu River was assessed with the periphyton species composition, abundance, diversity and biomass. The study revealed that some parameters including water temperature,

TDS, conductivity, flow rate, depth, and some nutrients varied between seasons. The periphyton abundance and diversity were also significant between seasons. Hence, the major factors that controlled the periphyton structure were water velocity, depth, temperature and nutrient.

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Conservation Agriculture Based Annual Intercropping System for Sustainable Crop Production: A review

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Abstract: The objective of this paper was to provide an inclusive view and evaluation of conservation tillage based annual intercropping, summarizing their main advantages and challenges to use as compared to conventional crop production system. Conservation tillage based intercropping (CTBI) controls soil erosion caused by conventional tillage based sole/mono-cropping as compared to conventional crop production system. Its long term effect gives higher percentage of organic matter and organic carbon as compared to conventional tillage based mono-cropping due addition of carbon input from the intercropped legumes and residues from conservation tillage. CTBI system in the long term significantly lowers the bulk density in the top layer and in turn improves the soil pore size distribution. Similarly, it resulted in higher total N, available K and Mg content than conventional crop production system. CTBI had significantly higher infiltration characteristics, soil water content, water use efficiency than continuous sole cropping and conventional tillage based intercropping. And also establishes more biodiversity into agroecosystems and reduces the addition of chemicals and gases that triggers greenhouse gas accumulation in the atmosphere. The CTBI is used as the primary means of sustainable crop production system by improving soil health, promoting diversity of diet, stability of production, reduced pests, efficient use of labor, intensification of production with limited resources, maximization of returns under low levels of technology and used as insurance against crop failure. However, in Ethiopia conservation tillage based annual intercropping system becomes effective if and only if inclusive research and extension service and appropriate land use policy over it should be implemented.

Keywords: Conservation tillage, Annual Intercropping, Soil fertility, Crop production

In the world the change from complex agricultural systems to less complex systems with lower species numbers was a major feature of agricultural development in the 21th century (Crews and Peoples 2003). In African, most crops are today grown continually as a monoculture and sole cropping system under conventional tillage practice (Itoa et al 2000, Lithourgidis et al 2011, Zerihun et al 2014). The improvement of crop varieties and fertilizers under intensive land cultivation has resulted in a change from rotational cropping to the continuous cropping of high yielding crops (Crews and Peoples 2003), allowing us to a large extent to ignore issues of soil fertility, crop pests (diseases, insect pests and weed infestation), yield stability and in general the issue of food and environmental security (Lithourgidis et al 2011). Thus, most present cultivation practices and cropping systems are relatively independent of internal ecological functions and are to a great degree based on the supply of inputs from the outside. In Ethiopia, little research and poor extension service on conservation tillage based annual intercrops are the main problems associated with sole cropping and mono-cropping under conventional tillage (Zerihun et al 2014, Bitew 2014). This is clearly exemplified by Ethiopian current agricultural lands decrease in soil fertility

(Tadesse et al 2012), occurrence of new pests and disease and recurrent drought and long dry spells in a short interval of years (FAO 2014). Natural resource degradation and in turn slow crop productivity per hectare increment due to improper land cultivation and cropping system are the main environmental problem in Ethiopia (Tadesse et al 2012, Gebru Hailu 2015). As a result, Ethiopia loses annually 1.5 billion metric tons of top soil by erosion (Enyew et al 2013). This could have added about 1 to1.5 million metric tons of grain to the country's harvest. Furthermore, at farmer's field, teff, maize, sorghum and wheat are the dominant grain crops in the country and gave about 64.42, 69.41, 66.57 and 57.81percent less grain yield as compared to their potential yield for the last decades (CSA 2013, EIAR 2016).

Restoring on-farm biodiversity and soil fertility through diversified farming systems that mimic nature is considered to be a key strategy for sustainable agriculture (Thrupp 2002, Jackson et al 2007). On-farm biodiversity, if correctly assembled in time and space, can lead to agro ecosystems capable of maintaining their own soil fertility, regulating natural protection against pests and diseases and sustaining productivity (IIRR and ACT 2005, Sheibani and Ahmad 2013). Biodiversity in agroecosystems can be enhanced in

time through conservation tillage (crop rotations cover cropping and zero tillage (Mal´ et al 2009). intercropping (Yayeh et al 2015) or through integrating conservation tillage and intercropping system (Thierfelder et al 2001, Ajayi 2015). While conventional agriculture containing intensive land preparation and sole/monocropping has brought vast increases in productivity for a short period of time, it is widely recognized that much of this may have come at the price of sustainability (Lichtfouse et al 2009).This is because this farming system implies the simplification of the structure of the environment over vast areas, replacing natural plant diversity with only a limited number of cultivated plants in extensive areas of arable monocultures and sole cropping system (Andersen et al 2007). Moreover, perhaps the most universally applicable one is that if one crop fails, or performs poorly, the other can compensate in an intercropping system under both tillage systems, such compensation clearly cannot occur if crops are grown separately in mono-cropping system (Alene Arega et al 2006, Duivenboodew et al 2000, Ouma and Jeruto 2010).

Moreover, conservation agriculture based intercropping systems are characterized by their great degree of genetic diversity in the form of multiple cropping (Lithourgidis et al 2011, Gebru Hailu 2015) and conservation tillage or an integration of the two, based on numerous varieties of domesticated crop species as well as their wild relatives (Lithourgidis et al 2011, Gebru Hailu 2015). These farming systems offer a means of improving soil fertility (Zerihun et al 2014), promoting diversity of diet and income, stability of production (Hobbs et al 2007, Preissela et al 2015) reduced insect and disease incidence, efficient use of labor, intensification of production with limited resources (Lithourgidis et al 2011) and also maximization of returns under low levels of technology (Mal´ et al 2009) and reduced climate change (Shames 2006, Kassam and Theodor 2010).Though, currently the practice like conservation agriculture as sustainable food production has been supported by international NGO's like CIMMYT (ACIAR) in Ethiopia, lack of sound agricultural policies, researches, extension packages, free grazing, intensive ploughing of cultivated land hiders the implementation of conservation tillage based intercropping system (Lithourgidis et al 20114). Only a few studies (Kassie et al 2009, Wellelo et al 2009) have reported on the status and effects of conservation tillage in the country. These studies focused on small areas of Ethiopia where drought and soil degradation are the most important agricultural constraints and high mono-cropping systems are practiced. Rockström et al (2001) presented results of on-farm trial that showed increased yields and improved water productivity using conservation farming in semi-arid and dry sub-humid locations in Ethiopia. Wellelo et al (2009) similarly reported higher on farm grain yield and biomass for teff (*Eragrostis abyssinica*) and reduced soil erosion for farms under conservation tillage in northern Ethiopia. Therefore, the objective of this paper were to provide an inclusive view and evaluation of conservation tillage based annual intercropping, summarizing their main advantages and challenges to use as compared to conventional crop production system, supported by a number of key examples from the published literature which point out its great value in the context of sustainable agricultural development in Ethiopia now and in the future.

Conservation Agriculture

Definition and principles of conservation agriculture: The historical development of agriculture with tillage being a major component of management practices was explained by different researchers (IIRR and ACT 2005, Małecka et al 2012). Currently, agricultural productivity levels have fallen in countries like Ethiopia, due to very small cultivated land per household (less than 1ha), high population growth, (land degradation as a result of many years of erosive cultivation mainly repeated, removal of crop residue due to free grazing and declining soil fertility as farmers fail to replenish soil fertility (IIRR and ACT 2005, Derpsch 2009). For this situation, countries like Ethiopia needs capable of borne or endured, upheld, defended and maintain some important agricultural practice. Thus, conservation agriculture is the greatest soil, water and environmental conservation practice and in turn give sustainable food security to come along in the 20th century (IIRR and ACT 2005, Thierfelder et al 2015). This is an important concept in today's agriculture, since the human race will not want to compromise the ability of its future offspring to produce their food needs by damaging the natural resources used to feed the population today. According to IIRR and ACT (IIRR and ACT 2005), conservation agriculture is an approach to growing crops that strives to achieve high and sustainable productivity, quality and economic viability, while also respecting the environment. It can be defined as an approach to managing agro-ecosystems for improved and sustained productivity, increased profits and food security while preserving and enhancing the resource base and the environment. Protecting soil and water are at the heart of this approach. It is also defined as a minimal soil disturbance (no-till) and permanent soil cover (mulch) combined with rotations, is a recent agricultural management system that is gaining popularity in many parts of the world (Hobbs et al 2007). Agriculture is not a rigid, formalized system, but a flexible set of guiding principles based on three interlinked principles which need to be adopted to particular cropping systems

(IIRR and ACT 2005, Hobbs et al 2007, Lane et al 2006).

Minimum mechanical soil disturbance: It refers to any conservation system that minimizes the total number of tillage primary and secondary operations for seed planting from that normally used on field under conventional tillage. It is also called reduced tillage because it reduces the use of tillage to minimum enough to meet the requirements of crop growth. Reduced tillage is a conservation management strategy that leaves at least 30% residue cover to minimize runoff and soil erosion, improve soil functions, and sustain crop production.

Permanent soil cover: Keeping a vegetative cover over the soil in the absence of a crop has an important role in protecting the soil and enhancing its properties. In annual crops this cover can be achieved by chopping and spreading the residues of the harvested crop, or by planting a cover crop which will either be incorporated or desiccated before drilling the next crop. In some instances the new crop may be drilled directly into the cover crop. These covers protect soil from the impact of raindrops and wind which lead to erosion, and enhance its properties by adding organic matter to improve its structure and fertility.

Diversified crop rotations: Appropriate sequences of crops will reduce the impact of weeds, pests and diseases on a single crop type and give opportunities for alternative methods of control or reduce the need for external inputs. Legume crops have bacteria associated with their roots which take nitrogen from the air and turn it into forms plants can use, hence, reducing the need for fertilizers.

Extent of conservation agriculture: Soils are vital for agricultural productivity and a normal rate of soil formation is estimated to be between half and one tone per hectare annually (Lane et al 2006) and may take a century or more to produce just one centimeter of new topsoil. Soil must therefore be regarded as a largely nonrenewable resource. Due to this reason conservation agriculture is widely adopted globally. However, the reliable estimates on the exact extent of all sorts of conservation agriculture practices are not available. However, there are some reliable estimates on the extent of zero-tillage, one aspect of conservation agriculture, largely adopted in different parts of the world. The estimates show that zero-tillage agriculture is adopted in an area of little more than 105 million ha (Evers 2001). The adoption of zero-tillage practices was rapid from 45 million hectare in 1999 to 95 million in 2005 and now estimated to be more than 105 million. In descending order South America (49.5 million ha and percentage of total 46.8), North America (40.1 million ha and percentage of total 37.8), Australia (12.2 million ha and percentage of total 11.5), Asia (2.5 million ha and percentage of total 2.3), Europe (1.15 million ha and

percentage of total1.1) and Africa (0.37 million ha and percentage of total 0.3) showed adoption of no-tillage (Hobbs et al 2007, Derpsch 2009, Joshi 2011). Though soil conservation practices, including minimum or no tillage have long been practiced by farmers in Ethiopia, conservation tillage were introduced in 1998 by Sasakawa Global on 77 maize plots (Matsumoto et al 2004). Despite the decade old national effort to systematically disseminate conservation tillage, no empirical evidence has been presented as to what extent the technology package is being adopted, or the extent to which farm yields are being influenced (Wellelo et al 2009). In Ethiopia, agricultural services are generally focused on increasing production through short-term technical packages such as small holder intensification through improved access to modern inputs like improved seeds and fertilizers, without paying attention to sustainable food security.

Intercropping

Definition and principles of intercropping: Intercropping is the simultaneous growing of more than one species in the same field to rise per unit productivity per unit time (Itoa et al 2000, Lithourgidis et al 2011, Zerihun et al 2014). Many crops have been grown in association with one another for hundred years and crop mixtures probably represent some of the first farming systems practiced as traditional agriculture (Zerihun et al 2014). Although intensive monocropping is much easier for large-scale farmers, who plant and harvest one crop, small-scale farmers, who often do not have readily access to markets and grow enough food only to sustain themselves and their families, recognize that intercropping is one good way of ensuring their livelihood (Najafi and Abbas 2014). However, at least 55 % of world farmers are resource poor mainly in Africa, Asia and Latin American (Ashenafi et al 2013). Due to this reason, today intercropping is commonly used in many tropical parts of the world particularly by small-scale traditional farmers. Traditional multiple cropping systems are estimated to provide as much as 15-20% of the world's food supply. In the tropical regions, intercropping is mostly associated with food grain production, whereas in the temperate regions it is receiving much attention as a means of efficient forage production (Zerihun et al 2014). In China, one-third of all the cultivated land area is used for multiple cropping and half of the total grain yield is produced with multiple cropping (Zhang and Long 2003). Other quantitative evaluations suggest that 89 per cent of cowpeas in Africa are intercropped, 90 per cent of beans in Colombia are intercropped and the total percentage of cropped land actually devoted to intercropping varies from as low as 17 % for India to as high as 94 per cent in Malawi (Lithourgidis et al 2011). Intercropping as greater land use intensification as

well as crop diversification is a common practice in many areas of Africa as a part of traditional farming systems commonly implemented in the area due to population growth and the consequent pressure on land resources coupled with frequent crop failures due to weather, pests and diseases and food security needs (Tadesse et al 2012, Kariaga 2004). It is mostly practiced on small farms with limited production capacity due to lack of capital to acquire inputs (Ashenafi et al 2013).

In subsistence economy, as the farmers in Ethiopia, uses a combination/mixture of crops on a piece of land due to scarcity of land to avoid risk of crop failure, soil conservation and labor economy (Tadesse et al 2012, Bantie et al 2014). Some of the chosen grain crop mixtures normally include cereals, pulses and/or oil seeds (Tadesse et al 2012).Though, there is lack of quantitative data on over all intercropping systems in Ethiopia, the most important grain crop mixtures commonly used by farmers are sorghum /chick pea, sorghum/faba bean, sorghum/barley, sorghum/finger millet, finger millet/rape seed, wheat /barley, pea /faba bean, maize/rape seed, maize/potato, maize/ faba bean finger millet/lupine, teff/safflower, rice/grass pea, sunflower with maize, finger millet (Bayu et al 2007). However, other traditional intercropping systems including horticultural crops are also commonly practiced by local farmers in Ethiopia. Although agricultural research originally focused on sole cropping and ignored the potential of intercropping, there has been a gradual recognition of the value of this kind of cropping system (Lithourgidis et al 2011). For instance, one of the most important progresses is use of intercropping as organic farming system even in North America and Europe who followed intensive agriculture. For organic sector, intercropping is considered an effective means of self-regulation and resilience of the organic agro ecosystems to meet environmental perturbations in the organic culture practice (Lampurlanes et al 2001). The last decades, several organic farmers are experimenting and gradually adapt intercropping systems in order to benefit from the advantages of intercropping (Entz et al 2011).

Spatial and temporal patterns of intercropping under conservation tillage: Intercropping is one type of multiple cropping in which growing two or more crops on the same piece of land in one cropping season (Tadesse et al 2012, Gebru Hailu et al 2015) . Several types of intercropping, all of which vary in the temporal and spatial mixture to some degree, have been described. The degree of spatial and temporal overlap in the component crops can vary somewhat, but both requirements must be met for a cropping system to be an intercrop (Bayu et al 2007, Lithourgidis et al 2011, Tadesse et al 2012). Thus, there are several different modes of intercropping, some of widely used intercropping systems according to the spatial and temporal arrangement are:

Mixed intercropping- is the growing of two or more crops at the same time with no distinct row arrangement. It is the intensification of cropping in space dimensions only (Lithourgidis et al 2011). Some example of mixed intercropping of annual crops are tef-sesame, tef-sesame-safflower, tef-safflower (Molla and Kemelew 2011), finger millet-lupine (Bantie et al 2014), finger millet-rape seed (FAO 2006), tef-sunflower (Bayu et al 2007) etc.

Row intercropping- is the growing of two or more crops at the same time with at least one crop planted in rows. It is the intensification of cropping in space dimensions only. This can be two types (Lithourgidis et al 2011).

Alternate-row intercropping- two or more plant species are cultivated in separate alternate rows; one crop may be planted in broadcasting or in row. An example of this type is maize/faba bean intercropping system (Lithourgidis et al 2011, Tadesse et al 2012).

Within-row intercropping- the component crops are planted simultaneously within the same row in varying seeding ratios. An example of this type is maize/climbing bean, intercropping system (Lithourgidis et al 2011).

Strip intercropping- several rows of a plant species are alternated with several rows of another plant species in enough space to allow separate crop production, but close enough for the crops to interact. It is the intensification of cropping in time and space dimensions. Examples of successful strip intercropping practices alternating strips of wheat, corn and soybean 6 rows wide each oat, corn and soybean and 6 rows of corn with 12 rows of soybean (Lithourgidis et al 2011).

Relay intercropping- a system in which a second crop is planted into an existing crop when it has flowered (reproductive stage) but before harvesting. The relay crop should be fairly tolerant to shade and trampling. Examples of relay crops are cassava, cotton, sweet potato and sesame with corn, chickpea, lentil and wheat with upland rice (Lithourgidis et al 2011), grass pea with rice (Bitew and Fekremariam 2014), lupine with finger millet (Bitew et al 2014) . This can be divided in two ways (Lithourgidis et al 2011),

Short temporal separation of relay intercropping- is the practice of sowing a fast-growing crop with a slow-growing crop, so that the first crop is harvested before the second crop starts to mature. During this time different planting dates of the component crops have differential influence of weather and in particular temperature on component crop growth.

Long temporal separation is found in relay intercropping- where the second crop is sown during the

growth, often near the onset of reproductive development or fruiting of the first crop, so that the first crop is harvested to make room for the full development of the second crop

Integrated Use of Intercropping and Conservation Tillage

The tremendous research and information were investigated separately on the effects of intercropping and conservation tillage methods on crop performance, soil physical and chemical properties, labor etc. However, there is paucity of sufficient research and information on the effect of integrated use of intercropping and conservation agriculture on the above parameters (Ajayi 2015, Thierfelder et al 2015). This is due to the complexity of their interaction effects on the crops which tends to discourage researchers and these have led to loss of basic research information on the benefit of conservation tillage based intercropping system. Different researchers showed that these system gave high grain yield, land use efficiency, soil fertility, growth return as compared to sole cropping and conventional tillage practices (Zerihun et al 2014, Ajayi 2015, Thierfelder et al 2015).

In the humid tropics, maize-groundnut intercropping is often practice under conservation tillage to produce food and obtain cash income from the same piece of land (Ishaq et al 2001). The reason for using this practice is because the humid tropics are characterized by highly erosive, erratic and poorly distributed rains (Osunbitan et al 2006, FAO 2016). While many workers have advocated the use of no-tillage for the tropical soil management, the dependent of no tillage on mulch has made its adoption very slow among farmers. This is because; mulching is time consuming and requires planting, cutting, transportation and spreading to the cultivated land. Moreover, mulch availability is a challenge in the tropics due to rapid decomposition of plant left-over after cropping season due to their inclement climate. To reduce this large dependence on mulch, works in no till methods which earlier emphasized sole cropping should look into intercropping (Patil et al 2015).

Improvement of soil physical and chemical properties through conservation tillage based annual intercropping: In the top end exposed soil can lose 60% of the rainfall through runoff and up to 50% of soil moisture can be lost through evaporation directly from the soil surface. The greatest benefit of conservation tillage stated by many authors is the reduction in soil erosion compared with the conventional plough-based system (Landers 2007, Thierfelder and Wall 2009). Soil loss was largest on conventional tillage compared with conservation tillage based direct seeding and Rip-line seeded-legume intercrop (Thierfelder and Wall 2009, Thierfelder et al 2012) and

amounted to a cumulative loss of 61.7 tons/ ha on conventional tillage after seven cropping seasons, compared with 29.2 tons /ha and 25.7 tons/ ha in the two conservation tillage cropping systems.

Thierfelder et al (2012) showed that bulk density at conservation tillage based maiz-cawpea intercropping system was significantly lower in the top soil, which confirms previous results of Mal´ et al (2009), although some other studies showed few, or inconsistent trends (Logsdon and Karlen 2004). Porosity is a measure of the total pore space in the soil and is measured as a volume or percent. The amount of porosity in a soil depends on the minerals that make up the soil and the amount of sorting that occurs within the soil structure. The air-filled porosity in conservation tillage based intercropping was 29.6% at the 0 to 0.01 m depth, this decreased by 27.3% in conventional tillage and for the 0.01-0.02 m depth, it decreased by 7.8% (Logsdon and Karlen 2004). Improved soil pore size distribution in the conservation tillage and intercropped plots indicates the ability of the soil to improve water supply to the plant. It also signifies improved soil utilization of precipitation leading to reduced run-off and less soil erosion (Logsdon and Karlen 2004, Thierfelder et al 2012).

The infiltration is one of the most immediate benefits of conservation tillage systems especially when measured on rotational plots (Thierfelder and Wall 2009, Nyagumbo 2008) and reveals the potential of a soil to utilize water instead of losing it to run-off (Rockström et al 2001). The reduction or absence of soil tillage has an impact on water conductivity and the infiltration rate. Conservation tillage based intercropping and conservation tillage based sole cropping had significantly higher infiltration characteristics than intercropping and sole cropping under conventional tillage (Fig. 1). Intercropped plot of conservation tillage (605mm) had significantly higher infiltration characteristics compared with intercropped plot of conventional tillage (248mm). Similarly, infiltration on three conservation agriculture (direct seeding, Rip-line seeded-legume intercrop and Rip-line seeded in descending order) was 145–331% higher than one conventionally ploughed system measured on plots with continues maize monocropping and maize-sun hemp rotation (Thierfelder et al 2012) and this reveals the potential of a soil to utilize water instead of losing it to run-off (Rockström et al 2001 (Figure 1). Zerihun et al (2014) conducted a long year research on conservation tillage based maize-legume intercropping system and observed that the lowest pH value was recorded when maize was continuously produced under conventional tillage. In addition maize and haricot bean in permanent plots showed significantly lower pH value as compared to bean-maize

rotation and maize-bean intercropping and even to the initial soil pH value. This result in agreement with other findings indicated that legume crops reduce soil pH since the crops absorb high concentration of base cations and available nitrogen in the form of nitrate by releasing H^+ into rhizosphere, which leads to soil acidification (Crews and Peoples 2003). Repeated application of acidic inorganic fertilizer could also enhance soil acidity, particularly in convectional system. Nitrification is more enhanced in much disturbed soil than minimum tilling so that nitrate leaching might be aggravated and leads to high concentration of H^+ in the soil solutions (Zerihun et al 2014). A permanent vegetative soil cover, using intercrop or green manure under no till, can strongly reduce nitrate losses. Similar to soil pH, CEC of the soil was increased in crop rotation and intercropping systems in combination with minimum tilling due to addition of soil organic carbon (Govaerts et al 2007, Zerihun et al 2014). Sole maize with conventional practice and conservation tillage practices significantly reduced nitrogen content whereas better improvement was observed in crop rotation and intercropping systems. The reduced nutrient availability under tilled may be due to removal of crop residue, higher decomposition rate of organic matter, and rapid leaching of the nutrients (Tesfay et al 2011, Zerihun et al 2014).

Tesfay et al (2011) showed that higher percentage of organic carbon was in maize-bean intercropping, sole haricot

bean and haricot bean-maize rotations under conservation tillage. However, farmers' practices considerably reduced the organic carbon content. The carbon content in the 0–30 cm soil profile showed the largest amount of soil carbon in conservation tillage based maize-cowpea intercropping (24.7 Mg ha^{-1}) and the smallest in conventional tillage (18.4 Mg ha^{-1}), suggesting additional carbon input from the intercropped legumes. Carbon accumulates mostly in the first horizons on the conservation tillage based sole and intercropping system suggesting some stratification, as highlighted by (Thierfelder et al 2012).

According to the long term study by Ajayi (2015), gravimetric soil water content showed that conservation tillage based sole and intercropping had higher soil water content in all cropping treatments than conventional tillage in both sole and intercropping conditions (Fig. 2). In the tillage treatments, higher soil water content was observed with no-tillage in all cropping methods than conventional tillage. In general, intercropped plots under conservation and conventional tillage had significantly higher soil moisture content than the sole crops of maize and groundnut under conservation and conventional tillage. The additional surface soil protection in maize-groundnut intercrop enhanced soil and water conservation and with careful selection of intercrops, competition for water under intercropping may be reduced (Preissela et al 2015). Available soil moisture (mm) was higher and increased under conservation tillage based
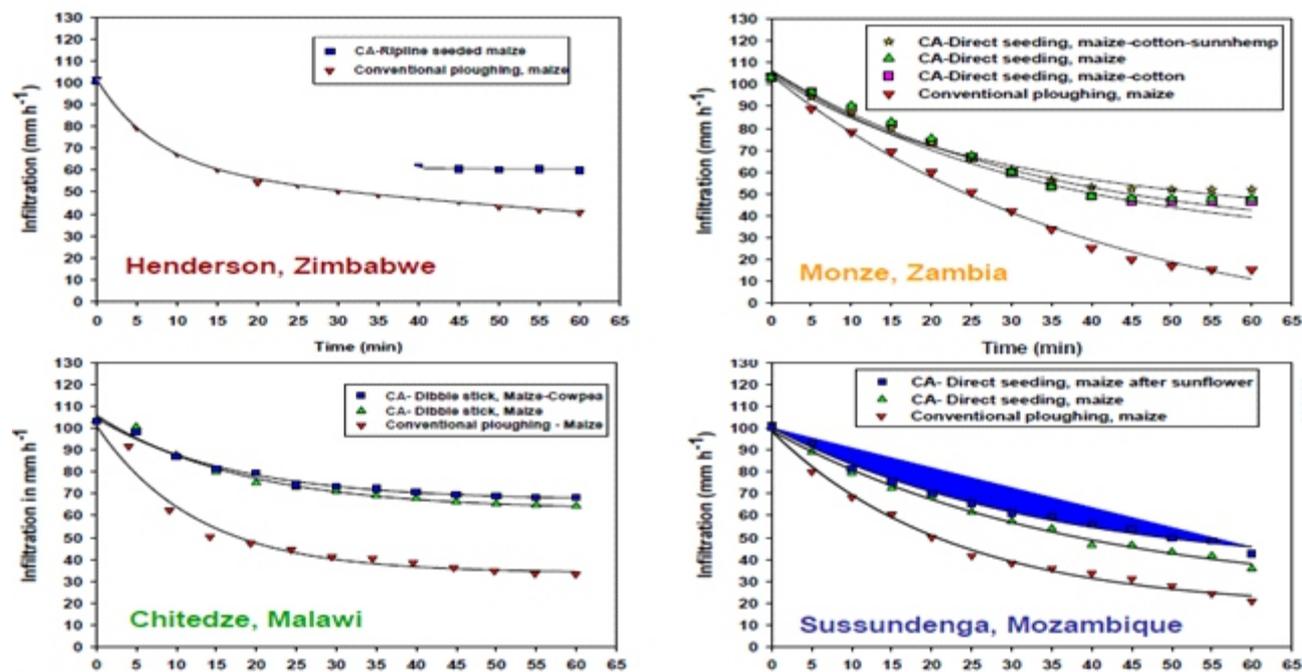

Fig. 1. Effect of conservation agriculture based intercropping system on infiltration (Thierfelder and Wall 2009, Thierfelder et al 2012)
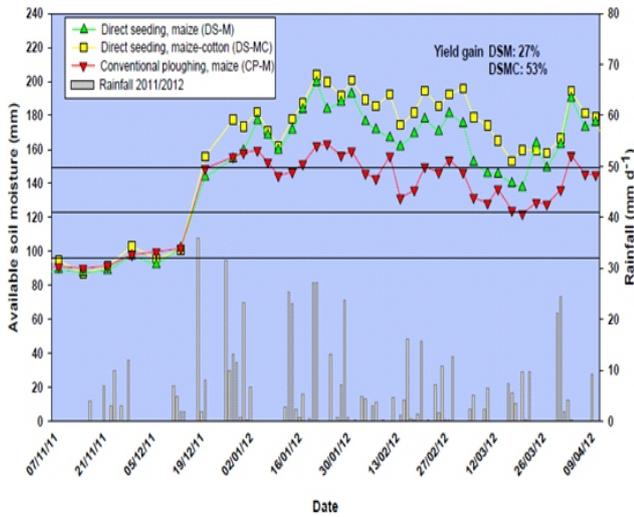
Fig. 2. Effect of Conservation agriculture based intercropping on soil moisture content (Thierfelder et al 2012)

maize-cotton intercropping system followed by conservation tillage based sole maize as compared to conventional ploughing based sole maize (Doets et al 2000).

Conservation tillage based intercropping systems considerably increased water use efficiency as compared to crop rotation or continuous production in conservation tillage or conventional tillage (Zerihun et al 2014). Ajayi (2015) observed soil moisture content of 0.01 m, 0.01-0.02 m and 0.02-0.03 m soil layers under tillage and cropping methods showed that higher soil water content and earthworm population were observed with no-tillage in all cropping methods than conventional tillage. The same author indicated that intercropped plots in both tillage methods had significantly higher soil moisture content than the sole crops of maize and groundnut.

Production of stable yields and incomes with reduced production costs: Maize-haricot bean intercrops under conservation tillage ensured risks free or avoidance in case of variable and short rainfall (West and Post 2002, Zerihun et al 2014). Zerihun et al (2014) confirmed that more than 38-41% in unfavorable season and 44-47% during favorable season of additional yield were obtained without significant reduction of the main crop in conservation tillage based maize-haricot bean intercropping. Ajayi (2015) investigated that the yield of sole maize under conservation tillage>conservation tillage based intercropping>conventional tillage based intercropping>conventional tillage based sole maize. Similarly, for groundnut, the trend in grain yield was conservation tillage based groundnut>conservation tillage based intercropped>conventional tillage based sole groundnut>conventional tillage based intercropped. The

experiment conducted by Adet agricultural research Centre (AARC) on conservation tillage based maize legume intercropping system for three years (2012-2014) at two districts (13 sites) of high maize production areas of Western Amhara region showed that maize productivity and production were highest in conservation tillage (both sole and intercropping) as compared to conventional tillage (sole cropping) at all locations and sites. This experiment also showed that maize production under conservation tillage based maize-haricot bean rotation (6.4 tons/ha) > conservation tillage based maize-haricot bean/cow pea intercropping (5.4tons/ha) > conservation tillage based sole maize (5.1 tons/ha) > conventional tillage based sole maize (4.8 tons/ha) (AARC 2015) (Fig. 3). Similarly, longer term experiment (8 years) on conservation tillage based-cropping system conducted at Malawi by CIMMYT showed that conservation tillage based maize-legume intercropping gave maximum yield next to conservation tillage based sole maize as compared to conventional (Thierfelder et al 2015). Thierfelder et al (2012) showed that it is more advantageous to grow crops under conservation tillage than conventional tillage: There are marked yield benefits in rotating crops (11–64% higher yield) or intercropping (10–35% higher yield) compared with continuous maize cropping under
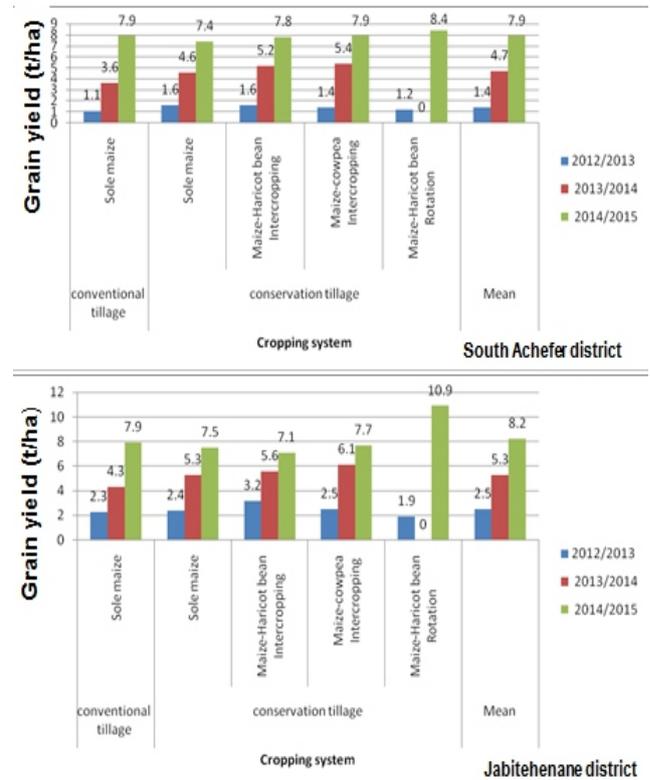

Fig. 3. Effect of Conservation agriculture based cropping system on maize grain yield (AARC 2015)

conventional tillage in Zimbabwe.

Zerihun et al (2014) showed that crop rotations had reduced by 15-27% labors as compared to continuous maize or legume production under conservation tillage practices. The highest growth return was obtained from maize-soybean intercropping under conservation tillage where as sole maize production with conventional tillage practice recorded the highest total variable cost. Minimum tilling with crop residue retention could reduce labor requirement up to 50-60% at a critical time of agricultural calendar (Doets 2000, Ken et al 2014). Intercropping practices with conservation tillage by far reduced from 29% to 52% of total time required for weeding as compared to conventional practice with both sole and intercropping system since there might be highly smothering effect on weed that might largely reduce its competitions effects (Zerihun et al 2014). Similar result was also reported that energy cost of crop production with conventional tillage and direct seeding estimated that the total inputs are about 40-50% lower for conservation agriculture and the increase net income ranged from 50% to more than 60% (Lange et al 2005).Thierfelder et al (2014) showed that returns to investment in sole maize under conservation were increased from about 11 $USD to 14 $USD while returns to investment maize/legume intercropping under conservation tillage were increased from 10 $USD to18 $USD.

Weeds and conservation tillage based intercropping: The control of weeds, pests and diseases by means of a suitable crop rotation significantly reduce the pesticides use and decreases the risk of pollution. A number of conservation agriculture practices designed to replace continuous maize/bean intercropping in the region intend to introduce nitrogen fixing cover crops, reduce soil disturbance and retain surface crop residues (Giller et al 2011). However, adoption of conservation agriculture is often hindered by farmers' limited understanding of the changes in weed control practices and crop performance during the transition period (Ngwira et al 2013). Long term intercropping under conservation tillage can smother weeds (Odhiambo et al 2014, Muoni and Mhlanga 2014). Thierfelder et al (2014) observed that conservation tillage based maize/legume intercropping (250 plants/ha) followed by conservation tillage based sole maize (850 plants/ha) had high striga control as compared to conventional control (3500 plants/ha) (Fig. 4). Muoni et al (2014) submitted that under conservation tillage based sole and intercropping system weed density was decline over time. The greatest declines of more than 50% were observed at minimum tillage and zero tillage in maize, bean and mucuna planted in a strip intercropping arrangement and continuous maize/bean intercropping and maize cropping systems as compared to conventional tillage
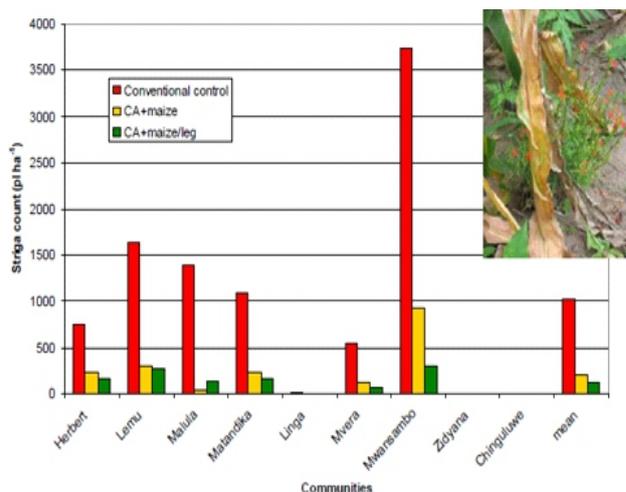
Fig. 4. Effect of Conservation agriculture based intercropping on weed infestation (Thierfelder and Wall 2009)

(Odhiambo et al 2014). Corresponding costs of weed management were reduced by $148.40/ ha in minimum tillage based continuous maize/bean intercropping and maize, bean and mucuna planted in a strip intercropping arrangement and $149.60/ha in no till based continuous maize/bean intercropping and maize, bean and mucuna planted in a strip intercropping arrangement compared with conventional tillage (Muoni and Mhlanga 2014).

Environmental benefits of conservation tillage based intercropping increasing biodiversity: Maintaining soil cover in conservation tillage based intercropping will reduce erosion, loss of soil fertility, soil compaction, and, eventually, landscape change (IIRR and ACT 2005). One aspect of conventional agriculture is its ability to change the landscape. The destruction of the vegetative cover affects the plants, animals and microorganisms. Most organisms are negatively affected and either they disappear completely or their numbers are drastically reduced. With the conservation of soil cover in conservation agriculture based intercropping a habitat is created for a number of species that feed on pests, which in turn attracts more insects, birds and other animals. The rotation of crops and cover crops restrains the loss of genetic biodiversity, which is favored with mono-cropping (Govaerts et al 2007, Ikuenobe and Anoliefo 2003, Odhiambo et al 2014). Soil organisms are important elements for preserved ecosystem biodiversity and services (IIRR and ACT 2005). One of the main threats to soil biodiversity occurred by mechanical impacts by soil tillage in agricultural management. Soil microorganisms regulate carbon and nitrogen cycling and provide nutrients to plants. Bacteria and fungi are critical for the production of soil aggregates and the conversion of plant residue to soil organic matter that increases aggregate stability, cation

exchange capacity, and water holding capacity, water infiltration and soil porosity (IIRR and ACT 2005, Salles et al 2006). Several recent studies have focused on the effects of agricultural practices on the community diversity of soil microorganisms. Soil microbial activity is affected negatively by soil tillage (FAO 2008, Henle et al 2008, Shaxson et al 2008, Médiène et al 2011). No-till or reduced tillage systems can reduce the erosion level of a soil, which is not a renewable resource (Papendick et al 2004).

The decrease of organic matter as a result of tillage in the soil can cause decreases in soil microbial activity (Kladivko 2001, Sagar et al 2001, Thierfelder and Wall 2010). Earthworms incorporate organic matter into the soil, stimulating decomposition, humus formation, nutrient cycling and the development of soil structure (Lane et al 2006). Thierfelder and Wall (2010), investigated a long-term trial in Zambia, observed significantly larger earthworm numbers in conservation tillage treatments, especially in rotations of cotton and sun hemp, which suggests that residue retention and crop rotations apart from no-tillage play a significant role in the increase in biological activity. In descending order, increased earthworm activity was observed in conservation tillage based intercropping and conservation tillage alone as compared to conventionally plowed fields in Zambia (Thierfelder et al 2014).

Intercropping under conservation tillage is one way of establishing more biodiversity into agro ecosystems and results from intercropping studies indicate that increased crop diversity may increase the number of ecosystem services provided (Hauggaard-Nielsen et al 2001, Lithourgidis et al 2011, Gebru Hailu 2015). Higher species richness may be associated with nutrient cycling characteristics that often can regulate soil fertility (Russell 2002), limit nutrient leaching losses (Hauggaard-Nielsen et al 2008) and significantly reduce the negative impacts of pests (Willey et al *2015)* including that of weeds (Mal´et al 2009). Intercropping of compatible plants promotes biodiversity by providing a habitat for a variety of insects and soil organisms that would not be present in a single crop environment.

Climate change adaptation and reduced vulnerability: Reduced vulnerability to effects of drought, less erosion, and lesser extremes of soil temperatures represent a managed adaptation of conservation tillage systems based intercropping to climate change effects (ICRISAT et al 2006). In Ethiopia, agriculture is highly sensitive to variability and change in climate. For instance, multiple severe impacts are likely to result from climate changes in future which are likely to cause lack of food for more than 10.4 million farmers and pastoralists (FAO 2015). Currently, agriculture and other forms of land use contribute 32 % to the world's greenhouse

gas emissions (Lal et al 2006). Moreover, each ton of carbon lost from soil adds approximately 3.7 tons of CO_2 to the atmosphere. The same author suggested that by adopting improved management practices on agricultural land (use of conservation tillage), food security would not only be enhanced but also offset fossil fuel emissions at the rate of 0.5 Pg C/ year (Hobbs et al 2007).Landers (2007) reported that a six fold difference was measured between infiltration rates under conservation tillage (120 mm/ hour) and traditional tillage (20 mm/ hour). Conservation tillage thus, provides a means to maximize effective rainfall and recharge groundwater as well as reduce risks of flooding. Due to improved growing season moisture regime and soil storage of water and nutrients, crops under conservation tillage require less fertilizer and pesticides to feed and protect the crop, thus leading to a lowering of potential contamination of soil, water, food and feed. In addition, in soils of good porosity, anoxic zones hardly have time to form in the root zone, thus avoiding problems of reduction of nitrate to nitrite ions in the soil solution (ICRISAT 2006).

Conservation tillage reduces the unnecessarily rapid oxidation of soil organic matter to CO_2 that is induced by inappropriate tillage practices (Preissela et al 2015, Lane et al 2006). Together with the addition of mulch as a result of saving crop residues in- situ as well as through root exudation of carbon compounds directly into the soil during crop growth (Jabro et al 2009). Thus, there is a reversal from net loss to net gain of carbon in the soil, and the start of long term processes of carbon sequestration. In the total balance, carbon is sequestered in the soil, and turns the soil into a net sink of carbon. This could have profound consequences in the fight to reduce greenhouse gas emissions into the atmosphere and thereby help to forestall the calamitous impacts of global warming. Making use of the above ground crop residues, the root organic matter (higher under conservation tillage because of the larger root systems) and the direct rhizospheric exudation of carbon into the soil represents the retention of much of the atmospheric carbon captured by the plants and retained above the ground. Some becomes transformed to soil organic matter of which part is resistant to quick breakdown (though still with useful attributes in soil), and represents net carbon accumulation in soil, eventually leading to carbon sequestration (Lane et al 2006, FAO 2008, Baig et al 2009). Tillage however, results in rapid oxidation to CO_2 and loss to the atmosphere (Lane et al 2006, Baig et al 2009). Similarly, results from long term trials over a 20 year period, have shown the soil under traditional practice (stubble burnt and traditional tillage) was losing carbon at a rate of 400 kg/ ha/year compared to conservation tillage (Heenan et al 2004). According to ICRISAT (2006), soil

carbon content increased by 47% in conservation tillage based maize–lablab system, and by 116 % in conservation tillage based maize–castor bean system, compared to the fallow–maize cropping system which was taken as a reference. Baker et al (2007) Found that crop rotation systems in conservation tillage accumulated about 11 tons/ha of carbon after nine years. Under tillage agriculture and with monoculture systems the carbon liberation into the atmosphere was about 1.8 tons/ha/ year of CO_2 (FAO 2001). In other words conservation tillage means that soils can sequester carbon until a new equilibrium is reached to counter balance greenhouse gas emissions. Thus, carbon dioxide fluxes from soils are directly related to the volume of soil disturbed. The ability of conservation tillage soils to sequester carbon presents farmers with additional business opportunities to enter carbon trading schemes. For instance, in 2005, Canadian no-till farmers could earn almost € 10/ha to help offset Canada's greenhouse gas emissions (Lane eta al 2006).

Conservation tillage can also help reduce the emissions for other relevant greenhouse gases, such as methane and nitrous oxides, if combined with other complementary techniques. Both methane and nitrous oxide emissions resulted from poorly aerated soils, for example, from permanently flooded rice paddies, severely compacted soils, or from heavy poorly drained soils. Conservation tillage improves the internal drainage of soils and the aeration and avoids anaerobic areas in the soil profile (FAO 2015). Methane emissions that have a warming potential of 21 times that of CO_2 are common and significant in puddle anaerobic paddy fields and also when residues are burnt. This greenhouse gases emission can be mitigated by shifting to aerobic, direct seeded or conservation tillage rice system (Joshi 2011).

Nitrous oxide has 310 times the warming potential of carbon dioxide and its emissions are affected by poor nitrogen management (Lane et al 2006, ICRISAT 2006, Hobbs et al 2007). The soil is a dominant source of atmospheric N_2O. In most agricultural soils biogenic formation of nitrous oxide is enhanced by an increase in available mineral nitrogen which, in turn, increases the rates of aerobic microbial nitrification of ammonia into nitrates and anaerobic microbial reduction (denitrification) of nitrate to gaseous forms of nitrogen (ICRISAT 2006, Lane et al 2006). The rate of production and emission of N_2O depends primarily on the availability of a mineral nitrogen source, the substrate for nitrification or denitrification on soil temperature, soil water content, and the availability of labile organic compounds. Addition of fertilizer nitrogen, therefore, directly results in extra N_2O formation as an intermediate in

the reaction sequence of both processes that leaks from microbial cells into the atmosphere. In addition, mineral nitrogen inputs may lead to indirect formation of N_2O after nitrogen leaching or runoff, or following gaseous losses and consecutive deposition of N_2O and ammonia. Conservation tillage generally reduces the need for mineral nitrogen by 30–50%, and enhances nitrogen factor productivity (ICRISAT 2006). Thus, overall, conservation tillage has the potential to lower nitrogen leaching and nitrogen runoff, N_2O emissions and mitigates other greenhouse gases emissions (ICRISAT 2006, Metay et al *2007,* Baig and Gamache 2009).

Insurance against crop failure: One important reason for which intercropping is popular in the developing world including Ethiopia is that it is more stable not only during normal seasonal conditions but also adverse conditions than mono-cropping (Lithourgidis et al 20111; Najafi and Abbas 2014); FAO 2015).Using risk as a criterion for evaluating stability of intercropping systems, (Waddington et al 2007) showed that the probability of reaching a given income level was higher in an intercrop when compared to sole crops of the same component species. Furthermore, intercropping is more extensively practiced by small scale or subsistence farmers (Waddington et al 2007**)**. Risk, as it applies to subsistence farmers, relates more to net production and less to market forces. The stability under intercropping can be attributed to the partial restoration of diversity that is lost under mono-cropping (Lithourgidis et al 2011; Mal´ eta l 2009). If a single crop may often fail because of adverse conditions such as frost, drought, flood, or even pest attack, farmers reduce their risk for total crop failure by growing more than one crop in their field. Lithourgidis et al (2015) thought that for intercropping to be risk advantageous, the components of the crop association needed to have different environmental requirements or contrasting habits. Long year experiment on ninety four experiments on mixed cropping of sorghum/pigeon pea showed that for a particular 'disaster' level, sole pigeon pea crop would fail one year in five, sole sorghum crop would fail one year in eight, but intercropping would fail only one year in thirty six (Lithourgidis et al 2011) (Fig. 5). Lithourgidis et al (2011) concluded that if one crop fails, or grows poorly, the other can compensate; such compensation clearly cannot occur if crops are grown separately. In India intercropping is effective for yield stability in erratic rainfall environments (Willey et al 2015).

Intercropping maize with beans reduced nutrient decline and raised household incomes compared with monocropping of either of the two crops. Regularly intercropped pigeon pea or cowpea can help to maintain maize yield when maize is grown without mineral fertilizer on sandy and in turn no dependent on chemical fertilizer
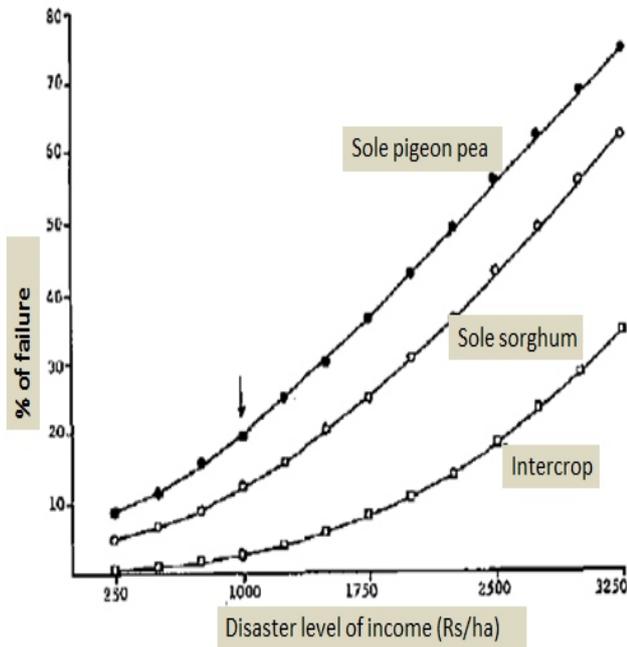
Fig. 5. Yield stability of sorghum and pigeon pea in sole cropping and intercropping: The probability of crop failure (Lithourgidis et al 2011)

(Waddington et al 2007). Kariaga (2004) showed that poor fertility land was returned to production under intercrop of maize with other low growing legumes like cowpeas and beans. During the past two decades studies in several years in semi-arid environments showed that intercropping has been advocated to increase crop yield and improve yield stability in environments where water stress occurs (Lithourgidis et al 2011, Kariaga 2004).

Combinations involving crops with slightly differing growth duration, e.g. millet and sorghum or mixtures of early and late maturing cultivars of the same species are used in areas with growing seasons of variable length to exploit the occasional favorable season yet insure against total failure in unfavorable seasons (Lithourgidis et al 2011, Najafi and Abbas 2014, Gebru Hailu et al 2015).This included intra species diversity such as different colors of maize with different maturation times. On average, late maturing cultivars of groundnut and sorghum gave higher dry pod and grain yield, respectively, when intercropped with early maturing cultivars of the associated crops (Tefera and Tana 2003). If the growing season is long, the late maturing type takes advantage of the abundant resources, whereas if the growing season is short, the early-maturing type can provide a reasonable yield. Differing growing seasons may thus lead to reversals of success in such intercrops, giving more stable yield in intercropping when measured over a run of seasons (Lithourgidis et al 2011).

Barriers to Implementing Conservation Agriculture in Ethiopia

Conservation based intercropping may not be readily adopted by policy makers and farmers in Ethiopia because it conflicts with conventional farming practices. Some barriers to promoting and implementing conservation agriculture based intercropping systems arise from deep rooted socio-cultural beliefs and the downgrading of indigenous farming methods which are poorly supported by researches over past decades. Some examples are given below (Shames 2006; Kassie et al 2009; Wellelo et al 2009; Salami et al 2010; Anderson and Elisabeth 2015) :

1. Research activity and research-extension linkage: Lack of strong research activity, and research-extension linkage on the impact of conservation based intercropping system on soil health, agricultural production, biodiversity and economic benefit in Ethiopia
2. Ploughing: For many years' higher Politian's, agricultural experts (excluding researchers) and farmers in Ethiopia have been taught that ploughing is essential for crop production because it makes the soil soft and enables roots to penetrate easily, when in fact the opposite is true.
3. Clean fields and free grazing: This barrier of cattle free grazing, burning or collecting stubble is promoted by extension officers and strengthened by the notions that a 'good farmer' has a clean field and that organic matter should be ploughed in fact mulch on the soil surface allows more rain to infiltrate and promotes fertility better.
4. Land ownership and tenure policy: This is an economic and political issue as well as a cultural and social one. The land in Ethiopia is owned by both government and the people. If the land is owned by the government or communally, individual farmers may have little incentive to improve it through conservation tillage based cropping system.
5. Agricultural production by Conservation tillage may not be profitable at the beginning rather after four years of implementation. This may disfavor the farmers to use Conservation tillage based intercropping system. However, the loss occurred at the beginning of conservation tillage could be compensated by adding intercropping system.

CONCLUSION

Conservation tillage based annual intercropping (CTBI) controls soil erosion and biodiversity loss caused by conventional crop production system. Its long term effect causes higher percentage of organic matter and organic

carbon pool compared to conventional tillage based mono-cropping due to addition of carbon input from the intercropped legumes and residues from conservation tillage. Besides, CTBI system in the long term significantly lowers the bulk density in the top-soil layer and in turn improves the soil pore size distribution. Similarly, it resulted in higher total N, available K and Mg content than conventional crop production system. CTBI had significantly higher infiltration characteristics, soil water content and water use efficiency than continuous sole cropping and conventional tillage based intercropping. CTIB also establishes more biodiversity into agroecosystems and reduces the addition of chemicals and gases that triggers greenhouse gas accumulation in the atmosphere. In conclusion, CTBI is used as the primary means of sustainable crop production system by improving soil health, promoting diversity of diet, stability of production, efficient use of labor, intensification of production with limited resources maximization of returns under low levels of technology and insurance against crop failure due to drought and frost. However, in Ethiopia conservation tillage based annual intercropping system becomes effective if and only if inclusive research and extension service and appropriate land use policy over it should be implemented.

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Effects of Soil on Understorey Species Composition in Three Forests of Kumaun Himalaya

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Abstract: Shrub and herb biomass with physical and chemical properties of soil in Chir Pine (*Pinus roxburghii* Sarg.), Oak-Chir Pine mixed (*Quercus leucotrichophora* A. camus – *P. roxburghii*) and Oak-Cypress mixed (*Q. leucotrichophora* – *Cupressus torulosa* Don.) forest located between 1300-2600 meters elevation was estimated for six months (October-February) in 2013-14. At each site three different slope positions (ridge slope, mid hill slope and hill base) were selected for the study. The shrub density across the study sites ranged between 1040 to 2347 ind. ha^{-1} and herb density ranged between 4613 to 11120 ind. ha^{-1}. The chemical and physical property of soil was estimated upto 30 cm soil depth. The total biomass ranged between 0.63 and 2.11 t ha^{-1} in herb species while it ranged between 0.045 and 0.63 t ha^{-1} in shrub species. The environmental variables of all sites showed high inter-set correlation in Canonical Correspondence. Our inventory showed that the most important factors increasing the diversity of the understory are carbon, nitrogen, pH and phosphorus. The plant community composition explained productivity very well and was a better predictor than environmental variables.

Keywords: Kumaun Himalaya, Soil depth, Biomass, Physical property, Chemical property

Himalayan forest plays an important role in tempering the inclemency of the climate, in cooling and purifying the atmosphere, in protecting the soil and in buffering up huge reserves of soil nutrients. Forest is the greatest achievement of ecological evolution – the largest, most complex, most self-perpetuating of all ecosystems; of which the organic continuity rests upon a delicate network of interdependent relationships (Kumar and Tewari 2015). Nutrient supply varies widely among ecosystems resulting in differences in plant community structure and production. The aboveground and belowground production influences the soil organic matter, soil development and its conservation. Several authors (Arya 2002, Kala et al 1998, Jina et al 2011, Joshi et al 2013) documented important characteristics of Himalayan soil. Soil organic carbon supports productivity of grassland while temperature and precipitation control grassland primary productivity. The evergreen oak canopy induced environmental changes and competitive ability of the herbaceous species. Estimation of biomass is essential for determining the status and flux of biological nutrients in ecosystems and for understanding ecosystem dynamics. Oaks are extensively distributed at elevation between 1800-3600 m in the central Himalaya (Adhikari 1992). The present study investigation was undertaken to study the nutrient dynamics in the soil and their effect on species composition and their productivity on Chir Pine, Oak-Chir Pine, and Oak-Cypress (*Cupress torulosa* D. Don) mixed forest.

MATERIAL AND METHODS

Study area: The study area is located between 29°20' and 29°30' N latitude and 79°42' E longitude between 1300 and 2600 a.s.l. in Uttarakhand, central Himalaya. Mean monthly maximum temperature ranged between 15°C (January) to 27°C (May) and mean minimum temperature ranged between 1°C (January) to 16°C (July). Average annual rainfall was 91.75 mm.

Vegetation sampling: Field survey was conducted from May 2013-April 2014. Fifteen quadrats of 50x50 cm were (5 at each hill base, mid hill slope, ridge slope) were established in each forest for determination of species richness and other vegetation parameters. Two vegetation layers, i.e. shrubs and herbs, were analysed for species richness, density and diversity. Equitability (E) or species evenness was determined following Whittaker (1972), Concentration of dominance (Cd) was calculated by following (Simpson 1949) and species diversity (H') was calculated using the Shannon-Wiener information index (Shannon and Weaver 1963). Index of similarity between forests was calculated following Sorensen (1948).

Soil sampling and analysis: Soil samples were collected from three depths i.e. 0-10, 10-20 and 20-30 cm from all sites. Fresh samples were weighed, dried in an Oven at 60°C till constant weight to determine the moisture content. Soil mechanical analysis was done to find out the percentage of different size particles, such as sand, silt and clay through

sieve method as proposed by Mishra (1968). Soil pH was determined in 1:5 soil solution ratio using pH meter (pH scan-2 electrode). Nitrogen estimation was done by the micro-Kjeldahl procedure (Misra 1968). Organic carbon was determined by following procedure described by (Walkely and Black 1934), phosphorus by phosphomolybdic blue colorimetric method and potassium by flame photometery (Jackson 1973).

Biomass: The belowground plant material was collected from each monolith (25 x 25 x 30 cm) from each harvested quadrat on sampling date after the aboveground components had been sampled. The monoliths were brought to the laboratory and washed with a fine jet of water using, successively, 2 mm and 0.5 mm mesh screens. The aboveground and belowground components were oven dried at 60°C to constant weight and their dry weight was recorded. The mean values were multiplied by their density and summed to get the total stands net primary production. The biomass values thus obtained were expressed in terms of tons per hectare (t ha^{-1}).

Statistical analysis: Canonical correspondence analysis (CCA) is an ordination technique that correlates the species directly with environmental variables (Ter Braak 1986). This works on two sets of variables, one set of variables (i.e., dependent variables, density etc.) are computed in linear combinations of explanatory variables (usually environmental parameters) in a second set. Here chemical properties of soil are taken in consideration because it has strong influence on the forest structure and composition. CCA extracts the major gradient in the data that can be accounted for by the measured explanatory variables. The analysis was done using following 4 variables: carbon, potassium, phosphorus and nitrogen content in the site.

RESULTS AND DISCUSSION

Physical-chemical properties of soil: The soil has high proportion of silt and clay particles and low sand in Oak-Cypress mixed forest while Chir Pine forest has higher proportion of sand particles. In all the forest sites the soil moisture content was maximum in Oak-Cypress mixed forest (18.78%) compared to Oak-Chir Pine mixed (18.02%) and Chir Pine forest (9.10%). All forest sites consist of texture composition of sandy clay loam. The minimum and maximum bulk density ranged from 0.92 gm/cm^3 in Chir Pine forest to 0.84 gm/cm^3 in Oak-Cypress and Oak-Chir Pine mixed forest, respectively (Table 1). Average soil organic carbon and nitrogen was maximum in Oak-Cypress mixed forest (0.65 and 0.21%). Maximum nitrogen content in Oak-Cypress mixed forest probably due to decomposed humus content added to the soil that maintain mineral content

Table 1. Chemical and physical properties of soil in Chir Pine, Oak-Chir Pine and Oak-Cypress mixed forest

Forest	pH	Carbon (%)	Nitrogen (%)	C:N ratio	Organic Matter (%)	Potassium (kg ha^{-1})	Phosphorus (kg ha^{-1})	Sand (%)	Silt (%)	Porosity (%)	Clay (%)	Moisture (%)	Bulk density (gm cm^{-3})
Chir Pine	5.60 ± 0.61	0.65 ± 0.21	0.20 ± 0.03	3.46 ± 0.47	1.12 ± 0.36	165.53 ± 4.76	21.54 ± 1.70	65.77 ± 6.86	26.27 ± 2.15	64.79 ± 1.75	7.95 ± 2.18	9.10 ± 1.28	0.92 ± 0.05
Oak-Chir Pine	7.22 ± 0.13	0.58 ± 0.15	0.22 ± 0.04	2.74 ± 0.31	1.00 ± 0.26	201.60 ± 5.45	19.99 ± 3.29	63.14 ± 2.43	27.90 ± 1.08	67.69 ± 0.80	8.96 ± 1.34	18.02 ± 1.02	0.84 ± 0.02
Oak-Cypress	7.32 ± 0.06	0.65 ± 0.16	0.21 ± 0.03	3.17 ± 0.41	1.12 ± 0.28	179.09 ± 6.34	15.97 ± 2.91	60.29 ± 1.73	30.64 ± 1.92	67.52 ± 1.42	9.08 ± 0.33	18.78 ± 1.71	0.84 ± 0.4

richness and fertility of the soil. Maximum available phosphorus was in Chir Pine forest (21.54 kg ha⁻¹) followed by Oak-Chir Pine mixed and Oak-Cypress. In the Oak-Cypress mixed forest potassium concentration was less (179.09 kg ha⁻¹) as compared to pine and Oak-Chir Pine mixed forest. The pH was moderately acidic (5.6) in Chir Pine forest compared to slightly acidic in Oak-Chir Pine (7.22) and neutral in Oak-Cypress mixed forest (7.32). In the Chir Pine forest, soil pH was slightly acidic as the soil had high humus content. In both Oak-Chir Pine mixed and Oak-Cypress mixed forest, removal of litter and lopping of branches for the fuel purpose had turned the soil slightly acidic. A significant relationship between sand with phosphorus and nitrogen, silt with phosphorus and nitrogen and clay with nitrogen across all the forest was observed.

Community structure: Species composition of these forests indicates the dominance of few species in these forests. Out of a total of 29 species (Table 3), 2 shrubs i.e. *B. albiflora* and *I. heterantha* in Oak-Cypress mixed oak forest have IVI<10%, while a large number of herb species have IVI<10%. Among shrubs *B. asiatica* and *P. crenulata* was present in all the forests. *A. racemosus, B. albiflora, I. heterantha. L. lanceolata* and *M. africana* were only in Oak-Cypress mixed forest. *A. lancifolius, C. rotundus* and *E. karvinskianus* were the dominant herb present in all the forests while *A. nilagirica* and *M. acuminate* were present

only in Chir Pine forest, *A. bidentata, A. latifoliya, G. aparine, O. corniculata* and *R. cordifolia* in Oak-Chir Pine mixed oak forest and *R. indica, S. media* and *T. gracilis* in Oak-Cypress mixed forest (Fig. 1). Herb density was maximum in Oak-Chir Pine mixed forest (11120 ind. ha⁻¹) while minimum density was found in Oak-Cypress mixed forest (4613 ind. ha⁻¹). Maximum shrub density was observed in Oak-Cypress mixed forest (2347 ind. ha⁻¹) and minimum in Chir Pine forest (1040 ind. ha⁻¹). High similarity in shrub species richness and herb species was present between Oak-Chir Pine mixed and Chir Pine forest (81% and 74% respectively) followed by Oak-Cypress mixed forest and Chir Pine forest (<50%) (Table 4). All the physical property showed high inter-set

Table 3. Percent similarity of shrub and herb species among different forests

Forest type	Pine	Oak-Chir Pine	Oak-Cypress
Shrub			
Chir Pine	*	81.32	26.77
Oak-Pine	*	*	24.29
Oak-Cypress	*	*	*
Herb			
Chir Pine	*	73.82	36.15
Oak-Pine	*	*	29.49
Oak-Cypress	*	*	*

Table 2. Details of the forest types studied

Forest type (as per Osmaston 1927)	Altitude (m a.s.l.)	Tree species	Shrub species#	Herb species#
Chir pine	1300 - 1700	*Pinus roxburghii* Sarg.	*Berberis asiatica* Roxb. ex D. Don, *Lantana camara* L., *Pyracantha crenulata* (D. Don) M. Roem., *Rubus ellipticus* Smith.	*Arthraxon lancifolius* (Trin.) Hochst, *Artemisia nilagirica* (Cl.) Pamp., *Bidens pilosa* L., *Cyperus rotundus* L., *Dicliptera bupleuroides* Nee, *Erigeron karvinskianus* DC, *Eupatorium adenophorum* Spreng., *Geranium nepalense* Sweet., *Goldfussia dalhousiana* Nee, *Malaxis acuminata* D. Don
Oak-chir pine mixed	1300 - 1700	*Quescus leucotrichophora* A. Camus, *P. roxburghii, Cedrus deodara* (Roxb. ex D. Don) G. Don, *Cupressus torulosa* D. Don, *Rhododendron arboretum* Smith	*B asiatica, P. crenulata, R. ellipticus*	*Achyranthes bidentata* Blume., *Ainsliaea latifolia* (D. Don) Sch-Bip, *A. lancifolius, B. pilosa, C. rotundus, E. karvinskianus, Galium aparine* L., *G. nepalense, Origanum vaulgare* L., *Oxalis corniculata* L., *Rubia cordifolia* L.
Oak-cypress mixed	1600 - 2000	*Q. leucotrichophora, C. torulosa, C. deodara, Myrica esculenta* Buch.-Ham ex D. Don	*Asparagas racemosus* Will, *B. asiatica, Boenninghausenia albiflora* Reich. ex Meisn., *Indigofera heterantha* Wall. Ex Brandis, *Leptodermis lanceolata* Wall., *Myrsine africana* Linn., *P. crenulata*	*A. lancifolius, C. rotundus, D. heterocarpon, D. bupleuroides, E. karvinskianus, E. adenophorum, G. dalhousiana, O. vaulgare, R. indica, Stellaria media* (L.) Vill., *Tragopogon gracilis* D.Don.

correlation in Canonical Correspondence. Monte-Carlo test for Eigenvalue and species - Environment correlation showed significant correlation for axis 1, 2, and 3 respectively (Table 4). Diversity indices of different forest sites are given in Table 5.

Biomass: Herb biomass was the maximum in pine mixed forest (2.11 t ha^{-1}) and minimum in Oak-Cypress mixed forest (0.63 t ha^{-1}) however the shrub biomass was the maximum in Oak-Cypress mixed forest (0.17 t ha^{-1}) and minimum in Chir Pine forest (0.045 t ha^{-1}) (Table 6). The below ground net primacy production ranged 0.15-0.41 t ha^{-1} in Chir Pine forest,

Table 4. Monte Carlo test, 499 results

Axis	Real data	Randomized data			
Eigenvalues					
		Mean	Minimum	Maximum	*P*
1	0.317	0.179	0.113	0.299	0.0020
2	0.166	0.125	0.072	0.196	
3	0.099	0.088	0.043	0.143	
Species-Environment Correlation					
1	0.794	0.688	0.539	0.869	0.0360
2	0.732	0.639	0.481	0.791	
3	0.603	0.582	0.433	0.767	

p = proportion of randomized runs with eigenvalue greater than or equal to the observed eigenvalue; i.e., p = (1 + no. permutations >= observed)/(1 no. permutations) p is not reported for axes 2 and 3 because using a simple randomization test for these axes may bias the p values

Table 5. Vegetation parameter in different forest sites

Diversity indices	Vegetation type	Chir Pine	Oak-Chir Pine	Oak-Cypress
E	Shrub	0.85	0.95	0.95
	Herb	0.55	0.66	0.81
H'	Shrub	1.18	1.05	1.85
	Herb	1.26	1.58	1.94
Cd	Shrub	0.35	0.37	0.17
	Herb	0.42	0.28	0.18

E = Equitability; H' = diversity; Cd = Concentration of dominance

Fig. 1. Abundance of all species across all the forest sites

0.12-0.23 t ha^{-1} in Oak-Chir Pine mixed forest and 0.037-0.14 t ha^{-1} in Oak-Cypress mixed forest, while aboveground net primary productivity ranged 0.22-0.54 t ha^{-1} in Chir Pine forest, 0.13-0.27 t ha^{-1} oak Chir Pine forest and 0.096-0.15 t ha^{-1} in Oak-Cypress mixed forest. The below biomass ranged 0.15-0.41 t ha^{-1} in Chir Pine forest, 0.12-0.23 t ha^{-1} in Oak-Chir Pine mixed forest and 0.037-0.14 t ha-^{1} in Oak-Cypress mixed forest, while aboveground biomass ranged 0.22-0.54 t ha^{-1} in Chir pine forest, 0.13-0.27 t ha^{-1} oak Chir Pine forest and 0.096-0.15 t ha^{-1} in Oak-Cypress mixed forest. There was significant relationship between shrub biomass across all the forest sites while herb biomass showed no relationship .

Decrease in soil organic carbon with depth has been reported by Ramachandran et al (2007) in Kolli hills in Eastern Ghats, Sharma et al (2010), Raina and Gupta (2013), Tiwari et al (2013) for Garhwal Himalaya. Percent nitrogen also increased with increase in total organic matter. Whitney and Zabowski (2004) studied on change in the concentration of total nitrogen when depth of soil increases. In present study concentration of nitrogen decreases as the depth of soil increases viz. in Chir pine forest the amount of total nitrogen (%) ranged between 0.17-0.29 in surface layer (0-10cm), 0.14-0.26 in middle layer (10-20cm) and 0.12-0.22 in deeper layer (20-30cm). Phosphorus cycling in forest

Table 6. Biomass (t ha^{-1}) of herb species and shrub species across all the forest sites

Forest	Hill base	Hill slope	Hill top	Total	Hill base	Hill slope	Hill top	Total
	Herb				Shrub			
Chir pine	0.37	0.95	0.79	2.11	0.001	0.014	0.030	0.045
Oak-Chir pine	0.40	0.50	0.25	1.15	0.018	0.038	0.035	0.091
Oak-Cypress	0.28	0.13	0.22	0.63	0.048	0.115	0.007	0.170

ecosystem can be described in terms of biological and geochemical cycles. Variability of the level of available P is related to land use, altitude, slope position and other characteristics, such as clay and calcium carbonate content (Mohammed et al 2005). Unlike nitrogen and phosphorus, the organic matter in soils contains very little potassium but can hold potassium by cation exchange. Therefore, plant available potassium comes mainly from readily available forms or fertilizers. Smaller amounts are released from the slowly available forms. The overall species richness was lower in pine and Oak-Chir pine mixed forest (14 species) as compared to Oak-Cypress mixed forest (18 species). The biomass was never in a stabilized state for any long duration. Obviously, the adaptations are primarily oriented to complete various life cycle activities within the limited favourable periods, rather than to develop stable and complex biomass structure.

CONCLUSIONS

An abiotic factor affects this region for fodder and fuel need. Relationships between environmental variables and vegetation provide valuable implications for regional ecological restoration and land management. To maintain the diversity and structure of ecosystems we should consider the co-evolution of both vegetation and soil. Further studies on the properties of other factors, such as climate and microorganism, are needed to further explore the interactive relationships among vegetation and soil properties.

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Impact of Rice Mill Wastes Dump on Soil Physico-chemical Properties in Abakaliki, Southeastern, Nigeria

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Abstract: Soil samples were collected at four distances away from rice mill waste dump and analyzed to determine their relative impacts on bulk density, total porosity, gravimetric moisture content, pH, P, N, OC, Ca, Mg, K, Na, CEC, EA and BS for two seasons. Results showed significantly (P<0.05) physicochemical properties of soil were obtained at 50 m distance from dump and diminished at other distances away that from dump in a trend higher of 150 m – 200 m for the period of study. It is recommended that rice mill wastes if properly managed promise to be a veritable amendment material for soil fertility improvement and sustainable productivity.

Keywords: Dump, High, Impact, Physicochemical, Rice wastes, Productivity

Rice mill wastes comprise of husks, bran, broken edible rice, stone and metals from milling process. The wastes are most widely available in many rice producing countries of the world. The husks contain nitrogen, phosphorus, calcium and organic carbon which contribute positively in soil fertility restoration, soil tilth improvement, crop production as well as in overall soil sustainability. The C:N ratio is moderate and can encourage effective mineralization and release of nutrients (Biswas and Murkherijee 2008) for enhanced soil fertility improvement. The wastes have high specific surface which is capable to sustain long term fertility status (Ohaekweiro 2016). Soil management practices can either improve or degrade soil properties and management of residues influence the soil properties and general fertility enhancement. Some agricultural practices impact negatively on soil properties which lead to their degradation. However, this trend can be reversed through maintenance of appropriate soil management programme. Rice wastes amendment is one of them as it improves soil physical properties which include resistance to structural degradation and increase aggregation and aggregate stability, porosity, hydraulic conductivity and reduce soil compaction (Uguru et al 2015). This was corroborated by Nnabude and Mbagwu (2001) as rice mill wastes amendment on soil recorded positive and significant influence on physicochemical properties and beefed up fertility status and productivity of the soil.

In the Abakaliki agro-ecological zone of south eastern Nigeria, large quantities of rice wastes accumulate from the numerous rice mills located in the area (Nwite 2017). In spite of the magnitude of these wastes which are generated on daily basis and their possible adverse effects on the environment such as pollution till today no serious attempt has been made either for their effective utilization or safe disposal (Nnabude and Mbagwu 2001). With intensive use of land and there is absence of any definite management system for soil sustainable productivity as there is rapid depletion of plant nutrients, it is therefore, imperative to evolve a practice that would be desirable to promote productive agriculture. It is because of this, that it has become necessary to study impact of rice mill wastes dump on soil properties. The major objective was to assess impact of rice mill wastes dump on physicochemical properties of soil at four impact points in Abakaliki, Nigeria.

MATERIAL AND METHODS

Study site: The experiment was carried out in 2016 and 2017 seasons at Rice Milling Industrial Site (RMIS). The area adjoins Ebonyi State University, Abakaliki with latitude 06° 4′N and longitude 08° 65′E in the derived savannah zone of Nigeria. The rainfall pattern is bimodal which begins in April and ends in July being first peak and resumes in September after August break and finally terminates in November. The minimum and maximum annual rainfalls are 1700 and 20000 mm with approximately mean annual rainfall of 1850 mm. Temperatures range from 27°C to 31°C throughout the year for rainy and dry seasons. The relative humidity is high during rainy season which is approximately 80% and declines to 60 percent in dry season (NIMET, 2016). The area is underlain by sedimentary rocks derived from successive marine

deposits of the tertiary and cretaceous periods. Abakaliki zone lies within "asu river" group and is associated with brown olive shales, fine grained sandstone and mudstone and the soil is unconsolidated up to 1 m depth and belongs to the order Ultisol which is classified as Typic haplustult. Abakaliki area.

The zone comprises of eight blocks conveniently administered as local Government areas (LGAs). The indigenes are homogenous in socio-economic aspect of their life; language, culture and tradition. They are mainly farmers and almost eighty percent of the population engage in crop and animal farming. The crops mostly grown are Yam (*Dioscorea* spp), Cassava (*Manihot* spp), Rice (*Oryzae sativa*), Cocoyam (*Colocassia spp*), maize (*Zea mays*), Okra (*Abelmoschus* spp), local cowpea (*Vignia* spp), Pepper (*Capisicum* spp) and vegetables. Tree crops such as mango (*Manganifera indica*), Orange (*Citrus* spp), Coconut (*Cocomus nucifera),* bush mango and breadfruit. Pawpaw (*Carica papaya*) are commonly found growing in the localities. Local cattle, sheep, goat, dog, cat and poultry are raised as source of income and means of livelihood. Less than ten percent are artisans and mostly engage in unskilled jobs and trades to eke out a living. Not more than five percent are civil servants with bottom heavy structure as large chuuk of the people who engage in civil service are with low certificates. The area is characterized by tropical environment. Due to urbanization and civilization, about eighty percent of the forests have disappeared; a situation where the place is now described as transiting to derived savannah. However tall trees, shrub, herbs and grasses are still found in clusters. There are abundance of Gmelina (*Gmelina aborea*), Teak (*Tecktonia* spp), afara and obeche trees in the area. Consequently issue of management of soil is taken seriously since the nature of its condition determines both fertility and productivity.

Field study and methods: The rice mill industry is located at the Eastern Flank along Old Ogoja Road now known as Sam Egwu way, being a gate way to cross River State. There are over five hundred milling machines which hull rice every day except on Sundays. The milling industry has lasted for more than sixty years. The rice mill wastes including husks, bran, broken edible rice, stone and metals which are separated from milled rice are collected by unskilled artisans and dump at 500 m away from the industry. The dump has accumulated to artificial mountains. During dry season, the dump is set ablaze by local hunters and because of this, there is partially burnt rice mill wastes and fresh unburnt wastes mixed together and lying at a particular dump site. The rice mill wastes have not been put into any economic use.

Soil sampling: Global Positing System (GPS) and tape were used to locate four distances away from the rice mill wastes dump. These were at 50m, 100m, 150m and 200m designated as very high, high, moderately low and low impact points respectively in respect to their proximities to the dump. At each distance, auger and core samples were collected at 0-30cm depth geo referenced with GPS. In 2016, samples were collected at westward direction and east ward direction in 2017, Auger samples were dried at ambient temperature of $27^{\circ}C$, ground and passed through 2mm sieve before using it for determination of soil chemical properties. Core samples were used to assess physical properties of soil.

Laboratory methods: Particle size distribution was determined using hydrometer (Gee and Or 2002). Dry bulk density was assessed using the formular:

$$\text{Bulk density} = \frac{\text{Dry soil}}{\text{Volume of core}}$$

where: volume of core is $\prod r^2 h$, r^2 = radius of core and h = height of core.

The gravimetric moisture content (GMC) of soil was determined as:

$$GMC\% = \frac{(W_s - \text{tare}) - (D_s - \text{tare})}{D_s - \text{tare}}$$

where: W_s = weight of wet soil, tare stands for calico cloth, rubber band and weight of empty core , D_s = is oven dry weight of soil and GMC % is percentage gravimetric moisture content.

Total nitrogen determination was done using the macro-Kjeldhal method of Bremner and Mulvaney (1982). Soil pH was obtained in 1:2.5 soil/water solution ratio using electronic pH meter. Soil organic carbon was determined by Nelson and Sommers (1982) method. Available Phosphorus determination was carried out using Bray-2 extract (Olsen and Sommers 1982). Total exchangeable bases of calcium, magnesium, sodium and potassium were determined using 1N NH_4OAC extractant solution. Calcium and magnesium were evaluated using atomic absorption spectrophotometer while potassium and sodium were determined with flame photometer. Cation exchange capacity was estimated using NH_4OAC displacement method (Jackson, 1958). Base saturation was calculated with the formular:

$$\text{Percent base saturation} = \frac{\text{Total exchangeable bases (cmolkg-1)}}{\text{Cation exchange capacity (cmolkg-1)}} \times \frac{100}{1}$$

RESULT AND DISCUSSION

Particle size distribution: Sand fraction was predominantly lower at 50 m distance from dump for the seasons but had higher silt and clay fractions (Table 1). The sand fractions increased with increase in proximities of the impact points

away from the dump yielding highest values (700 and 690 gkg^{-1}) for the two seasons at low impact points. Similarly, silt and clay fractions (finer particles) vitiated in like trend obtained in sand fraction with 200 and 100 gkg^{-1} and 210 and 100gkg^{-1} being respectively range of finer particles for two season at low impact points. The trend of rice mill wastes dump on soil particle size distribution at impact points is very high > high > moderately low > low. The soil for two seasons consistently maintained sandy loam texture.

Low sand content and increased finer fractions at very high impact point compared to other impacts further away from the dump could be attributed to positive influence of rice mill wastes dump on particle size distribution. This is supported by observations of Obi (2000) and Onwuka et al (2015) that good agricultural practice such as soil amendment altered particle size distribution but not texture. Particle size distribution play vital role in promoting soil physical condition as well as fertility and productivity of soil. Soil aeration propensity, water and nutrients retention, resistance to degradation, specific surface area and soil compatibility are all controlled by particle size distribution and texture of soil (Smith et al 1998). Sandy loam is a medium texture and it is ideal for root proliferation and enhances both fertility and productivity of soil as it will promote large nutrients flux, optimal moisture content and air circulation.

Bulk density, total porosity and gravimetric moisture content: The results indicated that bulk density, total porosity and GMC in 2017 and GMC in 2016 were significantly impacted at different impact points by rice mill wastes dump (Table 2). Similarly, there were significant differences in these soil properties among the impact areas. At very high impact in 2017, bulk density was lower by 3, 54, 96% when compared to high, moderately low and low impacts. Furthermore, the values (55.00 and 74.00%) of total porosity were 1, 19, 34% and 11, 25, 58% higher at very high impact relative to high, moderately low and low impacts for the seasons. The trend of positive impact of rice mill wastes dump on soil physical properties could be capitulated as very high > high > moderately low > low and decreased in revised trend,

respectively.

Several authors (Onwudike et al 2015, Liu et al 2011) observed that amendment of rice mill wastes on soil reduced bulk density and increased total porosity as well as gravimetric moisture content. Low bulk density and high total porosity would encourage good root anchorage which could aid crops in proper assessment of nutrient and moisture. The low bulk density and total porosity coupled with optimal moisture content especially at very high and high impacts compared to other impact points could have been facilitated by organic carbon contents at these impacts (Table 3 Nnabude and Mbagwu (2001) reported that organic carbon content had significant reduction effect on bulk density and increased total porosity which boosted water storage pores. Increase of bulk density and decrease of total porosity as impact points increased run concordant with report of Amadi et al. (1996) that soil properties were degraded at heavy impact (H1) zones of oil contamination compared moderate impact (M1) ones. Compared from very high to moderately low impact points, bulk density, total porosity and GMC at low impact were critical (Obi 2000) to soil sustainable fertility and productivity.

Chemical properties of soil: With exception for magnesium, exchangeable acidity and base saturation, the other chemical properties in 2017 and soil pH, organic carbon, calcium and magnesium in 2016 significantly

Table 2. Impact of rice mill wastes dump on soil physical properties

Sampling distances (m)	BD (gcm^{-3})	TP (%)	GMC (%)	BD (gcm^{-3})	TP (%)	GMC (%)
	2016			2017		
50	1.10	55.00	51.75	0.69	74.00	20.0
100	1.20	51.00	46.25	0.71	73.00	19.0
150	1.30	47.00	38.75	1.06	60.00	18.0
200	1.40	43.00	21.75	1.35	49.00	15.0
CD (p=0.05)	0.13	5.16	13.05	0.08	3.68	1.17

BD – Bulk density, TP-Total porosity, GMC – Gravimetric moisture content

Table 1. Impact of rice mill wastes dump on particle size distribution

Distances (m)	Particle size distribution (gkg^{-1})			Texture	Particle size distribution (gkg^{-1})			Texture
	2016				2017			
	Sand	Silt	Clay		Sand	Silt	Clay	
50	580	240	180	SL	570	230	250	SL
100	650	220	130	SL	650	210	140	SL
150	680	270	150	SL	660	210	130	SL
200	700	200	100	SL	690	210	100	SL

SL – sandy loam

Table 3. Impact of rice mill wastes dump on soil chemical properties

Sampling distances	pH (H$_2$O)	P (mgkg^{-1})	N (%)	OC (%)	cmol kg^{-1}						
					Ca	Mg	K	Na (%)	EA	CEC	BS (%)
50	6.2	12.40	0.60	1.66	6.40	2.60	0.72	0.10	5.52	17.40	98
100	6.1	10.80	0.50	1.63	5.30	2.30	0.17	0.08	8.08	15.80	91
150	5.6	9.40	0.50	1.19	3.50	2.10	0.08	0.13	9.92	12.04	89
200	5.5	6.60	0.30	0.66	3.30	1.70	0.06	0.13	10.40	10.48	87
CD (p =0.05)	0.4	NS	NS	0.14	1.49	0.45	NS	NS	NS	NS	NS
50	7.00	90.1	0.29	3.43	17.4	4.80	0.88	0.56	0.16	22.43	99
100	6.80	58.8	0.28	2.59	16.4	3.20	0.84	0.45	0.24	21.97	99
150	6.70	51.2	0.27	2.10	9.2	4.40	0.46	0.59	0.24	15.21	99
200	5.83	13.00	0.5	0.65	4.5	2.80	0.19	0.18	0.32	7.90	97
CD (p = 0.05)	0.42	3.15	0.02	0.43	3.37	NS	0.17	0.09	NS	3.33	NS

NS – Not significant

(P<0.05) effect by rice mill wastes dump and indicated significant differences in them among the impact points. Soil pH was strongly acidic at low impact for the two seasons. Available phosphorus varied from 12.40-6-60 mg kg^{-1} and 90.10- 13.00mgkg^{-1} respectively for the seasons for very high and low impact. This accounted for 47 and 86% significant increments in available phosphorus at very high impact compared to low impact. Nitrogen maintained low status throughout the impact points for the periods of study. Organic carbon decreased from 1.66–0.66gkg^{-1} and 3.43–0.65gkg^{-1} for very high and low impact for 2016 and 2017, respectively. This resulted to 60 and 81% significantly higher organic carbon at very high impact point relative to low impact for the periods. Exchangeable calcium and magnesium were significantly predominant at very high impact and plummeted at other impact points farther away from the dump. Potassium and sodium although higher at very high impact crashed with increase of impact points yielding lowest values (Table 3) for the periods at low impact. Exchangeable acidity (EA) was generally lower at very high impact than other impact points with highest value (10.4 cmol kg^{-1}) at very low impact in 2016. This account for 47% in crement of EA at low impact when compared to very high impact. Cation exchange capacity decreased from 17.4–10.48 cmolkg^{-1} and 22.43–7.90 cmolkg^{-1} for respective seasons representing 40 and 65% higher CEC at very high impact in respect to low impact for the periods. Base saturation was consistently high (Table 3) for the periods throughout the impact points. The relative significance and positive impact of rice mill wastes dump on soil chemical properties based on distances could be captured in the following trend very high > high > moderately low > low and decreased in reverse trend. High significant values of soil chemical properties various impact points are in tandem with the observations of Ojeniyi et al

(2010) and Onwudike et al (2015) that agro-wastes impacted significantly on soil chemical properties. This finding could be attributed to decay and mineralization of nutrients by rice mill wastes which influenced surrounding environment. Soil pH, available phosphorus, organic carbon, calcium, magnesium, CEC and base saturation at various impact points are above recommended critical values for soil fertility maintenance and for sustainable soil productivity (FMAWRD 2002). These findings suggest that rice mill wastes could improve fertility status of soil as well as sustain economical yield of crops.

CONCLUSION

The rice mill wastes dump could significantly impact on Grarimetric Moisture Content (GMC), reduce bulk density and increase total porosity of soil. Soil pH, organic carbon, calcium and magnesium were significantly and positively impacted for available phosphorus, nitrogen, potassium, sodium as well as cation exchange capacity. The positive and significant impact of rice mill wastes dump on soil physicochemical properties followed a trend of very high > high > moderately low > low impact. This shows that rice mill wastes if properly managed could be a veritable amendment material to sustainably increase fertility status and productivity of soil.

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Physico-chemical Analysis of Ground Water for Irrigation and Drinking Purposes around Moth Block of Jhansi District, Uttar Pradesh, India

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Abstract: The aim of the research work is to determine the physicochemical characteristics of groundwater and its suitability for drinking and irrigation purposes in Moth Block of Jhansi District in Bundelkhand region. Analytical results of physicochemical analysis showed fluoride content was higher than permissible limit in 13 samples and nitrite content higher in Pandauri and Kandaur. The obtained results were compared with International and National standards as World Health Organization (1997) and Bureau of Indian Standard (2012).The concentration of pH in groundwater was from 6.79-7.70 with average of 7.34 which indicates that it suitable for drinking water. A comparison of groundwater quality parameters in relation to specified limits for drinking water shows that the concentrations of turbidity, F-, SO_4^-, Cl-, Na^+, K^+, Ca^{2+} and Mg^{2+} were lower than the acceptable limits in few water samples. The good quality of groundwater of the study area measured with various irrigation indexes estimation of physiochemical parameters, US Salinity Laboratory (USSL) Classifications and Sodium Adsorption Ratio (SAR).The US salinity diagram show that the intermediate to high saline groundwater samples belong to C3S1 and C2S1 show that intermediate to low alkaline water. After all, US Salinity diagram shows that the mostly groundwater samples were suitable for irrigation purpose and lies within the acceptable limit except at few locations. In addition, few parameters are alarming in comparison with the BIS (2012) standards for drinking uses, thereby suggesting the need for treatment and precautionary measures for groundwater use. The water can be utilized for drinking after treatment.

Keywords: Groundwater, Physico-chemical parameters, Anions and cations, Irrigation and drinking purposes

Jhansi district is a part of Bundelkhand region. Groundwater is used for domestic, irrigation, drinking and other purposes around Moth block of the district and its villages. The groundwater supplying in the study area has few struggles namely as drying tube wells and defective the hand pumps, which has forced many inhabit internally the district to built hand pump in her houses in absentia someone hydro geological assistance construction their hand pumps susceptible to contamination. In Bundelkhand region, drinking water has been accessed in some area but not throughout the region. Groundwater is an important for agriculture purposes, domestic uses, recreational and industrial areas. In the last few decades, growing the population in the world there are increasing requirement of freshwater. Growing physical and chemical contaminants in the groundwater causes serious health problems and also affects the water properties. Due to few reasons the quality of groundwater is deteriorated containing water, salts, anthropogenic contaminations and soluble minerals (Subba et al 2016). The major sources of pollution into the freshwater due to the discharge of agriculture, physical and chemical (organic and inorganic sources), industries and domestic wastewater (Edokpayi et al 2018). Calcium, magnesium, sodium, potassium, fluoride, chloride, carbonates and bicarbonates and nitrates are major anions and cations found in the groundwater. The water quality is investigated for

agriculture by dissolved ions concentration and composition, generally determined by subsurface lithology, dissolved salt, speed and amount of groundwater flow, geochemical reaction and human activities Kaur et al 2017). If high amounts of anions, cations and physical characteristics found in the groundwater, it can cause serious health problems due to pollution and water may require to be investigated prior to utilization (Behailu et al 20.17). The high concentration of fluoride in the drinking water can cause fluorosis in the children, suggested by WHO (2003). About 62 million people with six million children across the country are believed to have many problems with fluorosis (skeletal or dental) such a long-term solution in high-fluoride contaminated water. About 62 million people with six million children across the country are believed to have many problems with fluorosis (skeletal or dental) such a long-term solution in high-fluoride contaminated water. The investigation of physico-chemical parameters could help to sympathetic the function and structure of any aqueous environment in relation to its residents (Kumar et al 2018). The study area often contains groundwater type NaCl or Na-HCO_3 reflecting increased salinity at low and high evapotranspiration rates. At some locations in the Bundelkhand belt, high concentrations of iron, fluoride and nitrate required a comprehensive study of groundwater resources for good management and utilization. It is

observed that ground water is substantially polluted by the use of human activity. In this paper, an attempt has been made to evaluate the quality indices of groundwater in order to understand the hydro geochemical relationships of the water quality parameters to ensure that groundwater resources are appropriate. The main aim of this research work is to determine the concentration of physical characteristics, anions and cations in the groundwater of Moth block and its surrounding villages and results compared with the International and national standards methods namely as WHO and BIS (2012).

MATERIAL AND METHODS

Study area: Moth block is located in Jhansi district of Uttar Pradesh in Bundelkhand Region and between 25.8001° and 25.2701° N latitude and 78.1510° and 79.2510° E longitudes and covers a total area of 799 km^2 (Fig. 1). The Yamuna flows from west to east and the main drainages of Yamuna River are Ken, Pahuj, Paisuni, Betwa, Gharara, Sindh and Bagain flow from south to north and others tributaries are Dhasan, Jamuni, Burma, Sonar, Patna (Singh et al 2013). These tributaries are the part of the Ganga River. The water bodies were mostly filled up during the rainy season and which in turn charged the groundwater. Thus, the most farmers are mainly dependent on the monsoon rains to recharge these wells in Bundelkhand region. The study area mainly comprises of alluvium soil of the age of quaternary and the area mainly found to be a zone of North. Moth Block comprises of alluvium soil, including, clay type soil, coarse to fine sand, pebble, boulder, silty-clay and kankar as a type of calcium carbonate were found in the study area (Singh et al. 2013). The thickness of the aquifer mainly lies between from 5-150 meters in the conditions of unconfined. The depth of tube wells for drinking water varied between 100-150 meters otherwise the depth of hand pumps varied from 30-50 meters and depth of dug wells varied from 10 to 20 meters below ground level.

Water sampling: Representative groundwater samples were collected for physicochemical and heavy metal analysis in polyethylene bottles along with their GPS coordinate during July 2015-January 2016 from 40 locations and preserved by adding an appropriate reagent (APHA 1992). The groundwater samples were collected from hand pumps and analysed for almost major anions, cations and physicochemical parameters using polyethylene bottles of 500, and 250ml from each site which was thoroughly washed thrice with the water to be analyzed. The hand pumps were continuously pumped for at least 15 minutes prior to the sampling, to ensure the groundwater to be sampled was representative of groundwater aquifer. The pH and electrical
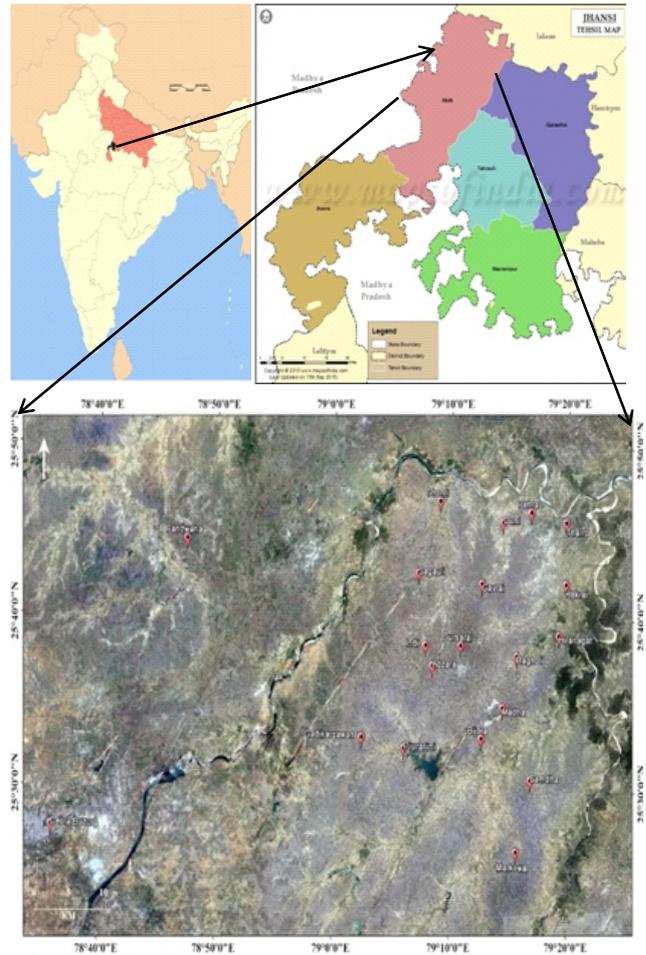
Fig. 1. Satellite image showing sampling location at moth block of Jhansi District

conductivity were measured at site using portable kits. The physico-chemical parameters were performed following APHA's Standard Methods for the Examination of Water and Wastewater (APHA 1992). The pH was analyzed with the electrometric method of pH meter-Hach, EC analyzed with the help of conductivity meter-Hach, and TDS analyzed with the help of gravimetric method and bicarbonate with the help of Titration by H_2SO_4 using digital burette. The major cations and anions in the samples were analyzed with the help of Dionex IC-5000 Ion Chromatograph. Ion chromatography (IC) is a form of fluid chromatography, wherein ion interchange resins are employed to an individual molecular and atomic ion for experimental. Ion chromatography (IC) involves the retention of ions from the sample being retained based on ionic interactions. Quantification of cations and anions in the sample is based on the calibration curve of standard solutions of cations/anions.

RESULTS AND DISCUSSION

pH: The pH varied between 6.79 to 7.70 with 7.34 is an

Physicochemical Analysis of Ground Water

average (Fig. 2) and according to BIS (2012), the value of pH within the 6.5-8.5 acceptable limits for different usage of water contain drinking purposes, irrigation purposes and locally supplies in cities.

Electrical Conductivity (EC): The electrical conductivity ranged 361 to 2165 µS cm⁻¹ with average 952 µS cm⁻¹ value (Fig. 2). The acceptable limit has prescribed <250 µmhos cm⁻¹ by WHO. All 40 samples showed were within the limit, whereas the groundwater samples of EC at some places indicated medium salinity show that it is suitable for drinking and agriculture purposes under normal conditions.

Total Dissolved Solid (TDS): The acceptable limit has prescribed 500 mg l⁻¹ and 2000 mg l⁻¹ is the permissible limit by

using (BIS 2012). The TDS value varied 277 to 1505 mg l⁻¹ and 662 mg l⁻¹ is an average value of TDS. Out of 40 groundwater samples (Fig. 3) 34 samples showed acceptable limit. The low concentrations of TDS produce undesirable taste of water but may be use for irrigation purposes.

Turbidity: The acceptable and permissible limits are 1 and 5 NTU by (BIS 2012). The turbidity value varied between from >1 to 60 NTU. The TDS value varied 0.24 to 28.5 NTU with an average of 2.09 NTU. Out of 40 groundwater samples shown in (Fig. 3) 13 samples were within acceptable limits and rest with lower values from the desirable limit.

Major cations

Calcium: The prescribed acceptable limit 75 and 200 mg l⁻¹ is

Fig. 2. Spatial variation of pH and EC

Fig. 3. Spatial variation of TDS and Turbidity

the permissible limit by (BIS 2012). The calcium value varied from 12.58 to 174.43 mg l^{-1} with average of 49.09 mg l^{-1}. The 32 samples showed the lower value from the acceptable limit and 8 were within the acceptable limit (Fig. 4).

Sodium: The sodium value varied between 15.59 to 205.51 mg l^{-1} with average of 88.07 mg l^{-1}. The 38 samples showed lower value than the acceptable limit of 200 mg l^{-1} (BIS 2012) and 2 samples were within the acceptable value of sodium in Chhota Mil and Puliya (Fig. 4).

Magnesium: The acceptable and permissible limit prescribed by BIS (2012) is 30 and 100 mg l^{-1}. In the groundwater samples magnesium value varied between

6.76 to 97 mg l^{-1} with 35.27 mg l^{-1} an average. The 18 samples showed lower than the acceptable limit and 22 samples were within the acceptable value (Fig. 5).

Potassium: The WHO acceptable and permissible limit is 200 and 300 mg l^{-1}. The potassium value varied from <1 to 277.77 mg l^{-1} with 12.36 mg l^{-1} an average value. The only acceptable limit of potassium in Pachowai village and rest were lower than the acceptable limit (Fig. 5).

Major anions

Fluoride: The acceptable limit has prescribed 1 mg l^{-1} and 1.5 mg l^{-1} is the permissible limit by using (BIS 212). The groundwater samples measured the fluoride value between
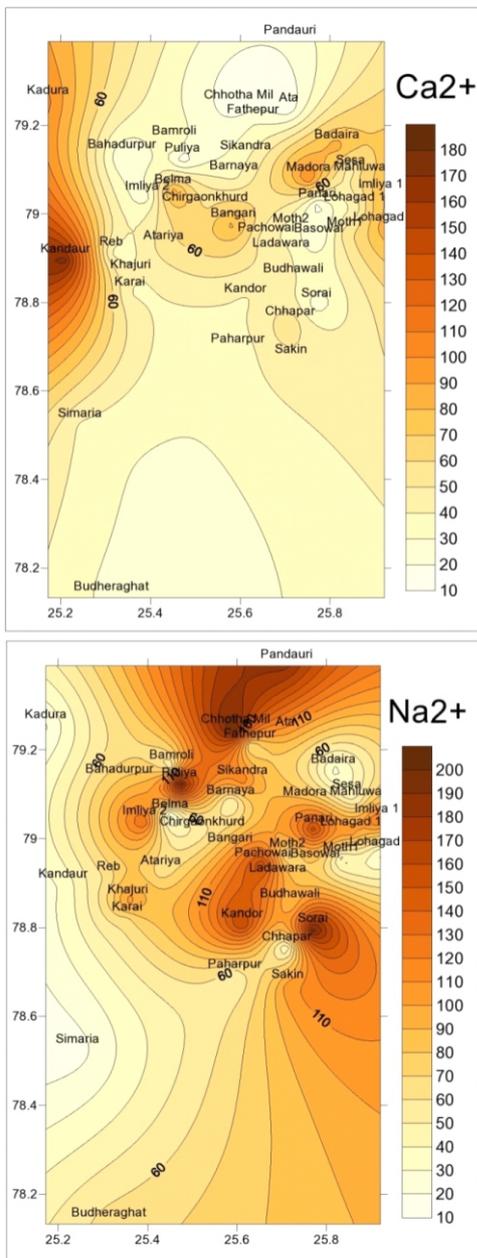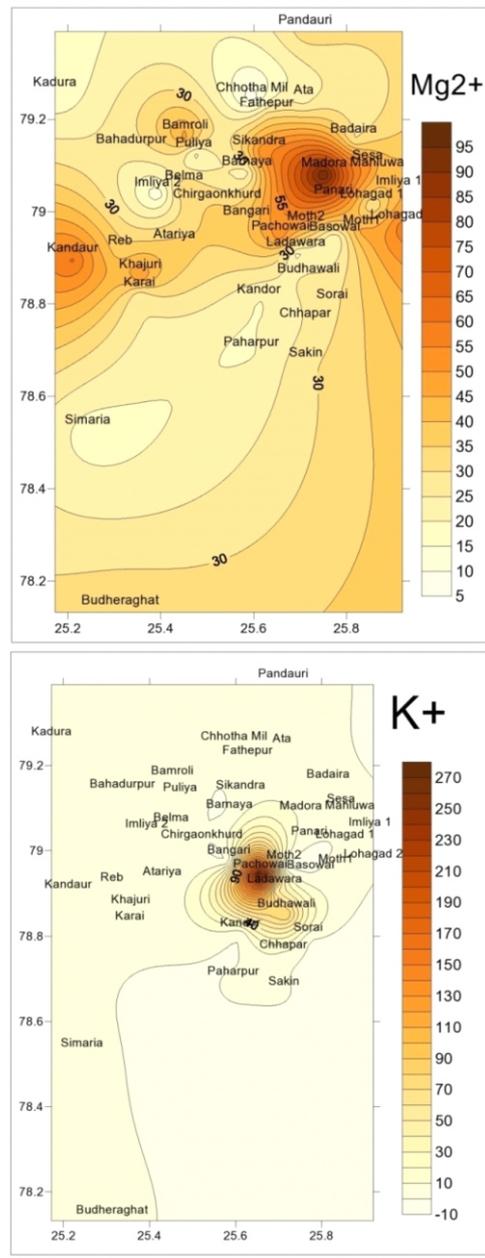

Fig. 4. Spatial variation of Ca^{2+} and Na^{2+}

Fig. 5. Spatial variation of Mg^{2+} and K^{+}

<1 to 3.68 mg l^{-1} and 1.38 mg l^{-1} as average value. The 19 samples showed (Fig. 6) the lower value from the acceptable limit and 13 samples showed high values greater than the permissible limit and rest were within the acceptable limit. High fluoride may cause fluorosis.

Chloride: The high amount of chloride is regarded to be the evidence of pollution caused by a biological component of animal or manufacturing material   –(Venkatesharaju et al 2010). The acceptable limit is 250 mg l^{-1} and 1000 mg l^{-1} is the permissible limit (BIS 2012). The chloride value varied from 3.2 to 264 mg l^{-1} with average of 43.3 mg l^{-1}. The 38 samples

showed (Fig. 6) lower than 200 mg l^{-1} value and 2 samples were in acceptable limit in Kandaur and Madora village.

Sulphate: The acceptable limit has prescribed 200 mg l^{-1} and 400 mg l^{-1} is the permissible limit (BIS 2012). The sulphate varied from 1.6 to 81 mg l^{-1} with average of 13.2 mg l^{-1}. All groundwater samples showed very low value from the acceptable limit of sulphate (Fig. 7).

Nitrites: The acceptable limit has 45 mg l^{-1} (BIS 2012). The nitrate varied between 0.52 to 206.13 mg l^{-1} with 16.33 mg l^{-1} as an average value against prescribed limit of 45 mg l^{-1} (BIS 2012). The 38 samples were within the acceptable limit and 2
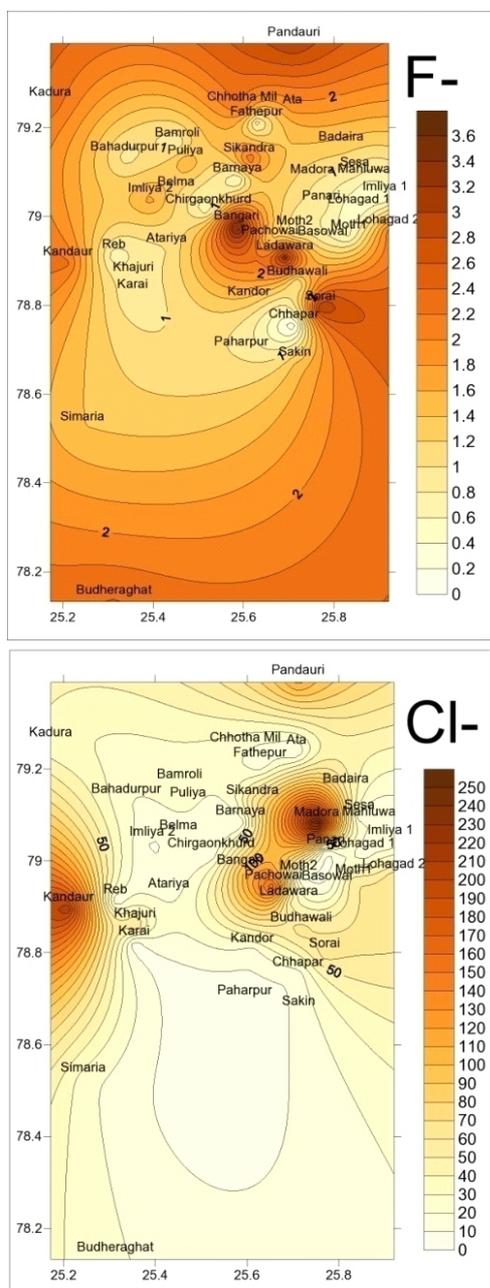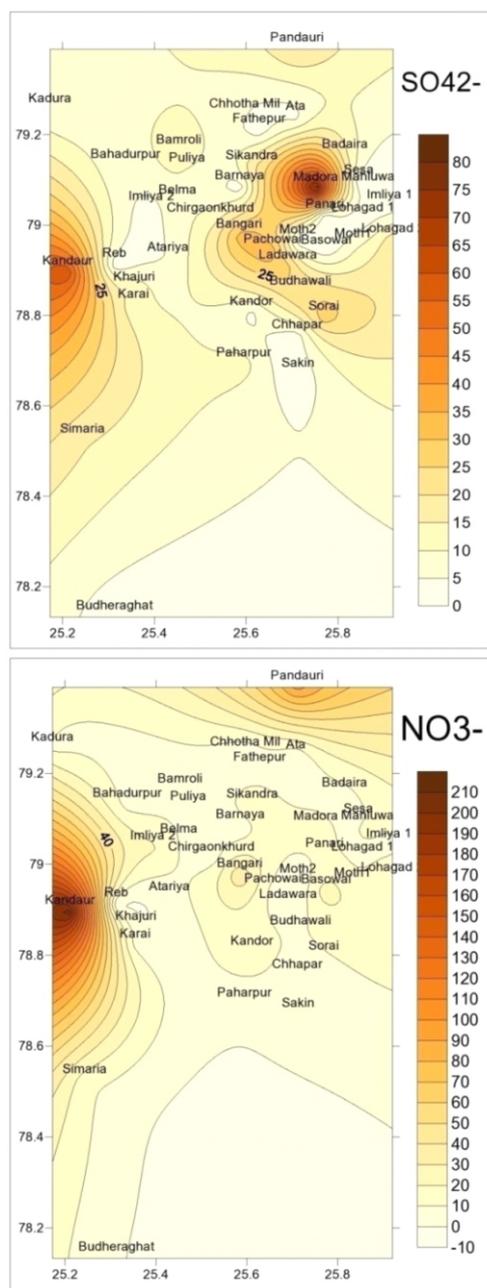

Fig. 6. Spatial variation of F$^-$ and Cl$^-$

Fig. 7. Spatial variation of SO$_4$$^{2-}$ and NO$_3$$^-$

samples showed (Fig. 7) value greater than 45 mg l^{-1} in Pandauri and Kandaur village.

Bicarbonates: Due to weathering of parent material, the bicarbonates originated mostly from the horizon of soil of CO_2 and which is merged with rainwater to form HCO_3. The permissible limit prescribed is 600 mg l^{-1} (BIS 2012). The bicarbonate value varied between from 148 to 803.6 mg l^{-1} with average of 433.1 mg l^{-1}. The 36 samples were within the permissible limit and 3 samples showed medium to high value range between 600-800 mg l^{-1} and 1 sample showed very high value in Pachowai village (Fig. 8).

Ground water quality appraisal

Results obtained from an analysis of the groundwater samples were considered for its suitability for irrigation and drinking purposes.

Groundwater suitable for domestic uses: The groundwater samples analyzed for irrigation, drinking and public health purposes and compared with the standard values of (WHO 2003) and (BIS 2012). The groundwater samples of pH varied between 6.79-7.70 and the average value of pH is 7 and the value of pH within the acceptance of 6.5–8.5 has prescribed by (BIS 2012) for drinking water. The groundwater samples of TDS prescribed 500 mg l^{-1} acceptable value lies with 85 % groundwater samples and

Table 1. Classification of Irrigation water on the basis of SAR and EC into four categories

SAR	Water category	Sample (%)	EC (µS cm^{-1})	Water category	Sample (%)
0-10	Excellent (S-1)	100	<250	Low (C-1)	0
I0-18	Good (S-II)	0	250-750	Medium (C-II)	27.5
8-26	Fair (S-3)	0	750-2250	High (C-3)	72.5
26	Poor (S-4)	0	>2250	Very high (C-4)	0

2000 mg l^{-1} are a permissible limit of TDS lies with 5 % groundwater samples of Moth block. The classification of groundwater on the basis of hardness into soft TDS 75 mg l^{-1}, the intermediate hardness of 75–150 mg l^{-1}, the hardness of 150–300 mg l^{-1} and very hard from 300 mg l^{-1} (Sawyer and McCarty 1967). The groundwater samples to measure the turbidity value varied between from 0.24-28.5 NTU and compared with the accepted value by (BIS 2012) of 5 NTU in 5% samples of the study area. The analyzed samples of nitrate are high compared with a permissible limit of 45 mg l^{-1} of (BIS 2012) in 5 % of the groundwater samples. The high concentration of nitrate in drinking water can cause many diseases, including gastric cancer, methaemoglobinaemia in infants, goitre, heart disease and birth malformations (Majumdar et al 2000). Fluoride is a fundamental metal for maintaining the typical growth of strong dentition and bones. But the higher concentration of fluoride causes skeletal and dental fluorosis, for example, mottling of teeth, bending of spinal cord and deformation of ligaments (Tiwari et al 2015). Concentration off exceeds the permissible limit of fluoride from 1.5 mg l^{-1} in almost 30 % of the samples of the study area. The acceptable limit of chloride and sulphate has prescribed 250 and 200 mg l^{-1} except at one site for chloride. The sodium is better cations for the human body. The high concentration of sodium creates many diseases, including as congenital heart diseases, hypertension heart disease and infection in the kidney. The analyzed values of sodium are within the acceptable limit of 200 mg l^{-1} of the study area of Moth block.

Groundwater suitable for irrigation uses: Three very important parameters for irrigation water are soil types, water quality and cropping practices. The irrigation suitability of groundwater was investigated based on sodium and electrical conductivity. EC is a useful parameter for measuring the salinity hazard to crops. The sodium percentage of the groundwater samples as calculated by the formula formulas.

$$Na\% = \frac{Na+K}{Ca+Mg+Na+K} \times 100$$

The sodium percentage of Moth block ranged from 9.46 to 87.69% (average 42.16%). The maximum 60% groundwater samples of sodium are recommended for the
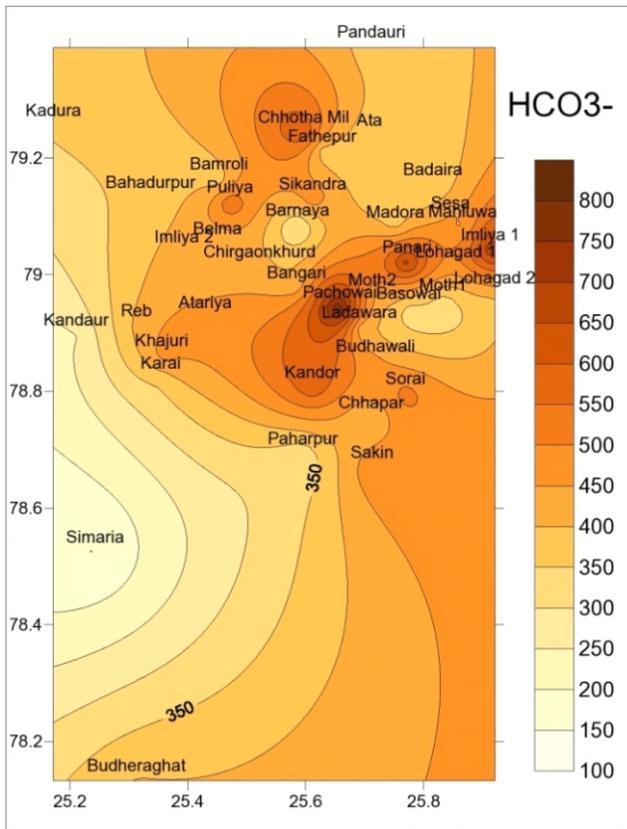

Fig. 8. Spatial Variation of HCO_3^-

Table 2. Physical parameters analysis of groundwater of Moth block

Lat	Long	Village	pH	EC (µS cm⁻¹)	Turbidity (NTU)	TDS (mg l⁻¹)
25.70807	79.42277	Ata	7.43	719	28.5	525
25.42973	78.92561	Atariya	7.54	860	1.10	588
25.81578	79.15383	Badaira	6.83	745	2.41	504
25.33733	79.13137	Bahadurpur	7.46	750	0.76	529
25.45325	79.16281	Bamroli	7.67	793	7.97	561
25.58626	79.08394	Barnaya	7.50	558	0.45	406
25.77492	78.94145	Basowai	7.51	686	0.85	495
25.45074	79.05238	Belma	7.51	712	0.3	512
25.58472	78.97663	Bangari	7.23	1170	2.74	777
25.31305	78.13255	Budheraghat	7.16	751	1.00	558
25.71856	78.85094	Budhawali	7.39	1165	0.36	709
25.71137	78.75432	Chhapar	7.45	618	2.68	457
25.52183	79.01293	Chirgaonkhurd	7.11	794	3.54	567
25.59655	79.2434	Chhotha Mil	7.67	1165	0.60	857
25.62842	79.21058	Fathepur	7.24	734	0.36	524
25.91302	79.04182	Imliya 1	6.99	1220	0.62	890
25.39365	79.03785	Imliya 2	7.70	825	0.62	585
25.17233	79.25458	Kadura	7.07	793	2.24	544
25.61174	78.80592	Kandor	7.63	1215	0.44	785
25.21123	78.89565	Kandaur	6.85	1360	4.15	995
25.35455	78.82155	Karai	7.40	708	2.96	493
25.35617	78.86031	Khajuri	7.47	1094	0.54	720
25.69148	78.90875	Ladawara	7.34	1023	0.39	734
25.85515	79.01317	Lohagad 1	7.15	943	0.38	676
25.92067	78.96752	Lohagad 2	7.23	1005	0.65	669
25.75229	79.08037	Madora	7.47	1590	0.74	1024
25.8663	79.08126	Mahluwa	7.24	874	0.27	616
25.8332	78.95576	Moth1	7.24	840	2.35	513
25.71296	78.96425	Moth2	7.53	840	0.55	614
25.65794	78.94328	Pachowai	7.28	2165	0.60	1505
25.59523	78.69217	Paharpur	7.50	552	0.59	371
25.71112	79.38963	Pandauri	7.45	1310	3.57	849
25.77178	79.02087	Panari	7.51	1300	*0.24*	902
25.47148	79.12357	Puliya	7.36	1100	1.82	790
25.31288	78.91189	Reb	7.50	752	0.66	525
25.71293	78.66887	Sakin	7.27	896	0.49	625
25.84563	79.09655	Sesa	7.15	815	0.35	560
25.61209	79.12883	Sikandra	7.18	1097	0.31	780
25.24308	78.52363	Simaria	*6.79*	*361*	3.74	*277*
25.7694	78.79521	Sorai	7.62	1187	0.55	881
Average			7.34	952	2.08	662

Table 3. Anions and cations analysis of groundwater of Moth block

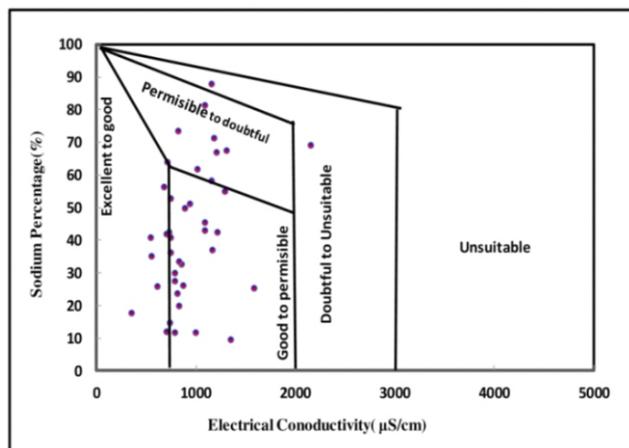| S. No.	Cl⁻ (mg l⁻¹)	HCO₃⁻ (mg l⁻¹)	SO₄²⁻ (mg l⁻¹)	NO₃⁻ (mg l⁻¹)	Ca²⁺ (mg l⁻¹)	Mg²⁺ (mg l⁻¹)	Na⁺ (mg l⁻¹)	K⁺ (mg l⁻¹)
1	8.8	369.2	3.7	1.42	12.58	23.44	102.60	1.55
2	16.5	462.3	5.4	6.92	56.05	36.97	63.22	2.43
3	58.0	355.0	16.5	7.00	85.00	30.00	25.27	1.38
4	20.8	366.8	6.0	6.14	19.45	27.03	80.75	0.95
5	26.6	372.8	14.7	5.86	40.35	48.00	50.13	2.03
6	9.3	284.8	2.1	3.66	37.49	21.99	44.57	1.15
7	13.4	330.6	2.6	26.56	22.46	18.86	78.00	1.49
8	18.2	408.2	10.0	9.68	88.42	35.81	20.14	3.80
9	94.0	422.3	32	39.00	84.00	39.00	98.96	0.86
10	21.8	402.8	2.3	0.93	27.24	34.21	64.90	1.62
11	65.3	465.6	25.3	9.07	41.64	27.75	88.61	84.32
12	13.9	395.0	2.2	1.39	58.00	25.53	36.27	5.83
13	11.8	426.0	11.9	4.73	58.52	35.72	55.85	1.50
14	22.3	601.6	5.6	1.27	13.74	6.76	202.53	1.33
15	10.5	374.8	1.7	5.81	28.76	31.96	67.32	2.12
16	10.2	695.0	2.2	6.60	79.10	43.45	124.75	2.04
17	8.5	424.0	2.9	21.75	25.02	10.76	133.68	1.59
18	31.9	357.6	5.8	8.30	102.73	15.81	18.51	0.95
19	16.0	590.5	4.1	19.41	38.81	19.69	163.62	1.29
20	209.2	248.8	59.5	206.13	174.43	61.01	32.03	1.61
21	3.2	364.3	11.2	6.89	39.93	26.08	67.30	1.58
22	66.3	465.5	14.3	5.78	42.15	50.82	107.05	1.77
23	51.0	424.8	26.1	0.52	45.93	18.58	108.94	54.47
24	13.5	474.4	2.5	7.27	42.48	28.41	106.54	0.64
25	67.9	405.2	18.5	20.21	86.47	59.04	26.81	1.15
26	264	390.0	81.0	14.00	102.39	97.00	96.29	8.76
27	21.8	440.2	1.7	13.69	61.98	43.19	52.36	1.91
28	59.4	325.3	8.6	13.28	55.83	47.10	35.08	4.18
29	12.4	451.2	2.0	1.87	36.19	44.83	61.83	2.45
30	161.9	803.6	32.5	6.06	41.08	52.82	160.88	277.77
31	8.1	312.0	12.0	2.27	33.90	19.59	51.04	1.60
32	114.3	373.9	20.5	94.81	23.12	33.35	183.37	2.37
33	10.1	680.0	2.6	10.65	16.32	60.28	159.83	1.33
34	22.8	545.2	9.8	8.11	12.77	17.75	205.51	5.40
35	11.9	411.2	2.0	0.93	37.86	36.55	62.68	1.47
36	12.5	492.0	2.1	5.55	47.89	28.93	106.53	1.59
37	10.2	457.6	1.6	7.51	42.58	53.31	44.97	1.61
38	64.6	483.2	18.8	19.12	38.21	53.36	118.66	2.19
39	25.0	148.0	15.9	14.0	38.76	17.29	15.590	1.23
40	64.7	522.4	28.0	8.92	23.96	28.63	199.91	1.16
Average	43.8	433.0	13.20	16.32	49.08	35.26	88.07	12.36

Fig. 9. Rates of groundwater samples on the basis of the EC and NA % (after Wilcox)
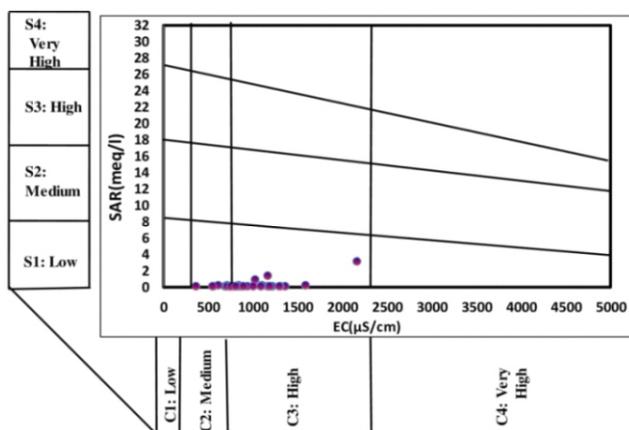

Fig. 10. US Salinity diagram for classification of irrigation water

irrigation water by Indian Standard (BIS 2012). The Wilco x 1955) and US Salinity Laboratory Staff (1954) established the irrigation water standards. Wilcox (1955) classified the groundwater for irrigation purposes based on percent of electrical conductivity and sodium. Wilcox (1955) diagram shows that the percentage of sodium was within the permissible limit of groundwater of Moth block. Generally, the groundwater of the Moth block can be used for irrigation is better for permissible quality. The US Salinity Laboratory Staff (USSL 1954) diagram classified into four categories for the suitability of groundwater for irrigation purposes based on EC and SAR. The concentration of EC is high in water leads to the creations of saline soil and the concentration of sodium is high leads to formation of alkali soil. This permits the level of saturation to rise near to the root area of plants, causing the aggregation of Na salts in the soil solvent through capillary rise following the evaporation of surface water. The sodium or alkali hazard is found in the ground water for agriculture is measured by the perfect and approximate concentration of

cations and is communicated regarding sodium adsorption ratio (SAR).It is calculated by the equations:

$$SAR = NA \sqrt{\frac{(Ca + Mg)}{2}}$$

If high sodium and low calcium are present in irrigation water, the interchange of cations may become saturated with sodium. The groundwater samples show that (SAR) value in the Moth block ranged between from 0.01-2.99 (meq/l). The plot of data on the (US salinity) diagram, in which the EC is taken as a salinity hazard and sodium adsorption ratio (SAR), is shown from 9.46 to 87.69% with an average 4.16%. The groundwater sample belongs to C3S1 and C2S1 show intermediate to high saline water and intermediate to low alkaline water in the Moth block.

CONCLUSION

The pH of groundwater samples varied from 6.79-7.70 with average of 7.34, indicating that there was no acidification and low concentrations of TDS in Simaria, Paharpur, Barnaya, Chhapar, Karai and Basowai indicates its unsuitability for drinking. The major cations and anions in the order of $Na^+ > Ca^{2+} > Mg^{2+} > K^+$ and $HCO_3^- > SO_4^- > Cl^- > NO_3^- > F^-$. In few samples, the concentration of TDS, turbidity, Ca, K, Mg, Na, Cl, F and SO_4 was lower than the acceptable limits and may be utilize after treatment. However, the high concentration of fluoride exceeds the permissible limits at few locations indicating that and the water must be treated previously domestic use. Plot the analytical data indicate that sodium percentage is within the permissible limit and groundwater is suitable for irrigation purposes.

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Rural Natural Resource Management (RNRM) and Social Capital: Contribution of Grassroots Women's Organisations in Rural India

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Abstract: Natural resources have central relevance in sustainable rural development process. This article aims to examine gender centric enhanced insights of social capital evinced in rural grassroots women's organisation's (henceforth GWO's) for rural natural resource management (henceforth RNRM) by analysing four distinctive cases encompassing pan-rural India canvas. Coupled with four stages this paper uses both qualitative and review based data to analyse subtle issues involved in RNRM. A careful exercise has also been done to explore the taxonomy of fundamental determinants of GWO's and social capital for RNRM validating six essential criteria's which may help in designing and replicating such models in similar environments for future policy implications. The findings reported few dominant factors that played crucial role for the emergence of social capital among the GWO's such as: microfinance activities, social space, ecological incentives, external support, nature-defensible actions and strong group accountability towards resource stewardship facilitated in conservation of RNRM. One of the significant findings is it strengthen grassroots women's group agency and self-reliance towards negotiating local challenges in the endowed social space for RNRM.

Keywords: Social capital, Rural women, Rural resources, Management, Participation

With the dawn of new development paradigm thinkers, practitioners and planners have explicitly realised that ecological assets (land, water and biodiversity) received threat by the disruptive actions, hence to be protected, yet in fact native, initiatives of people. The history of natural resource management by people recalls that, the beginning of this relationship was purely relied on group cohesion. In particularly, women were centre at such progressive human-ecological connections and always worked in close association with nature and their contribution has forever nurtured and sustained the environment. However, their role has always been remained silent at both societal and academic environment. Although the term, sustainable development was used for the first time in 1972, at Stockholm, rural and ethnic grassroots women of the third world countries have practiced it for centuries together. Ecological resources in rural areas are having largest quantum of rich natural capital. The traditional economic sources of production and domestic chores complies typical resource poor rural woodland women in the less developed nations to engage in agro-ecological formation which are the soul means of their survival for daily and year-round period. The primary resources are: land and water for food, forest properties for firewood and ethno-medicine and many allied resources that provide petty income generating avenues likewise satisfies their domestic needs. Such long-lasting relationships with nature created deep impact on women, as a result, are intimately affected by any awful changes in it. Studies confirm that such sustained relationships and reliance on agro-ecological resources encourage few rural women to conserve, foster and amplify the treasure of rural bio-ecological knowledge and information in tune with sustainable conservation traditions and practices for the present and future generations (Stevens 2010). In recent times women's contribution to conservation of environment and their misery due to environmental degradation are being recognised, grudgingly by the society (Coleman and Mwangi 2013). Earlier, such traditional human structures have deeply involved in conservation practices at local level. Later, the liability of managing rural ecological resources has progressively taken by the state, under false impression that these recourses are wrongly managed by the grassroots people where the role of women folk was central (Pretty 2003). The conceptualisation of (GWO's) confines to the group of women those associated with micro credit and saving groups, traditional forums, groups organised by CBO's, neighboured groups, peasant groups and indigenous organisations in rural India. In this context this paper with select cases of (RNRM) in India tries to put forth the fact that, when people in particularly rural, ethnic(GWO's)come together in groups, sought their knowledge for common goal, norms with trust and connectedness among the group

networks creates an ideal environment for social capital (henceforth SC) such initiatives are more collective, sustainable and inclusive. By employing theoretical underpinnings of social capital theory this study illustrates how (GWO's) are reconstructing associations with societal structures and helping to common community assets particularly natural assets to condense vulnerability found at the community level. Such local (GWO's) have seen as an effective alternative and regarded as 'third way' this theoretical perspective has been evolved and matured in the philosophy of SC (Bourdieu 1986, Coleman 1988, Putnam 1995). Concept of SC confines a notion that social connections and customs are fundamental for individuals and communes. Institutions mainly local are effectual since they permit us to carry on our daily lives with a minimum of repetition and costly negotiation (Bromley 1993, Pretty and Ward 2001). SC's functioning is relied on following pillars: relationships of faith; interactions and reciprocity; general regulations, customs and consents, togetherness and associations. Thus, to build structures of community organisations which are fundamentally suitable for the RNRM at local level, it is therefore apparent that a neo-wisdom and practice are needed. During few decades' India's rural parts seen growing recognition of such grass roots women's local groups in preserving and sustaining their local natural resources. However, in spite of their contribution in RNRM they have not fully been recognised by state and society at large. Against this backdrop, the paper intends to address itself to the three decisive research questions) what is the contribution of (GWO's) in the production of (SC) congenial for RNRM? ii) What are the structural determinants for collective actions to form and sustain women's groups for (RNRM)? And factors responsible to hinder (GWO's) participation in the process of RNRM at local level) What policy options are feasible for the replication of such initiatives for future strategy implications?

MATERIAL AND METHODS

The study uses threefold strategy to fulfil data required for present investigation. Considering the contextual differences of four cases selected for this study data collection varied in three sets: March-May-November, 2012-2015-2016.Stagefirst: In a study like this the question of 'whom to interview becomes more important than the representative sample of the larger population as it requested for survey interviews' (Warren 2002 p. 87). At first stage a comprehensive list of direct actors (conservators, activists and villagers) and indirect actors (researchers, policy makers and practitioners) associated with these cases was prepared. In some cases where direct actors were not available indirect actors selected for data gathering. Stage two: On the basis of research questions specific data was collected by using informal consultation (interview, telephonic and email conversation), and focus group discussion. Stage three: The collected data was also validated with secondary policy reports and articles on respective cases, comprehensively. In all total 18 direct/indirect actors were purposively engaged. Stage four: Finally, both primary and secondary data was broadly classified and analysed based on analytical structure of paper and key words from an interpretative sociological perspective. That helped researcher to analyse the determinants responsible for production of (SC) and collective actions of rural women's organisation for (RNRM). The core part of the data was applied to develop categorisation and taxonomy of GWO's towards RNRM and drawing conclusion and policy options.

RESULTS AND DISCUSSION

Select cases of GWO's in the participation of (RNRM) although seems small in number and fairly diverse in approaches and functioning, present fairly consistent and simple lessons that can be readily replicated, provided with required conditions (Table 1). These cases are merely indicative there may be numerous initiatives alive in different parts of India but are relatively undocumented otherwise unexplored.

***Chipko Andolan* (Embrace movement) Saga of rural women's collective actions:** An excellent example of significant involvement of grass roots women in natural resource conservation is Chipko movement of rural Garhwal. Shiva and Bandyopadhyay (1986) describes the original Chipko movement which was led by Amrita Devi of Bisnoi community in Rajasthan, 300 years ago to save tress. Women of rural Garhwal took lead in protesting against the exploitative commercial policies of the government. In March 1974 when forest officials and contractors came to fell tress for commercial use, women literally hugged tress to prevent their cutting. This action brought home the point that women have a high stake in protecting the forest, and they can also show initiative. These women finally succeeded in putting an end to indiscriminate felling of tress. Their success has proved their social responsibility and strength. The forests are valuable since they produced profits, resin and timber and these forests abide water, soil and clean air likewise sustains mother-earth finally everything mother abides. This amply illustrates the difference between male and female view point regarding natural connectedness towards environment. The Chipko movement is not only significant as a protest movement but more importantly as widely

renowned efforts made by poor rural women's groups in rehabilitation and afforestation work in India.

Salient features:

1. The women in Chipko movement were inspired by a local community organisation (*Dhasholi Gram Swarajya Mandal*, DGSM) which was working on afforestation programs in this region earlier to this movement.

2. In a traditional village social structure women require social space to come together. DGSM has provided an ideal space for women to involve in this movement.

3. Due to high level of ecological consciousness, mutual trust, cooperation and connectedness among the group associates lead was taken by women members and the survival rate of the plantation was very high (75 per cent) as compared to the rate of Forest Department plantations (14 per cent)(see Gadgil and Guha 1993).

4. Due to deep involvement in afforestation program with sufficient firewood and fodder available nearer the village women's workload was reduced substantially. This kind of short term eco- incentive is another aspect that motivates GWO's in RNRM.

5. To maintain the sustainability of natural resources (for long term eco-incentive) these women groups tried to secure common lands for firewood and fodder production. Most importantly, they have also attempted to distribute the available firewood and grass impartially among the community members. This also confirms the maturity of SC emerged among the group members that reflected in to community conservation.

6. Women's group actions might have been mainly significant for the success of Chipko since, being deprived, collective actions improved their power of negotiation although they were particularly powerless.

7. It is certainly not simple to encourage cohesion within group. During Chipko movement, a number of factors combined to facilitate this process-namely, the relative absence of class and social divisions among

participating communities and the immediacy of threat to community survival due to deforestation (Mehra 1993).

From Wastelands to Silk Farms-land conservation with economic progress: This is one of the distinctive initiatives in rural India where women's collective actions were transformed in managing natural resources (land reclamation and renewing fallow land) along with improving their self-capabilities (providing livelihood and earnings and constructing woman's managerial and leadership abilities) in a tiny village of Bankura district, West Bengal. This initiative began in 1980's with an objective to empower local rural marginal women called as *Santhal* predominantly poor, illiterate, and landless in a convention organised by the West Bengal Minister for Land Reforms in cooperation with Centre for Women's Development Studies (CWDS) a Delhi based research institute. Their livelihood was in risk due to the deforestation in the surrounding locale, that deprived their livelihood opportunities in agriculture, hence shifted to petty jobs based on forest resources. Forced migration for livelihood was frequent around the year among these groups. To protect income and livelihood mainly at local level was their main need as expressed in the pre-planing meeting. After said meeting, CWDS and state administrators supported few women to formalise self-help groups *(bachat gats)* along with small-scale income generating ventures. Soon after, initial three (bachat gats) obtained aid to reclaim local wastelands for planting silk trees. In almost three years the initiative got immense success with blooming silk trees on a productive land. The successive group actions motivated women other than the (bachat gats) to take similar actions. Within eight years (1988) the rate of replication had been increased from three to 12 (bachat gats) with massive involvement of more than 1,500 women in this initiative. The group strength worked well, nearly 100 hectors of previous rural waste-land cultivated and regenerated. Soil erosion was minimised and ground water also revitalised. Eventually, apart from silk production the self-help groups expanded

Table 1. Initiatives of grass roots women's organisations (GWO's) in RNRM

Name of the initiative	Place	Thrust areas
Chipko Andolan	*Dhasholi* village of Garhwal district, Himachal Pradesh	Right of access to rural common grass land, forest, the resources, non commercial use of rural natural resources.
From Wastelands to Silk Farms	North west Rural region of Bankura District of West Bengal	Land reclamation, renewing fallow land, providing livelihood and earnings for rural woman, and constructing woman's managerial and leadership abilities.
Nagewadi Roof top water Harvesting Project(RTWHP)	Village Nagewadi, District Sangli, Maharashtra	Rural Water Conservation and management. Initiated total (RTWHP) in all households in a drought affected village.
Vasantha Sena (Green women brigade)	Thekkady rural region, Kerala	Forest-rural bio-diversity conservation. Willingly with no remuneration conducts jungle patrolling each day since 11 am to 5 pm with six individuals limited batch on alternation.

Source: Based on respondents qualitative insights and Murali (2006).

their economic actions with the help of local raw materials like paper shits, table-ware and rope making.

Salient features:

1. This case shows that similar to ecological incentive few others like economic incentive at group level also creates necessary conditions for collective actions for RNRM. For instance substantial amount of credit for (bachat gats) turned into SC and eventually for land reclamation together with sustaining their rural livelihoods.

2. The women worked initially with locally available resources, skills and knowledge they already had and this demonstrates the vitality of traditional knowledge and skills of these grassroots women that provides internal confidence for RNRM initiative.

3. They were greatly helped by the CWDS, which organised workshops and training sessions, arranged consultants to provide technical assistance, and intermediated with government officials and agencies.

4. These GWO's have few inherent culturally dominant features of group work and affinity. This contributing factor includes the practice of collective act amongst the Santhal women that facilitated these women to organise and act collectively.

5. In a traditional Indian society access to and control over land makes women more independent and socially recognisable. In case of Bankura the assurance of right to and control over land which enabled them to generate employment for themselves played a great role.

6. Linkages amongst preservation and enhancement of rural natural resources considered as central feature of the successful reclaim of local wastelands by local women. The project linked with survival issues of local populations mainly women who were extremely encouraged to commence such difficult initiative was a crucial factor.

Nagewadi Roof Top Water Harvesting Project (RTWHP)

Water a scare resource, the very basic need and right of life, is the most threatened natural resource today. Particularly, in an agrarian county like India where world's two third people survive issues of water crises have become severe. Villages under the drought prone rain-fed areas face a great challenge of water conservation. Women are the real victims of these shocks. Mrs. Nanda Pawar, President of Pragati women self-help group expressed the off stage narrative of Nagewadi Roof top water harvesting project (RTWHP) 'Nagewadi' at Sangli district of Maharashtra State, was a drought affected village. In an inadequate monsoon and huge pumping of ground water for cash crops water level depleted severely. The water supplied by Zilla Parishad

through water tanker was even not adequate to fulfil our daily basic needs moreover, conflicts occur frequently during collecting water at community level. To meet daily water requirement they had to travel at least 8-10 km daily. To overcome with this drudgery we 105 women members of eight SHG's in Nagewadi village took lead to implement (RTWHP) in our village. The technology is low cost, highly decentralised empowering individuals and communities to manage their water at local level. In case of Nagewadi the positive energy of microfinance programs has been encouraged the perceived positive role of women's group which resulted not only in economic terms but also created an ideal condition for emergence of SC.

This process has wider social benefits in which they live that has resulted to reduce community vulnerabilities like water scarcity through implementing rain water harvesting system successfully at all the households in a tiny village (Nagewadi) of southern Maharashtra during 2006-2010 and still maintained. Findings suggest that near about 16 liter per person per day water can be made available through this project throughout the year and about 31 liters per person per day water available in dry days against 40 liters requirement (Patil 2014).

Salient features:

1. The RTWHP at village Nagewadi is one of the outstanding examples of the intervention of SHG's in RNRM. The SC through working together brought strength which helped in bringing out the grassroots rural women out of isolation, provided community identity and moral power for collective action for initiative like RTWHP.

2. This case illustrate that once organised, the poor and marginalised women have been able to make collective actions to overcome with local problems they face.

3. To implement RTWHP the members of eight SHG's have visited a model village for water sufficiency '*Ralegansiddhi*' in Maharashtra developed by Anna Hazare. Such field visits are becoming an increasingly important feature of SHG. It supports sharing of experiences not only as learning tool but also stimulates self-esteem and social cohesion among the grassroots women involved.

4. SHG's have created sufficient and necessary conditions for implementing RTWHP at village level such as awareness meetings with villagers and Gram Panchyat members, common agreement on this project by the villagers and community consciences for 10 per cent capital investment for RTWHP.

5. The emergence of such federated groups created positive conditions for government agencies at micro-

macro level to develop direct link in community managed resource initiatives like RTWHP at Nagewadi by providing partial financial assistance.

6. Peer learning exchanges, local to local dialogs among the SHG members of Nagewadi gave space and encouragement for affirming, refining, and sharing knowledge-base to tackle local problems like water scarcity.

7. The moral upliftment of the village has helped towards developing self-status of SHG members at society and home, which involves changing attitudes of men towards women. This advanced status may works like a catalyst for GWO's to involve in reducing community vulnerability like RTWHP at Nagewadi.

Vasantha Sena (Green women brigade)

This is the real story that raises a question: How an unarmed Vasantha Sena (Green brigade) of women has protected a tiger reserve for years? For the last 15 years, the lobbying of women have banded together to form a community group called Vasantha Sena, to protect rural forests of Idukki district, Kerala and have refused to take any remuneration for this work. In 2002, a group of women from villages on the edges of Periyar Tiger Reserve approached forest department and offered to carry out day-time patrolling. The forest department readily agreed and roped 101 women as the Vasantha Sena (Green brigade) under the World Bank's India Eco Development Project (EDP's), which had begun in 1996. Highly spirited 101 women from eight EDP's, willingly manages jungle patrolling each day between 11 am to 5 pm in limited groups of six members. Such exceptionally courageous actions contributed a lot for conservation and management of bio-ecological resources such as: sensitisation and control on plastics and firewood use, livestock grazing, unlawful entrance and wildlife's shooting. Mostly daily wage workers, despite losing two work days a month to patrol. Consequently, they achieved the eminence of woodland managers, and further turned in-to symbol of transformation and motivated people from cross-section (John 2015).

Salient features

1. This case is altogether different from earlier cases where rural women formed groups to protect their surrounding forests without any incentive. The ethos of eco-voluntarism has deeply involved among these women folk which may be an outcome of historical cultural characteristics'. And, it could also be due to the process of healthy eco-socialisation.

2. This is a unique case which shows common people particularly grassroots women's accountability towards nature. Another equally significant factor is the freedom that they got at every stage of decisions and executions in this initiative.

3. The formation of grassroots women's volunteer groups helped in the construction of SC and functioning as community screen towards maintenance of rural ecological capital.

4. The local people were not facing any severe problem both at community and personal level like water scarcity, livelihood security and firewood-fodder for household chores.

5. This is an important case of self-motivated group of women volunteers dedicated to ecological conservation.

6. The involvement of even most poorest of the poor section women in this Vasantha Sena once again proved that they are the people who historically established primary relationships with the nature and have long been known as managers of common resources effectively without external help and incentive.

Structural determinants collective actions and group formation: The four cases explored above represent a range of natural resource management initiatives. Although SC and GWO's have become fundamental for these successful initiatives however, the paradigms and determinants for motivation differ significantly. Based on these varied taxonomy the above cases have been divided into three broad categories viz: Group (a) Groups motivated by internal factors (GMIF); Group (b) Groups motivated by external factors (GMEF) and Group (c) Groups motivated by combined (Internal & External) factors (GMCF) (Table 2). Similarly, a careful exercise has also been done to explore the structural determinants for collective actions to form groups for (RNRM). The study applies six essential criteria's which helps to diagnose fundamental taxonomy of these groups and may help in designing and replicating such models in similar environments (Table 3).

Structural factors hindering participation: Although, grassroots rural women have distinctive knowledge and role in RNRM they face severe barriers to their inclusion in governance systems, decision making and benefit sharing

Table 2. Categorisation of Group's of GWO's towards RNRM

Name of the GWO's initiative	Categorisation of group's	
	Type	Group motivation
Chipko Andolan	A	Internal factors (GMIF)
From wastelands to Silk Farms	C	Internal and External combined factors (GMCF)
Nagewadi Roof top water Harvesting Project (RTWHP)	B	External factors (GMEF)
Vasantha Sena (Green women brigade)	A	Internal factors (GMIF)

Source: Authors conceptualisation based on respondents qualitative insights

related to RNRM which marginalises their roles, contributions and rights. Based on the qualitative data few important socio-structurals constrains which hinder GWO's to fully participate in RNRM are discussed below.

Exclusion from land-based rights: The central aspect which challenges rural woman's economic viability and capability to make use and manage of natural recourses relied on denial of right to use and management of land-based rights. Historically they were excluded from this right which also deprive them socially and technically to participate in RNRM.

Lack of access to extension education and support: There are very few female extension workers employed by department of forest and environment, agriculture and rural development. They also lack adequate training in terms of roles and liability, within natural resource management and community economics and gender friendly technology. This obstructs sternly to involve women fully in RNRM (Rivera and

Table 3. Taxonomy of GWO's in RNRM: fundamental determinants and features

Criteria	Fundamental determinants and features	Type	Name of the GWO's Initiative
I	Criteria: Group objectives		
	To preserve or-else reinstate ecological assets to an earlier position (to renovate the past for the futures sustainability is the aim of this group).	A (GMIF)	Chipko Andolan and *Vasantha Sena*
	To acclimatise towards changes in an ecological assets (to alter towards the newer-realities).	C (GMCF)	From Wastelands to Silk Farms
	To construct new-fangled visions towards management of ecological assets (aim of such groups mainly to initiate somewhat entirely new-fangled initiative).	B (GMEF)	Nagewadi Roof top water Harvesting Project(RTWHP)
II	Criteria: Group formation		
	Since any exterior organisation posed to form a group.	B (GMEF)	Nagewadi Roof top water Harvesting Project(RTWHP
	Initiated by any single or few associates of the group with an exterior assistance for group formation.	C (GMCF)	From Wastelands to Silk Farms
	Since group members themselves took the initiative with space provided by internal agency for forming group with no exterior assistance. Reflects high eco-sensitivity (HES).	A (GMIF)	Chipko Andolan and *Vasantha Sena*
III	Criteria: Group perspective's		
	Such groups are anxious towards changes, reflects defensiveness.	C (GMCF)	From Wastelands to Silk Farms
	Such groups are altering towards changes, reflects reactiveness.	B (GMEF)	Nagewadi Roof top water Harvesting Project(RTWHP)
	Such groups are making new-fangled openings, reflects proactiveness.	A (GMIF)	Chipko Andolan and *Vasantha Sena*
IV	Criteria: Group- evaluation		
	The groups often measure their development to fulfil self-set goals for RNRM through (SHG's, NGO's and VO's).	B (GMEF)	Nagewadi Roof top water Harvesting Project(RTWHP)
	The group has self-evaluative communitarian practice for meeting its objectives for RNRM	A (GMIF)	Chipko Andolan and *Vasantha Sena*
	The group evaluates its progress jointly with internal and external agencies for RNRM	C (GMCF)	From Wastelands to Silk Farms
V	Criteria: Group problem solving		
	Initially assisted by externals for solving problems later adopts internal group problem solving methods.	B (GMEF)	Nagewadi Roof top water Harvesting Project(RTWHP)
	Initially attempts to solve problems themselves prior to take external assistance.	C (GMCF)	From Wastelands to Silk Farms
	Groups not necessarily require external help for solving their struggles towards RNRM.	A (GMIF)	Chipko Andolan and *Vasantha Sena*
VI	Criteria: Group planning and action		
	Planning and action both in coordination with external and internal agency	C (GMCF)	From Wastelands to Silk Farms
	Believes in group planning and group action	A (GMIF)	Chipko Andolan and *Vasantha Sena*
	Planning in coordination with external agency and thereby action specifically at group level without outside help	B (GMEF)	Nagewadi Roof top water Harvesting Project(RTWHP)

Source: Authors conceptualisation based on respondents qualitative insights

Coming 1990, Beevi et al 2018).

Access to right to credit-system: The lack of women's institutional credit creates chronic poverty and ultimately sometimes results in resource depletion and degradation. Many times, rural projects do not relate their economical requirements with management, may results further unlikely diversions. However, due to '*jandhan yojana'* hopes are emerging.

Lack of social space and access to organisational membership: Active representation of women in local public bodies such as Gram Panchyat, Zilla Parishad and committees related to natural resources (land management, watershed, afforestation and joint forest management etc) is necessary where positions are reserved for women exclusively. Expect few elite sections of women, the women's groups mainly rural marginalised repeatedly not capable to take part. However, studies (Seeley et al 2002) also observe women's aloofness clearly in such bodies commonly, along with Panchyat. They remained limited to fill the quota. Women received institutional space but not social space which makes key hurdle to contribute in RNRM effectively. Therefore, such requirements may kindly be seen from demand side not merely supply side.

Policy and program constrains: Women have frequently less recognised in planning-programs relating for the protection as well as management of RNR. Naturally, women have unique skills and experience towards RNRM but systematically repeatedly ignored at structural designing and execution of such plans and programs based on discriminatory gender principals (Stevens 2010).

Policy options: Replication of such initiative is an essential and crucial matter for future policy implications. Results from this exercise suggest, following four point strategy provides crucial policy options for integrating women into RNRM programs i) Creation of economic and ecological equilibrium in RNRM programs ii) Federating and intersecting GWO's at local to national forums iii) Concurrent efforts to keep alive the connectedness of SC among the GWO's and iv) Develop locally relevant strategies for ecological incentives for RNRM.

CONCLUSION

Thus, the cases analysed above found that few dominant factors played crucial role for the emergence of SC among the GWO's such as: microfinance activities, social space, horizontally organised networks, eco-incentives,

external support, nature- defensible actions and strong group accountability towards resource stewardship facilitated in conservation of RNRM. The key contribution that emerges from the present analysis is these initiatives have given agency and self-esteem to the grassroots women. Finally, to make GWO's more active and sustainable towards RNRM proper contextual and locally relevant norms and incentives can be designed for the desired future outcomes in the light of policy options.

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Assessing Fluoride Intensity of Ground Water in Dindigul District, Tamil Nadu

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Abstract: This study is purely based on the secondary data. The study area is Dindigul district of Tamil Nadu. Due to anthropogenic activities, groundwater in the district has getting contaminated. Considering the importance of fluoride in human health, a temporal study has been made on groundwater for pre and post monsoon season. The results indicate that all the 30 samples in pre monsoon season are under permissible limit during both the years. But in post monsoon season, except one sample all other samples are under permissible. Compared to post monsoon, high fluoride level is found in pre monsoon season, this may be due to monsoonal rainfall gets evaporated leads to precipitation of fluoride salts on the soil reached groundwater through percolation. The study on fluoride leads to assess the hazard index based on fluoride exposure dose and displayed as a map using GIS software.

Keywords: BIS, Seasons, Fluoride, GIS, Temporal study

Water is most vital for all living and non-living beings for their survival and surface water is very limited in most part of the areas, where groundwater play's a major role. This resource cannot be used effectively if the quality of the water is not good. This precious resource is getting depleted both by human and anthropogenic activities. There are number of trace elements presented in the water among them fluoride ion is one. This is one of the most important chemical parameter present in the water and also it is the 13th most abundant element in the earth (Jothimani et al 2017). Any mode of water containing dissolved ions beyond the permissible is harmful to domestic and irrigation use. Fluoride is considered as one of the top ten chemicals concern for human health (Rango et al 2017). The pollution in drinking water with fluoride is caused both naturally and human action (Roy et al 2017). Water scarcity in many parts of the world has increased over the years. This provoked water pollution or contamination problem for both surface and subsurface water. Almost 200 million people around the globe consuming drinking water with fluoride concentration are higher than the permissible value (Ayoob and Gupta 2006, WHO, 2008). In India it is about 70 million people (Edmunds and Smedledy 2005). Due to improper water resources management and environmental degradation leads to freshwater crisis in India. High fluoride content is reported in 13 states of India (Hema and Subramani 2017). Fluoride is one of the undesirable element found in many areas while extracting for drinking purposes in India (Tirumalesh 2007, Brindha and Elango 2011). The major source of fluoride intake naturally is drinking water and its concentration is typically ranges between 0.1

and 10 mg l^{-1} in the groundwater (WHO 2008). In groundwater the maximum permissible limit of fluoride is 1.5 mg l^{-1} (BIS, 2012). Due to the importance of fluoride in water an attempt has been made to identify the fluoride content in the Dindigul district. It helps to understand the risk assessment for health based on hazard index (HI).

MATERIAL AND METHODS

Study area: Dindigul district lies in between Tiruchirappalli and Madurai districts between 10°05' and 10° 09' north latitude and 77° 30' to 78°20' east longitude (Fig.1). The total geographical area of the district is 6036.11sq.km. Dindigul district is divided into 8 taluks namely, Palani, Natham, Oddanchatram, Vedasandur, Dindigul, Kodaikanal Nilakkottai and Attur. Administratively, it has 14 Community Development Blocks and 306 village panchayats in the district.

Based on the secondary data from state ground and surface water resources data centre, Tharamani, Chennai for the temporal year's (2006 and 2016) were used. The base boundary of the study area has been prepared by using Survey of India Toposheet (SOI) in the scale of 1: 50,000.

Exposure dose determination: The fluoride exposure dose is measured in terms of the Estimated Daily Intake (EDI). The EDI values are derived from United States Environmental Protection Agency (US EPA, 1992). The equation is,

$$EDI = \frac{C \times IR \times EF \times ED}{BW \times AT} \qquad \text{equation 1}$$

where:
EDI = estimated daily intake of fluoride from groundwater

C = mean fluoride (F) concentration in ground water sources (mg/L) – Based on Table 1

IR = daily water intake rate (L/day) - 1 for children, 2 for adults

EF = exposure frequency (days/yr) - 365

ED = exposure duration (yr) - 6 for children, 30 for adults

BW = average body weight (kg) - 16.2 for children, 61.8 for adults

AT = averaging time for fluorosis - ED×365 for children, Lt×365 for adults. Where LT (yr) indicates life time (65yrs)

The values of the different variables used for the estimation of the fluoride (F) exposure dose in mg/kg body weight/day based on (US EPA 1992; US EPA 2011 and US DOE 2011).

Hazard Index: Fluoride exposure dose values were used for risk assessment for children and adults based on Brahman et al. (2014) with slight modification. EDI values were compared with the fluoride Reference Dose (RfD) as like equation 2 to identify the hazard index in the study area, which in the ratio of EDI to the RfD.

$$\text{Where,} \quad HI = \frac{EDI_{Water}}{RfD} \quad \quad \text{equation 2}$$

HI = Hazard index, EDI_{water} = estimated daily intake of fluoride from groundwater

RfD= Reference dose for fluoride (oral toxicity reference) with the value of 0.06mg/ kgbw/ day.

The spatial analysis tool in GIS has been used extensively mainly the interpolation technique. In this present study one of the interpolation techniques such as the Inverse Distance Weight (IDW) method is used for to generating the surfaces.

Analysis of fluoride content: In pre monsoon season the fluoride is ranging from 0.10 (Perumalai and Kodaikanal village of Kodaikanal block) to 1.30 mg l^{-1} (Usilampatti village of Vedasandur block) in 2007 and between 0.05 (Kodaikanal, Pappampatti village) to 1.43 mg l^{-1} (R. Kombai of Gujiliamparai block) in 2016. Among the 30 samples studied, 10 samples in 2007 and 9 samples in 2016 are below 0.50 mg l^{-1} during the study period. All the samples in pre monsoon for both time periods are under permissible. In the post monsoon season the fluoride levels varied from 0.62 to 1.50 mg l^{-1} in 2007. The minimum was in Vedasandur village of Vedasandur block and the maximum in Thumbalapatti village of Thoppampatti block. Only 2 samples in post monsoon season are range between 0.50 to 1.50 mg l^{-1} and all other samples during this season were below 0.50 mg l^{-1}. All the samples in the groundwater are under permissible in 2007. In 30 samples, 12 samples contain <0.50 mg l^{-1} and 17 samples are > 0.50 to 1.50 mg l^{-1} during post monsoon season of 2016 are under permissible (Table 2). One sample (Usilampatti village of Vedasandur block) is above permissible limit due to over usage of inorganic fertilizers.

Spatial distribution of fluoride map indicates that in 2007 pre monsoon season, <0.5 mg l^{-1} level of fluoride was observed as patches in the blocks of Oddanchatram, Nattam, Dindigul, Attur and Palani. The remaining blocks of the district was >0.5 mg l^{-1}.

In 2016, blocks such as Oddanchatram, Palani, Dindigul, Attur, Nattam and Vathalagundu were below 0.5 mg l^{-1} as a patch and remaining blocks are above 0.5 mg l^{-1}. During 2007, post monsoon season except Oddanchatram block all other blocks were below 0.5 mg l^{-1} but in 2016 post
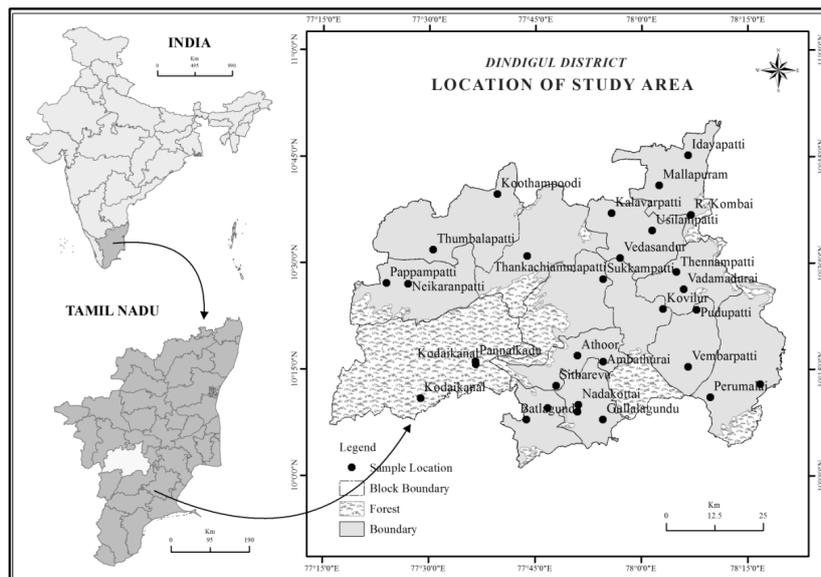

Fig. 1. Location and sampling point map of the study area

monsoon season the concentration of fluoride level is varied in nature (Fig. 2). The western and southern blocks such as Thoppampatti, Oddanchatram, Dindigul, Attur and Natham were below 0.5 mg l^{-1}. The remaining blocks of the district has the fluoride content of 0.5 to 1.5 mg l^{-1}. A small patch at Vedasandur has recorded > 1.5 mg L^{-1} during this study period over the Dindigul district.

Hazard index: The estimated daily intake of fluoride clearly portrays that from 2007 to 2016 in all the groundwater samples has increase in nature for both children and adult (Table 3 & Fig.3). The EDI (Estimated Daily Intake) value for this study has calculated to find out the Hazard Index (HI). A HI value of above 1 indicates a high risk of health effects and

Table 2. Concentration of fluoride levels and number of samples during post and pre monsoon season- Dindigul district (2007 and 2016)

Fluoride levels	BIS standards	Pre monsoon season		Post monsoon	
		2007	2016	2007	2016
<0.5 mg l^{-1}	Permissible	10	9	28	12
0.5 to 1.5 mg l^{-1}		20	21	2	17
>1.5 mg l^{-1}	Above permissible	0	0	0	1

less than 1 indicate symptoms of fluorosis may not develop. In the current study, hazard index on adults have significant increase from 2007 to 2016 but, it was under control (Fig. 4). In the case of children, it exceeds the normal level (<1) in few

Table 1. Pre and Post monsoon sample location and EDI, HI values for adult and children (2007 and 2016)

| Village	Latitude	Longitude	Pre Monsoon (mg L^{-1})		Post Monsoon (mg L^{-1})	
			2007	2016	2007	2016
Kovilur	10°37'00"	78°05'00"	0.72	0.91	0.30	0.67
Pappampatti	10°27'09"	77°24'20"	0.42	0.05	0.30	0.48
Sukkampatti	10°28'48"	77°55'23"	1.00	0.68	1.50	1.32
Neikaranpatti	10°27'00"	77°27'45"	0.61	1.02	0.41	0.62
Thankachiammapati	10°31'25"	77°44'40"	0.25	0.40	0.11	0.30
Usilampatti	10°34'20"	78°15'50"	1.30	0.88	0.40	1.78
Kalavarpatti	10°37'27"	77°56'30"	0.67	0.96	0.18	0.23
Perumalai	10°51'48"	77°32'53"	0.10	0.06	0.09	0.09
Ambathurai	10°16'30"	77°54'50"	0.26	0.09	0.08	0.17
Athoor	10°17'10"	77°51'02"	0.45	0.39	0.14	0.41
Thennampatti	10°31'45"	78°03'28"	1.00	0.92	0.24	0.92
Vembarpatti	10°15'25"	78°07'19"	1.00	0.64	0.29	1.16
Sitharevu	10°13'36"	77°48'30"	0.96	0.84	0.18	0.56
Vadamadurai	10°26'30"	78°06'08"	1.00	0.80	0.10	0.49
Pudupatti	10°18'35"	78°08'31"	0.58	0.52	0.17	0.40
Thumbalapatti	10°32'02"	77°31'35"	0.68	0.95	0.09	0.15
Batlagundu	10°08'58"	77°44'34"	1.20	0.33	0.11	1.00
Nadakottai	10°05'20"	77°49'50"	0.74	0.65	0.24	0.68
Sithargalnatham	10°06'18"	77°51'15"	0.43	0.98	0.17	0.61
Samutrapatti	10°12'55"	78°17'24"	0.36	0.99	0.23	1.26
R. Kombai	10°34'22"	78°05'26"	0.99	1.43	0.19	1.43
Mallapuram	10°40'55"	78°00'45"	0.59	0.73	0.09	0.91
Vedasandur	10°31'36"	77°57'18"	0.93	0.82	0.18	0.62
Koothampoodi	10°40'54"	77°40'50"	0.68	0.62	0.05	1.06
Kodaikanal	10°11'43"	77°29'42"	0.10	0.05	0.05	0.17
Kodaikanal	10°16'50"	77°37'50"	0.16	0.26	0.05	0.41
Gullalagundu	10°08'56"	77°54'46"	1.10	1.02	0.21	0.94
Keelakovilpatti	10°09'34"	77°47'01"	0.82	0.74	0.62	1.04
Idayapatti	10°45'12"	78°01'42"	1.10	0.70	0.33	1.35
Pannaikadu	10°16'30"	77°37'33"	0.19	0.10	0.07	0.09
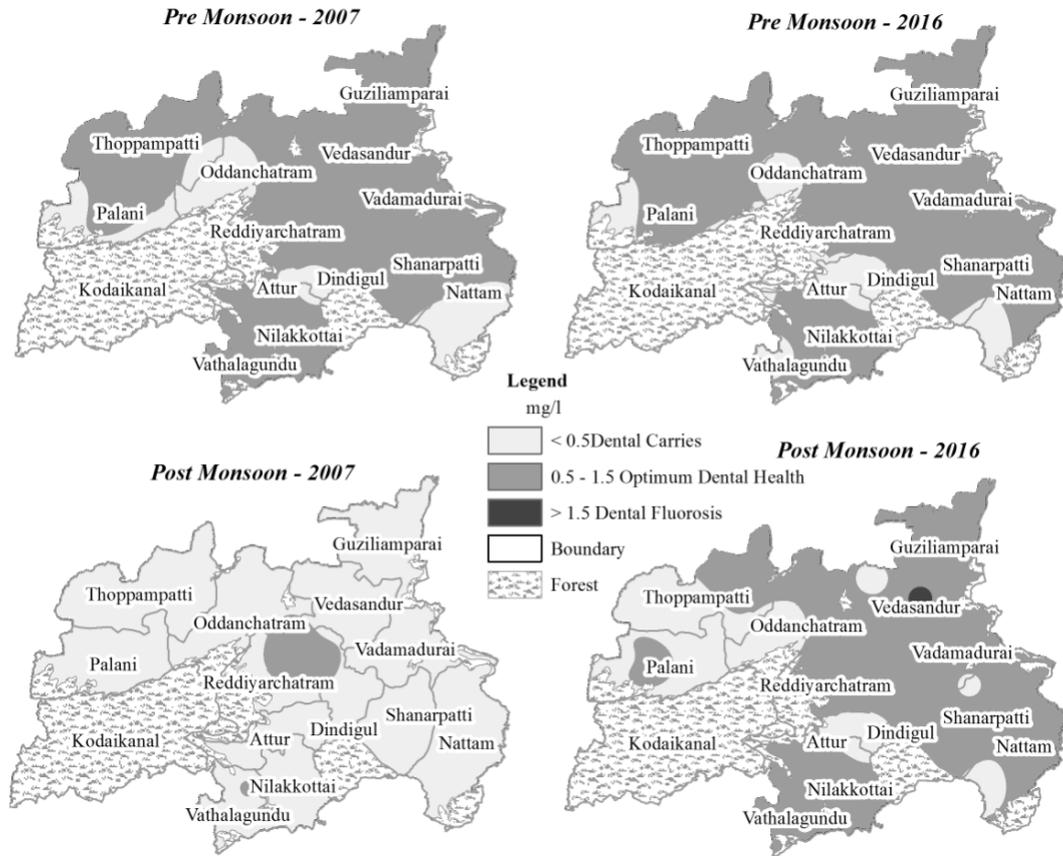
Fig. 2. Spatio-temporal variation of fluoride content in groundwater over Dindigul district
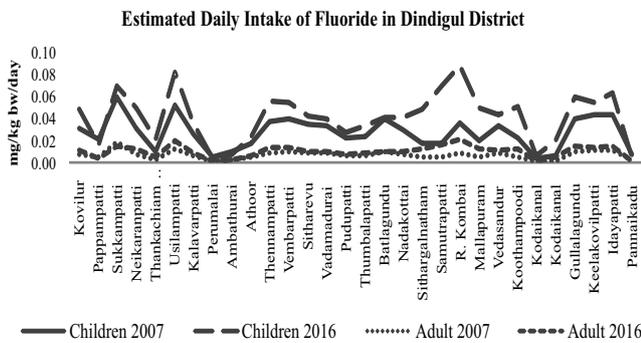

Fig. 3. Estimated daily intake of fluoride in Dindigul district
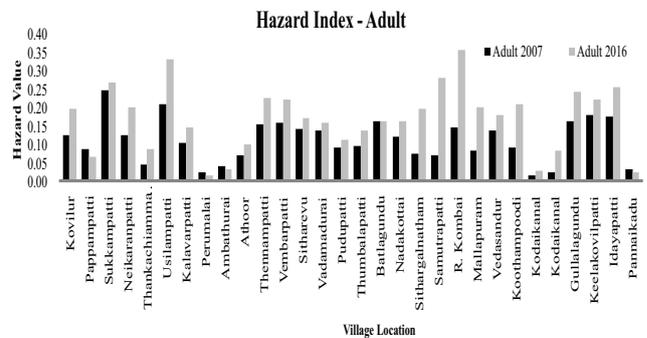

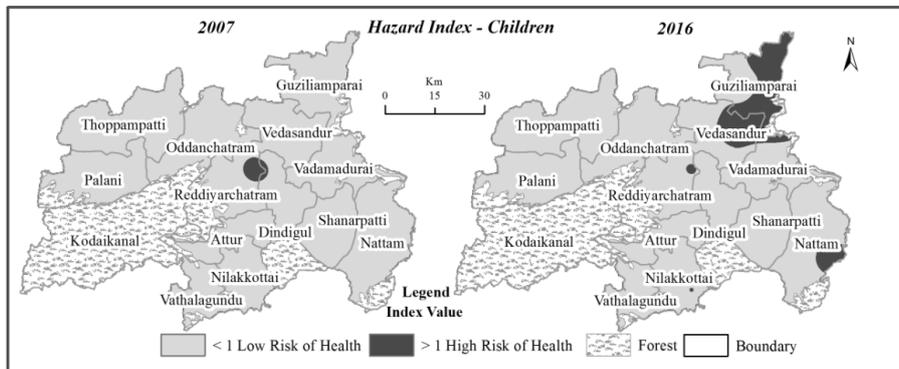**Fig. 4.** Estimated Hazard Index Value for adult – Dindigul district

Fig. 5. Hazard index - children

Table 3. Temporal variation of EDI and HI values for children and adult in Dindigul district

Village name	2007				2016			
	Children		Adult		Children		Adult	
	EDI	HI	EDI	HI	EDI	HI	EDI	HI
Kovilur	0.03	0.52	0.01	0.13	0.05	0.81	0.01	0.20
Pappampatti	0.02	0.27	0.01	0.09	0.02	0.31	0.00	0.07
Sukkampatti	0.08	1.29	0.02	0.25	0.06	1.03	0.01	0.27
Neikaranpatti	0.03	0.52	0.01	0.13	0.05	0.84	0.01	0.20
Thankachiammapati	0.01	0.19	0.00	0.04	0.02	0.36	0.01	0.09
Usilampatti	0.05	0.87	0.01	0.21	0.08	1.37	0.02	0.33
Kalavarpatti	0.03	0.44	0.01	0.11	0.04	0.61	0.01	0.15
Perumalai	0.01	0.08	0.00	0.02	0.00	0.10	0.00	0.02
Ambathurai	0.01	0.13	0.00	0.04	0.01	0.17	0.00	0.03
Athoor	0.02	0.30	0.00	0.07	0.02	0.41	0.01	0.10
Thennampatti	0.04	0.64	0.01	0.15	0.06	0.95	0.01	0.23
Vembarpatti	0.04	0.66	0.01	0.16	0.06	0.93	0.01	0.22
Sitharevu	0.04	0.59	0.01	0.14	0.04	0.72	0.01	0.17
Vadamadurai	0.03	0.57	0.01	0.14	0.04	0.66	0.01	0.16
Pudupatti	0.02	0.39	0.01	0.09	0.03	0.47	0.01	0.11
Thumbalapatti	0.02	0.40	0.01	0.10	0.03	0.57	0.01	0.14
Batlagundu	0.04	0.67	0.01	0.16	0.04	0.68	0.01	0.17
Nadakottai	0.03	0.50	0.01	0.12	0.04	0.68	0.01	0.17
Sithargalnatham	0.02	0.31	0.00	0.07	0.05	0.82	0.01	0.20
Samutrapatti	0.02	0.30	0.00	0.07	0.07	1.16	0.02	0.28
R. Kombai	0.04	0.61	0.01	0.15	0.09	1.47	0.02	0.36
Mallapuram	0.02	0.35	0.01	0.08	0.05	0.84	0.01	0.20
Vedasandur	0.03	0.57	0.01	0.14	0.04	0.74	0.01	0.18
Koothampoodi	0.02	0.38	0.01	0.09	0.05	0.86	0.01	0.21
Kodaikanal	0.00	0.08	0.00	0.02	0.01	0.11	0.00	0.03
Kodaikanal	0.01	0.11	0.00	0.03	0.02	0.34	0.01	0.08
Gullalagundu	0.04	0.67	0.01	0.16	0.06	1.01	0.01	0.24
Keelakovilpatti	0.04	0.74	0.01	0.18	0.05	0.92	0.01	0.22
Idayapatti	0.04	0.74	0.01	0.18	0.06	1.05	0.02	0.26
Pannaikadu	0.01	0.10	0.00	0.03	0.01	0.13	0.00	0.02

* EDI unit is (mg/kg bw/day). HI is Index Vale

groundwater samples (Table 3). During the year 2007, HI value of above 1 is noticed only in Sukkampatti village (1.29) of Dindigul block (Fig. 5).

But in 2016, Sukkampatti (1.03) village of Dindigul block, Usilampatti (1.37) village of Vedasandur block, Samutrapatti (1.16) village of Natham block, R. Kombai (1.47) village of Gujiliamparai block, Gullalagundu (1.01) village of Nilakkottai block and Idayapatti (1.05) village of Gujiliamparai block have high risk of health effect (>1). The groundwater samples in all the location have increase in HI value compared to 2007 and 2016. The increase of HI in the study area is due to leachates from stone quarries, cement factories, spinning

mill and over usage of inorganic fertilizers.

CONCLUSION

The fluoride content in the district is varied in characteristic from one year to another. This may be due to physical nature of the area, such as geology or rainfall. Generally, the fluoride content in most of the samples during pre monsoon season of both temporal years and post monsoon season of 2016 has the fluoride level of 0.5 to 1.5 mg L^{-1}, results in optimum dental health among the local residents. Except one sample in post monsoon (2016) all other 29 samples are under permissible limit during temporal

years. Hazard index clearly portrays that even though fluoride level in most of the groundwater samples are under permissible, the risk of health is increased from year to year particularly for children may due to lack of immunity power but under control for adult. The study area has distinct behavior in fluoride concentration in pre and post monsoon season, so *in-situ* and *ex-situ* treatment method, are needed to ensure the safe drinking water to the people. The result will be helpful for the policy makers, planners and other government officials to establish de-fluoridation plant in the area where ever it is necessary.

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Impact of Gaseous Pollution in Surgical Theatres and Its Management

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Abstract: In the present work surgical theatre chemical gaseous pollution and its effect on health care workers is examined. A small cohort population consisting of doctors, nurses and theatre assistants are subjected for methaemoglobin screening from their blood samples. There is an increase of 1.219% methaemoglobin among doctors than the counterpart control subjects (r= -0.027) while nurses have higher methaemoglobin (r= -0.247) than doctors and theatre assistants (r= -0.377). This would suggest that the nurses are spending longer duration and standing in surgical theatre polluted with nitrogen based anesthetic gases. The nurses may have the risk of occupationally acquired methaemoglobinemia. The best air scavenging system should be installed in surgical theatres to prevent methaemoglobinemia among health care workers.

Pollution of chemicals at working environment often poses health threat among workers. A unique environmental pollution is prevailing in surgical theatres in corporate hospitals where frequent operations are taking place. In order to achieve an anesthetic condition before performing surgical curative measures often nitrogen derived gases are used for sedation. These gases are having significantly higher molecular weight and float on the floor of surgical theatres. Even persist in the air for longer duration, if theatres do not have effective ventilation. The inhalation of contaminated air in closed surgical theatres may pose ill effect among health care workers occupational hazard. It has also been argued that the management of medical waste poses a very high risk to the health of medical practioners. This includes poor handling, collection, sorting, segregation and disposal of medical waste such as sharps, medical devices, and blood and body tissues. Unsafe disposal of medical wastes is a major environmental challenge. It contributes largely to occupational injuries and infections. Moreover it has been explained that the increase in occupational health hazards in health workers are largely not practicing universal safety precautions such as hand washing, wearing of gloves and the usage of protective personal equipment (Kaur and Bains 2016). This unsafe working environment exists in surgical theatres and among workers deputed in surgical theatres (Arasi et al2015). Younger nurse are more at risk of experiencing high burnout than their older counterparts. Additionally, nurses working in the surgical department tend to be more exposed to occupational hazard as compared to their peers in other departments as they are more likely to stand for longer hours during work in theatres. Burnout during work among nurses has also been observed as a cause for physical fatigue, emotional exhaustion, depersonalization and psychosomatic problems which increased feelings of failure. The above negative effects of work-related stress prevent health care workers from achieving effective work performance (Rawlance et al 2015). Apart from the above situations, inhalation of escaped anaesthetic gases from the apparatus has also contributing significant occupational hazard and pollution in operating theatres. The gaseous anesthetic agents such as nitrous oxide, halothane, enflurane, isoflurane, desflurane and servoflurane are having direct adverse effect. Various ill effects such as malignancy, neuropathy, bone marrow toxicity, abortion and infertility in operation theatre personnel are documented. Number of studies have reported that there is high prevalence of these gases are in theatre floor where poor gas scavenging system in theatres (Spagnolo et al 2013).

Methemoglobinemia is a blood disorder in which too little oxygen is delivered to cells. Oxygen is carried through bloodstream by hemoglobin, a protein that's attached to rred blood cells. Normally, hemoglobin releases that oxygen to cells throughout our body. However, there's a specific type of hemoglobin known as methemoglobin that carries oxygen through blood but doesn't release it to the cells known as carboxyhaemoglobin. If body produces too much methemoglobin, and the accumulation of more than 20% of methemoglobin out of total Hb is explained as methemoglobinemia. This can lead to a situation that enough

oxygen is not supplied to cells. The acquired methemoglobinemia is due to continuous exposure of certain gaseous substances which are mostly of nitrate derivatives (Jayaprakash 2003). Since anaesthetic gases are mostly nitrogen based formulation, it may also be speculated that theatre health care workers are subject to develop an occupationally acquired methemoglobinemia (Agarwal et al 2009). Therefore in this present study an attempt is made to screen doctors, nurses and theatre workers to known their status of methemoglobin.

MATERIAL AND METHODS

The blood samples of healthy individuals (200 numbers) working in different executive professions were served as controls. An equal number of surgical theater workers including doctors, nurses and assistants were considered as experimental batch. Much care was taken for the comparison of other anthropological parameters such as age, weight, lifestyle etc., between controls and experimental. The estimation of methaemoglobin pigment was done by the method proposed by Cruz-Landeira et al (2002). A double beam UV spectroscope (Shimadzu, Japan) was used. Methaemoglobin can be identified spectroscopic ally by its absorption band in the red part of spectrum at 645 nm. This band disappears on addition of yellow ammonium sulphide. The cyanomethaemoglobin formed on adding cyanide does not absorb at 630 nm. So the difference in reading is proportional to the amount of methaemoglobin present in the blood specimen.

Preparation of standards: Oxyhemoglobin (OxyHb), deoxyhemoglobin (DeoxyHb), carboxyhemoglobin (COHb), and methemoglobin (MetHb) standards were prepared from a stock standard containing 13 g% of hemoglobin. Following dilution to 1% (v/v) in distilled water, a 100% saturated solution of oxyhemoglobin was obtained by bubbling oxygen for 10 min, excess O_2 being removed by bubbling N_2 for 5 rain. The resulting solution was used to make the following four aliquots: aliquot A, which consisted of oxyhemoglobin; aliquot B (deoxyhemoglobin), which was obtained by adding sodium nitrite; aliquot C (carboxyhemoglobin), which was prepared by bubbling CO for 5 rain, followed by N_2 to remove excess gas from the solution; and aliquot D (methemoglobin), which was obtained by oversaturation with potassium ferricyanide. Recording of spectra absorbance and derivative spectra (D1, D2, and D3) for the pure standards were recorded in order to determine the best spectrophotometric conditions for the determination of metHb.

Procedures : Following dilution of the 13 g% hemoglobin (Hb) standard to 1% in distilled water and 100% saturation with oxygen, the two working standards were prepared: standard A, which contained 1.3 mg/mL MetHb (following saturation with potassium ferricyanide) and standard B, which contained 1.3 mg/mL OxyHb. Mixtures of the previous two standards in appropriate proportions gave the solutions which contained increasing amounts of MetHb but the same concentration of Hb. Another standard C was prepared with 2.6 mg/mL methaemoglobin which was served as a sample for total concentration of met Hb.

RESULTS AND DISCUSSION

The results have shown that the healthy executive human subjects have a mean value of 2.4640 mg/mL metHb. On the other hand the estimations on doctors, nurses and theatre assistant subjects, the corresponding metHb quantities were 3.0039, 5.9657 and 5.4517, respectively. This would suggest that there was 1.29% rise of metHb among doctors, 2.42% increase in nurses and 2.12% in theatre supportive staff. The above data was processed for statistical correlation and regression analysis to know the significance. For this an online statistical calculator spss 20.0 version was utilized. The results are given below as graphical forms here (Figs. 1 to 4). The statistical regression analysis clearly exhibited those methaemoglobin variations in doctors, nurses and theatre assistants. This was comparatively higher in the nurses (r = -0.027) followed by (r= -0.247 and r= -0.377) (Fig.1).

Cortazzo et al (2014) have reviewed that the great preponderance of reports of methaemoglobinemia is due to the action of exogenous chemical agents which increase the rate of auto oxidation of Hb in RBC. It is inferred from the present study that the acquired methaemoglobinemia in surgical theatre health care personals is anesthetic gaseous induced or drug pollution that exist in theatres, an incident of occupational hazard. Information on the identification and analysis of occupational health and safety problems among workers of surgical theatres is very limited. Good ventilation and best gas scavenging system should be adopted to reduce this burden of occupational hazard. Methaemoglobinemia is also relevant to clinically important in anaesthesia with regard to the administration of prilocaine (an amide) the epidural analgesia. It is disclosed that one of the byproduct O-toluidine resulted during the rapid metabolism of prilocaine, persuades excess appearance of metHb. Therefore the subjects of environmentally or occupationally acquired methaemoglobinemia may be avoided for these drugs (RyotaHiguchi et al 2013). Another important clinical significance of acquired methaemoglobinemia is, when a patient is brought to clinic with cyanosis and has no respiratory or cardiac cause for the
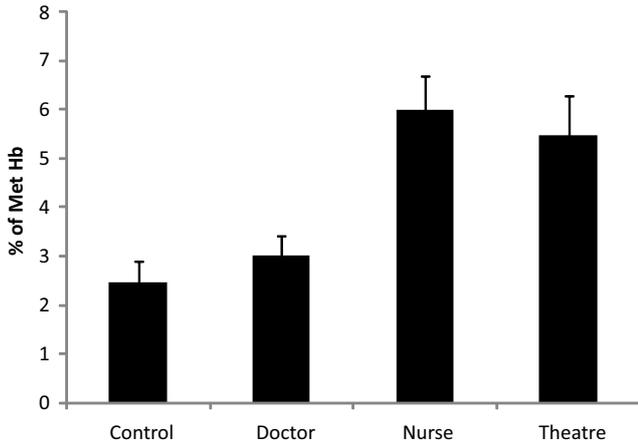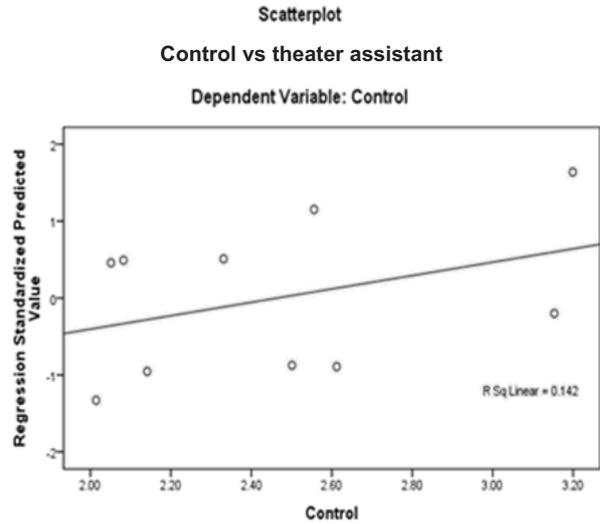
**Fig. 1.** Met Hb status in surgical theatre health workers


x = 3.568 – 0.202 (y) r = -0.377

cyanosis, methaemoglobinemia may be suspected. Injection of 2 mg methylene blue/kg body weight in 1% sterile aqueous solution (or) vitamin C 100 ml intravenous could be curative (Agarwal et al 2009, Coratazzo et al 2014).

CONCLUSION

Anesthesia plays a major role in surgical theatre environment. Proper control of pollution by scavenging equipment, regular monitoring , preventative maintenance of apparatus, education and training of the staff involved and good housekeeping are mandatory. Current knowledge that linking anesthesia and environmental toxic nature of theatre that harm workers is feeble and there are no substantial evidences. In future the manufacturer of the equipment and technology should take care for the prevention of leaking and suspension of anesthetic gases in surgical theatres.
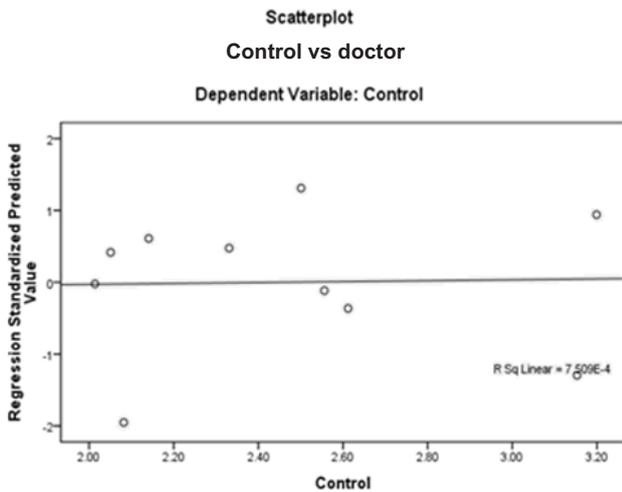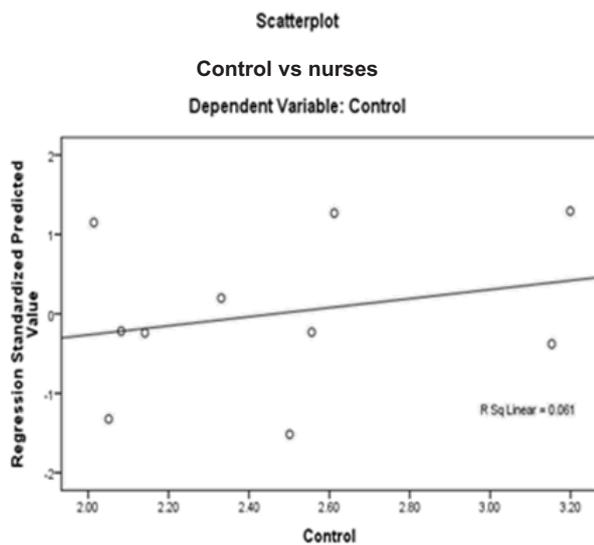
x = 2.552 – 0.029 (y) r = -0.027

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Ecological Risk Assessment in Port Harcourt Jetty Polluted by Petroleum Products Spillage

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Abstract: The level of heavy metals (Cu, Cd, Pb and Zn) in soils and plant from a petroleum jetty contaminated by petroleum products spillage were determined using digestion and atomic absorption spectrophotometer methods (AAS). Soil and plant samples were collected from soils around the petroleum jetty in Port Harcourt, Nigeria and other samples were collected from an area 1 km away from the jetty, which served as control. Environmental risk assessment measurements were calculated using contamination index, pollution load index and potential ecological risk and ecological risk index. The mean concentration of heavy metals in soil from polluted and unpolluted site were 0.800 and 0.729 mg kg^{-1} respectively for copper, 0.240 and 0.183 mg kg^{-1} respectively for cadmium, 0.851 and 0.586 mg kg^{-1} respectively for lead and 2.665 and 2.197 mg kg^{-1} respectively for zinc. The heavy metals mean concentration in plant from polluted and unpolluted site were 0.588 and 0.543 mg kg^{-1} respectively for copper, 0.272 and 0.240 mg kg^{-1} respectively for cadmium, 0.587 and 0.518 mg kg^{-1} respectively for lead and 3.205 and 2.567 mg kg^{-1} respectively for Zinc. The values of all the heavy metals analyzed for soil samples from the polluted sites were significantly higher than those from the control site by between 8.5 - 31.1 % whereas heavy metal values in plant sample were significantly higher in polluted sites between 7.7-19.9% when compared to the uncontaminated sites. The analysis of transfer factor, indicates an order of Cd >Zn > Cu >Pb in the uptake of heavy metals from soil to plant. Typical metal transfer factors are 0.7-0.8, 1.1-1.3, 0.5-1.1 and 1.1-1.4 for Cu, Cd, Pb and Zn, respectively. The relationship between transfer factor and the ratio of heavy-metal concentration in plants to that in soil can be used to assess the effect of heavy-metal concentration in the polluted soil on the heavy-metal uptake capabilities of plants growing on those soils. Environmental risk assessment measurement indices using contamination index indicates low to moderate contamination. Pollution load index indicate no pollution to moderate pollution among the three locations under both background scenario whereas potential ecological risk and ecological risk index indicates low ecological risk. Pollution of soils by oil spills increase metallic burden of soils, influence other soil properties and plant uptake of heavy metals in polluted soils. The ecological risks associated with usage of contaminated soil and plants should be continuously assessed and controlled.

Keywords: Heavy Metals, Transfer Factor, Ecological risks**,** Petroleum products, Petroleum Jetty

Heavy metals are found under natural conditions in the ecosystem with large variations in concentrations (Tchounwou et al 2012). In modern times, anthropogenic sources, i.e. pollution from the anthropogenic factors have brought in some of the heavy metals into the environment. The existence of heavy metals in the environment is of ecological importance due to their toxicity at certain concentrations, and translocation through food chains (Opaluwa et al 2012). Heavy metals are environmental contaminants of great concern, because, due to their biochemical properties, they accumulate in environmental media (Kabata-Pendias 2011).

Soil is an important portion of our ecosystem. Its filter, buffer, storage, and transformation functions contribute to the regulation of the water, thermal and energy balance. In terms of food production, soils are a livelihood of human beings. All heavy metals occur naturally in soils, at least in trace quantities. Depending on the soil parameters, the processes of adsorption and desorption, complexation, precipitation, sequestration and occlusion, diffusion and migration, and

metal competition can alter the concentration of available heavy metal forms in soil (Kabata-Pendias 2011). The contamination of soil with a single heavy metal element is rare (Shute and Macfie 2006). Especially as the association of Cu, Cd, Pb and Zn are highly abundant in urban environments (Cizmecioglu and Muezzinoglu 2008). The dynamics of heavy metals in plant-soil interactions depends mainly on the levels of soil contamination and plant species. Plants take in heavy metals from the soil through the root and from the atmosphere through over ground vegetative organs. Plant parts contain different heavy metals quantities; the highest quantities are in roots and leaves, and the lowest are in fruits and seeds (Guala et al 2010). The analysis of the plant roots may show the degree of heavy metals aggregation in the polluted soil and could offer insights on the soil pollution degree, while the analysis of leaves may even suggest the atmosphere pollution degree (Smical et al 2008). Petroleum is an important environmental pollutant. Pollution from this source emanates from two major ways; release of the petroleum into the atmosphere from combustion

processes and direct spill of the petroleum into the environment.

Transmission of heavy metals from soil to plant tissues is studied using an index called Transfer Factor (TF). Higher TF values (≥1) indicate higher absorption of metal from soil by the plant and higher suitability of the plant for phyto-extraction and phytoremediation. On the contrary, lower values indicate poor response of plants towards metal absorption and the plant can be used for human consumption (Kabata-Pendias 2010). Thus, the study will show if the plant studied will be suitable for phyto extraction and phytoremediation which can be used to clean up pollution. The general objective of this research work is to examine the levels of heavy metal (Cu, Cd, Pb and Zn) concentration in the plants and soil within petroleum products polluted environment, compare them with concentrations outside the zone of the spillage and evaluate the transfer ratio of heavy metals from soil to the plants in a polluted and unpolluted environment and assess environmental risks associated with oil spills in soils around a petroleum jetty.

MATERIAL AND METHODS

Site characterization: The study area is located at Masters Energycity, Rumuolumeni in Obio Akpor local government area of Rivers State and lies between latitude 4° 46′ 26.2013′N and longitude 6° 58′4.4051′E. Average temperatures vary between 25 °C−28 °C while Relative humidity rarely dips below 60% and fluctuates between 90% and 100% for most of the year. The soil is classified as Alboll (Soil Survey Staff, 2010) and has an aquic soil moisture regime with an eluvial horizon.

Field methods: A reconnaissance survey of the study site was carried out and three sampling points (50 m apart) (sites A, B, C) within the jetty were selected. Observation points were selected at each site using a free survey technique. The observation points that are representative of the site are chosen by the surveyors based on personal judgment and experience (Mulla and McBratney 2000). Soil samples (5 m apart) were collected within each sampling point and were also collected from one sampling site as control (site D) 1000 m away from the Jetty site. The control site near the jetty was undeveloped plots used as farmlands for more than 20 years. A total of 12 soil samples were collected at the three sampling spots and control site and analysed in the soil reference laboratory of University of Nigeria Nsukka, Nigeria. Yellow nut Sedge (*Cyperus esculentus*) served as plant material and samples were collected at the three sampling spots and the same species of the plant sample was also collected as control site.

The soil samples from each site were dried under ambient temperature, mixed to get a representative sample, crushed and sieved with 2 mm mesh before being stored in labeled polythene bags prior to analysis. Two grammes of prepared soil sample was digested with 15.0 ml nitric acid, 20.0 ml perchloric acid and 15.0 ml hydrofluoric acid and placed on a hot plate for 3hrs. On cooling, the digest was filtered into a 100.0 ml volumetric flask and made up to the mark with distilled water. Similarly, dry powdered plant samples were digested with 60% $HClO_4$, concentrated HNO_3 and H_2SO_4. Blanks were prepared to check for background contamination by the reagents used.The digest samples were analyzed for copper(Cu), cadmium (Cd), lead (Pb) and zinc (Zn) using atomic absorption spectrophotometer (AAS VGB 210 System).

Transfer factor: Soil-plant heavy metal transfer factor (TF) was calculated as

Transfer Factor (TF)   = C_{plant}/C_{soil}

Where, C_{plant} and C_{soil} are metals concentration in the plant (mg kg^{-1}) and soil (mg kg^{-1}), respectively. When a linear relationship is observed between the concentrations of grass and soil for a given element, TF can be an appropriate measure for the assessment (Chojnacka et al 2005). TF was categorized further as accumulator and excluder to those samples which accumulated metals>1 mg kg^{-1}, and < 1, respectively (Ma et al 2001, Cluis 2004).

Environmental risk assessment: Several indices are used to assess the level of contamination by heavy metals in the environment especially soil. The indices studied include contamination factor, degree of contamination, pollution load index, potential ecological risk and ecological risk index for the 3 contaminated soil samples.

Contamination factor: Contamination factor (CF) is used to assess contamination levels relative to average concentration of the respective heavy metals when compared to officially permitted levels in the environment (Izah et al 2017c). CF method was developed by Hakanson (1980).

$$\text{Contamination factor} = \frac{\text{Element contamination in soil (CL)}}{\text{Background values (BV)}} \quad (1)$$

CL is the mean concentration of each metal under study, while BV is the background value

Contamination degree: Degree of contamination (CD) is the sum of all contamination factors (Bhutiani et al 2017, Izah et al 2017c, Singovszka et al 2014). Contamination degree was expressed as follows (Hakanson 1980) .

$$\text{Degree of contamination} = \Sigma CF_{cu} + CF_{ca} + CF_{zn} + CF_{Pb} \quad (2)$$

Pollution load index: Pollution load index (PLI) gives information about the toxicity of the metal in each respective

sample locations (Izah et al 2017c, Bhutiani et al 2017). PLI was calculated as follows (Tomlinson et al1980).

$$PLI = \sqrt[n]{CF_{Cd} \, xCF_{Zn} \, xCF_{Pb} \, xCF_{Cu}} \qquad (3)$$

Where CF is the contamination factor

Ecological risk index: Ecological risk index (ERI) is used to determine the extent of risk a particular activity posed to the environment. The potential ecological risk (ER) is calculated for each individual metals, while the summation of ecological risk based is on location and is often expressed as R' (Izah et al 2017d, Singovszka et al 2014). Both ER and R' was developed by Hakanson (1980) ER and R' was calculated based on equation 4 and 5 respectively.

$$ER = Tr \times CF \qquad (4)$$

Where Tr is the toxic response factor viz: Pb = 5, Cu =5, Cd = 30 and Zn = 1 (Hakanson 1980), and CF represents the contamination factor.

$$While \ the \ R' = \Sigma ER_{Cu} + ER_{Cd} + ER_{Zn} + ER_{Pb} \qquad (5)$$

RESULTS AND DISCUSSION

The limit of classification for the various environmental risk indices under study is presented in Table 1.

Heavy metals concentrations in soil: The concentration of copper, cadmium, lead, and zinc, in the soil and plant samples from the study sites and control sites are presented in Tables 2 and 3. The Table 4 present statistical results for heavy-metal concentrations in soil around a Port Harcourt jetty polluted by petroleum products spillage and control location (unpolluted location). The heavy metals mean concentration in polluted and unpolluted site were 0.800 and 0.729 mg kg^{-1} respectively for copper, 0.240 and 0.183 mg kg^{-1} respectively for cadmium, 0.851 and 0.586 mg kg^{-1} respectively for lead and 2.665 and 2.197 mg kg^{-1} respectively for Zinc. These results show that the values for all the metals analyzed for soil samples from the polluted sites were significantly higher than those from the unpolluted (control) site by between 8.5 - 31.1 %. The preponderance of the heavy metals in the polluted environment when compared to the control sites suggest that spillage of petroleum oil from the activities in the jetty increased the soil

Table 2. Heavy-metal concentrations (mg/kg) in soil around a Port Harcourt jetty polluted by petroleum products spillage at different soil depths

Heavy metals soil depth (cm)	Cu		Cd		Pb		Zn	
	0-15	15-20	0-15	15-20	0-15	15-20	0-15	15-20
Site A	0.730	0.924	0.193	0.224	1.143	0.869	2.231	3.017
Site B	0.831	0.779	0.285	0.294	0.681	0.601	2.866	2.894
Site C	0.775	0.762	0.216	0.227	0.988	0.825	2.337	2.645
Control	0.707	0.750	0.157	0.208	0.624	0.547	1.843	2.550

Table 3. Heavy-metal concentrations (mg/kg) in plant around a Port Harcourt jetty polluted by petroleum products spillage

Heavy metals	Cu	Cd	Pb	Zn
Site A	0.577	0.262	0.545	3.561
Site B	0.604	0.310	0.678	3.163
Site C	0.582	0.244	0.538	2.892
Control	0.543	0.240	0.518	2.567

Table 4. Statistical results for Heavy-metal concentrations (mg/kg) in soil around a Port Harcourt jetty polluted by petroleum products spillage (Mean± SD)

Parameters	Polluted (n=9)	Unpolluted (n=3)	t-value	P-value
Cu	0.800 ± 0.068	0.729 ± 0.030	1.327	0.233
Cd	0.240 ± 0.040	0.183 ± 0.036	1.797	0.122
Pb	0.851 ± 0.198	0.586 ± 0.05	1.785	0.125
Zn	2.665 ± 0.32	2.197 ± 0.500	1.609	0.159

The mean concentration of site A, B, and C represents the polluted site while the Control site represents the unpolluted site

load of heavy metals. Anikwe et al (2017) documented that as a result of crude oil pollution, soil physical properties such as pore spaces might be clogged which reduces soil aeration, infiltration of water into the soil, decreased saturated hydraulic conductivity and increased bulk density of the soil which may negatively impact on biodegradation of petroleum products through natural attenuation. The microbes such as *Fusarium*, Mucor, *Penicillium*, *Aspergillus*, *Saccharomyces* (fungi), *Pseudomonas*, *Xanthomonas*, *Micrococcus* and *Bacillus* are among the common soil microbes that could degrade petroleum oils under suitable nutrients condition

Table 1. Limit of classification for the various environmental risk indices under study

Indices	Low risk	Moderate risk	Considerable	High risk	Very high
Contamination factor (CF)	CF < 1	1 ≤ CF < 3	3 ≤ CF < 6	-	CF ≥ 6
Contamination degree (CD)	CD < 8	8 ≤ CD < 16	16 ≤ CD < 32	-	CD > 32
Ecological risk (ER)	Er < 40	Er 40 ≤ Er < 80	80 ≤ Er < 160	160 ≤ Er < 320	Er ≥ 320
Ecological risk Index (R')	R'<150	150 ≤ R'< 300	300 ≤ R'< 600	-	R'≥ 600
Pollution load index (PLI)	No pollution	-	Moderate	Heavy pollution	Extremely heavy pollution
	PLI < 1	-	1< PLI < 2	2 < PLI < 3	3 < PL I

Note: CF, CD, ER, R" was developed by Hakanson (1980)

depending on the physical state of the petroleum oils spilled and physicochemical condition of the soil (Bhattacharya et al 2002, Ajao et al 2011, Ekhaise and Nkwelle 2011,Umanu et al 2013).

Copper showed positive significant relationship with cadmium (r=0.786,) and zinc (r=0.905), whereas, cadmium showed significant positive relationship with zinc (r=0.833) (Table 5). The positive significant relationship suggests that copper, cadmium and zinc in the soil of the study area are from similar sources. Furthermore, this suggests that these heavy metals are enriched by lithogenic factor and/ or from the petroleum products in the study area. These heavy metals under study have been reported in crude oil spill sites (Aigberua et al 2017).

Heavy metals concentration in plants: The heavy metals mean concentration in plant from polluted and unpolluted site were 0.588 and 0.543 mg kg^{-1}, respectively for copper, 0.272 mg kg^{-1} and 0.240 mg kg^{-1}, respectively for cadmium, 0.587 and 0.518 mg kg^{-1} respectively, for lead and 3 and 2.567 mg kg^{-1} respectively for zinc (Table 6). Heavy metal values in plant sample were significantly higher in polluted sites by between 7.7 – 19.9 % when compared to the uncontaminated sites. This significant variation suggest that the plants assimilated more heavy metals in polluted sites when compared to the unpolluted sites. This suggests the tendency for *Cyperus* plant to bio accumulate heavy metals in their tissues (conspicuous consumption) in the midst of plenty. This might be a good quality for the plant to be selected for use in phytoremediation of heavy metal polluted soils. Several studies have suggested that plants bio accumulate heavy metals in their different parts such as leaves, stem, root, flower and even fruit/ edible parts depending on plants. Izah and Aigberua (2017) reported the presence of heavy metals such as nickel, iron, copper, zinc, chromium and absence of cobalt, cadmium and lead in some vegetables (viz: *Gongronema latifolium, Amaranthus hybridus, Piper guineense, Talinum triangulare, Telfairia occidentalis and Ocimum gratissimum*) commonly used for culinary purpose in Yenagoa metropolis, Nigeria. Furthermore, heavy metals such as copper and zinc are essential nutrients required at trace amount for plant for optimum growth and productivity. The heavy metals such as cadmium and lead are highly lethal to biodiversity including plants. Typically, lead is a major component of petroleum products such as gasoline and premium motor spirit. As such, its presence suggests possible assimilation from the contaminated site and/ or other lithogenic source of heavy metals in the environment.

Transfer factor (TF) of heavy metals in the study sites from soil to plants: The TF values for Cd, Cu, Pb and Zn for yellow nutsedge-*Cyperus esculentus* varied significantly between sampling sites (Table 7). The analysis of transfer factor, indicates an order of Cd >Zn > Cu >Pb in the uptake of heavy metals from soil to plant. The relationship between transfer factor and the ratio of heavy-metal concentration in plants to that in soil can be used to assess the effect of heavy-metal concentration in the polluted soil on the heavy-metal uptake capabilities of plants growing on those soils. The TF values for Cu were generally higher than those for Pb, but lower than Cd and Zn. The TF values for Cu varied from 0.697 to 0.757 in the polluted sites and 0.745 in control site. The values for Pb were much lower than those for Cu in all sampling sites, except in site B where it was relatively higher than Cu but lower than Cd and Zn. The values of Pb varied from 0.541 to 1.057 in polluted sites and 0.885 in the control site. The TF values for Cd varied from1.072 to 1.259 in the polluted sites and 1.318 in the control site. The values of Zn varied from 1.098 to 1.357 in the polluted sites and 1.168 in the control site. On the whole, the order of the transfer factor was Cd >Zn > Cu >Pb. Typical metal transfer factors are 0.697- 0.757, 1.072–1.318, 0.541–1.057 and 1.098–1.357 for Cu, Cd, Pb and Zn, respectively.

Table 5. Spearman's rho correlation matrix of the heavy metals in soil around a Port Harcourt jetty polluted by petroleum products spillage

Parameters	Cu	Cd	Pb	Zn
Cu	1.000			
Cd	0.786[*]	1.000		
Pb	0.071	-0.190	1.000	
Zn	0.905[**]	0.833[*]	-0.167	1.000

*and **. correlation is significant at the 0.05 and 0.01 level (2-tailed)

Table 6. Statistical results for heavy-metal concentrations (mg/kg) in plants around a Port Harcourt jetty polluted by petroleum products spillage

Parameters	Polluted (n=3)	Unpolluted (n=1)	t-value	P-value
Cu	0.588±0.014	0.543±0.000	2.693	0.115
Cd	0.272±0.034	0.240±0.000	0.812	0.502
Pb	0.587±0.079	0.518±0.000	0.757	0.528
Zn	3.205±0.337	2.567±0.000	1.643	0.242

The mean concentration of Site A, B, and C represents the polluted site while the Control site represents the unpolluted site

Table 7. Statistical results of transfer factor of plant-soil heavy-metal concentrations (mg/kg)

Site	Cu	Cd	Pb	Zn
Site A	0.697	1.259	0.541	1.357
Site B	0.750	1.072	1.057	1.098
Site C	0.757	1.104	0.593	1.160
Control (D)	0.745	1.318	0.885	1.168

TF >1 Accumulator; TF <1 Excluder

In all the sampling sites, TF of Cu and Pb was <1 (except in Site B where Pb had TF>1) which suggests a low bioaccumulation of Cu and Pb from soil and shows that yellow nutsedge- *Cyperus esculentus* could be an excluder of Cu and Pb. On the other hand, the high TF values of > 1 for Cd and Zn which suggests a considerable bioaccumulation of Cd and Zn from the soil and indicates a high performance of yellow nutsedge-*Cyperus esculentus* for phytoremediation of Cd and Zn-contaminated soil.

Environmental risk assessment: The contamination factor showed instances of heavy metal contamination under both background scenarios. The contaminations were within low to moderate contamination (Table 8) and the degrees of contamination among the various locations were within low risk. Pollution load index indicate no pollution to moderate pollution among the 3 locations under both background scenario, however, in location C, there was no pollution, while in location B, the pollution was close to no pollution level. Potential ecological risk and ecological risk indicates low risk (Table 9). The values of ecological risk showed that heavy metals at the time of this study, at the petroleum products contaminated location under study have low ecological risk. Thus, suggesting that pollution associated to it is minimal. This trend has been reported by Izah et al (2017c) and Bhutiani et al (2017). The values of degree of contamination and ecological risk were lower than the values previously

reported in cassava mill effluent contaminated site by Izah et al (2017c). This could be due to a lesser quantity of metals under consideration.

CONCLUSIONS

The Pb, Fe, Cu and Zn content in the soils and plant in sites polluted by petroleum products spillage increased relative to the non-polluted sites and this must be attributable to contamination of petroleum products on the environment around the jetty. Increased heavy metal content of the soil is likely to cause elevated levels of plant uptake of metals that may be harmful to human and animal health.There was a positive significant relationship between Cu - Cd and Cd - Zn from the correlation matrix which suggested that copper, cadmium and zinc in the soil in the study area are from similar sources which could be from the petroleum products in the study area and/ or by lithogenic factor. The TF > 1 for Cd and Zn indicates a high performance of yellow nutsedge-*Cyperus esculentus* for phytoremediation of Cd and Zn-contaminated soil. While the TF<1 for Cu and Pb indicates that Yellow nutsedge- *Cyperus esculentus* could be an excluder of Cu and Pb. Results obtained from this work indicate that continuous uncontrolled pollution increase metallic burdens in the soil and this can ultimately result to increased bioaccumulation in plants. Ultimately optimal management lies with controlling the source of these pollutants. Pollution of soils by oil spills increase metallic burden of soils, influence other soil properties and plant uptake of heavy metals at the polluted sites. The ecological risks associated with usage of contaminated soil and plants should be continuously assessed and controlled.

Table 8. Contamination factor of heavy metal in the soil samples (mg/kg)

Scenario	Site	Cu	Cd	Pb	Zn
Median Mean	A	1.064	0.925	2.288	0.952
	B	1.036	1.283	0.757	1.045
	C	0.990	0.982	1.071	0.904
Geometric Mean	A	2.036	0.882	1.212	0.991
	B	1.009	1.224	0.770	1.088
	C	0.964	0.937	1.090	0.941

CF < 1 (low contamination); 1 ≤ CF <3 (moderate contamination); 3 ≤ CF < 6 (considerable contamination); CF ≥ 6 (very high contamination)

Table 9. Potential ecological risk (ER) of heavy metals in the soil samples (mg/kg)

Scenario	Site	Potential ecological risk				ER index (R')
		Cu	Cd	Pb	Zn	
Median Mean	A	5.30	27.75	5.94	0.952	39.942
	B	5.18	38.49	3.785	1.045	48.500
	C	4.95	29.46	5.355	0.904	40.669
Geometric Mean	A	5.175	26.46	6.06	0.991	38.686
	B	5.045	36.72	3.85	1.088	46.703
	C	4.80	28.11	5.45	0.941	39.301

Er<40 (Low risk); Er 40 ≤ Er<80 (Moderate risk); 80 ≤ Er <160 (Considerable); 160 ≤ Er<320 (High); Er ≥ 320 (Very high)

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Study on Paddy Phenomics Eco-system and Yield Estimation using Multi-temporal Remote Sensing Approach

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Abstract: Accurate estimation and management of paddy phenology is necessary to monitor the crop growth and yield estimation. Spatial time-series data playvitalrole for assessment of phenology across massive areas. In the present study the paddy phenological stages namely transplanting, heading, and harvesting stages are detected in Chittoor district of Andhra Pradesh, India. A comparative study is conducted using ground observation data collected in *rabi* season and MODIS NDVI data. The phenological stages are detected using MODIS time-series NDVI data. The phenological stages namely transplanting stage, heading stage and harvesting stages are observed on 26-12-2017, 06-02-2018 and 26-03-2018 respectively. The RMSE error calculated for transplanting, heading, and harvesting stage. 4, 5.5, 4 days respectively. The polynomial equation is developed using NDVI and yield data collected from field. The accuracy achieved to estimate yield is 80%.

Keywords: Remote sensing, Phenology, Paddy, Time series MODIS NDVI, Growth monitoring, Yield

Remote sensing plays vital role to monitor and predict crop condition. The monitoring crop phenology across large areas is essential to estimate net primary production and crop yield (Subbu Lakshmi and Yarrakula 2016, Vignesh and Yarrakula 2017, Palakuru et al 2019). The crop planting and harvesting time plays an important role and it also influences the spatial and inter-annual variability of terrestrial carbon cycles. Ground observation provides phenological data with high temporal resolution (Gu et al 2009, Matkan et al 2010, Jayawardana 2016). The present study of remote sensing data provides significant information to estimate crop phenological stages of paddy. To detect the crop phenological stages the most common approach is the utilization of vegetation indices (VI) such as Normalized difference vegetation Index (NDVI) and Enhanced vegetation index (EVI).The present study is aimed to identify the phenological stages of paddy crop namely transplanting stage, heading stage and harvesting stages. Finally yield is also estimated from field and compared the observed yield with MODIS NDVI paddy yield.

MATERIAL AND METHODS

Study area: The geographical area of Chittoor district is 15468 km^2. The study area contains 4805km^2 of forest (He et al 2018, Palakuru et al 2019, Mahesh et al 2018) and is in the southern part of Andhra Pradesh lies between latitudes of 13° 36' 18" to 13° 56' 55" N and longitudes of 79°07' 51" to 79°30' 18" E. The climate is generally dry with temperatures ranging from 16°C to 45°C. The average annual rainfall is about 934 mm and it

mainly received from northeast monsoons. Figure 1 shows the study area of Chittoor district, Andhra Pradesh, India.

Data used: Moderate resolution imaging spectroradiometer (MODIS) data is used to identify the phenological stages of paddy crop. MODIS centre mission, standard VI items incorporate the standardize distinction vegetation file and the improved version (NDVI) are used to identify bio-physical properties. It consists worldwide time arrangement record of 6 VI items from every one of the MODIS Terra data, at different resolutions (250m,500m, 1km) and fleeting (16-day) goals to address the issues of the exploration and application networks.

The sampling points are taken by observing extent of paddy crop area grown. The MODIS data with resolution of 500m is downloaded from USGS earth explorer from 1stDecember 2017 to 20th April 2018. the MODIS tool is used to extract the MODISNDVI data. EVI values are calculated using the following equation 1.

$$NDVI = \left[\frac{\lambda_{NIR} - \lambda_{RED}}{\lambda_{NIR} + \lambda_{RED}}\right]$$

where, λ_{RED} and λ_{NIR} are reflectance of MODISRED and NIR bands respectively. Figure 2 shows the methodology adopted to identify the phenological stages and yield estimation.

RESULTS AND DISCUSSION

Estimation of phenological stages: The NDVI profile has been selected to estimate the paddy phenological
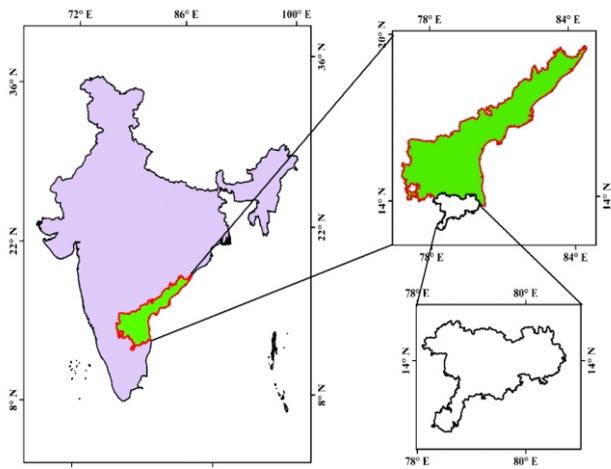
Fig. 1. Study area

parameters from December 2017 to April 2018 of *rabi* season. The experiment is performed at 20 locations in the study area. The sample locations selected based on the spatial data resolution and paddy crop area. The results are validated with the ground truth data to analyse the results precisely. From the field observations it is detected that the second season field preparation starts from third week of December 2017. The first vegetation stage in paddy crop growth cycle is transplanting stage. The transplanting of paddy crop is performed withhand or with trans-planter (Palakuru and Yarrakula 2019, Subu Laksmi and Yarrakula 2018).

Arrangement of shallow trenches at an interim of 3 meters up and down the field will encourage the depleting of overabundance water at the early grown stage (Sreechanth and Yarrakula 2017, Mahesh et al 2018, Park et al 2018). From the field observations and from MODIS NDVI(Figure 3) the second season paddy crop is started from 26th December 2017 and it matches the transplanting date derived from remote sensing data. After the transplanting the paddy experienced the growth period till harvesting stage i.e first week of April 2018. The vegetation index at the transplanting stage of paddy crop in the study area is 0.36. The heading stage in the paddy crop growth has highest vegetation index i.e 0.65. The heading stage begins after transplanting stage and the period is 40 to 55 days from transplanting stage, the vegetation index maximum range of paddy is 0.75. The heading stage usually defined as when 50% of the pods exerted. The heading stage takes 10-15 days for complete pods heading because there is a difference in pods generation inside tillers of the same plant and among plants in the same crop land (Li et al 2016, Hussain et al 2017). Heading stage is observed on first week of February 2018.
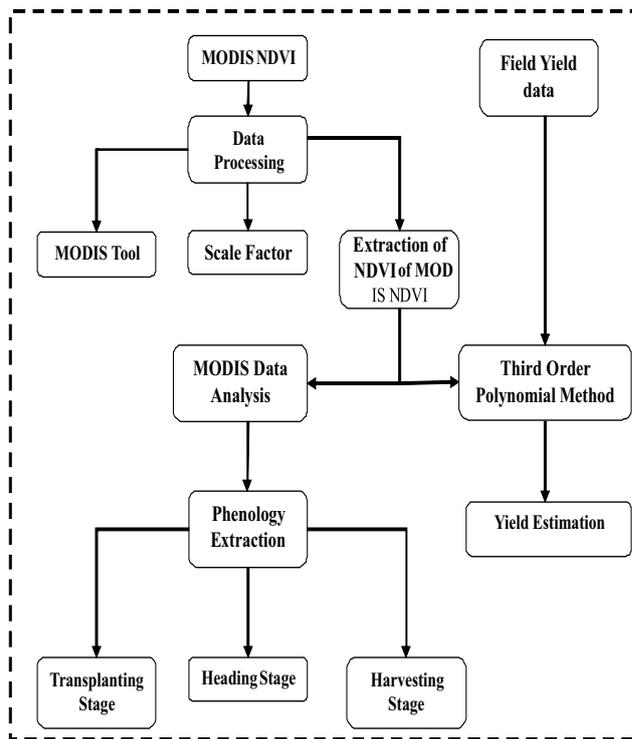

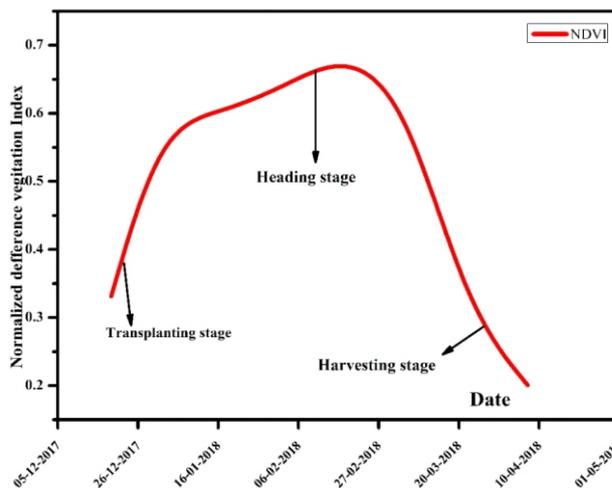**Fig. 2**. Methodology used to extract of phenological stages

Fig. 3. The phenological stages of paddy crop in the study area

The harvesting stage is observed on first week of April 2018. Harvesting stage is the ripened stage of the paddy crop. In ripened stage, the chlorophyll of the crop is approximately zero. The ripened stage is derived using the NDVI. The vegetation index is 0.25 at harvesting stage (Fig. 4). The NDVI time-series reflects the morphological and physiological condition of the paddy during the period (Wang et al 2014, Reddy and Yarrakula 2018). The date of phenology is identified using remote sensing is well matched to every key stage of paddy growth and concluded that
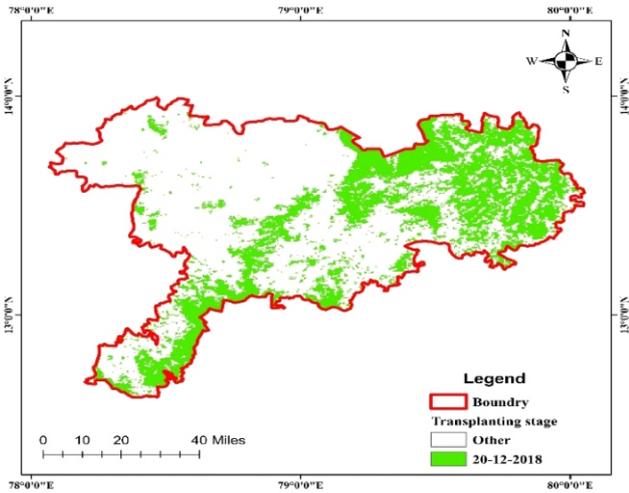
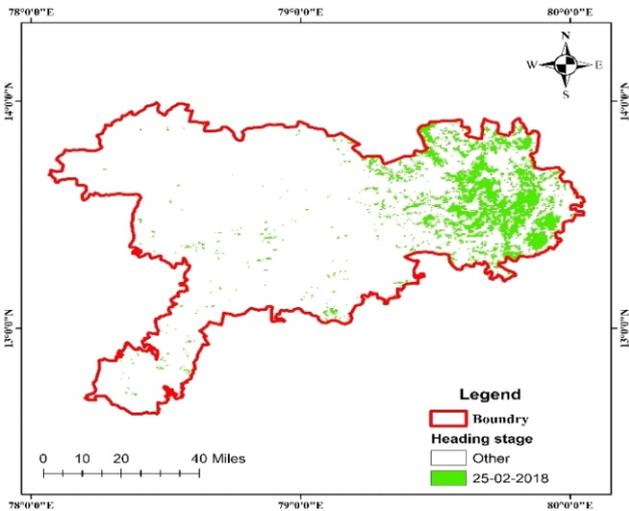**Fig. 4**. Spatial distribution of transplanting stage

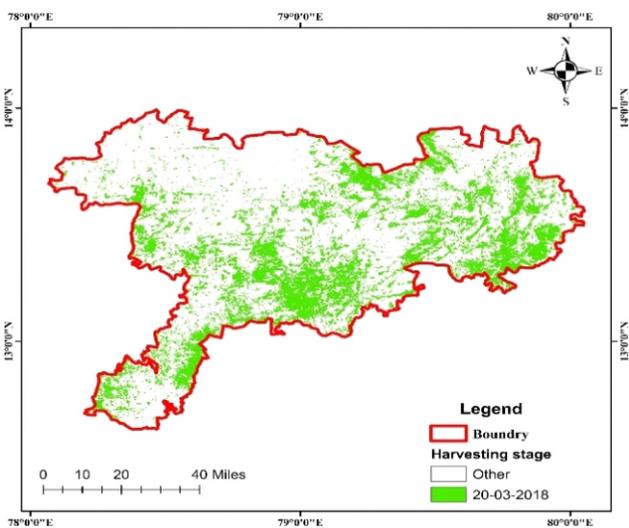**Fig. 5**. Spatial distribution of heading stage

Fig. 6. Spatial distribution of harvesting stage

remote sensing data is viableto monitor paddy growth conditions. The results showed that MODIS NDVI data are good to identify the phenological stages. Figures 4, 5 and 6 show the spatial distribution of transplanting stage, heading stage and harvesting stage in the study area, respectively.

Yield estimation: The third order polynomial model developed using NDVI and field measured yield data. In the present study 80% of the accuracy is achieved from the developed polynomial model. The developed polynomial model helps to predicts the yield 80% precisely w.r.t to vegetation index (Fig. 7). The developed polynomial model accommodates the end users to predict yield precisely and alert them to make precautionary measures in case low yield. The spatial mapping of yield is performed in the study area with the help of developed polynomial model. The measured average yield of the paddy crop is 2.7 tones/acre in the study area. The polynomial model results show that there is strong agreement between estimated yield and measured yield.

Accuracy assessment: The accuracy assessment is performed to test the precision of identified phenological stages of paddy crop using ground truth data and estimated data. the ground truth data is collected at transplanting stage, heading stage and harvesting stage at all sample points. The precision of findings performed by comparison of ground truth measured data and estimated data. Figures 8, 9 and 10 show the comparison of estimated and ground truth data for transplanting stage, heading stage and harvesting stage, respectively. The root means square error (RMSE) at transplanting, heading, and harvesting stages are 4, 5.5, 4 days respectively.
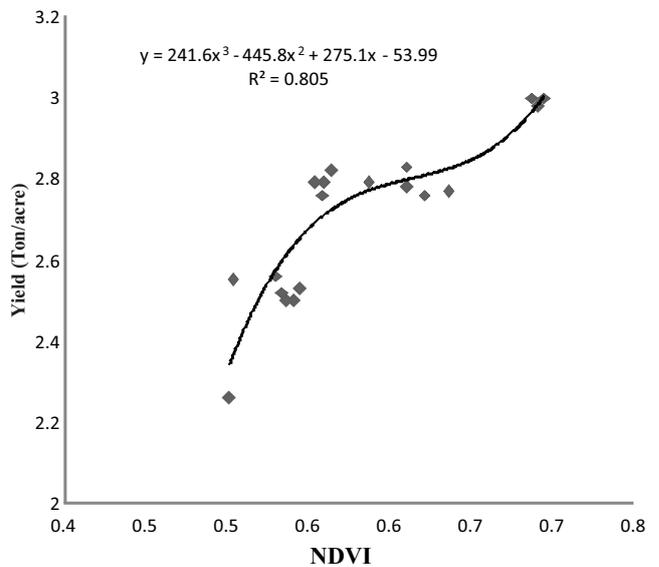

$y = 241.6x^3 - 445.8x^2 + 275.1x - 53.99$

$R^2 = 0.805$

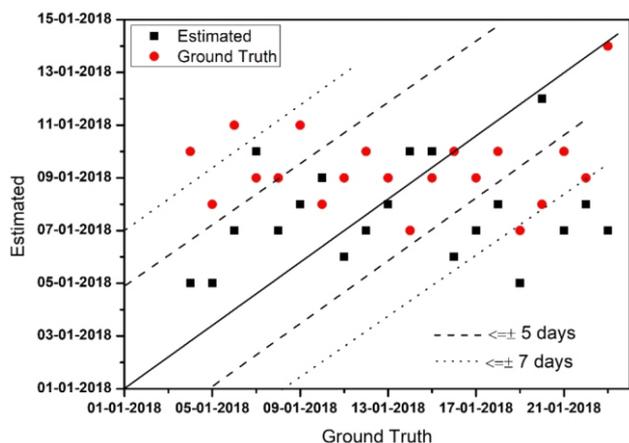**Fig. 7.** Paddy yield and NDVI$_{max}$ relationship

Fig. 8. One to one comparison of NDVI derived dates and ground truth dates at transplanting stage
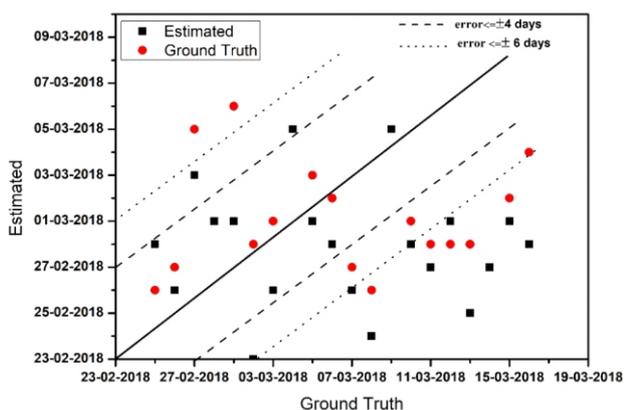

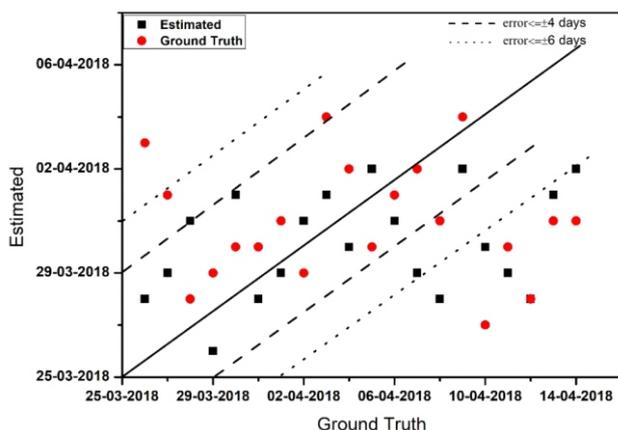**Fig. 9**. One to one comparison of derived and ground truth at heading stage

Fig. 10. One to one comparison of derived and ground truth at harvesting stage

CONCLUSIONS

The investigation precisely recognized various paddy crop phenological stages from MODIS NDVI data. The vegetation index at the transplanting stage is 0.36 and heading stage is 0.65 while at harvesting stage is lowest in the season (0.25). The phenological stages such as transplanting, heading and harvesting stages are observed on December 26, 2017, February 6, 2018 and March 26, 2018, respectively. The root means square error at transplanting stage, heading stage, harvesting stages are4, 5.5, 4.0 days, respectively. The paddy yield is also estimated using NDVI and empirical formula developed for large scale estimation. The accuracy achieved in yield estimation is 80%. The outcomes showed that MODIS NDVI dataset is feasible to identify the crop phonemics and yield precisely.

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Identification of Soil Quality Indicators for New Alluvial in Rice Based Cropping Systems of Jorhat District, Assam

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Abstract: Rice based cropping system is one of the most important cropping system grown year after year in Jorhat district of Upper Brahmaputra Valley Zone of Assam. The present investigation was undertaken for soil quality assessment in new alluvial rice based cropping systems. Through principal component analyses, critical soil quality indicators identified in New Alluvium Rice-Fallow Cultivated sequence were BD, CEC, TN, Av Fe, DHG, OC, Av B, EC, Av Zn, Av. K_2O and Ex Ca. Among these, most sensitive indicator of soil quality was BD and its less value contributed to 16.74% towards SQI.MDS indicators in New Alluvium Rice-*Toria* cultivated sequence were DHG, MWD, pH, Av Fe, BD and Min N and among them highest contribution of 35.04% towards SQI was from BD.Porosity, pH, MWD, CEC, Av B, MBC and Av P_2O_5were MDS for New Alluvium Rice-Vegetable Cultivated sequence and porosity was the most sensitive indicator of soil quality. The contribution of soil porosity towards SQI was 33.45 per cent.

Keywords: Upper Brahmaputra valley, Jorhat, Principal component analysis, Rice, Soil quality indicators, Soil quality index

Agriculture and its allied activities have played an important role in socioeconomic development of Assam. The total cultivated area of Assam is 28.27 lakh ha (Economic survey Assam 2014-15). Out of which about 88 per cent of the total land available for cultivation. The rice cultivation occupies 92.5 per cent of the net cropped area in the state during year 2016-17. In the alluvial flood free soils, the rice based farming system is mostly practiced. In Assam, new alluvial soil occupies around 33.6 per cent of total area and it is included under entisols. Mostly the farmers of Assam prefer rice fellow monocropping system. But due to continuous cultivation practices, the yield of crops under the rice mono- cropping system has reached a plateau and has been showing a dwindling trend for last few years. Recently, declining trend of factor productivity of rice in the state of Assam shows the evidence of un-sustainability of this cropping system (Singh 2011). Among other factors, unsustainable production of this particular cropping system is mainly associated with the gradual deterioration of soil quality. Deterioration in soil quality caused by the imbalanced fertilizer use, acidification and decline in soil organic matter may take several years to appear. Studies on soil properties of long-term rice-based cropping system provide the best means of studying changes in soil properties and processes over time, and these studies are important for obtaining information on long-term sustainability of agricultural systems to formulate future strategies for maintaining soil health. There is a growing concern among farmers that long-term monoculture of rice may not be sustainable owing to their negative effects on soil quality. Information on assessment of the quality of soil particularly in rice ecosystem is very limited which is needed to raise crop productivity and its sustainability in present day agricultural system. It is therefore important to identify the soil characteristics responsible for changes in SQ, which may eventually be considered as soil quality indicators for assessing sustainability of rice based agricultural practices. However, there is currently no consensus on a definitive set of soil properties for soil quality monitoring, nor consensus on how the indicators should be interpreted (Sparling, and Schipper 2002). This lack of consensus is partly due to the fact that soil quality is a complex concept and that different site-specific soil conditions may be desirable, depending on the purpose of cropping system.

MATERIAL AND METHODS

Study area and soil sampling: Jorhat district of Assam is located in the upper Brahmaputra valley zone of Assam, between latitude 27°35 N to 26°30 N and longitude 93°45 E to 94°30 E. It has a geographical area of 2851sq. km. Mean annual rainfall is 1865 mm and the average temperature is 26°C. The maximum temperature goes up to 33.50°C whereas the minimum temperature falls to 10°C.Out of two dominant physiographic units belonging to New alluvial plain and Old alluvial plain of Jorhat district, the new alluvial was selected for the study. Dominant cropping sequences practiced by the farmers in the district were identified and the sequence *viz.* Rice-Fallow was selected. Two categories of

farmer practicing each sequence continuously along with a check (uncultivated) under two physiographic units were selected for the present investigation. Surface soil samples (0-15 cm) in triplicate from ten different farmers were sampled immediately after crop harvest. After retaining a portion of the samples in triplicate for each farmer, all three remaining samples for each physiographic unit, category and sequence were mixed together for analysis.

After taking the record of rice yield, these samples wereair-dried and passed through 2 mm sieve, and soil attributes *viz.,* Mechanical analysis, bulk density (BD), mean weight diameter (MWD),particle density (PD), hydraulic conductivity (HC), field capacity (FC), wilting point (WP),pH, electrical conductivity (EC), organic carbon (OC), total nitrogen (TN), mineralizable nitrogen (MN),available phosphorus (Av P_2O_5), cation exchange capacity (CEC), available potassium (Av K_2O), available zinc (Av Zn), available iron (Av Fe), availble boron (Av B), exchangeable calcium (Ex. Ca), exchangeable aluminium (Ex. Al), microbial biomass carbon (MBC), dehydrogenase (DHG), bulk density (BD) was determined using standard methodologies.

Soil quality index: Determination of soil quality index mainly concerned with the integration of representative highly performed minimum datasets (MDS) that best reflects the soil function in terms of a specific goal (Chaudhury et al 2005).The principal components receiving high eigen values and variables with high factor loading were assumed to be variables that best represented system attributes. Therefore, only the PCs with eigen values ≥1 (Brejda et al 2000) and those that explained at least 5% of the variation in the data (Wander and Bollero 1999) will be accounted for identifying the MDS. Within each PC, only highly weighted factors were retained for MDS. After determining the MDS indicators, every observation of each MDS indicator was transformed using a linear scoring method (Andrews et al 2002b). Soil Quality Index (SQI) was determined after summation of weighted MDS variables scores for each observation using the following equation:

$$SQI = \sum_{i=1}^{n} WiSi$$

where Si is the score for the subscripted variable and Wi is the weighing factor derived from the PCA. Here the assumption is that higher index scores meant better soil quality or greater performance of soil function (Chaudhury 2005).

Soil analysis	Methods	References
Mechanical analysis	International Pipette	Jackson (1973)
Bulk density	Tube core	Chapman (1965)
Particle density	Pycnometer	Baruah and Barthakur (1999)
Hydraulic conductivity	Constant Head	Baruah and Barthakur (1999)
Field capacity	Approximation method	Baruah and Barthakur (1999)
Wilting point	Approximation method	Baruah and Barthakur (1999)
Mean weight diameter	Yoder technique (1936).	Baruah and Barthakur (1999)
Soil pH	pH meter	Jackson (1973)
Electrical conductivity	Conductivity meter	
Organic carbon	Walkley and Black's method	Jackson (1967)
Cation exchange capacity	leaching the soil with 1N NH4OAC, pH 7.0 followed by distillation method	Chapman (1965)
Total nitrogen	Kjeldahl method	Bremner and Mulvaney (1982)
Available nitrogen	Alkaline Potassium Permanganet method	Subbiah and Asija (1956)
Available phosphorus	Bray and Kurtz No. 1	Jackson (1973)
Available potassium	Flame Photometric method	Jackson (1973)
Available Iron	Orthophenanthroline method	Baruah and Barthakur (1999)
Exchangeable aluminium	Aluminon method	Baruah and Barthakur (1999)
Exchangeable calcium	Complexometric titration method	Baruah and Barthakur (1999)
Available zinc	DTPA extraction method	Lindsay and Norvell (1978)
Available boron	Azomethine-H method	Wolf (1971)
Microbial biomass carbon estimation	Chloroform fumigation extraction technique	Vance et al (1987)
Dehydrogenase activity	Reduction of triphenyltetrazolium chloride(TTC) to triphenylformazan (TPF)	Casidaet al (1964)

RESULTS AND DISCUSSION

New alluvium rice-fallow cultivated (NARFC): Significant correlation (P<0.01) was observed between 6 of 253 soil property pairs for the cultivated rice-fallow samples of new alluvial plain. Significant positive correlations were observed for clay with WP (0.962); Porosity with FC (0.901) and CEC with TN (0.938).Significant negative correlations were observed for BD with Porosity and FC (-0.939 and -0.941) and Ex. Al with MBC (-0.785).

Grouping of soil quality indicators: The 23 soil quality properties considered in the principal component analysis were grouped into components (Table 1). The Cattel scree test was performed to plot components as the X- axis and the corresponding eigenvalues as the Y-axis (Fig. 1).

It showed that as one moves to the right, towards later components, the eigen values drop. When the drop ceased and the curve made an elbow towards less steep decline, scree test is said to drop all further components after the one
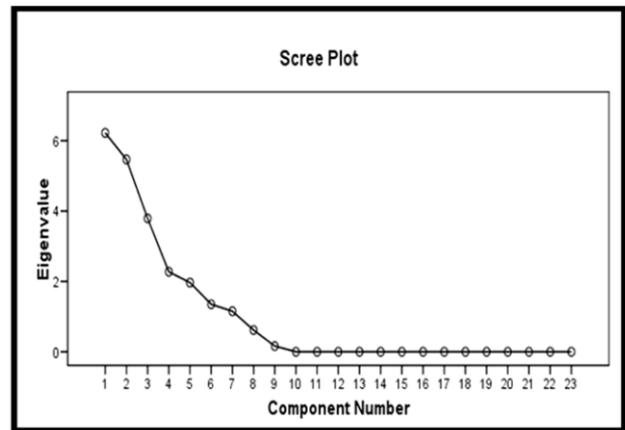

Fig. 1. Screen plot for selecting principal components under NARFC

starting the elbow. The first seven principal components had eigenvalues >1 and accounted for 96.61% of the total variance in the entire data set and therefore were retained for

Table 1. Rotated Component loadings and communalities of soil properties under rice-fallow sequence in new alluvial plains of Jorhat district, Assam

Soil properties	PC1	PC2	PC3	PC4	PC5	PC6	PC7	Communalities
Clay	-0.779	0.273	0.541	-0.130	0.048	0.024	-0.021	0.994
BD	*0.947*	0.096	0.071	0.101	-0.217	0.168	-0.059	1.000
PD	-0.305	-0.442	-0.027	*0.802*	0.143	-0.137	0.084	0.979
Porosity	*-0.894*	-0.240	-0.068	0.209	0.227	-0.188	0.079	0.997
HC	0.775	-0.452	-0.111	-0.079	-0.040	-0.224	0.018	0.875
FC	-0.826	-0.235	-0.286	-0.102	0.282	-0.225	0.078	0.965
WP	-0.625	0.295	*0.679*	-0.065	0.071	0.132	-0.065	0.969
MWD	0.444	0.655	0.531	-0.111	0.056	0.041	-0.069	0.929
pH	0.713	0.138	0.445	0.239	0.187	0.176	-0.178	0.880
EC	0.207	0.612	-0.379	0.057	*-0.610*	-0.131	0.200	0.993
OC	-0.311	0.354	*-0.669*	-0.044	0.270	0.157	*0.466*	0.986
CEC	0.205	*0.890*	-0.143	-0.099	0.273	-0.024	0.160	0.966
TN	0.205	*0.890*	-0.143	-0.099	0.273	-0.024	0.160	0.966
Min N	-0.037	0.646	0.570	0.175	0.069	-0.047	0.416	0.955
Av P_2O_5	-0.022	0.560	0.537	-0.360	0.108	-0.475	0.013	0.970
Av K_2O	-0.254	-0.399	0.275	-0.230	0.015	*0.783*	0.170	0.994
Av Fe	0.535	0.088	*-0.695*	-0.104	0.271	0.203	0.250	0.966
Ex Al	0.312	-0.664	0.282	-0.430	-0.119	-0.249	0.295	0.966
Ex Ca	0.262	-0.354	0.339	0.347	-0.457	-0.204	*0.474*	0.905
Av Zn	-0.573	0.465	-0.149	0.177	*-0.587*	0.237	-0.001	0.998
Av B	0.528	0.058	-0.030	0.556	*0.600*	-0.052	-0.137	0.974
MBC	-0.214	0.614	-0.036	0.708	-0.238	0.025	-0.109	0.994
DHG	0.237	-0.434	*0.653*	0.273	0.228	0.168	0.416	0.999
Eigen values	6.22	5.45	3.79	2.28	1.97	1.35	1.15	
% of variance	27.05	23.77	16.48	9.89	8.55	5.87	5.01	96.61

interpretation. Andrews et al (2002a) reported that the choice to retain or drop a variable from the final MDS should be based on the logic and interpretability of the variable(s) concern. Considering all these, finally eleven variables *viz.* BD, CEC, TN, Av Fe, DHG, OC, Av B, EC, Av Zn, Av. K$_2$O and Ex Ca were chosen as MDS. Sharma et al 2005, Chaudhury et al 2005 and Lima et al 2007also reported that BD, TN, DHG, OM, EC, Av Zn, Av K$_2$O were important variables to be included in the MDS while computing soil quality index in rice production system. In this rice based production system soil quality index was found 16.33. If all eleven MDS were considered to be responsible for contributing ideal (100%) soil quality index for rice ecosystem, then we can assess that decrease inBD has immense contribution towards overall SQI. Higher bulk density have negative influence on different soil properties and processes like moisture retention, water flow, root development, nutrient cycling and the sustainability of micro and macro organisms. The increase in bulk density

reflect an increase in soil compaction due to tillage operations and decrease in other soil quality indicators which indicates degradation in soil quality (Minh Van Dang 2007). Application of FYM helps in decreasing the BD by diluting the soil matrix with organic matter (Masto et al 2007).

Soil quality index interpretation: The MDS variables were transformed by using scoring functions. The selected indicators can be transformed following a linear or a non-linearing scoring rule. For 'more is better' indicators, each observation is divided by the highest observed value such that the highest observed value received a score of 1. For 'less is better' indicators, the lowest observed value (in the numerator) is divided by each observation (in the denominator) such that the lowest observed value receives a score of 1 (Lebig et al 2001). Once transformed, the MDS variables for each observation were weighted by using the PCA results. Each PC explained a certain amount (%) of the variation in the total data set. This percentage, divided by the

Table 2. Rotated Component loadings and communalities of soil properties in rice-*toria* sequence under new alluvial plains of Jorhat district, Assam

Soil properties	Component						Communalities
	PC1	PC2	PC3	PC4	PC5	PC6	
Clay	-0.806	0.508	-0.059	0.213	-0.178	-0.005	0.988
BD	0.906	-0.293	0.112	-0.152	-0.211	-0.017	0.987
PD	0.538	0.410	0.057	-0.224	0.278	0.500	0.838
Porosity	-0.657	0.542	-0.087	0.038	0.376	0.295	0.963
HC	0.725	-0.527	0.041	-0.091	0.393	-0.043	0.969
FC	-0.926	0.098	-0.116	0.243	0.208	-0.102	0.993
WP	-0.759	0.567	-0.013	0.077	-0.233	-0.137	0.976
MWD	-0.366	-0.394	-0.222	-0.259	-0.312	0.664	0.945
pH	0.296	-0.007	0.142	0.829	-0.224	-0.030	0.846
EC	0.262	0.452	-0.361	0.727	0.152	0.198	0.995
OC	0.016	-0.797	-0.191	0.381	-0.191	0.197	0.893
CEC	0.515	0.527	0.476	0.346	0.159	-0.129	0.931
TN	0.577	0.506	0.259	0.068	-0.416	0.166	0.862
Min N	-0.199	0.149	0.775	-0.336	0.346	0.164	0.922
Av P$_2$O$_5$	-0.633	-0.162	0.638	0.111	-0.163	0.258	0.938
Av K$_2$O	-0.454	-0.214	0.689	-0.345	0.008	0.017	0.847
Av Fe	0.170	0.123	-0.339	-0.072	0.878	0.008	0.935
Ex Al	0.631	0.491	-0.080	-0.362	-0.394	-0.185	0.966
Ex Ca	0.684	0.415	-0.299	-0.033	0.074	0.394	0.891
Av Zn	0.466	0.662	-0.036	-0.202	-0.326	0.198	0.844
Av B	0.631	0.052	0.539	0.238	0.173	-0.293	0.864
MBC	0.125	-0.113	0.590	0.507	0.103	0.413	0.815
DHG	0.231	-0.912	-0.079	0.177	-0.008	0.122	0.937
Eigen values	7.26	4.75	2.91	2.51	2.18	1.53	--
% of variance	31.58	20.66	12.66	10.93	9.46	6.63	91.92

total percentage of variation explained by all PCs with eigenvectors greater than 0.5, provided the weighted factor for variables chosen under a given PC. The SQI was calculated by using weighing factors for each scored MDS variable according to the formula:

SQI=Σ(0.280BD+0.246CEC+0.246TN+0.171Av Fe+0.171DHG+0.17OC+0.088 Av B+0.088EC+0.088 Av Zn+0.061 Av K_2O+0.0518 Ex Ca) **=** 16.33

If all eleven MDS were considered to be responsible for contributing ideal (100%) soil quality index for rice-fallow ecosystem in new alluvium, then the relative soil quality explained would be maximum for BD followed by Fe, CEC, TN, DHG, OC,EC,Av B, Av Zn, Ex Ca and Av K_2O (Fig. 2).

New alluvium rice-*toria* cultivated (NARTC): In order to test the consistency of correlation values with the hypothesized factor structure, correlation matrix among the observed variables was performed. Significant correlation ($P<0.01$) was observed between 10 of 253 soil property pairs for the cultivated rice-*toria* sequence of new alluvial plains. Significant positive correlations were observed for clay with porosity, FC and WP; OC with DHG. Significant negative correlations were observed for clay with BD, HC; BD with Porosity, FC and WP and HC with WP.

Grouping of soil quality indicators: The first six principal components had eigenvalues >1 and accounted for 91.92% of the total variance in the entire data set and therefore were retained for interpretation. Communalities for the soil properties indicated that the six components explained >90% of the variance in Clay, BD, Porosity, HC, FC, WP, EC, CEC, MWD, Min N, Av P_2O_5, Av Fe, Ex Al and DHG and >80% in PD, pH, OC, TN, Av K_2O, Ex Ca, Av Zn, Av B and MBC. Under PC1, PC2, PC3, PC4, PC5 and PC6, DHG, MWD, pH, Av Fe, BD and Min N were retained for MDS because of their better correlation sums and were not correlated with each other. Finally six variables viz. DHG, MWD, pH, Av Fe, BD and Min N were chosen as MDS that these are sensitive indicators of soil quality in crop production systems (Brejda et al (2000), Sharma et al (2005), Chaudhury et al (2005) and Lima et al (2007).

Soil Quality Index 9nterpretation: The MDS variables were transformed by using scoring functions. After scoring, the SQI was calculated by using weighing factors foreach scored MDS variable according to the formula:

SQI=Σ(0.344BD+0.225DHG+0.138 Min.N+0.119pH+0.103 Av Fe+0.0722MWD)=9.65

Assuming six selected MDS considered to be responsible for contributing ideal (100%) soil quality index for NARTC ecosystem, the relative soil quality explained would be maximum for BD followed by DHG, Min N, pH, Av Fe and MWD (Fig. 4). Soil Quality Index under this cropping system
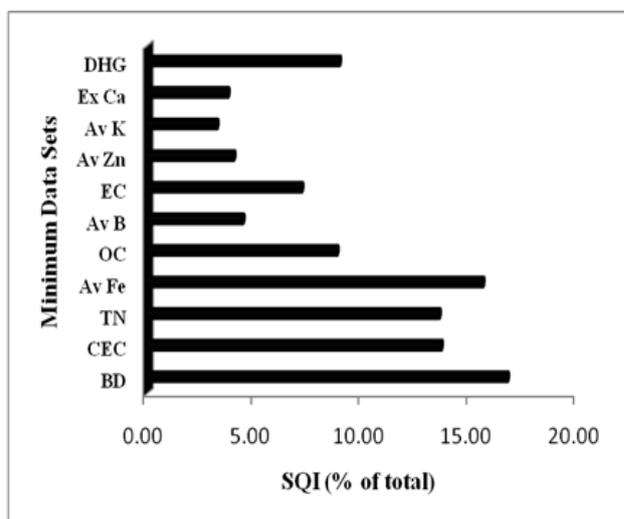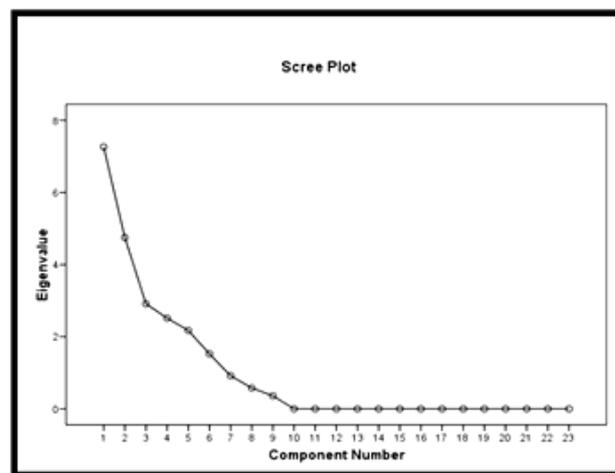

Fig. 2. SQI under NARF

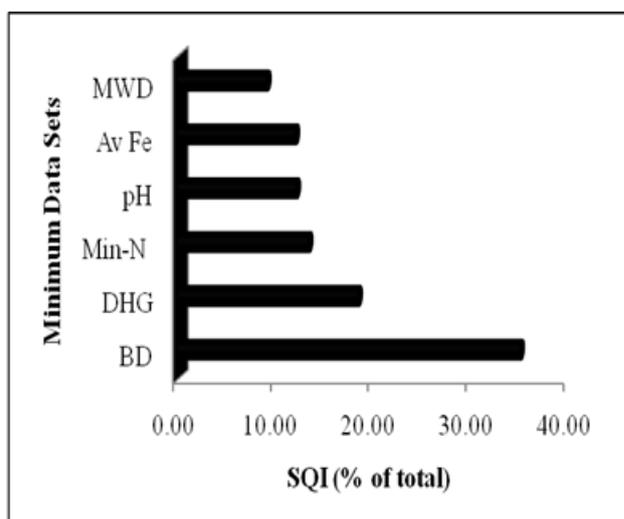**Fig. 3.** Scree plot for selecting principal components under NARTC

Fig. 4. SQI under NARTC

was 9.65. BD is the key indicator of soil quality in this cropping system. The increase in bulk density reflect an increase in soil compaction due to tillage operations and decrease in most other soil quality indicators which indicates degradation in soil quality (Minh Van Dang 2007). DHG is the second MDS indicator that contributes maximum soil quality index next to BD. Enzymes plays a key biochemical functions in the overall process of organic matter decomposition in the soil system. Enzyme activity assessment can be used in the evaluations of soil quality as well as a degree of recovery of degraded soils (Sotreset al 2005).

New Alluvium Rice-Vegetable Cultivated (NARVC)

Correlation matrix to test the significant levels of variables was studied separately and their consistencies were tested with the hypothesized factor structure. Significant correlation (P<0.01) was observed between 5 of 253 soil property pairs. Significant positive correlations were observed for clay with porosity while, significant negative correlations were observed for clay with BD and HC; BD with Porosity and Porosity with Av Zn.

Grouping of soil quality indicators: The first seven principal components had eigenvalues >1 and accounted for 94.69% of the total variance in the entire data set and therefore were retained for interpretation. Communalities for the soil properties indicate that the seven components explained >90% of the variance in Clay, BD, PD, Porosity, HC, WP, EC, CEC, pH, MWD, TN, Av P_2O_5, Av K_2O, Av Fe, Ex Al, Ex Ca, Av Zn, Av B, MBC and DHG and >80% in FC, OC and Min N..Finally seven variables *viz.* Porosity, pH, MWD, CEC, Av B, MBC and Av P_2O_5 were retained in MDS. Sharma et al (2005), Brejda et al (2000), Chaudhury et al (2005) and Lima et al (2007) also reported that Porosity, BD, pH, MWD, MBC and Av P_2O_5 were important variables to be included in the MDS while computing soil quality index.

Table 3. Rotated Component loadings and communalities of soil properties under rice-vegetable sequence in new alluvial plains of Jorhat district, Assam

Soil properties	Components							Communalities
	PC1	PC2	PC3	PC4	PC5	PC6	PC7	
Clay	-0.940	-0.018	-0.086	0.060	-0.186	0.024	-0.243	0.989
BD	0.880	-0.223	-0.209	-0.250	-0.015	0.238	-0.018	0.988
PD	-0.432	-0.342	0.128	-0.675	-0.268	0.266	0.231	0.972
Porosity	-0.917	-0.043	0.234	-0.227	-0.150	-0.014	0.157	0.997
HC	0.877	0.064	0.148	-0.062	0.131	-0.173	0.366	0.979
FC	-0.728	-0.290	0.114	0.102	0.405	-0.275	-0.082	0.884
WP	-0.221	0.637	0.396	0.255	0.421	0.038	0.362	0.986
MWD	0.274	0.442	-0.782	0.244	0.108	0.203	-0.062	0.998
pH	0.372	0.805	-0.140	-0.038	-0.282	-0.241	-0.158	0.970
EC	-0.123	0.811	-0.338	-0.042	0.331	0.015	0.302	0.989
OC	0.127	-0.562	0.211	0.422	0.455	-0.269	-0.220	0.881
CEC	0.721	-0.021	0.167	0.229	-0.615	-0.050	-0.083	0.989
TN	0.423	0.393	0.569	0.200	0.202	0.415	-0.108	0.922
Min N	-0.265	0.537	0.472	0.389	-0.021	-0.227	-0.133	0.802
Av P_2O_5	-0.268	0.496	-0.383	0.464	-0.350	0.076	0.419	0.983
Av K_2O	0.034	-0.622	-0.340	0.599	-0.172	0.137	-0.107	0.923
Av Fe	-0.204	0.511	0.610	0.347	-0.097	0.277	-0.318	0.982
Ex Al	-0.076	-0.462	-0.527	0.155	0.541	-0.035	0.091	0.823
Ex Ca	0.329	-0.661	0.130	0.392	-0.036	0.407	0.136	0.900
Av Zn	0.663	0.375	-0.378	-0.084	0.175	-0.227	-0.309	0.908
Av B	0.527	-0.135	0.396	-0.504	-0.072	-0.453	0.046	0.920
MBC	0.176	0.255	0.153	-0.604	0.463	0.483	-0.253	0.996
DHG	0.573	-0.304	0.596	0.331	0.095	-0.027	0.317	0.996
Eigen values	6.35	4.78	3.28	2.74	2.03	1.39	1.19	--
% of variance	27.62	20.80	14.28	11.93	8.82	6.05	5.17	94.69

Soil Quality Index Interpretation: The MDS variables were transformed by using scoring functions.Here the SQI was found 8.55 by using following formula:

SQI = Σ (0.291 Porosity+0.220 pH+0.151 MWD+0.093 CEC+0.064 Av B+0.064 MBC+0.055 Av P_2O_5) =8.55

If all seven MDS were considered to be responsible for contributing ideal (100%) soil quality index for rice ecosystem, then the relative soil quality explained would be maximum for porosity, followed by pH, MWD, CEC, MBC, Av B and Av P_2O_5 (Fig. 6). If all seven MDS were considered to be responsible for contributing ideal (100%) soil quality index in this rice-based cropping system, then we can conclude that soil porosity is the key indicator of soil quality in this cropping system. Low soil porosity is an indicator of high bulk density and soil compaction (Mulugeta 2004). It may cause poor movement of air and water through the soil.
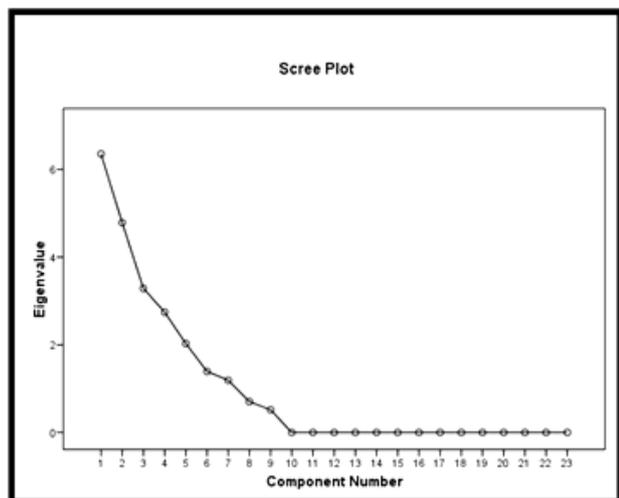

Fig. 5. Scree plot for selecting principal components under NARVC
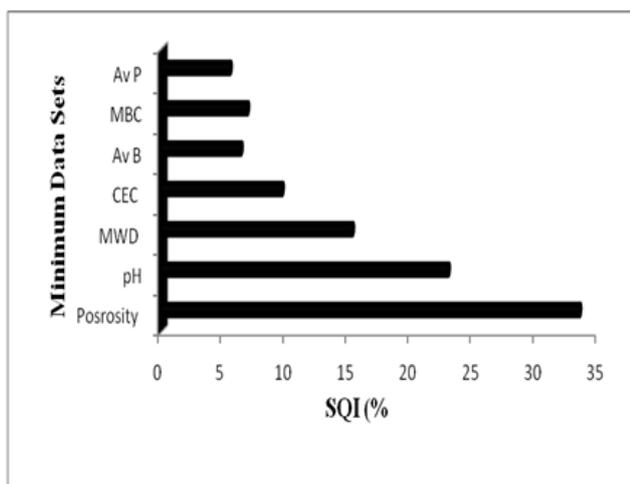

Fig. 6. SQI under NARVC

Intensive cultivation causes soil compaction and degradation of soil properties including porosity. Singh et al 2011 reported that use of inorganic fertilizers in combination with farmyard manure (FYM), green manure (GM) crop, wheat straw and rice straw plays an important role in decreasing the bulk density to desired level and increasing infiltration rate and mean weight diameter of aggregates.

CONCLUSION

SQI was found to be significantly superior in new alluvial than that of old alluvial soils which reflect the overall process of aggradations in such soils. In new alluvial soil, significantly highest SQI was in rice-fallow system followed by Rice-*Toria* and rice-vegetable systems. Among the cropping systems, SQI in rice-vegetables sequence, irrespective of the physiography, was significantly low. This shows negative impact of intense vegetable cultivation after rice leading to the process of un-sustainability with this continuous cropping sequence. Therefore, management practices must aim to correct those identified soil quality indicators which were sensitive for Rice-Vegetable system.

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Temporal Analysis of Rainfall Trend for Udaipur District of Rajasthan

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Abstract: Climate change for an area is referred to long term changes in hydrological conditions. In the present study, trend analysis in monthly rainfall over the Udaipur district during the period from 1975 to 2013 has been detected for Udaipur district. Udaipur is situated in Rajasthan which is a western state in India, comes under semi-aired area where rainfall is very low as compared to average rainfall of India. Trend in rainfall characteristics were determined by both parametric and non-parametric tests. In parametric test linear regression method has been used and in non-parametric test Mann-Kendall test and San's slope estimator test has been used. Based on linear regression method, six month shows negative rainfall trend whereas 4 month shows positive rainfall trend. Based on this method trend in month of March and September is not clear. Mann – Kendall test indicated that April, May, June, July and September months show increasing trend whereas January, February, March, August, October, November and December months show decreasing trend in monthly average rainfall. San's slope estimator gives result only for monsoonal month because rainfall is not linear in non-monsoonal months. The test indicated May, June July and September months show positive trend in rainfall whereas August month shows negative trend in rainfall. This study may be very helpful in future water resource planning and agriculture planning of this area.

Keywords: Rainfall, Trend detection, Mann – Kendall, Sen's slope estimator, Udaipur

The precipitation plays a significant role in hydrological cycle, precipitation is considered as one of the important part of surface water as well as ground water. According to Indian Water Resource Society (2016) report, in India rainfall shows high spatial and temporal variability. The mean yearly rainfall varies from 250 cm in north-eastern to 10 cm in the western Rajasthan. Maximum annual rainfall (75%). India receives during June to September months. (Guhathakurta et al 2008). The agricultural planning in India mainly depends upon the monsoonal rainfall.The water requirement in India continuously increasing and it may be double in year 2050 if compare with year 2000 (Kaur et al 2017). The global climate changes may affect long-term rainfall patterns in India. Many researcher worked on the trend of rainfall in the different part of the word which result some places have increasing trend, some places have decreasing trend and few places have no trend in rainfall pattern. Patra et al (2011) detected rainfall trend over Orisa state of India and found the month of August shows increasing trend and all other monsoonal months show decreasing rainfall trend. Barua et al (2013) studied rainfall trend with in the Yarra River catchment, Australia. With Cumulative Summation test, Pre-whitening process, Mann-Kendall test, Sen's slope estimate method and concluded that there are almost decreasing trend in rainfall for this region except January and June. Mondal et al (2014) also documented decreasing trend of rainfall in India for most

of the places. Daniel Bekele (2017) analyzed rainfall trend and variability for agricultural water management in Awash River basin Ethiopia and concluded that there is high variation in rainfall for this region. Kaur et al (2017) have studied long term rainfall trend over meteorological sub divisions and districts of India and observed that in annual rainfall 10% area of the India is showing significant increasing trend and 8% of the area of India showing significant decreasing trend. The objective of this study is to analysis temporal rainfall trend for Udaipur by parametric and non-parametric methods.

MATERIAL AND METHODS

Study area: Udaipur is one of the district of the 33 district of Rajsthan situated in the western India and is limited on the northwest by the Aravalli Range, crosswise over, which lie the regions of Sirohi and Pali. It is limited on the north east and south by Rajsamand district and Pratapgarh district. The coordinate of the Udaipur district is 24.2^0 N and 73.6^0 E and the average elevation is 335 m above mean sea level. Monthly rainfall data has been used of 39 years from 1975 to 2013. For this study, daily rainfall data were converted into the monthly rainfall data by adding the daily rainfall for all respective months.The monthly trend in rainfall analysis was done by parametric and non-parametric method both. In parametric method linear regression is used where as in non-

parametric method Mann – Kendall test and Sen's estimator method are used. Both these parametric and non-parametric method assumed there is linear trend in time series.

Linear regression: Linear regression is a parametric test and used for predictive analysis of data. Regression analysis is considered with time as the independent variable and rainfall as the dependent variable. A linear regression equation is presented as $y = nx + k$ where x is the independent variable, y is the dependent variable on x, n is the slope of the line fitted by the trend in data and k is a constant used in the equation. Linear regression assumed normal distribution in data.

Mann- Kendall test: Mann- Kendall test is a non-parametric test used to determined trend in long term series data to check data follow either positive trend or negative trend or no trend. It is the rank based test for determining statistically trends in a time series data and is not effected by outliers. In the Mann - Kendall test, a time series x_p was ranked from $p = 1, 2, …,n-1$ and another time series x_q from $q = 2, 3, …, n$, where n is the number of data points. Each data point in x_p was then used as a reference point and compared with all other data points in $x_q (q > p)$, to obtain the values of the sign for each comparison using following equation

$$\text{Sgn } (x_q - x_p) = \begin{cases} +1 & \text{if } (x_q > x_p) \\ 0 & \text{if } (x_q = x_p) \\ -1 & \text{if } (x_q < x_p) \end{cases}$$

The Mann – Kendal's statistic S is calculated using following equation

$$S = \sum_{p=1}^{n-1} \sum_{q=p+1}^{n} Sgn (x_q - x_p)$$

where n is the number of observed data point. For $n = 10$, the Mann- Kendal's statistic S is approximately normally distributed with zero mean (Mann 1945, Kendall 1975). The variance of S is calculated as

$$\text{var}(s) = \frac{n(n-1)(2n-5) \sum_{i=1}^{m} t(p)(p-1)(2p-5)}{18}$$

where, m is the number of tied groups (a tied group is a set of sample data having the same value) and t_p is the number of data points in the pth tied group.

The Mann - Kendall test statistic Z is computed as

$$Z = 0 \quad \text{if } S = 0 \begin{cases} \frac{S-1}{\sqrt{\text{Var (S)}}} & \text{if } S > 0 \\ \\ \frac{S-1}{\sqrt{\text{Var (S)}}} & \text{if } S < 0 \end{cases}$$

If the calculated Z has positive value then the trend in data is positive whereas the negative Z value shows negative trend in time series data. In a two sided test, the null

hypothesis of no trend, Howas rejected at a certain significance level if $|Z| > Z_{cr}$, where Z_{cr} is the point on the normal distribution that has a probability of exceed at a certain significance level.

San's slope estimator test: This test compute linear rate of changes in rainfall with respect to time. This test produce better result when a linear trend is present in time series data. If a trend is linear, the slope can be estimating by using this simple non-parametric test. The slope Q_i is computed as

$$Qi = \frac{x_m - x_n}{m - n}$$

Where x_m and x_n are considered as values of time series data at m and n time as m > n.

RESULT AND DISCUSSION

Rainfall characteristics: Mean annual rainfall is 20.95 mm (Table 1). The maximum average rainfall 6.51 mm with 0.002 standard deviation (SD) achieved in July month and the minimum average rainfall 0.05 with 0.008 mm with 0.008 SD in March month. During the monsoonal months (June to September) the coefficient of variance in rainfall is very low in which 0.02% in month of July is minimum whereas February shows the maximum coefficient of variance with 37.33%.

Based on linear regression: Based on linear regression method, April, May, June and July show positive trend in rainfall and January, February, August, October, November, December show negative trend while March and September months follow no trend (Fig. 1).

Based on Mann – Kendall Test: The Mann-Kendal statistical values (Z values) for different months are -0.645, -1.483, -0.168, 0.658, 0.206, 0.387, 1.277, 0.013, 0.116, -1.999, -1.329 and -0.903 respectively for January to December (Fig. 2).

Table 1. Statistical parameters for monthly rainfall analysis

Month	Rainfall, mm		
	Mean±SD	Variance	CV %
January	0.12±0.029	0.00083	24
February	0.06±0.022	0.00050	37.33
March	0.05±0.008	0.00006	15.49
April	0.34±0.009	0.00009	2.79
May	0.98±0.029	0.00083	2.94
June	3.93±0.027	0.00074	0.69
July	6.51±0.002	0.000003	0.02
August	5.19±0.002	0.000003	0.03
September	2.42±0.013	0.000164	0.53
October	0.26±0.022	0.000502	8.6
November	0.47±0.011	0.000126	2.38
December	0.12±0.029	0.000831	24

January

February

March

April

May
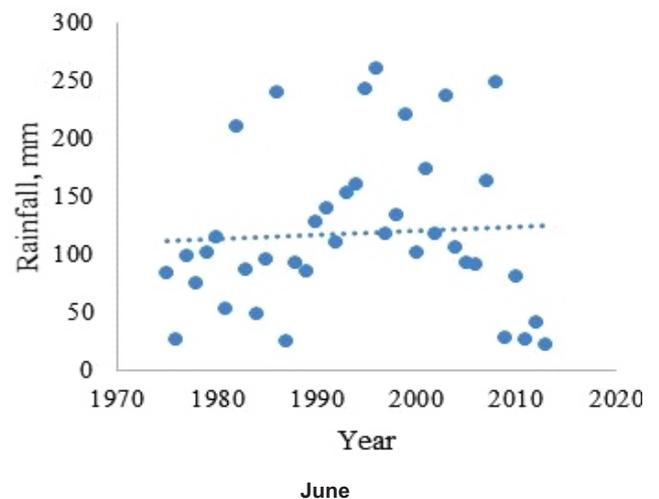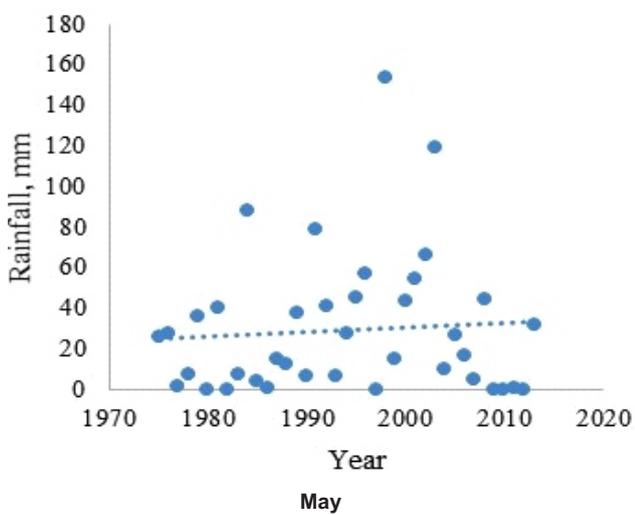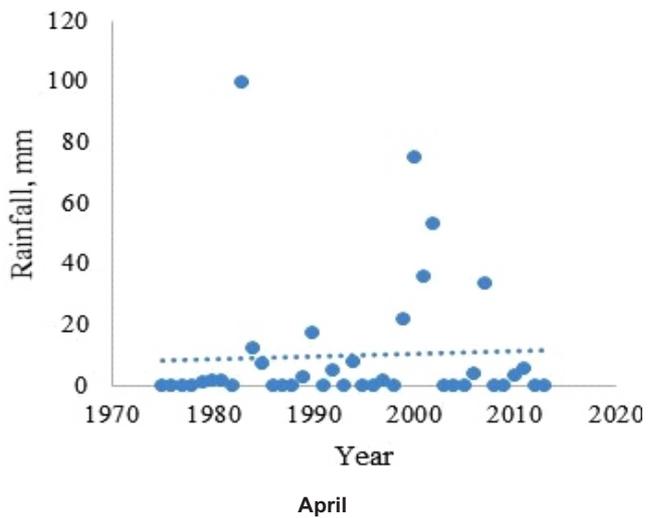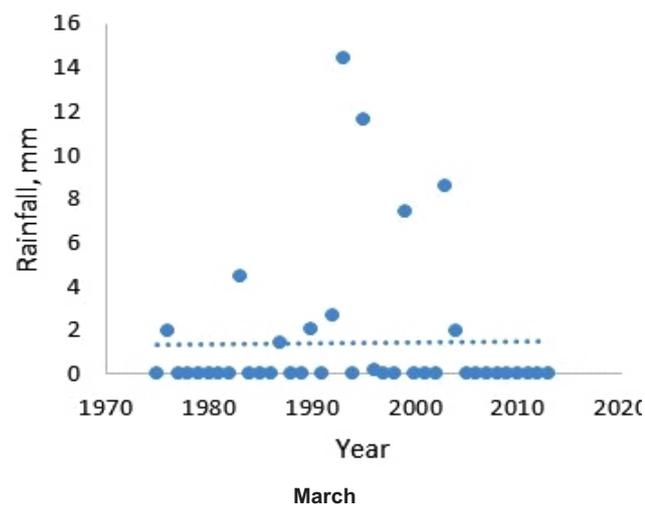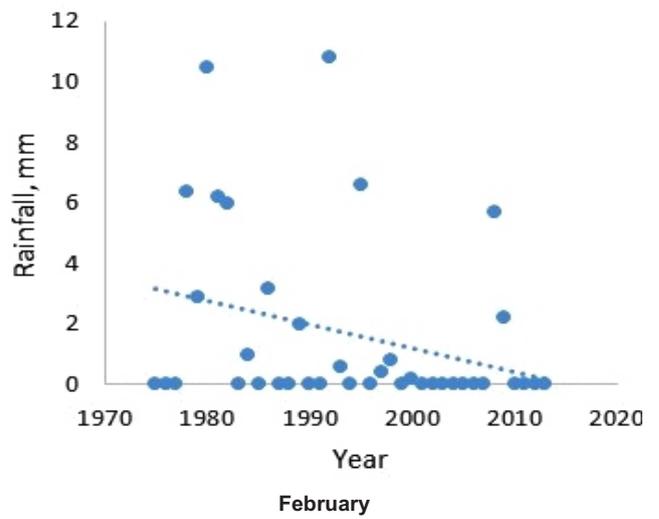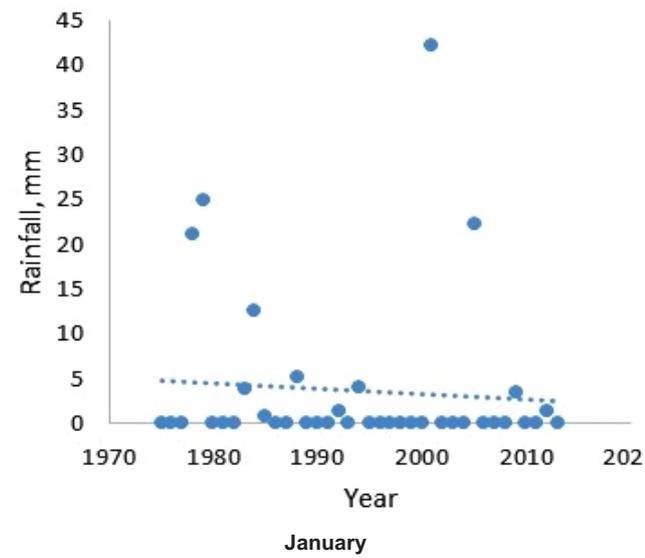
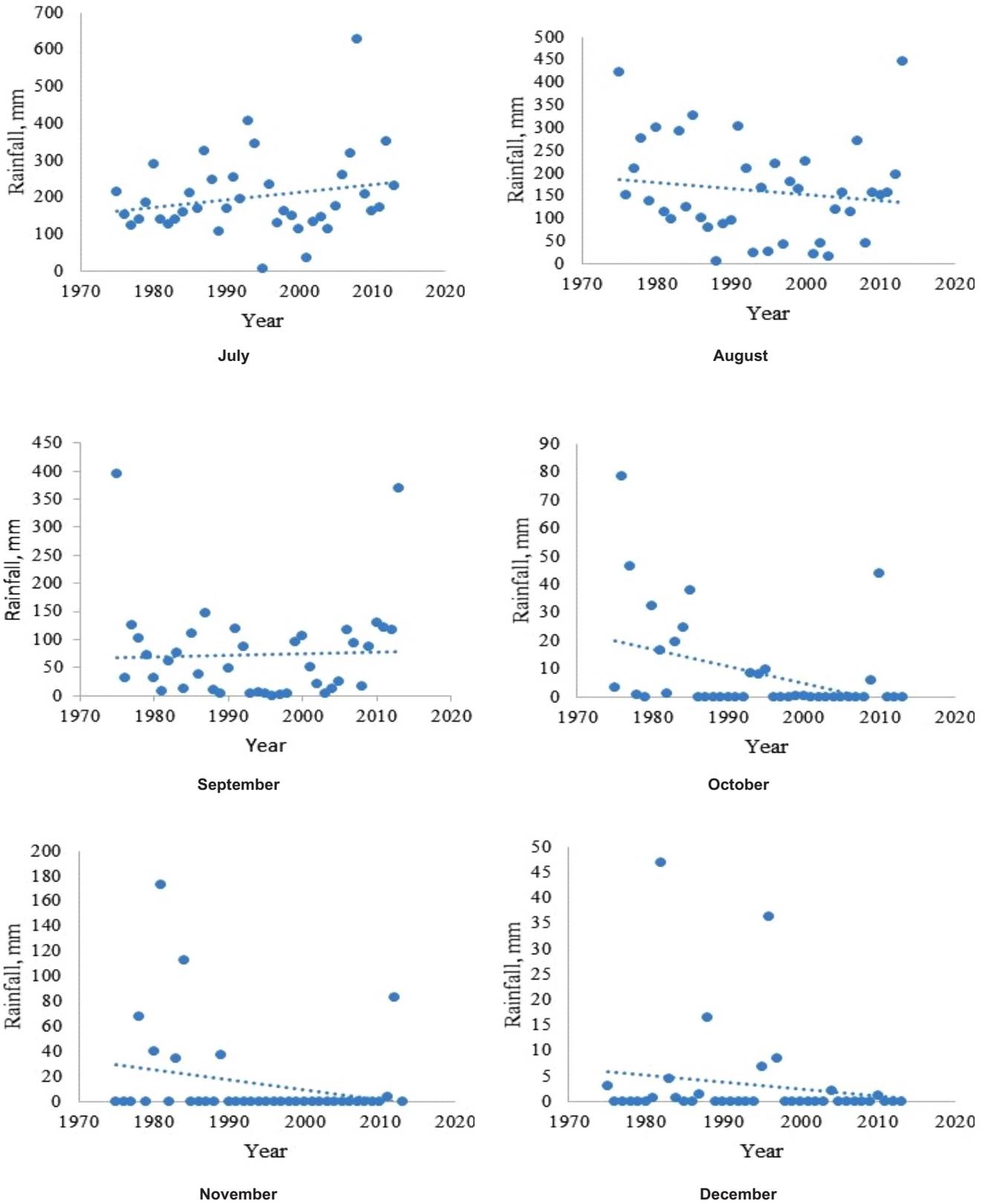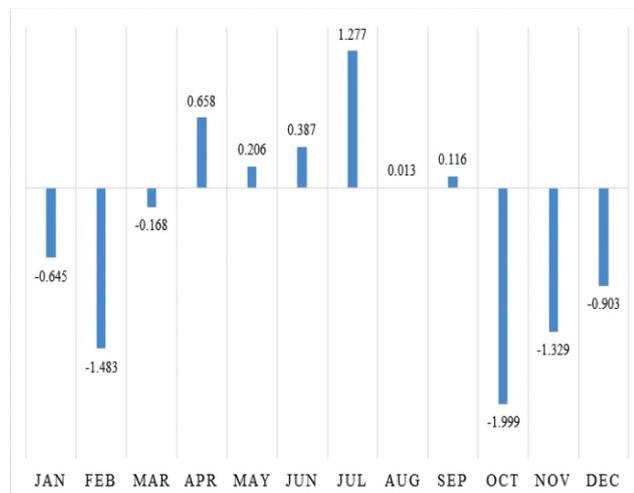
June

Cont...

Fig. 1. Rainfall trend by liner regression method during different months

Table 2. San's slope values for different months

Month	January	February	March	April	May	June	July	August	September	October	November	December
San's Slope value	0	0	0	0	0.045	0.42	1.01	-1.6	0.17	0	0	0

Fig. 2. Mann Kendal Statistic for different months

The January, February, March, October, November and December, months clearly show the decreasing trend in rainfall whereas April, May, June July, August and September months represent the increasing trend in rainfall. Among the months of negative trend October shows maximum negative and March shows minimum negative trend in rainfall. Similarly, July represents maximum positive trend, whereas August shows negligible positive trend.

Based on San-slope test: Based on san slope test May, June, July and September months showed positive trend in rainfall and August month showed negative trend in rainfall for the study period. All other months don't show any trend based on this test (Table 2). Table shows the value of San's slope for different months.

CONCLUSION

Linear regression and Mann-Kendal test shows better results in rainfall trend for all the months whereas the San's slope estimator shows result only for monsoonal months in this study. From the study, it has been revealed that rainfall trend in monsoonal months (June-September) is increasing, whereas rainfall trend in winter (November - February) is decreasing in this area. Thus, the rainfall trend detection is very helpful in understanding the rainfall pattern of Udaipur district and also beneficial for future planning in irrigation and water resource planning, flood estimation, agricultural planning, etc.

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Clonal Variability in Mango (*Mangifera indica* L.) Orchards cv. Dashehari

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Abstract: The present study was aimed to assess the intra-varietal variability of 45 Dashehari morphotypes of mango (*Mangifera indica* L.).A significant intra-varietal variability was observed for trunk girth, number of secondary branches and similarly for fruit morpho-chemical characters like fruit width, fruit length, fruit weight and peel thickness, pH of the juice, ascorbic acid, TSS and TSS:acid ratio. The highest PCV (22.46) for number of secondary branches indicating more environmental effect. Maximum heritability (98.40) and genetic advance (43.83) was for trunk girth followed by total soluble solids (TSS), TSS:acid ratio and ascorbic acid content resulting establishment of intra-varietal variability among different morphotypes of existing Dashehari orchards at mango export zone of Uttar Pradesh. High heritability and moderate to high genetic advance and narrow difference between GCV and PCV were found in trunk girth, number of secondary branches, ascorbic acid, TSS:acid ratio and total soluble solids which indicated predominance of additive gene action for these characters and these characters may be considered in heritability study for intra-varietal analysis of Dashehari mango for further crop improvement.

Mango (*Mangifera indica* L.) is a highly cross-pollinated and heterozygous plant whose performance varies with the climate which resulted in a high level of genetic diversity. Characterization and assessment of diversity is essential to utilize these unique cultivars in crop improvement programmes and also for better conservation of genetic resources that especially benefits a plant breeder in choosing proper parental materials. Effective selection of genotypes for desirable traits is determined by the estimates of heritability along with genetic advance for crop improvement study.The intra-varietal variability of few varieties of mango from India and other countries have been studied based on morphological traits and genetic markers (De Souza and Lima 2004, Rocha et al 2012). Tree and fruit morphological variation were studied for mango varieties indicating phenotypic and genotypic variation. Morphological analysis based on 17 fruit characters also detected prominent variation in the landraces Banganapalli, Langra, Dashehari and Mallika (Singh et al 2009). Since mango is an allogamous species, high genetic diversity exists within populations. Occasional sexual propagation generates intravarietal variability which could be exploited for breeding within the cultivar. Morphological characterisation is the primary step useful in identification, assessment and subsequent selection of elite forms and in mango these are the oldest and most widely used markers, where the cultivars were identified based on leaf, fruit and other physical characters (Begum et al 2014). Dashehari is an important

export variety of mango for attractive appearance, excellent taste and pleasing flavour which is cultivated in the plains of Uttar Pradesh. The parent tree is located in the Dashehari village of district Lucknow in Uttar Pradesh and commercial orchards of cv. Dashehari have been established through clonal propagation in the adjoining areas (over approximately 1000 sq km) declared as the agri-export zone for mango. However, a large variation has been observed in the fruits harvested from these orchards and brought to the markets for sale but, reduces its export potential. This led to the hypothesis that there may be an element of variation even in the clonally propagated plants of cv. Dashehari which needs to be explored and the present worked was done on his line.

MATERIAL AND METHODS

The study was conducted to establish intra-varietal variability for which three plants (25-30 years old) each from 15 different orchards of cv. Dashehari (45 trees) were selected for study in agri-export zone for mango for Uttar Pradesh. The leaves of all morphotypes were collected for study according to leaf sampling technique (Poffley 2005) and observations were recorded by using measuring scale and vernier calipers (Mitutoyo, Japan). Fruits were selected for study at full mature stage in accordance with the computational fruit maturity index for mango (Sharma and Singh 2000) (Table 2). Observations were recorded for morphological characters of fruit by digital vernier calipers (Mitutoyo, Japan). Fruit weight (g) was measured on a digital

Table 1. Variability in mango tree and leaves cv. Dashehari collected from different orchards in the agri-export zone for mango of Uttar Pradesh

Morpho types	Trunk girth (cm)	Number of secondary branches	Leaf length (cm)	Leaf width (cm)	Leaf thickness (mm)	Petiole length (cm)
DM_1	132.00	12.00	21.62	5.22	0.38	3.72
DM_2	126.17	20.67	19.52	4.50	0.29	2.67
DM_3	131.83	20.00	21.18	5.03	0.29	3.00
DM_4	136.33	17.67	20.21	5.47	0.29	3.07
DM_5	122.17	14.00	22.32	5.62	0.27	3.52
DM_6	132.17	16.00	20.30	4.93	0.26	2.62
DM_7	112.50	18.00	20.13	4.73	0.25	2.78
DM_8	120.17	12.00	22.27	4.68	0.26	2.85
DM_9	102.50	15.00	19.95	4.82	0.38	3.33
DM_{10}	145.33	13.33	21.27	5.03	0.29	3.65
DM_{11}	147.67	21.00	19.50	4.75	0.28	2.92
DM_{12}	139.17	20.00	21.72	4.67	0.27	3.93
DM_{13}	150.00	20.33	20.78	4.58	0.25	3.07
DM_{14}	148.33	29.00	20.33	5.23	0.26	3.22
DM_{15}	132.17	20.00	21.38	3.95	0.27	3.38
DM_{16}	130.67	16.33	17.45	4.87	0.27	2.75
DM_{17}	125.50	15.00	19.57	4.52	0.25	2.42
DM_{18}	132.67	19.00	21.77	5.47	0.28	3.22
DM_{19}	142.83	26.00	20.52	5.05	0.24	4.18
DM_{20}	116.50	15.33	20.47	4.65	0.24	3.93
DM_{21}	120.67	24.67	21.37	4.87	0.27	3.53
DM_{22}	138.50	22.00	21.08	5.05	0.30	2.97
DM_{23}	141.67	24.33	20.83	4.73	0.28	3.78
DM_{24}	138.17	12.00	20.50	4.47	0.24	3.12
DM_{25}	151.33	20.67	18.82	4.77	0.27	3.18
DM_{26}	149.00	20.00	20.70	5.08	0.25	2.78
DM_{27}	132.00	17.67	20.47	4.83	0.29	3.68
DM_{28}	131.00	14.00	22.55	5.43	0.26	2.93
DM_{29}	125.50	16.00	20.02	5.38	0.26	3.22
DM_{30}	132.67	20.33	22.38	4.95	0.25	3.18
DM_{31}	130.83	29.00	20.84	4.90	0.27	3.20
DM_{32}	132.17	20.33	21.08	4.92	0.29	3.07
DM_{33}	140.67	21.33	21.17	4.88	0.24	3.02
DM_{34}	142.33	22.67	18.80	4.75	0.22	3.35
DM_{35}	140.17	20.67	20.52	4.80	0.26	2.68
DM_{36}	145.50	18.00	22.22	5.08	0.25	2.87
DM_{37}	132.33	18.00	21.90	5.08	0.25	2.67
DM_{38}	144.67	14.00	22.78	4.88	0.24	4.33
DM_{39}	139.33	17.33	19.80	4.80	0.25	2.97
DM_{40}	147.50	14.67	21.30	4.98	0.24	3.03
DM_{41}	138.83	17.33	20.25	4.55	0.25	3.13
DM_{42}	133.33	17.00	20.85	5.17	0.23	2.48
DM_{43}	132.00	22.00	22.13	4.47	0.23	3.73
DM_{44}	145.67	20.00	20.03	5.42	0.21	3.53
DM_{45}	136.00	21.00	21.00	5.02	0.25	3.52
CD (p=0.05)	1.76	1.41	2.25	0.67	0.04	0.78

Table 2. Intra-variability study for fruits of mango cv. Dashehari grown at different orchards in the agri-export zone for mango of Uttar Pradesh

Marpho types	Fruit width (cm)	Fruit length (cm)	Fruit weight (g)	Fruit volume (ml)	Fruit specific gravity (g cc^{-1})	Peel thickness (mm)	TSS (^{0}Brix)	pH of the juice	Ascorbic acid (mg 100g^{-1})	TSS: Acid ratio
DM$_1$	6.48	11.00	238.83	228.17	1.05	1.74	21.09	5.25	0.31	68.74
DM$_2$	6.10	11.22	211.83	202.33	1.05	2.07	21.34	5.52	0.32	67.41
DM$_3$	5.60	11.98	248.33	231.67	1.08	2.15	20.82	5.82	0.33	64.10
DM$_4$	6.37	12.78	238.67	227.17	1.05	1.84	20.45	5.77	0.33	62.33
DM$_5$	6.17	11.35	231.83	218.33	1.06	1.95	19.90	5.98	0.33	60.68
DM$_6$	5.83	10.37	259.83	240.00	1.08	1.24	20.30	6.07	0.35	58.85
DM$_7$	6.28	10.57	205.83	202.00	1.10	2.13	18.87	6.75	0.33	58.68
DM$_8$	6.38	10.77	270.00	256.50	1.05	1.59	18.02	5.10	0.32	56.90
DM$_9$	6.80	12.12	230.67	217.50	1.06	2.44	18.67	4.52	0.32	59.92
DM$_{10}$	6.03	11.77	226.00	216.67	1.04	1.93	11.74	4.77	0.36	33.07
DM$_{11}$	5.93	12.85	262.83	249.17	1.06	1.51	13.50	5.07	0.36	38.23
DM$_{12}$	5.98	12.18	342.33	325.00	1.06	2.78	11.80	5.94	0.35	33.89
DM$_{13}$	6.85	12.75	225.17	214.17	1.05	1.88	15.74	5.50	0.30	53.70
DM$_{14}$	6.40	10.60	255.50	250.00	1.01	1.99	14.65	5.75	0.28	52.68
DM$_{15}$	6.48	12.37	231.17	220.33	1.05	2.15	14.20	4.77	0.31	47.11
DM$_{16}$	5.52	10.70	216.33	201.67	1.07	1.98	14.92	5.33	0.31	49.19
DM$_{17}$	6.18	11.17	221.17	206.17	1.07	2.02	12.29	5.80	0.32	39.23
DM$_{18}$	5.83	10.92	219.50	201.67	1.09	1.85	15.49	4.25	0.31	50.01
DM$_{19}$	5.75	11.15	235.67	222.00	1.06	1.45	14.89	4.90	0.34	43.59
DM$_{20}$	6.38	11.30	254.33	238.33	1.06	2.22	12.52	5.62	0.34	37.59
DM$_{21}$	5.97	10.83	218.83	204.50	1.07	1.90	13.75	6.20	0.34	41.08
DM$_{22}$	6.22	11.23	241.17	220.83	1.09	1.68	15.48	4.80	0.37	42.81
DM$_{23}$	6.20	10.42	233.17	216.33	1.07	1.51	15.64	5.45	0.35	45.77
DM$_{24}$	6.27	10.67	224.33	208.50	1.08	2.00	13.82	6.98	0.31	45.06
DM$_{25}$	6.30	10.53	220.67	205.00	1.08	1.72	12.99	5.48	0.34	39.02
DM$_{26}$	6.33	11.57	257.33	243.50	1.06	1.50	15.52	4.87	0.37	41.98
DM$_{27}$	6.77	11.28	223.67	209.33	1.07	1.82	12.10	4.94	0.37	33.16
DM$_{28}$	6.13	9.88	201.83	196.00	1.03	1.90	12.57	5.47	0.37	34.61
DM$_{29}$	6.23	10.97	210.00	201.00	1.04	1.80	13.75	5.67	0.33	42.35
DM$_{30}$	6.52	11.97	260.83	242.50	1.08	2.16	14.85	6.74	0.28	54.37
DM$_{31}$	5.72	9.83	191.00	175.83	1.05	1.63	12.09	6.25	0.30	40.27
DM$_{32}$	6.08	11.08	209.00	201.00	1.04	1.21	14.82	5.09	0.32	46.82
DM$_{33}$	6.45	11.13	227.00	211.67	1.07	2.07	13.57	5.57	0.35	39.32
DM$_{34}$	6.28	10.83	201.83	192.50	1.05	1.59	13.80	5.18	0.36	38.89
DM$_{35}$	6.25	10.98	229.83	215.33	1.07	1.70	15.63	6.23	0.30	53.35
DM$_{36}$	5.87	11.63	224.50	205.67	1.09	2.30	13.98	6.30	0.27	52.17
DM$_{37}$	6.67	11.50	256.17	240.00	1.07	1.75	13.22	5.25	0.29	46.69
DM$_{38}$	6.45	11.15	289.67	271.50	1.07	1.85	12.67	5.85	0.31	41.54
DM$_{39}$	6.58	11.65	236.00	223.17	1.06	2.11	13.55	5.28	0.31	44.44
DM$_{40}$	6.42	10.98	243.83	224.17	1.09	1.81	15.95	5.08	0.33	49.37
DM$_{41}$	6.97	11.20	247.33	231.83	1.07	1.60	15.63	5.95	0.32	49.16
DM$_{42}$	6.13	10.98	246.83	230.00	1.07	1.51	12.30	5.02	0.34	36.16
DM$_{43}$	6.30	11.02	208.50	190.00	1.10	2.16	13.24	5.22	0.34	39.18
DM$_{44}$	6.62	11.63	222.67	209.00	1.07	1.71	15.60	6.02	0.34	46.58
DM$_{45}$	6.00	11.22	229.00	210.17	1.10	2.04	14.87	5.54	0.36	42.08
CD (p=0.05)	0.55	1.02	13.72	12.11	0.05	0.27	0.68	0.433	0.01	2.58

weighing balance while fruit volume (ml) and fruit specific gravity (g/cc), along with the fruit bio-chemical parameters was computed using standard procedures (Ranganna 2000). Analysis of variance using a randomized block design was done for all the characters by ICAR-SPAR (Statistical Package for Agricultural Research). Heritability was estimated according to Falconer (1989) while, GCV, PCV, genetic advance and GAM% were computed by the method as suggested by Singh and Chaudhury (1985) and Allard (1960).

RESULTS AND DISCUSSION

The significant intra-varietal variation was observed in vegetative characteristics of 45 Dashehari morphotypes of mango (Table 1). The variation on tree trunk girth ranged from 102.50 to 151.33 cm, number of secondary branches 12 to 29, leaf length 17.45 to 22.78 cm, leaf width 3.95 to 5.47 cm, leaf thickness 0.21 to 0.38 mm and petiole length 2.42 to 4.12 cm were observed in Dashehari morphotypes. Similarly, fruit width ranged from 5.52 to 6.97 cm, fruit length 9.83 to 12.85 cm, fruit weight 191.00 to 342.33 g, fruit volume 175.83 to 325 ml, fruit specific gravity 1.01 to 1.10 g/cc and peel thickness 1.45 to 2.78 mm (Table 2) as well as in fruit biochemical parameters (TSS 11.74 to 21.34 °Brix, pH of the juice 4.25 to 6.98, ascorbic acid 0.27 to 0.37 mg/100g and TSS:acid ratio 33.07 to 68.74).

Singh et al (2009) also detected prominent variation in the cultivar 'Banganapalli' based on morphological analysis of 17 fruit characters. The intra-cultivar heterogeneity of mango has been characterized mostly at the morphological level by several researchers (Singh et al 2009, Kundu et al 2018). From the study, a vision is obtained about the range of intra-varietal heterogeneity in 'Dashehari' mango conserved in farmers' orchards in the collection sites, However, GCV, PCV analysis showed the variation is very much influenced by external environmental factors rather than genetic level. The prime advantages of morphological traits are simplicity and rapid, inexpensive assays, even from herbarium specimens and other dead tissues. Differences in fruit size may be primarily due to plant vigour, competition among fruits in the inflorescence, number and size of developed achenes, differences in activity among the achenes in the production of growth material, climatic conditions, irrigation and plant nutrients. High heritability estimates for the characters indicate less influence of the environment and so there is a good scope for the improvement of these traits through direct selection (Kumar et al 2012).

There is a close difference between PCV and GCV for trunk girth, number of secondary branches, TSS, TSS:acid ratio and ascorbic acid which indicated the genetic as well as environmental control on these characters (Table 3). However, higher PCV, GCV and GAM were obtained for number of secondary branches, TSS:acid ratio, ascorbic acid and TSS. Estimates were very low for fruit volume, leaf width, fruit weight, fruit specific gravity and leaf length suggesting very limited scope for improvement of these traits through selection. Ranpise and Desai (2003) observed high estimates of phenotypic coefficient of variation and genotypic coefficient of variation in lime for number of fruits per plant, flower twig, tree volume and yield per plant. High phenotypic coefficient of variation (PCV) indicated high environmental effect upon the expression of leaf length, leaf width, petiole length, fruit weight, fruit volume, fruit width, fruit length and peel thickness which means these characters should not be considered for selection. Negligible heritability for fruit weight and fruit volume indicated that they are not governed by genetic level. Higher values of heritability indicated that either these were simply governed by a few major genes or additive gene effects even if, they were under polygenic control and therefore, selection of these characters would be more effective for improvement (Majumder et al 2012). Ranpise and Desai (2003) also observed high values of heritability for fruits per plant, average fruit weight, juice percentage, TSS and acidity. The genetic advance expressed in percent mean was very high for some of the characters, such as number of secondary branches (88.87), TSS:acid ratio (81.46) and TSS

Table 3. Estimates of genetic parameters for mango cv. Dashehari clones grown in the agri-export zone for mango of Uttar Pradesh

Characters	PCV	GCV	h^2	GA	GAM (%)
Trunk girth (cm)	7.78	7.72	98.40	43.83	32.50
Number of secondary branches	22.46	21.69	93.20	16.70	88.87
Leaf length (cm)	6.74	0.15	0.10	0.00*	0.00*
Leaf width (cm)	4.27	0.64	2.30	0.02	0.40
Leaf thickness (mm)	6.28	4.05	14.50	0.02	7.69
Petiole lengths (cm)	6.07	0.99	2.70	0.02	0.62
Fruit width (cm)	7.84	0.51	0.40	0.00*	0.00*
Fruit length (cm)	7.96	0.28	0.10	0.00*	0.00*
Fruit weight (g)	5.11	0.01	0.00*	0.00*	0.00*
Fruit volume (ml)	4.80	0.01	0.00*	0.00*	0.00*
Fruit specific gravity (g/cm³)	5.13	2.97	33.50	0.08	7.54
Peel thickness (mm)	13.66	3.00	4.80	0.62	33.33
TSS (°Brix)	18.27	17.84	95.30	11.20	73.87
pH of the juice	10.38	7.79	56.20	1.56	28.20
Ascorbic acid (mg/100g)	8.09	7.71	90.90	0.10	31.25
TSS:acid ratio	20.33	19.76	94.50	38.41	81.46

*Very negligible

(73.87). It might be due to high range of variation among the genotypes. The characters, such as peel thickness, trunk girth and ascorbic acid expressed moderate genetic advance. However, the highest heritability and genetic advance was recorded for trunk girth, thus, suggested for effective selection of these characters for further crop improvement programme.

CONCLUSION

The study concluded that trunk girth, number of secondary branches, ascorbic acid, TSS:acid ratio and total soluble solids characters having high heritability as well as moderate to high genetic advance and narrow difference between GCV and PCV indicated predominance of additive gene action and thus, these characters may be considered for intra-varietal analysis of Dashehari mango for further crop improvement.

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Factors Effecting Change in Rice Production Practices and Technologies among Smallholder Farmers in Kamwenge District, Uganda

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Abstract: This study unraveled the factors effecting change in rice production practices and technologies among smallholder farmers in Kamwenge district, Uganda. A longitudinal study involving six focus group discussions and 100 semi-structured interviews were conducted in August 2015 to February 2016, and later 21 key informant interviews in June 2018 to generate data from farmers and local extension staff. While thematic-content analysis was used for the qualitative data, SPSS v.18 was used for quantitative data analysis. Our findings indicate that changes in rice production practices and technologies were mainly influenced by a combination of factors including technological advancement, farmer ambitions, power dynamics, edaphic and climate variations, access to extension advisory services, use of Information and Communication Technologies (ICTs) such as video and information sharing among farmers. Informants approved the use of video as an important extension service delivery tool in equipping farmers with the necessary knowledge and skills that are key in influencing change in rice production practices and technologies. Video also triggers discussions among participants during and after the show through various knowledge sharing mechanisms with serious implications on change in production practices and technologies. As policy and decision makers attempt to reform extension delivery mechanisms, there is need to acknowledge that video alone cannot produce a desirable change in production practices and technologies among farmers but play a complementary role to other extension approaches in efforts to effectively disseminate relevant information.

Keywords: Learning, Production practices and technologies, Video participants, Videos, Uganda

Smallholder farmers in developing countries need appropriate technologies to enhance agricultural productivity (Bell 2015, Ssebaggala et al 2017). Videos are recognized for promoting change in production and post-production practices where farmers get together to view and later put in practice what was observed (Bentley et al 2013, Cai and Abbott 2013). Van Mele (2006) pointed out that since 2002, Africa rice has produced farmer-friendly rice videos by interacting with farmers where they are able to share their experiences with fellow farmers in order to facilitate change in production practices and technologies (Bentley et al 2011). In Bangladesh, a concept of videos resulted in transfer of technology to farmers (Van Mele et al 2010, Karubanga et al 2017a, Gramzow et al 2018). However, the context in which farmers learn, produce and how they are organized and managed are presumed to affect the choice of the production practices and technologies. For example, prior knowledge about production practices and technologies, leadership, prevailing extension service delivery, farmer expectations, information sharing and use of audio-visual tools are likely to influence the choice of practices employed by the farmers (Bentley et al 2015).

In Uganda, since 2007, the Sasakawa Global 2000 (SG 2000), a non-government organization (NGO) piloted use of videos in 14 districts across the country in four regions, Western (Kamwenge and Ntungamo), Central (Mukono, Buikwe and Wakiso), Eastern (Jinja, Kamuli, Namutumba and Tororo) and Northern (Lira, Dokolo, Apac, Oyam and Gulu). In Kamwenge district the rice videos were shown from 2007 with the intention of promoting better rice production practices among smallholder farmers and later stalled in 2010. Even without external support from SG 2000, farmers produced rice based on the information got from the videos and continuously learn from each other through various knowledge sharing mechanisms. Karubanga et al (2016a, 2017a) basically focused on the farmer learning about rice production practices and technologies through video-mediated extension approach with limited focus on factors that trigger change in the rice production practices and technologies from the perspective of farmers. Thus, this paper focuses on unraveling the factors effecting changes in rice production practices and technologies from the perspective of video participants with particular focus on the potential of video in triggering these changes.

MATERIAL AND METHODS

Study area and design: A longitudinal study was conducted in Mahyoro sub-county in Kamwenge district, Uganda. The district was selected for this study because SG 2000 showed videos there from 2007 to 2010 with the aim of enhancing change in rice production practices and technologies. The study was conducted in eight purposively selected villages within the same sub-county (Fig. 1). The villages were purposively selected because it is where the video participants that were recorded in the register came from. The villages were also selected by census, taking all those that were in the records of the association. The study employed a qualitative approach relying mainly on group interviews of the smallholder rice farmers who were targeted by SG 2000 in the sub-county. To gain more quick understanding of the factors fostering change in rice production practices, a longitudinal study was conducted by following up and interviewing the respondents.

Sample selection: About 100 video participants were selected by taking all those whose names appeared in the records of Mahyoro Rice Farmers Association (MARFA). Out of these 100 video participants, a total of 71 men and 29 women (Table 1) respectively were contacted to gain their insights about the factors that influence change in the rice production practices and technologies. A total of 48 Focus Group Discussion (FGD) participants were purposively selected from a list containing 100 video participants following the farmers' experience in rice production as guided by local extension staff. The selection of FGD participants was based on gender and the villages where participants came from. Out of 48 FGD participants, 19 were men and 29 were women (Table 1). More women were selected for FGDs because of their involvement in rice production. Together with the chairperson of MARFA, the video participants were sorted in alphabetical order of the names using the attendance lists to avoid double selection in case they registered twice. Following the registers of the association, FGD participants were selected per village as indicated in Table 1. Notably, in five villages characterized as being distant from the association such as Rwentuma, Buhindagi, Kitonzi, Katanga and Burembo registered low attendance of 1-2 video participants (Table 1). All the participants from these villages with low attendance were purposively selected for FGDs. In June 2018, a follow up study was conducted whereby 21 key informant interviews were held with purposively selected participants including 16 rice farmers and five local extension staff (those who organized and managed video shows). These interviews were conducted to clarify some of the key issues that emerged in the focus group discussions regarding the factors that influence change in the

Table 1. Number of FGD video participants per village (n=48); Individual interviews (n=100)

Village	Number of men	Number of women
FGD participants		
Rwetuma*	1	1
Buhindagi*	1	1
Kitonzi*	0	1
Burembo*	0	1
Katanga*	1	1
Kitomi	3	5
Karere	7	9
Kyendangara	6	10
Sub-total	19	29
Individual and key informants		
Individual interviews	71	29
Key informant interviews	14	7
Sub-total	85	36
Totals	104	65

Source: MARFA registers, FGDs = Focus Group Discussions,*Villages with low attendance of video participants

rice production practices and technologies. The farmers were purposively selected because during the FGDs they exhibited vast knowledge and experience about the factors that enhanced change in rice production which required a follow up as well as observing the changes in the way they produced rice.

Data collection methods: Various methods were used to collect data from the informants including focus group, individual, and key informant interviews as well as field observations. For example, six FGDs were conducted in above stated eight purposefully selected villages. Some of the key issues that were discussed were mainly related to how the video enhanced learning about new rice production practices and technologies. In particular, the focus of the interviews was to understand how the various factors influenced change in the rice production practices and technologies. The factors assessed were related to farmers' knowledge about rice before viewing the video, farmers' ambitions, technological advancement, power dynamics, edaphic and climatic related factors, extension service delivery and the influence of information sharing. These factors were arrived at during the analysis stage of the data that were collected from the FGDs. Semi-structured individual interviews were also conducted to ascertain the proportions of changes in the key aspects of rice production practices and technologies. To complement the FGD and individual interview findings, 21 field observations were made to ascertain the extent to which video participants during key informant interviews implemented rice production practices and technologies.

Data analysis: The qualitative data generated through FGDs, field observation and key informant interviews were analyzed by applying content analysis and coding through extracting and relating information on the factors that influence change in rice production practices and technologies. The qualitative contextual data analysis was done in the field during and after data collection process. This minimized the loss of meaning of video participants' explanations. It also involved writing, re-writing, re-visiting the data and verifying the findings with the respondents before making conclusions. Quotes were used to support the narrative description and explanation of the study variables. Quantitative semi-structured individual interview data were entered in the SPSS 18.0 version to generate percentages on the key aspects of rice production practices and technologies.

RESULTS AND DISCUSSION

Farmers' knowledge about rice: Farmers' knowledge and awareness about rice and the associated practices is one of the key triggers that fostered changes in the rice production practices and technologies. Our findings indicate that, before 1998, most farmers did not know about rice and the associated production practices and technologies. Prior to the introduction of videos by MARFA, rice was first heard

being grown in the neighboring districts of Kasese and Bushenyi. During the FGDs, participants revealed that rice production in Mahyoro sub-county of Kamwenge district started in 1998 and farmers were using primitive methods to produce rice (Karubanga et al 2017b). Initially, farmers in their respective villages were involved in growing maize, millet, beans, soya beans, cassava and groundnuts for both income and food (Karubanga et al 2017a). Cotton was also grown mainly by men as a source of income while millet and ground nuts were largely grown by women for the same reason. Rice was only seen being served at various social functions. Kyendangara and Karere FG participants pointed out that, in late 1990s rice was mainly seen in images of published papers and books with limited knowledge about how it could be grown. Rice was believed to be the food for the whites or Indians as well as for the rich people. Because of this perception, adoption of rice production and associated practices occurred gradually in the respective villages as farmers took time to experiment rice production and assessing its profitability (Bentley et al 2015, Karubanga et al 2017b). Principally, farmers learnt about rice production from their fellow farmers because they lacked support from extension agents and farmer organizations to foster learning about new rice production practices. This lack of external support made farmers to depend on the experiences of their
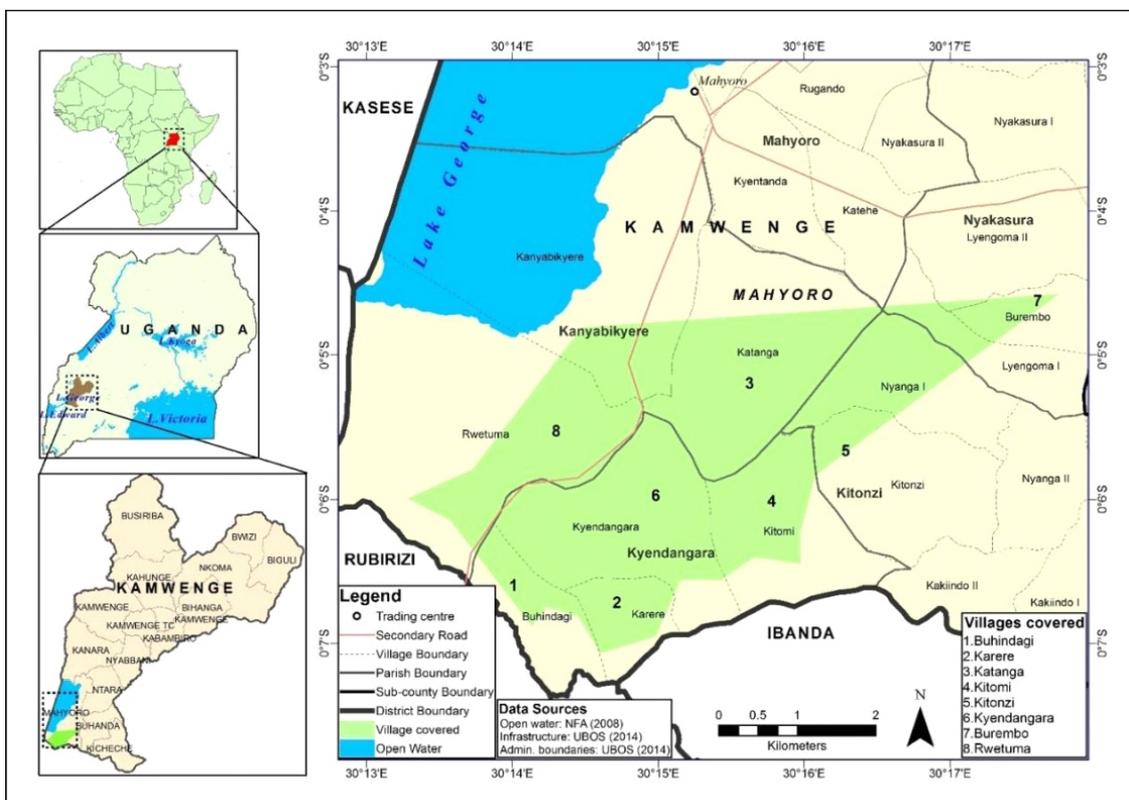

Fig. 1. Villages selected for the study in Mahyoro sub-county, Kamwenge district

fellow farmers. FG participants noted lack of prior knowledge about rice production and post-production practices and technologies as a key contributor to poor quality and quantity of rice. For example, one of the male FGDs in Karere village revealed that in 2001 farmers in the area knew little about rice and its associated production and post-production practices, thus leading to low rice productivity.

Farmers' expectations about rice: Farmers' ambitions about rice as a major source of income and food security was cited during the FGDs and individual interviews as a major motivational factor that led to diverse changes in rice production and post-production practices. Majority of the respondents (41%) grew rice as a primary source of income while 36% grew rice for food and 23% for seed. In order to enhance rice production, farmers had diverse expectations that would boost rice production from SG 2000 through MARFA regarding access to free or subsidized production inputs and information in order to influence change in rice production practices and technologies. The 20 per cent of farmers expected the availability of free or subsidized inputs and equipment for rice production while 31 per cent expected more information about agricultural markets from SG 2000. Others expected information from SG 2000 staff on quality of rice and information about crop problems that are likely to affect rice productivity. Because of their higher ambitions, the farmers forged mechanisms geared towards improving rice production (Danielsen et al 2015). Farmers were able to form groups in order to access advisory services and support from the association such as access to clean rice seed. The emergence of farmer groups also led to timely performance of rice production activities such as planting, weeding and harvesting.

During FGDs, farmers described rice as the most profitable crop. Because of this belief, farmers sought for support from the association to provide them with free production inputs such as seed, equipment and fertilizer to enhance rice productivity. The association initially provided these inputs freely to farmers that belonged to the association and later ceased because the numbers were growing bigger and could not sustain the demand. Conversely, to ascertain the profitability of rice, farmers compared costs involved in rice production with that of maize and cotton. The farmers considered the costs of rice production in terms of expenses in land preparation, securing the seed, and labor requirements alongside the existing market prices (Ssebaggala et al 2017). The farmers who managed to meet the production costs especially those attached to the association reportedly exhibited better production practices and technologies as they were exposed to advisory services from SG 2000 staff. Besides, the relative

costs involved in producing rice, FG participants concluded that rice had more economic returns than maize and cotton. Because farmers had developed higher expectations from growing rice, they changed their cropping systems by abandoning some traditional crops characterized as being low in terms of profitability such as cotton and millet resorting to rice production.

Power dynamics: Discussions with the focus group participants revealed that before the formation of MARFA, farmers in Mahyoro sub-county struggled to access some of the social services such as trainings and production inputs. Farmers mainly depended on the experiences of their fellow farmers in order to change the production practices and technologies (Bentley et al 2014, Karubanga et al 2017a). In late 1990s there was no champion to help farmers to have access to the social services meant to enhance the way farmers produce. The use of traditional technologies was partially attributed to lack of a focal person to link farmers to services providers. It was thus problematic for farmers to take up new practices and technologies without technical support. To avert the situation, in 2001 MARFA was formed to help farmers access some of the social services. The leadership of the association was composed of nine committee members who collectively worked with the farmers to enhance rice production in the area. FG discussions and key informant interviews revealed that good leadership from the chairperson relatively influenced farmers' access to social services. For example, FG participants pointed out that the trainings which farmers received from the association was attributed to the efforts and commitment of the chairperson. Farmers described the chairperson as a trusted and committed person with high reputation that made the association grow. Farmers were able to access new technologies that influenced the way they produced rice (Nijbroek and Andelman 2016). For instance, they had access to rakes, threshers, milling machines, herbicides, pesticides and fertilizers. In their opinion, farmers commented that the use of these technologies helped them to enhance the quality and quantity of rice. On the contrary, in 2010, conflicts among the committee members over leadership positions emerged. FG participants commented with concern that the emergence of conflicts partly contributed to the standstill of key organizational activities such as trainings through demonstrations, video shows, exchange visits and field days which were key in enhancing knowledge about rice production practices and technologies. In addition, bulking and collective marketing of rice by the farmers stalled. In the same year, a three-year SG 2000 project that supported farmers with training through video shows also ended with serious implications on farmers'

ability to access information on improved rice production (Karubanga et al 2016a). Following the decline of the association, farmers resorted to old ways of rice production such as using home-saved seed and planting rice by broadcasting. There was no more application of chemicals by farmers because they were expensive to buy (Karubanga et al 2017a, Ssebaggala et al 2017). In their opinion, resorting to old ways somehow affected the quality and quantity of rice. As a result, this forced farmers to change their cropping systems. Female farmers, in particular, opted for their traditional crops such as millet, ground nuts and sweet potatoes which they grew for both cash and source of food while some men resorted to producing maize purposely for income generation. In their opinion, Kitomi and Rwentuma FG participants pointed out that traditional crops do not require use of expensive chemicals and are not much susceptible to changes in climate.

Edaphic and climate related factors: The general environment within which farmers produce rice is an important factor that influence change in rice production practices and technologies (Martins et al 2014, Ssebaggala et al 2017). Holding discussions with video participants in their respective villages revealed that changes in rice production and post-production practices were due to environmental and climate related factors. For example, one of the FG participants from Buhindagi village mentioned that in 1990's the soils were still fertile and farmers never applied fertilizers and other related chemicals like herbicides and pesticides because the weeds, pest and disease related problems were not prevalent. However, since 2001 the soils became exhausted with high invasion of resistant weeds like couch grass, nut grass and star grass. Pests and diseases such as rice stalk borers and root rot respectively became prevalent; affecting the yield and quality of rice. In 2004, farmers started using fertilizers, herbicides and pesticides to regain soil fertility, control weeds and pests and disease respectively. Other farmers practiced crop rotation because they lacked finances to buy expensive chemicals (Karubanga et al 2017a). In their opinion, FGD participants believed that crop rotation enables soil fertility regeneration. However, this only applies to farmers with three or more acres of land (also see Karubanga et al 2017b). For example, discussions with FG interviewees from Buhindagi, Burembo, Katanga, Kitonzi and Rwentuma villages revealed that farmers rotate rice with beans and ground nuts to generate soil fertility and break the pest and disease life cycle. Individual interviews showed that about 46% of farmers with small pieces of land (about one or half an acre) hire fertile land to enable them produce higher yields of quality rice.

In particular, climate changes characterized by drought threatens rice production among farmers (Mabe et al 2014, Ssebaggala et al 2017). Majority of the rice farmers (95%) described the effects of drought as being disastrous to rice production. For instance, drought causes stunted growth, drying and total failure of rice leading to low and poor quality of rice (Ssebaggala et al 2017). In response, farmers started growing alternative crops which they believed to be fast growing and tolerant to drought such as beans and maize. These were mainly grown in the first season associated with the longer dry spells (December-March). Rice is grown in the second season (July-early December) because during this time farmers experience high rainfall intensity. This helps farmers to counteract the effects of drought. Generally, changes in rice production practices have been attributed to variations in soil and climatic conditions. FG participants recommended that provision of free or subsidized inputs by local agencies and government would help farmers to combat the soil and climate related challenges, thus enhancing both the quantity and quality of rice produced.

Extension services delivery: Conversations with FGD participants revealed that between 1990's and late 2004, farmers in Mahyoro sub-county had not yet exhibited proper rice production practices and technologies because they were not yet fully exposed to extension services. This was attributed to the way extension services under recent National Agricultural Advisory Services (NAADS) were organized and operationalized (MAAIF 2016, Danielsen et al 2015). Rwentuma and Buhindagi FGD participants pointed out that at that time NAADS services were irregular and unreliable. For example, individual interviews indicated that NAADS through its extension staff reached a small proportion of rice farmers (6%). As earlier stated, because of lack of adequate extension service provision from NAADS the survey findings showed that farmers mainly relied on their fellow farmers (21%) for information in order to learn about new practices and technologies in rice production (also see Karubanga et al 2017a). Farmers mainly acquired trainings in beans and maize production, the major enterprises that were selected by farmers under NAADS program. Besides being the most profitable enterprise, farmers never selected rice under the recent NAADS program because it was a new crop in the area and easily affected by drought.

Despite the existence of NAADS since 2001, farmers in Mahyoro sub-county still lacked the necessary knowledge and skills in rice production and post-production practices and technologies. This partly was attributed to inadequate human resource capacity coupled with inadequate transport facilitation thus limiting wider geographical coverage. There were no motorcycles provided to NAADS staff to reach all the farmers in the sub-county. Only easy to reach farmers were

put 'be

covered. The chairperson of MARFA further commented with concern that some farmers traveled to the sub-county headquarters located far away to consult the extension worker. In his opinion, the chairperson recommended that there was need for approaches that can bring farmers together for collective on-the-spot information access such as through the video. The video was described as a cheap, reliable tool providing on-the-spot information to many farmers at one point in time (Okry et al 2014, Karubanga et al 2016b). In 2007, SG 2000 introduced the use of video developed in Benin to train and capacitate farmers in proper rice production and post-production practices. Working in liaison with MARFA leadership, SG 2000 staff showed the English version videos to farmers on predetermined Fridays, starting at 7:00 pm to 10:30 pm at MARFA offices to promote better rice production practices and technologies among farmers over a period of three years (Karubanga et al 2016b). The video covered all the eleven steps necessary in rice pre-production and post-production practices and technologies. In their opinion, FG participants approved the video as an important tool in fostering learning about new technologies and change in practices among rice farmers (Van Mele et al 2016, Karubanga et al 2017a). Some of the new practices which the FG participants pointed out as key lessons learnt included: timely land preparation, timely planting of clean seed, timely weed control, drying rice on tarpaulins, timely fertilizer application and finally timely harvesting of rice to avoid pre and post-harvest losses. Individual conversations with video participants revealed that video is an important tool in triggering change in rice production practices and technologies because it is able to demonstrate to the viewers the necessary steps chronologically (Bandura 1997, MacGregor 2007, Bede 2016). Key informants and FG participants appreciated the role played by SG 2000 in showing the videos that provided them with necessary knowledge and skills that enhanced learning about proper rice production practices and technologies. However, they recommended that for more effective service delivery and change in rice production practices and technologies, the use of video needs to play a complementary role to the conventional extension. This is because more technical support is needed by farmers from extension staff besides viewing the video as affirmed by Karubanga et al (2016a).

Technological advancement: Focus group discussions revealed that initially, rice farmers employed traditional technologies to grow rice. Planted Superica variety which was procured from their fellow farmers. This variety was characterized as having low weight, susceptible to birds and took about six months to mature. Farmers were also not using fertilizers, pesticides and herbicides. Planting was mainly done by broadcasting rice and the knife was used during harvesting to cut only mature tussles. Rice was threshed by beating using sticks and the mortar and pestle were used to mill rice. In addition, individual interviews revealed that 92% of the farmers initially dried rice on bare ground. In 2007-2010, through the efforts of the association, the emergence of new technologies in rice production occurred. These new practices and technologies triggered changes in the way farmers produced rice. There was an introduction of new rice varieties such as NERICA 4 and 10 that were high yielding, resistant to diseases and took about 3-4 months to maturity. Planting of rice was done using forked rakes, farmers started using chemicals such as fertilizers, herbicides and pesticides. The sickles were used to harvest rice, milling of rice was done by modernized millers located at the association. Farmers used one thresher provided by the association to thresh their rice which was later dried on tarpaulins. Holding discussions with MARFA chairperson revealed that the use of these new technologies by farmers led to enhanced quality and quantity of rice. The planting of new varieties in lines using the forked rake coupled with the use of chemicals enhanced crop yields. In addition, use of milling machines, sickles and threshers quickened the accomplishment of rice production processes and activities. The sickles and threshers respectively quickened the harvesting and threshing activities. Furthermore, the use of tarpaulins by farmers ensured the production of quality rice without stones and sand. Overall, such technological advancements partly explain the kind of changes in the rice production practices and technologies among rice farmers.

Influence of video on rice production practices and technologies: Individual interviews with video participants revealed that majority of the rice farmers (94%) regarded the information got from the video as being useful in fostering change in rice production practices and technologies. About 73% of video participants implemented the practices and technologies viewed in the video and approved the information they got as helping in fostering change in rice production practices and technologies. FG participants stipulated that the video clearly showed the eleven activities involved in rice production. Field observations revealed that, farmers were able to select seed for planting. Seed selection was done during harvesting where only clean and uniform varieties were picked to prevent the mixing of varieties. This practice also allowed for more viable and clean seed to be selected for the subsequent seasons. Analysis of multiple responses revealed that about 40% of the farmers were able to timely manage the weeds. Some farmers exhibited capacity to plant rice in lines (17%). Other changes were observed among the farmers trying to use Butanyl 70 to

control weeds (16%), 10% tried to plant different rice varieties such as NERICA. About 8% of the farmers were drying rice on tarpaulins and 6% applied artificial fertilizers to improve on soil fertility. Only three farmers in Rwentuma village were able to irrigate their rice fields because they had access to water. While FG participants attributed the changes to efforts of SG 2000 in showing rice videos to farmers, the chairperson of the association pointed out that the changes were to some extent due to farmers gaining information from other sources such as fellow farmers, leaders and extension agents. Overall, SG 2000 rice videos coupled with demonstrations allowed farmers easy acquisition and understanding about the new knowledge and skills that enabled farmers change in the way they produced rice.

Conversely, in an attempt to implement the practices promoted via videos and other sources of information, farmers were faced with vast challenges. Particular challenges associated with the video was the use of more technical language "English" to document the farmers during filming process. FG participants pointed out that the use of technical language limited their understanding of the promoted practices and technologies. This partly explains why particular farmers especially the less educated did not apply the recommended practices and technologies and resorted to the old ways of producing rice. Key informants recommended documenting local farmers for easy understanding of the information, identification and adaptation of the acquired practices and technologies. The process of acquiring information about the use of agricultural inputs and ability to acquire them is a major concern among farming communities (Danielsen et al 2015). Focus group discussions identified other challenges which farmers faced in implementing what they saw in the video. The identified challenges included: lack of access to clean seed for planting, lack of equipment (sickles, threshers, milling machines and tarpaulins), and chemicals (pesticides, herbicides and fertilizers), and inadequate technical knowledge and skill in chemical mixing and use of a thresher. The lack of these production inputs had a direct and/or indirect influence on adoption of technology. In other words, the seed sold in the local agro-shops was mixed and did not meet the market demands such as uniform grains. Field observations revealed that some farmers were harvesting rice using knives, threshing using sticks and drying rice on bare ground. Some farmers resorted to planting home-saved seed while others secured loaned seed from their fellow farmers. Thus, video participants recommended the government through local agencies to provide free or subsidized production inputs to ensure effective change through implementation of the recommended practices/ technologies.

Table 2. Influence of video use on change in rice production practices and technologies

Practice and technology	Percentage
Timely planting	40
Line planting	17
Timely weed control	16
Planting diverse rice varieties	10
Fertilizer application	6
Drying rice on tarpaulins	8
Irrigating rice fields	3
Total	100

Source: Survey data, 2016

Information sharing: Change in rice production practices and technologies are also influenced by sharing of information among farmers. Focus group participants pointed out that information sharing is one of the key triggers fostering change in rice production practices among rice farmers. Farmers had diverse mechanisms through which they shared information among themselves and the extension staff. Individual interviews revealed that farmers sought information from various sources in order to change. Some of the mechanisms which farmers used to share information about rice, and its related practices and technologies included: i) consulting fellow farmers; ii) consulting group leaders; iii) consulting local extension workers; iv) holding discussions at the demonstration sites; v) through group and community meetings; vi) attending field days; viii) viewing video and ix) through songs and drama. The farmers shared information with fellow farmers when they visited each other at their respective homes and/or fields for purposes of adapting the acquired knowledge and experiences regarding rice production practices and technologies. Others shared information while performing home-based or group-based garden activities like planting, weeding and harvesting rice. In their discussion farmers focused on how well and when the practices are being implemented.

Regarding the effectiveness of the video to influence change in rice production practices and technologies, farmers preferred video shows because they were able to see and hear what was being demonstrated. The only challenge was that the people talking in the video were foreign (from Benin) to the viewers. They also suggest that use of video to influence change in the way rice is produced should be coupled with demonstration sites, field days and exchange visits to allow video participants an opportunity to practice and observe the technologies viewed in the video. In particular, FG participants deemed the video as important tool in triggering discussions among the participants during

and after the show. It is a tool that convinces and motivates viewers to try out the best practices and technologies being demonstrated (MacGregor 2007, Bentley et al 2015). FGD and individual interviews with video participants described video as effective because of its positive attributes that enhance farmer learning and change such as clarity of images, ability for farmers to use visual and audio senses, attractiveness of images as well as ability to enhance memory of farmers. In their opinion, informants believe that these attributes could have contributed to the changes in rice production practices. In addition, informants said that holding guided discussions with fellow farmers after the video show allows for comprehension of the messages communicated in the video. FGDs revealed that interactive learning never occurred in a video hall as farmers were busy viewing the video. They believed that learning mainly occurred outside the video hall as they discussed and implemented what was shown in the video. They commented that changes in rice production practices cannot be reflected while viewing the video but can be exhibited when the farmers try to implement what they have seen (Danielsen et al 2015). Thus, the video mainly triggers discussions among the video participants during the viewing and interactive learning occurs after when they discuss and share their experiences. For example, FGD participants added that learning took place later after the video show when farmers started working together and sharing experiences among themselves on how to implement what they had acquired.

CONCLUSION

This study unraveled the factors effecting change in rice production practices and technologies among smallholder farmers in Kamwenge district, Uganda. Our findings indicated that change in rice production practices and technologies was mainly influenced by a combination of factors including technological advancement, farmer ambitions, power dynamics, edaphic and climate variations, access to extension advisory services, use of Information and Communication Technologies (ICTs) such as video and information sharing among farmers. Among various contributing factors, the use of video proved to be key in triggering change in rice production practices and technologies through fostering learning as it elicits discussions that lead to critical reflection and sharing of experiences among participants. The videos enhance uptake of new practices and technologies leading to high rice yields. As policy and decision making body attempts to re-formulate the extension delivery, efforts have to be made to integrate videos into the existing mode of extension delivery in order to produce desirable and adaptive changes. Thus, in

the current drive towards reforming extension services in Uganda, video is a promising option that triggers change in practices and technologies among rice farmers and those involved in other agricultural related enterprises. It is also known for providing the large audiences with better knowledge about production practices, especially if they are taken close to the farming communities. Video as a medium is suited for the transmission of information, knowledge and skills meant to change the way farmers produce, particularly those with low literacy levels. However, this requires a more holistic extension approach that supports effective use of video to equip farmers with new knowledge and skills geared towards ensuring more contextualized change in production practices and technologies.

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Utilization of Agri-horticultural Crops/Wastes for Making Dry and Value-added Products to Generate Employment

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Abstract: The present investigations apart from cultivated flower crops and native flora, the agri-horticultural crops/waste like maize, bajra, sorghum, cotton, sesamum, linseed, wheat, coconut, leek, sponge gourd etc were utilized for making dry flower products like dry flower arrangements, sticks, maize sheath dolls, greeting cards, dry flower wall-pictures, floral designs, pomanders, pot-pourries and other gift items which are in high demand today. Different dyes like fabric, indicator, food and bio-colours were used to enhance the value of dried flowers for aesthetic beautification and product diversification. The findings revealed that among four different categories of dyes, fabric dye (yellow, dark green, violet and pink) and indicator dye (Brilliant Green, Eosin Yellow, Crystal Violet, Methylene Blue and Metanil Yellow) were found excellent in performance when used for dyeing bajra spikes and maize (Brilliant Green and Eosin Yellow) spathe and scored maximum for quality parameters even after ten months of storage in bajra spikes. Quality parameters in case of food dyes were medium to high at the time of dyeing in bajra and low to medium in maize spathe. Out of the bio-colours, turmeric was quite satisfactory, whereas coffee, lilium pollen and punica were very poor in performance when used for dyeing bajra spikes.

Keywords: Agri-horticultural crops, Dyeing, Dry flower, Value added products

Flowers are entwined with the social fabric of our life. But the fresh flowers have limited vase-life. The beauty of flowers can be enjoyed for a longer time with the technique of dehydration or drying of flowers. The 'dry flowers' or everlastings are rapidly gaining popularity for decoration since these are less expensive, long-lasting, eco-friendly and are available throughout the year. Dry Flowers industry has emerged as one of the most significant agro-based industry in the country which holds a special place in domestic & export market. The dry flower industry is expected to contribute a lot to the country's economy in the future, in comparison to the fresh cut flowers and live plants. From the last two decades the dry flowers are contributing about 1/3rd of the total floricultural export. In the year 2014-15 out of total floricultural export of 6.54 US dollar from India, about 5.18US dollar was contributed only by the dried flowers (Anonymous 2016). Out of the total floricultural exports, 71 per cent were comprised of dry flowers (Anonymous 2010). The dried flowers from India are exported to USA, Europe, Japan, Australia, Far East and Russia. Dried flowers constitute nearly 15 % of the global floriculture business. The dried flowers and foliage can be utilized for making a large number of value added products like greeting cards, dry flower sticks and arrangements, wall-pictures, floral designs, pomanders, pot-pourries and other gift items which are in high demand today. This business can be a source of income generation to unemployed youth, women and even the handicapped

persons. Indians are famous for their creativity and craftsmanship. People can grow/ collect the material and prepare the handicraft/ floral craft in their pastime. The agricultural crops & waste of crops like maize, sesamum, linseed, wheat, cotton. leek, cocounut etc can be utilized for making dry flower products. Although dried flowers today is a lucrative industry, yet a little attention has been given towards it.

The technology for dehydration and value-addition of a large number of cultivated crops, native flora has already been standardized in the Department of Floriculture and Landscape Architecture and a laboratory for demonstration of technology and the value-added products has been established in the Department which is acting as a role model for the students, distinguished guests and the farmers. Many NGO's, SHG's and farmers have shown interest in adopting the technology. A small cottage industry/ entrepreneurship can be started in the field of dried flower with the minimum amount of rupees 10,000. Single stick of bajra, jowar, wheat after proper treatments can fetch an amount of Rs 10-30/ stick which otherwise is not possible when we grow them as edible crops. The dried flower products fetch good returns in the market and a single person can earn from rupees 200 to 1000/day. Moreover, the dried flowers do not require very large area for cultivation. It can be started by the farmers who have limited landholdings. The dried flowers do not have the problem of storage unlike fresh flowers which are perishable

commodities. This can be a remunerative business for the unemployed youth, women folk and even the disabled persons. APEDA, GOI has also identified dry flowers as a potential item for export. Seeing the importance of dried flowers and their immense potential, there is an urgent need to disseminate the dried flower technology among the common people so that their living standard could be raised and employment can be generated.

MATERIAL AND METHODS

Agrihorticultural crops used for dry flower production:

Bajra (*Pennisetum glaucum*, Poaceae): Bajra seeds were sown in the month of May-June. Bajra spikes were used for the preparation of dry flower sticks and flower arrangements and ornamental wreaths. Usually spikes are creamy in colour but through dyeing and painting different colours can be imparted.

Maize (*Zea mays,* Poaceae): Male and Female inflorescence, stem, spathe, cob and silk all were used for making dry flower products like dry flower sticks, flowers, flower arrangements, dolls, pot porries etc.

Apart from these, other agri-horticultural crops like sorghum, alsi, wheat, cotton calyx, leek, coconut husk, luffa etc were also used for making various dry flower products (Plate 5).

Techniques of Flower Drying

Air drying: The plant materials were tied with the help of a rope in a hanging position to a stand. It requires a warm clean dark and well ventilated area with low humidity. Spike of bajra, sorghum, wheat, leek etc were tied with thin rope or wire and hanged vertically down in a wooden frame or stand. Whereas, maize spathe, luffa etc after colouring were spread on the blotting sheets and kept under fan for drying.

Press drying: The flowers and foliage are placed between the folds of blotting sheets by giving some space among flowers. These sheets are kept one above the other and cardboards of same size are placed in between the folded sheets to allow the water vapours to escape. Maize spathe and silk were dried by this method. The press-dried material in maize results in smooth textured maize spathe which can be used for making dolls and greeting cards.

Hot air oven drying: Flowers and foliage embedded in desiccants are kept in hot air oven at controlled temperature for appropriate time. Maize spathe, spike of bajra, sorghum, wheat, alsi etc. were dried in hot air oven at 50^0C for 1-2 days.

Dyeing of crops: After drying bajra spikes and maize spathe were dyed in floral craft lab. Different dyes like fabric dyes (dark green, pink, yellow, violet, orange and red maroon), indicator dyes (brilliant green, crystal violet, eosin yellow, metanil yellow, methylene blue and methyl orange), food

dyes (green, orange, yellow and raspberry red) and biocolours (coffee, turmeric, punica and lilium) were used for colouring these crops. Fabric dyes are the commercial dyes available in powdered form for colouring of fabric in local market. Food dyes are food colours available in the market. Bio- colours were extracted from the parts of dye -yielding plant like from the peel of *Punica granatum* var nana (darhu), which were dried, powdered and colour was extracted by boiling the sample in water. Apart from this; coffee and turmeric were procured from the local market. Lilium pollens were collected from the field, dried and colour was extracted with acetone. About 4 g/l of fabric dyes, 2g/l of indicator dyes, 4g/l of food colours and 5g/100ml of bio-colours were used. Dye solution was prepared by properly mixing dyes in boiling water. Crops were immersed in the solution for about 1-2 minutes or when it appeared these had absorbed the colour uniformly. After colour absorption these were taken out and spread over the blotting sheet in shade for drying. The colours of the dyed materials were recorded with the help of RHS colour chart and scoring was done on the basis of colour absorption and colour intensity. The 5,4,3,2 and 1 points were given to the specimens, which gave excellent, very good, good, poor and very poor colour absorption respectively. For colour intensity 5, 3 and 1 points were given which showed high, medium and low value. Wash fastness of dyed flowers was recorded by washing the dyed flowers in distilled water and their impression with a finger was taken from each sample on white paper. The 5, 3 and 1 points were given to the specimens, which gave low, medium and high impression on paper. Final evaluation was done out of a total 5 points allotted on the basis of quality parameters like colour intensity (score out of 5), colour absorption (score out of 5) and wash fastness (score out of 5) in highest to lowest order by visual observation for different dyes under study on the basis of 9-point hedonic scale as suggested by Peryam (1957) and a modified score was developed (Table 1). All the dyed bajra spikes were kept at room temperature for 10 months for checking deterioration/fading with time.

RESULTS AND DISCUSSION

Studies on the identification of suitable dyes for dyeing of *Pennisetum glaucum* (Bajra): Four different types of dyes were used for dyeing of Bajra like, indicator dyes, fabric dyes food dyes and biocolours (Plate 2). The fabric dyes like dark green, yellow, violet and pink were the best for dyeing of bajra followed by indicator dyes i.e Brilliant Green, Eosin Yellow, Metanil Yellow and Crystal Violet. Out of the biocolours dyeing with turmeric was quite satisfactory. Food dyes in case of bajra was not satisfactory at the time of colouring except Yellow and Orange food dyes. Among

biocolours used only turmeric gave good results. Various types of value-added products like dry flower sticks, arrangements, bouquets, urns etc. were made out of the dried as well as dyed spikes. Kashyap et al (2016) mentioned that fabric dyes i.e. Yellow, Violet, Pink and indicator dyes Brilliant Green, Eosin Yellow, Crystal Violet and Metanil Yellow were the best for dyeing of *Lagurus ovatus* in terms of colour intensity and colour absorption. The results are also in agreement with the finding of Lourdusamy et al (2002), who reported that vat group of dyes scored the highest score rating values in terms of visual aesthetic qualities followed by direct and acid colours. This group had low level of colour fading on storage. Food dyes had good quality but the colours fade very fast and retention is poor even after ten months. Among bio-colours, turmeric were satisfactory, whereas other colours like, coffee, punica and lilium pollen were very poor in performance, thus cannot be recommended for dyeing. Similar results were also reported by Sangeeta Kumari et al (2017) while working on *Gomphrena globosa* with these dyes.

Dyeing of maize spathe: In this experiment spathe of maize cobs was used for dyeing with fabric dyes, food colours and Indicator dyes (Plate 3). Dye solution was prepared by

Table 1. Score card for different quality parameters of dyes flowers (Scoring out of 5 in each parameter)

Wash fastness		Colour absorption		Colour intensity	
Low impression	5	Excellent	5	High	5
Medium impression	3	Very good	4	Medium	3
High impression	1	Good	3	Low	1
		Poor	2		
		Very poor	1		

properly mixing dyes in boiling water. Then whole spathe of maize cobs were immersed in the solution for about one minute or when it appeared that maize spathe have absorbed the colour uniformly. After colour absorption these were taken out and spread over the blotting sheet in shade for drying. The colour intensity was very high and colour absorption was excellent in case of maize spathe dyed using indicator dyes i.e. brilliant green and eosin yellow. Results pertaining to fabric dyes also reveal that colour intensity was high and colour absorption was also found very good when maize spathe were dyed using fabric dyes. The results are in agreement with the finding of Kashyap et al (2017) who reported that fabric dyes and indicator dyes were the best for

Table 1. Effect of dyeing with various dyes/colours on bajra (*Pennisetum glaucum*)

Type of dye	Colour intensity		Colour Absorption		Colour (RHS Colour Chart)	
	0 hours	After10 months	0 hours	After10 months	0 hours	After10 months
Fabric dyes						
Dark Green	High	High	Good	Good	Green group 127A	Green group 127A
Yellow	Very high	Very high	Excellent	Very good	Yellow group 12A	Yellow group 12A
Orange	Low	Low	Poor	Poor	Yellow orange group 20A	Yellow orange group 20A
Violet	Very high	High	Very Good	Good	Violet blue group 89A	Violet-blue group 89B
Pink	Very high	Very high	Very good	Very good	Red-purple group 64A	Red-purple group 64A
Red Maroon	Low	Low	Poor	Poor	Greyed Orange group 176A	Greyed Orange group 176A
Food dyes						
Orange	High	High	Medium	Medium	Orange red group 30A	Orange red group 30B
Yellow	High	High	Good	Good	Yellow group 12A	Yellow group 12A
Green	Medium	Medium	Medium	Medium	Yellow green group 144B	Yellow green group 144B
Indicators dyes						
Brilliant Green	Very High	Very high	Excellent	Good	Green group 126A	Green group 126B
Eosin Yellow	Very High	Very high	Excellent	Good	Red group 41A	Orange red group 34A
Methylene Blue	High	High	Medium	Medium	Blue group 1023A	Blue group 102A
Crystal Violet	High	High	Good	Medium	Violet blue group 89A	Violet blue group 89 B
Metanil Yellow	High	High	Good	Medium	Greyed Orange group 163A	Greyed Orange group 163B
Methyl Orange	Low	Low	Poor	Poor	Greyed orange group 164C	Greyed orange group 164D
Biocolours						
Coffee	Low	Low	Poor	Poor	-	-
Lilium with acetone	Low	Low	Poor	Poor	Yellow orange group 22A	Yellow orange group 22A
Punica	Low	Low	Poor	Poor	Greyed orange group 165 B	Greyed orange group 165 B
Turmeric	Medium	Medium	Medium	Medium	Yellow orange group 15A	Yellow orange group 15B

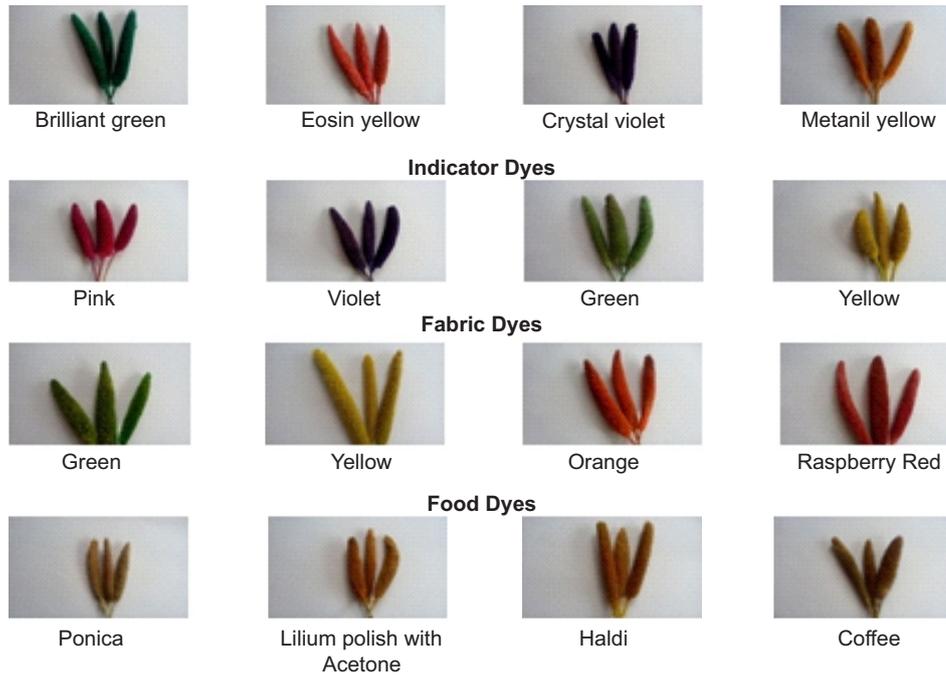***** **-** colour does not match to any of the colours of RHS Colour Chart

Brilliant green	Eosin yellow	Crystal violet	Metanil yellow

Indicator Dyes

Pink	Violet	Green	Yellow

Fabric Dyes

Green	Yellow	Orange	Raspberry Red

Food Dyes

Ponica	Lilium polish with Acetone	Haldi	Coffee

Plate 1. Dyeing of Bajra by using different dyes viz. Indicator dyes, fabric dyes, food dyes and different biocolours

Plate 2. Value added prepared from Bajra

Green   Magenta   Yellow   Violet   Brilliant green   Green   Orange

Fabric Dyes   **Indicator Dye**   **Food Colours**

Plate 3. Dyeing of maize spathe

Dry flower sticks from maize spathe   Dolls prepared from maize spathe

Flower arrangement prepared from maize spathe

Plate 4. Value addition in maize spathe

Flower arrangement from Sorghum   Key ring from Sorghum

Flower sticks from] cotton calyx

Flower arrangement from Alsi

Hanger from Sorghum

Flower arrangement from maize spathe

Plate 5. Value added products from other agrihorticultural crops

Table 3. Effect of dyeing with various dyes/ colours on maize spathe (*Zea mays*)

Type of dye	Colour intensity	Colour absorption	Colour (RHS colour chart)
Fabric dyes			
Violet	High	Very good	Violet Blue group 89-A
Pink	High	Very good	Red Purple group 67-A
Orange	High	Very good	Orange group 28-A
Dark Green	High	Very good	Green group 126-A
Yellow	High	Very good	Yellow group 12-A
Food colours			
Orange	Medium	Good	Orange Red group 30-D
Yellow	Low	Poor	Yellow Green group 145 A
Green	Low	Poor	Green group 142-A
Indicator dyes			
Brilliant Green	Very high	Excellent	Green group 124-A
Eosin Yellow	High	Excellent	Red group 38-A

dyeing of ornamental grasses like Bromus and Brizain terms of colour intensity and colour absorption. Value added product like dolls, gift items, flower sticks and key rings were prepared using these coloured maize spathe (Plate 4).

Different Value Added Products from Dried Flowers

Pot pourries: Pot pourri is a sweet smelling dried floral arrangement which is a mixture of dried flowers, petals, fruit, pod, leaves, spices, seeds, root and distilled essential oil which are filled in pillows or transparent sachets. It consists of an attractive mixture of dried plant materials of different shapes, size, texture and colour which makes it as a decorative item as well. The important agrihorticultural crops used for making pot-pourries are maize cob, luffa, cotton pods, walnut, almond, Areca nut& citrus slices.

Dry flower sticks: Elegant sticks can be prepared by agrihorticultural crops like maize sheath, coconut husk, luffa, etc. Some of the natural materials from natures trove with long sturdy stems can directly be used as dry flower sticks such as millet, pearl millet, leek, cotton calyx, sesamum, Alsi, Areca nut etc.

Flower arrangements: These are used to decorate tables, shelves, corners of offices and home. To make a flower arrangement we need a vase/ bamboo basket, floral foam, dried flowers, spike, leaves, grasses, pods, bajra, sorghum, alsi, wheat can be used for making flower arrangements.

Wall pictures: Dry seed and spike of wheat, sorghum and maize sheath and silk can be used to make wall pictures. We can also frame the wall picture to maintain their beauty.

Dry flower ornaments: Different ornaments like bangles, ear rings, garlands and pendants can be prepared from sorghum, maize, linseed, etc.

Wall hangers: Beautiful wall hangers can be prepared from sorghum, alsi and maize sheath. For preparing wall hangers we also need some support like breaded rope.

Dolls: Maize sheath, cob and silk can be used for making different types of dolls. Where coloured /natural maize sheath can be used to prepare their dresses, silk for making hairs and cob for internal body support/structure of dolls.

Rakhi: Maize sheath, pista and alsi can be used to make beautiful rakhis.

CONCLUSIONS

Agri-horticultural crops like bajra, maize, sorghum, wheat, oats, cotton calyx, leek, coconut husk, luffa can effectively be used as dry flower crops. The fabric dye (yellow, dark green, violet and pink) for both bajra and maize and indicator dye (brilliant green, eosin yellow, crystal violet, methylene blue and metanil yellow) for bajra and brilliant green, eosin yellow indicator dyes for maize spathe were found excellent in performance. Among biocolours dyeing with curcuma has been found satisfactory for bajra.

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Carbon Stock Assessment of Selected Tree Species in Maharshi Dayanand University Campus, Rohtak (Haryana) India

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Abstract: *Azadirachta indica, Callistemon lanceolatus, Eucalyptus globulus, Ficus virens, Pongamia pinnata* and *Terminalia arjuna* were selected for carbon stock estimation. Field survey method was used for sampling trees. Carbon stock of dominant tree species was calculated with allometric equations. The carbon stock was 366.82 Mg in *Eucalyptus globulus*, 35.23 Mg in *Pongamia pinnata*, 30.79 Mg in *Callistemon lanceolatus*, 23.75 Mg in *Azadirachta indica*, 22.32 Mg in *Ficus virens* and 7.91 Mg in *Terminalia arjuna*. Maximum carbon stock was found in *Eucalyptus globulus* and minimum in case of *Terminalia arjuna*. The data obtained from the present study can be used to assess the role of trees in reducing the atmospheric CO_2. The study will also be useful in calculating the carbon budget of the educational institutions and urban settlements in near future.

Keywords: Carbon stock, Climate change, Carbon sequestration, Carbon budget and trees

Global climate change is an important environmental issue that has caught world's attention. Temperature is increasing globally and last four years have been warmest ever in the human history. This increase in atmospheric temperature is attributed to the high levels of different green house gases. Due to deforestation, land use change, fossil fuel burning and other factors the current level of CO_2 has reached upto 408.18 ppm (Anonymous 2018). India being a developing country yet stands on the 4th spot among the top carbon emitting nations contributing nearly 7% to total carbon emission in the world (Boden et al 2017). The diverse and dreadful impacts of climate change are impacting ecology and economies all over the world. The present scenario with climate change risks necessitates the reduction in carbon dioxide emission for environmental stability. International discussions, various economic (carbon credit) and political (Kyoto protocol) interests have somehow made carbon stock estimation an essential pre-requisite for climate change mitigation and adaptation (Wauters et al 2010, Oliveira 2018).

Worldwide, tropical forests account for storage of nearly 55% of total carbon captured from atmosphere followed by boreal forests which store 32% of carbon and 13% of carbon is stored in temperate forests (Pan et al 2011). Trees due to their dominance have a higher capacity of carbon sequestration as compared to other group of plants. India with a forest and tree cover of 24.39% of the total geographical area (FSI 2017) is at advantage, as more vegetation will store more of carbon stock. Forests, tree plantations, agroforestry and several other practices act as a carbon sink where carbon dioxide captured from the atmosphere is stored in form of biomass. Among these practices, tree plantation in urban areas is quite useful as trees act as a carbon sink for reducing environmental pollution. Apart from capturing atmospheric CO_2, trees also provide many other invaluable services to mankind and bring environmental stability. The tree cover not only maintain environmental sustainability in these campuses and surrounding area but also helps in oxygen generation, ground water recharge, improves mental health of the people and relieve stress caused by city pollution (Bassett 2015). Several studies have been carried out at international as well as the national level to estimate carbon stock, therefore an attempt has been made to estimate biomass, carbon stock in different tree species in Maharshi Dayanand University campus, Rohtak (Haryana) India. The study also takes into account various socio-economic benefits of the selected tree species apart from the estimation of carbon stock.

MATERIAL AND METHODS

Study area: Maharshi Dayanand University (MDU) is located in Rohtak district of Haryana, India. Geographically, MDU campus is situated between 28° 54′ 0″ N and 76° 34′ 12″ E, spreads over an area of 665.44 acres. The annual rainfall of the district is about 58 cm. Temperature ranges from 2° C in winter to 46.2° C in summer. Total 13982 trees representing 53 species are present in different parts of the university campus and age of trees varies from 3 years to 20 years but majority of plants belong to the age group of 5-8 years of age. A total of 4561 fruits trees that represents 25 species are

present in campus with age of tree ranging from 3 to 10 years. Number of ornamental plants in the campus are 15510 and plants of age between 3 to 15 years are observed. The total area covered by fine grassing and rough grassing is 319901 m^2, 323214 m^2, respectively. There are 239 flowerbeds and 6252 flowerpots in the campus. Soil is sandy loam that contains enough amount of clay. *E. globulus, F. virens, Ficus benjamina, P. pinnata, T. arjuna* and *A. indica* are among the dominant tree species of the campus.

Methodology: The sampling of tree layer vegetation was undertaken during February to April, 2018. Each tree of selected species was individually sampled. Non-destructive method was used for sampling. The quantitative vegetation characteristics like basal area, plant height, biomass and carbon stock were studied. *A .indica* A. Juss*., C. lanceolatus* (Sm.) Sweet*, E. globulus* Labill*., F. virens* Aiton*, P. pinnata* L. Pierre and *T. arjuna* (Roxb. ex DC.) Wight and Arn. were the tree species selected for carbon stock estimation. Measuring tape at 1.37 m height from ground level was used for measurement of girth at breast height (gbh) of individual tree species and value was converted to get diameter at breast height (DBH) by dividing girth by 3.14 (value of pie).

Population structure of tree species: From the gbh, the tree population structure was prepared according to guidelines set by NRSA Manual (NRSA, 2008) and following girth classes were recognized.

Class	Range in gbh (cm)
A	0 – 30
B	31 – 60
C	61– 90
D	91 – 150

Total number of individuals belonging to different girth classes was counted and accordingly percent proportion in each girth class was calculated. Basal area was calculated $[(CBH)^2 \div 4\pi]$.

Estimation of plant biomass: Biomass of trees was estimated by dimension analysis of sampled trees using volume regression equations between diameter at breast height (dbh) and using specific gravity. Above-ground, below-ground biomass and total biomass of all tree species was calculated using allometric equations. For this volumetric equations, which were species-specific and wood specific gravity as published by Forest Survey of India (FSI 1996) and ICFRE (1996–2002) were used.

A. indica V= 0.27-2.953×D^2+12.336×D^2, Specific gravity = 0.68

E. globulus V= 0.02894-0.89284×D +8.72416×D^2, Specific gravity = 0.64

F. virens SQRT V= 0.03629+3.95389×D-0.84421+9.4664×SQRT D, Specific gravity = 0.65

T. arjuna V/D^2 = -0.00342/D^2-0.0922/D+2.28178+9.4664×D, Specific gravity = 0.69

Where, V = Volume of the tree, D = Diameter at breast height, SQRT = Square root transformation

The biomass of *P. pinnata* and *C. lanceolatus* was calculated by multiplication of volume with its wood density (Reyes et al 1992). Biomass expansion factor (BEF) was used for expanding stem wood biomass to the total above ground biomass of tree, which included its leaves, branches, twigs, bole and bark. The mean BEF value of 1.5 was used for this study as prescribed by Brown and Lugo (1992).

Above-ground biomass (AGB) = Stem wood volume × wood density × BEF

Below-ground biomass (BGB) = exp {-1.0587 + 0.8836 × *ln* (AGB)}

Carbon stock estimation: For calculation of carbon stock of trees it was assumed that the carbon content is 50% of the total biomass (Dixon 1994, Ravindranath et al 1997).

RESULTS and DISCUSSION

A total of 9092 trees of six species were inventorised, maximum were of *E. globulus* and minimum of *A. indica*. Diameter and circumference at breast height were also different for different species. Various growth parameters contributing to carbon stock are height, diameter at breast height, volume and basal area of the plant and varied significantly within different tree species and were highest in *E. globulus.* Minimum average height was observed in case of *C. lanceolatus* (4.87 m). Minimum average dbh and average basal area were in of *P. pinnata* having respective values of 10.22 cm and 0.0082 m^2. *T. arjuna* has minimum average volume (0.033 m^3/tree) (Table 1).

Tree population structure: Guidelines as set by Manual of NRSA (2008) were used for preparing tree population structure. Most of the trees were in the range of girth class 31-60 cm (Table 2).

Biomass and carbon stock of different tree species: Plant biomass, which refers to the amount of organic matter accumulated in different plant components was observed to vary significantly in different tree species. *E. globulus* has the maximum amount of biomass. The average biomass (kg/tree) and average carbon stock (kg/tree) values of *E. globulus* and *A. indica* are highly comparable to each other (Table 3). *T. arjuna* has the least amount of biomass. *E. globulus* has maximum above ground (630.28 Mg) as well as below ground (103.34 Mg) biomass, therefore, maximum total biomass (733.64 Mg) among all the selected tree species. Minimum total biomass (15.82 Mg) was in *T. arjuna.* Lower values of biomass owe to lower circumference at

breast height (CBH) of trees which is also indicative of their younger age. For calculation of carbon stock of trees it was assumed that the carbon content is 50% of the total biomass (Brown and Lugo, 1982, Dixon, 1994, Ravindranath et al 1997). The highest values for above-ground, below-ground and total carbon stock were in case of *E. globulus* with respective values of 315.14 Mg, 51.67 Mg and 366.82 Mg. Minimum total carbon stock value of 7.91 Mg was in *T. arjuna*.

The maximum height and maximum diameter at breast height were observed for *E. globulus* that stores more carbon than other tree species. Of all the sampled trees, *E. globulus* has maximum average carbon stock per tree i.e. 66.87 (kg tree^{-1}) and these values are highly comparable to the carbon stock values of *A. indica* i.e. 66.74(kg tree^{-1}). Although the carbon stock value of *E. globulus* is slightly more than *A. indica* but the other benefits which *A. indica* provides are far more important ecologically as well as economically. Various medicinal properties, cultural and religious values, and its importance as a shade tree somehow out-compete the services provided by *E. globulus*. Also, *E. globulus* is an exotic species as compared to *A. indica* which is native to the Indian subcontinent. Other tree species have considerably lesser amount of carbon stored and nearly comparable to each other except in case of *T. arjuna* where the values of carbon stock are extremely low.

The contribution of above-ground and below-ground biomass of trees to the total biomass in the present study was 81.4 to 85.9 and 14.1 to 18.6 percent, respectively and the above-ground carbon pool was most sensitive to human disturbances due to its economic importance. Total aboveground and belowground biomass in Indian forests was estimated as 79 and 21 %, respectively (Chhabra et al 2002). The results obtained are comparable with that of study of Kraenzel et al (2003) in Panama. It was also proved that the capability of tall trees to sequester carbon is more than the other group of plants. The relative contribution of AGB and BGB in total biomass was 80.8 and 19.2 per cent, respectively for Garhwal Himalaya, India (Gairola et al 2011). Mahajan et al (2018) assessed the carbon stock value of land use system and concluded that average total biomass in tree

component was 14.28 Mg ha^{-1}, out of which the contribution of AGB and BGB was respectively 75.28 and 24.78 percent. Jithila et al (2018) estimated the carbon sequestration potential of 610 trees and found that *A. indica* has minimum carbon sequestration value this might be due to young tree plantations of *A. indica*. Pragasan and Karthick (2013) at Coimbatore, estimated carbon stock of five different tree species among which *Eucalyptus* has maximum amount of organic carbon stock i.e. 48.05 tonne/ha. Arora et al (2014) at Kurukshetra in Northern India estimated the carbon sequestration potential of *Eucalyptus tereticornes, Tectona grandis* and *Syzigium cumini* and observed that *Tectona grandis* has maximum amount of carbon stock i.e. 81.33 MgC ha^{-1} followed by *Eucalyptus tereticornes* and *Syzigium cumini*. Suryawanshi et al (2014) in North Maharashtra University campus concluded that *Moringa olifera* (15.775 ton/tree) has maximum carbon stock followed by *A. indica*.

Low tree cover in the case of urban plantation accounts for less carbon storage than forest trees. However, while considering carbon storage on a per unit tree cover basis, the amount of carbon stored in urban trees may be greater as compared to forest trees and this might be contributed by relatively fast growth rates due to more open urban forest structure (Nowak and Crane 2002). Increasing forest land area to enhance carbon sequestration is an effective measure that has been suggested for mitigating the elevated levels of carbon dioxide (CO_2) concentration in the atmosphere which ultimately contribute towards the prevention of global warming (Watson 2000). Excellent management plans and national policies can be framed to

Table 2. Girth class distribution of tree species

Girth classes (cm)	Total number of trees					
	A_i	C_l	E_g	F_v	P_p	T_a
0 – 30	59	146	600	128	706	211
31- 60	206	439	2896	292	642	338
61- 90	81	153	1750	144	36	-
91- 150	10	-	240	44	02	-

Where, A_i = *A. indica*, F_v = *F. virens*, C_l = *C. lanceolatus*, P_p = *P. pinnata*, E_g = *E. globulus*, T_a = *T. arjuna*

Table 1. Tree count and variations in diameter and girth at breast height and average of different growth parameters

Tree species	Total no. of trees	Variation in dbh (cm)	Variation in cbh (cm)	Avg. height (m)	Avg. dbh (cm)	Avg. basal area (m^2)	Avg. volume (m^3 tree^{-1})
A. indica	356	3.50 - 43.63	11 - 137	8.55	15.42	0.0220	0.159
C. lanceolatus	738	2.71 - 28.54	8.5 - 89.6	4.87	15.07	0.0206	0.105
E. globulus	5485	1.97 - 44.90	6.2 - 141	23.10	17.52	0.0276	0.179
F. virens	578	4.46 - 36.21	14 - 113.7	11.1	16.24	0.0245	0.161
P. pinnata	1386	1.59 - 37.58	5 - 118	5.31	10.22	0.0082	0.043
T. arjuna	549	2.42 - 18.47	7.6 - 58	6.64	11.09	0.0105	0.033

Table 3. Average biomass, carbon stock, AGB, BGB, TB, above-ground carbon stock, below-ground carbon stock and total carbon stock of different tree species

Tree species	Average biomass (kg/tree)	Average carbon stock (kg/tree)	AGB (Mg)	BGB (Mg)	TB (Mg)	Above-ground carbon stock (Mg)	Below-ground carbon stock (Mg)	Total carbon stock (Mg)
A. indica	133.48	66.74	38.73	8.78	47.51	19.36	4.39	23.75
C. lanceolatus	83.44	41.72	50.48	11.10	61.58	25.24	5.55	30.79
E. globules	133.75	66.87	630.28	103.34	733.64	315.14	51.67	366.82
F. virens	77.25	38.62	36.34	8.30	44.64	18.17	4.15	22.32
P. pinnata	50.84	25.42	57.93	12.54	70.47	28.96	6.27	35.23
T. arjuna	28.81	14.41	12.57	3.25	15.82	6.28	1.62	7.91

Where, AGB = Above-ground biomass, BGB = Below-ground biomass, TB = Total biomass

improve the quality of environment and human health by understanding these ecosystems in a better way and by taking steps for their conservation. Urban tree management practices should also be taken into consideration when studying the cumulative effects of urban trees on carbon dioxide concentration (CO_2) in the atmosphere. Hence, this study will also be helpful in selection of suitable tree species to be planted for increasing green cover for mitigating microclimate changes.

CONCLUSIONS

More than 9000 trees were sampled and majority of the trees were of 6-8 years of the age and were having 31-60 cm girth size. Various growth parameters contributing to carbon stock are height, diameter at breast height, volume and basal area were also measured and found highest in case of *E. globulus* but the minimum was in *T. arjuna.* Though the average biomass and average carbon stock values of *E. globulus* and *A. indica* were comparable but *A. indica* provides many other benefits which are ecologically as well as economically very important. It can also be concluded that trees not only play an important role in carbon sequestration but also provide a number of other ecosystem services besides having an aesthetic value as well. Hence, multipurpose tree species preferably native ones should be selected for plantation to bring ecological sustainability.

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Assessment of Germination Attributes in Candidate Plus Trees (CPTs) of Malabar Neem (*Melia dubia* Cav.)

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Abstract: Seeds of twenty candidate plus trees of *Melia dubia* selected from South Gujarat region of India were assessed and significant variation among CPTs for the germination and related vigour attributes was recorded. Highest germination of 38.05%, mean daily germination, 0.51%, germination value, 1.72 and germination index, 1432.5 was recorded in seeds of NAU-12. Earliest initiation of germination process was recorded in NAU-9 after 23.50 and 38.25 days of sowing, respectively. Findings of the present study suggested that seeds of CPTs like NAU-12, NAU-9 and NAU-17 performed better on germination and vigour traits. Hence, seeds of these candidate plus trees can be employed to develop quality planting material for farm forestry.

Keywords: Malabar neem, *Melia dubia*, Germination, Vigour

Melia dubia commonly known as Malabar neem is an industrially important fast growing short rotation tree species valued for its high quality termite resistant timber used in furniture, agricultural implements and house construction. It is also known to be an excellent fuel wood and fodder tree species and almost every part has medicinal value as well. It is also promoted under industrial plantations as an alternate source of pulpwood (Parthiban et al 2009) and under agroforestry models as an amenable agroforestry ideo type (Mohanty et al 2017, Jilariya et al 2017, Bhusara et al 2018 a&b and Thakur et al 2018) without any allelopathic effect on under-storey crops (Thakur et al 2017 a&b, Kumar et al 2017 and Parmar et al 2018). After the huge success on farmlands of Kerala and Tamil Nadu, this species became the choice of farmers nationwide as money spinning tree (Bijalwan 2015). Despite its fast growing habit, natural seed germination is still a constraint. Although uniform germination of seed with good magnitude and vigour is necessary for the production of uniform planting stock for large scale plantation programs, contrary to other species of *Melia*, seed germination of *M. dubia* is reported very poor (Chauhan et al 2008, 2018, Nair et al 2005 and Anand et al 2012). A study was undertaken to screen candidate plus trees for seed germination and vigour attributes to select and propagate the best planting material for higher productivity.

MATERIAL AND METHODS

Different localities, where *Melia dubia* found growing naturally *viz*. Dharampur, Kaprada, Dabkhal, Waghai, Dediyapada, Sagai and Sagbara falling in three districts of south Gujarat region of India were extensively surveyed to identify the phenotypically superior CPTs (Table 1). Selection was made from sparse population, growing naturally around the habitat, farm boundaries and forest area that were average or better in morphological traits of interest *viz*. commercial bole height, girth and tree height (Table 2). Out of the trees visited, twenty CPTs were selected and marked (Table 2). Ripen drupes were collected from marked CPTs in the month of February-March, de-pulped manually and dried in the shade for further study. Assessment of variation in seed germination and vigour were carried out among selected 20 CPTs in the Forest Nursery situated at College of Forestry, NAU, Navsari during 2015-16. The experimental place experiences the humid climate. The minimum mean temperature registered during the experiment period was 22.4°C. Maximum mean temperature reached up to 34.9°C in the month of May. Mean relative humidity remained above 68.27 percent throughout the year. The experiment was laid out in Completely Randomized Design (CRD). The treatments were replicated four times. The uniform sized de-pulped drupes were chosen for the seed germination trial. Stones of *Melia dubia* were sown in germination tray filled with sterilized sand. The whole experiment was carried out in shade net condition during May to July during 2014-16. For each replication, 100 stones were sown. The numbers of seeds germinated on each day were counted; emergence of plumule above the sand was taken as the criteria of germination. Counting of germination was started from 15 days after sowing (1st count of on 16th Day) and continued up to 75 days from the day of sowing. After stipulated period germination experiment was terminated. Based on daily germination count and pattern, different parameters were

recorded with standard procedure. Mean daily germination percentage calculated by dividing the cumulative number of germinates with respective number of days. Germination value (GV) was assessed according to formula proposed by Djavanshir and Pourbeik (1976). Daily germination speed (DGS) obtained by dividing daily germination percent by the number of days elapsed after sowing and summation of all DGS values were presented in data form. Time to 50% of final germination percentage (t50m) denotes the day on which half (50%) of the final germination achieved after sowing (Soltani et al 2015).

RESULTS AND DISCUSSION

Result of the experiment indicates significant variations in final germination as well as germination vigour among seeds of 20 CPTs. Highest germination (38.05%) and maximum mean daily germination (0.51%) was recorded in seeds of NAU-12, whereas, minimum germination (7.25%) and mean daily germination percent (0.10) was recorded in seeds of NAU-11.Germination value, a measure of speed of germination proposed by Djavanshir and Pourbik (1976) is closely related to survival of plants in nurseries. The seeds of NAU-12 recorded highest cumulative daily germination speed (27.55) and germination value (1.72), which was at par with NAU-9 (27.18 and 1.62), however, seeds of NAU-13 obtained minimum respective values of 3.00 and 0.04 (Table 3). Germination milestones are also important indicators to

judge the vigour and stress resistance (Kader et al 2005). The length of time taken by first and last seed to germinate has direct bearing on vigour of seeds. In this study, seeds started to germinate after 23 days of sowing and continued up to 70 days. Earliest germination initiation (23.50 days after sowing) was recorded in NAU-9, whereas, NAU-13 took maximum (39.50) days for initiation of germination. On the other hand, seed germination process reached to halt earliest (after 57.73 days of sowing) in NAU-12 while it was longest (70.23) in progenies of NAU-4. Time to achieve 50% of final seed germination percentage (t50m) varied significantly among the CPTs of *M. dubia* under the present investigation. Perusal of data indicates that, seeds of NAU-9 took least time i.e. 38.25 days after sowing, to reach 50% of final germination while, seeds of NAU-4 took maximum time (53.00 days after sowing) to achieve 50% of final germination. Germination index (GI), confounding total germination as well as speed in which higher values indicates better and quickest germination than lower values. Observation of data (Table 1) suggested that seeds collected from NAU-12 gave higher GI value of 1432.5, which was at par with NAU-9 (1423.25). Least germination index (177.00) was observed in NAU-4.

The germination studies are important tool to assess the variation present in the species as well as selecting the promising genotype that can be helpful to boost the efforts of mass afforestation programmes. In the present investigation,

Table 1. Geographical detail of selected candidate plus trees (CPTs) of *Melia dubia* in Gujarat

Tree code (Accession number)	GPS co-ordinates		Altitude (m)	Place	District
	Latitude	Longitude			
NAU-01	20° 29' 25" N	73° 09' 31" E	87	Dharampur	Valsad
NAU-02	20° 26' 04" N	73° 08' 58" E	63	Nanapondha	Valsad
NAU-03	20° 24' 49" N	73° 09' 03" E	68	Nanapondha	Valsad
NAU-04	20° 23' 33" N	73° 08' 52" E	70	Nanapondha	Valsad
NAU-05	20° 24' 17" N	73° 08' 38" E	73	Nanapondha	Valsad
NAU-06	20° 22' 29" N	73° 09' 48" E	129	Kaprada	Valsad
NAU-07	20° 21' 41" N	73° 11' 22" E	112	Kaprada	Valsad
NAU-08	20° 19' 92" N	73° 16' 65" E	467	Dabkhal	Valsad
NAU-09	20° 18' 43" N	73° 19' 02" E	424	Dabkhal	Valsad
NAU-10	20° 20' 23" N	73° 15' 22" E	387	Dabkhal	Valsad
NAU-11	20° 45' 47" N	73° 29' 9" E	144	Waghai	The Dangs
NAU-12	20° 46' 25" N	73° 30' 23" E	127	Waghai	The Dangs
NAU-13	20° 48' 42" N	73° 29' 55" E	132	Waghai	The Dangs
NAU-14	20° 45' 5" N	73° 29' 56" E	150	Waghai	The Dangs
NAU-15	20° 47' 33" N	73° 31' 14" E	128	Waghai	The Dangs
NAU-16	21° 42' 16" N	73° 48' 8" E	340	Sagai	Narmada
NAU-17	20° 41' 17" N	73° 47' 31" E	385	Sagai	Narmada
NAU-18	21° 36' 19" N	73° 45' 19" E	405	Sagai	Narmada
NAU-19	21° 36' 23" N	73° 44' 50" E	53	Sagbara	Narmada
NAU-20	20° 45' 5" N	73° 29' 56" E	394	Sagbara	Narmada

Table 2. Growth attributes of selected CPTs of *Melia dubia* in Gujarat

CPT No.	Girth at breast height (GBH in cm)	Clear bole height (CBH in m)	Tree height (TH in m)
NAU- 01	108.20	7.75	15.30
NAU- 02	129.10	5.50	17.50
NAU -03	151.40	5.20	20.70
NAU -04	141.10	6.80	18.50
NAU-05	148.60	10.10	16.50
NAU- 06	132.20	7.40	20.10
NAU -07	131.30	8.40	25.60
NAU -08	120.70	6.60	18.20
NAU- 09	136.30	5.60	18.50
NAU- 10	104.20	5.80	14.20
NAU -11	165.10	8.10	26.20
NAU -12	101.80	6.80	18.80
NAU -13	106.70	10.80	20.00
NAU -14	156.20	7.50	22.20
NAU -15	155.10	10.50	25.40
NAU -16	105.30	10.10	24.20
NAU- 17	166.10	7.10	24.80
NAU -18	129.60	7.40	26.10
NAU -19	103.90	5.10	20.00
NAU- 20	170.20	5.30	17.20
Min.	101.1-	7.75	14.2
Max.	170.2	10.8	26.2
Mean	133.15	7.39	20.5
SE±	5.16	0.41	0.84
CV%	17.31	24.59	18.34

significant variation in germination and its attributes was observed among selected candidate plus trees of *M. dubia*. Since, the experiment was conducted under controlled condition by providing the same environment, the probable reason for the variation in seed germination and its attributes may be the arousal of parental genetic effect in the offspring (Rix et al 2012). In angiosperms, the primary control of germination and dormancy is known to govern through maternal tissue immediately surrounding the embryo (Mayer and Poljakoff-Mayber 1982), maternally derived seed coat and additional genetic contribution to the endosperm (Donohue 2009). Variability in seed germination may also be attributed owing to other maternal provisioning during seed development like hormones, proteins and nutrients. Significant variation in terms of seed germination attributes have been documented in other woody perennials also. Chavan and Anand (2013) reported significant variation in half-sib progenies of *Azaditrachta indica.* Similarly, significant variation in germination was found in *Tecomella undulata* by Kant and Kumari (2016), in *Faidherbia albida* by Fredrick et al (2015), in *Dalbergia sissoo* by Singh and Pokhariyal (2001) and by Divakara et al (2011), Jaisankar et al (2014) and Gupta et al (2016) in *Pongamia pinnata.*

CONCLUSION

CPTs like NAU-9, NAU-12 and NAU-17 excelled on seed germination and vigour attributes. Hence, seeds of these CPTs can be used as an interim source for development of
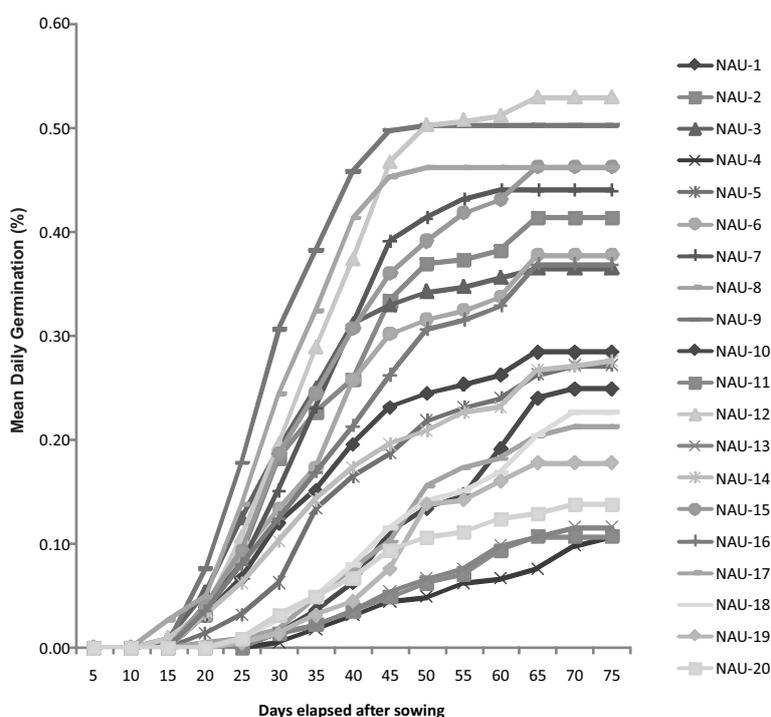
Fig. 1. Pattern of daily germination among 20 selected CPTs of *M. dubia*

Table 3. Variation in seed germination and attributes among 20 selected CPTs of *M. dubia*

CPTs	MDG (%)	Final ∑DGS	GV	FDG	LDG	t50m (days)	GI
NAU 01	0.24	8.22	0.24	31.00	62.48	50.50	444.25
NAU 02	0.41	18.98	0.97	24.50	61.48	40.25	1018.25
NAU 03	0.36	18.57	0.83	24.50	61.48	40.50	965.50
NAU 04	0.12	3.08	0.05	35.50	70.23	53.00	177.00
NAU-05	0.26	11.41	0.37	29.25	62.73	43.75	633.50
NAU 06	0.38	17.86	0.83	24.50	63.48	42.50	954.00
NAU 07	0.43	20.13	1.09	25.00	59.98	41.25	1096.00
NAU 08	0.21	7.31	0.19	31.50	64.23	49.25	414.50
NAU 09	0.48	27.17	1.62	23.50	58.98	38.25	1423.25
NAU 10	0.29	13.02	0.46	26.50	61.73	39.75	701.50
NAU 11	0.10	3.29	0.04	39.25	67.23	51.00	177.50
NAU 12	0.51	27.55	1.72	23.75	57.73	38.50	1432.50
NAU 13	0.11	3.00	0.04	39.50	68.48	50.00	232.75
NAU 14	0.27	12.91	0.45	27.00	62.48	41.75	702.00
NAU 15	0.44	21.67	1.17	24.25	60.48	38.75	1155.75
NAU 16	0.36	17.43	0.77	25.00	61.98	42.75	940.75
NAU 17	0.46	25.35	1.43	24.00	57.98	38.25	1310.75
NAU 18	0.23	8.26	0.24	33.00	63.48	47.75	481.00
NAU 19	0.18	5.58	0.13	36.00	65.48	51.75	332.00
NAU 20	0.13	5.70	0.09	31.00	65.73	45.50	320.25
Maximum	0.51	27.55	1.72	39.50	70.23	53.00	1432.5
Mininum	0.10	3.00	0.04	23.5	57.73	38.25	177.00
Mean	0.30	13.82	0.64	28.93	62.89	44.25	745.65
SE(m)	0.04	0.72	0.07	0.84	1.83	1.33	38.76
CD (p=0.05)	0.13	2.05	0.19	2.37	5.19	3.77	109.93

MDG= Mean daily germination, DGS= Daily germination speed, GV= germination value (Djavanshir and Pourbik,1976), FDG= First day of germination, LDG= Last day of germination, t50m= Time to 50% of final germination percentage, GI= Germination Index

quality planting material. Further, these CPTs can also be utilized for tree improvement programme.

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Fuelwood Profile of the Mapulana of Ehlanzeni district in Mpumalanga Province, South Africa

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Abstract: African countries depend on fuelwood for their livelihood strategies and its scarcity has been on the rise with time. The increase of population size, unemployment and urbanization are among the reasons causing fuelwood scarcity. A semi-structured questionnaire was used of the elderly, community adults and youth through snow ball sampling to collect data. The study has identified sixteen tree species utilized as fuelwood and twenty-eight tree species utilized as alternative fuelwood. The family represented by most of the species is Fabaceae. The state of fuelwood species preference differed within the communities. The preference in utilization of naturalized over native species as fuelwood is motivated by the shortage of native fuelwood species within villages. The ignorance of community members on aspects of unsustainable harvesting and adherence to rules placed by traditional leaders has led to the destruction of vegetation around most of Mapulana villages. Villagers have therefore resulted in purchasing fuelwood for their livelihood.

Globally the utilization of plants as fuelwood has sustained many communities, whereby a total of 54% of forests vegetation has been degraded (Martínez 2015, Hussain 2017). It is prevised that a large number of rural communities depend on fuelwood for their sustainability and greater amount of fuelwood is harvested (Cardoso et al 2012, Johnson and Bryden 2012, Hussain 2017). Johnson and Bryden (2012) further elaborated that the larger families the lower the fuelwood consumption as compare to a smaller family. Plant species utilized as fuelwood are mostly native as compared to naturalized species (Cardoso et al 2012, Cardoso et al 2017). Plant species preferred as fuelwood should have a low ash moisture and high calorific value (Martínez 2015, Sedai et al 2016, Bhatt et al 2017). Because high moisture and ash content reduce high heating value of fuelwood species (Sedai et al 2016).

The southern African countries like Swaziland, Angola, Namibia, Zimbabwe, Malawi, Lesotho and Zambia utilize 65.5% of fuelwood for their sustainability (Makonese et al 2017). In Botswana above 80 % of communities from rural, peri-urban and urban areas use fuelwood collected within communal land and around settlements (Joos-Vandewalle et al 2018). Although eighty-four percent of South Africans households are electrified, 11% still rely on fuelwood for cooking, while 12% use it for provision of heat. In Mpumalanga Province, 45% of communities still rely on fuelwood for cooking and heating (TRS 2012). The preference to utilization of plant species for fuelwood is

based on choice, regardless toits scarcity. Choice enabled communities to supplement or balance their livelihood strategies using preferred plant species with other types of fuel. In selection of firewood species factors such as nutritional crisis, socio-economic or cultural aspects of plants are well understood by the communities (Makonese et al 2017, Scheid et al 2018, Findlay and Twine 2018, Sole and Wagner 2018). In most countries the number of markets trading fuelwood are escalating despite the efforts of governments to electrify households (Puentes-Rodriguez et al 2017, Guild and Shackleton 2018). Demand for firewood as a results of increasing fuelwood markets result in loss of fuelwood conservation values or culture and biodiversity, vegetation depletion, soil erosion and deforestation (Kunwar et al 2018, Masunungure and Shackleton 2018).

Institutional rules and regulations employed bytraditional leaders has indeed conserved tree species since time immemorial (Giannecchini et al 2007, Kurui et al 2016). Recently, over exploitation and harvesting of plant species has left the vegetation around most villages depleted. Decline of tree species used for fuelwood has been voiced in many villages around the Bushbuckridge municipality (Kirkland et al 2007, Giannecchini et al 2007). The latter was observed due to total dependence on tree species for fuelwood, cutting of live tree species, poverty, large population and high unemployment rate (Kirkland et al 2007, Giannecchini et al 2007, Findlay 2013). Shackleton and Shackleton (2004) reported that there is an average of

approximately 5.3 tonnes of fuelwood consumed per household per annum in South Africa. It is obvious that biodiversity within villages is gradually decreasing and resulting in no vegetation for the future generations. Although Mapulana are aware of municipal intervention through provision of electricity within the communities, it has been difficult to render cooperation in preserving the vegetation due to misinformation or ignorance. Lack of law enforcement and community misunderstanding can sometimes result in ecosystem degradation of wild plants (Shumsky et al 2014). The aim of the study was to investigate tree species used by Mapulana as fuelwood. Understanding the profile of preferred species may assist the authorities in management and monitoring of populations of such species.

MATERIAL AND METHODS

The study was conducted in fifteen villages within three local municipalities namely: Bushbuckridge, Mbombela and ThabaChweu which falls within Ehlanzeni district at 25.39'46° S, 31.26'26° E on the north-eastern part of Mpumalanga Province of South Africa.

A semi-structured questionnaire was used to collect data. The interviews were face to face among participants comprised of elderly people, community adults and youths. Snowball technique based on referrals was used in getting participants, whereby participants identified others who can participate in study to be interviewed. The interviews focused on plants used as fuelwood, their alternatives in the absence of preferred species, the rules regarding harvesting of fuelwood, and prohibited fuelwood species. All participants signed prior informed consent forms as a way of acknowledgement of understanding what the interviews were all about. Plant specimens collected for each plant species mentioned during the interviews were identified and deposited in the Department of Botany Herbariumat the University of Venda. For ethical compliance the research was approved and registered by the University of Venda Research Ethics Committee as project number SMNS/17/BOT/01/0905. The frequency index of preferred fuelwood species was calculated as FI=FC/N x 100 where FI denotes the frequency index, which expresses the percentage of frequency of listing a plant species by participants. FC is the number of participants who listed the plant species and N is the total number of participants (Madikizela et al 2012).

RESULTS AND DISCUSSION

Sixty-eight participants were interviewed in the study and the demographic profile is given in Table 1.

Utilization of fuelwood tree species: Sixteen fuelwood species of which thirteenare native tree species while three are naturalized tree species (*Eucalyptus grandis Pinus patula* and *Acacia cyclops*) were preferred fuelwood plants (Table 2). Chamier et al (2012) recorded similar naturalized species where some of the species demonstrated great impact on soil quality in South Africa. The increased litter or
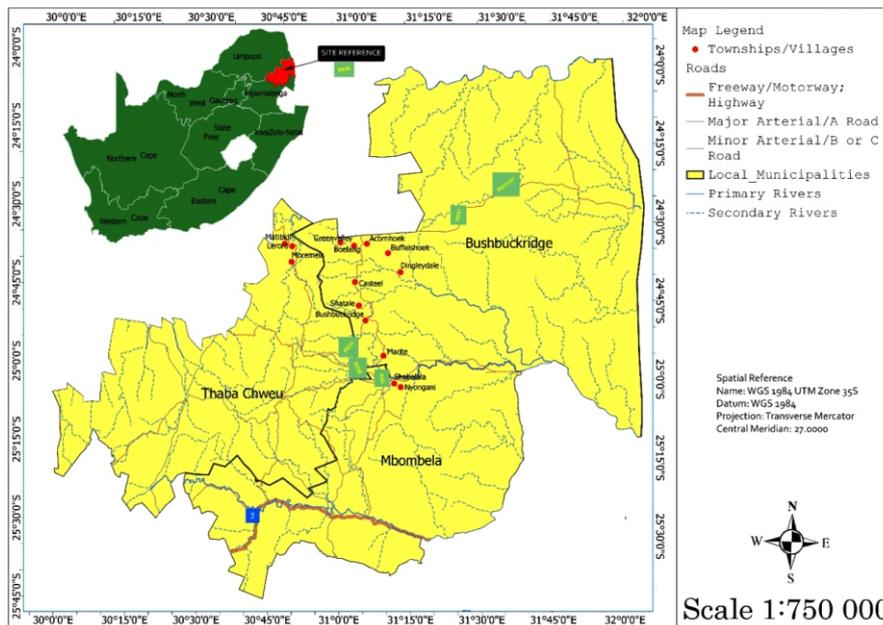
Fig. 1. Map of Ehlanzeni local municipalities of Mpumalanga Province in South Africa (study sites are marked with red dots)

Table 1. Demographic structure of participants

Parameter	Specification	Frequency	Percentage (%)
Gender	Male	10	15
	Female	58	85
Status	Youth (20-35)	9	10
	Community adult (36-59)	24	35
	Elder (60-99)	35	50
Education	None	12	18
	Primary	17	25
	Secondary	34	50
	Tertiary	5	7

biomass production changed the soil or litter chemistry and nitrogen fixation system. Even though naturalized tree species are used, preference of native species has not shifted and pressure on native species remains high as the utilization levels rise. Pressure from utilization and naturalized species result in the displacement of native species (Shackleton et al 2015). The villages where Mapulana people inhabit are surrounded by commercial farms of *Eucalyptus* and *Pinus* species (Shackleton 2000). Puentes-Rodriguez et al (2017) also observed thirteen preferred plant species depicting a limited number of plants species to be used in the future. Cardoso et al (2017) recorded 19 native species and three naturalized species.

In this study *Dichrostachys cinerea* sub sp. *africana* had the highest frequency index followed by *Senegalia ataxacantha*, *Peltophorum africanum* and *Combretum* spp.

(Table 2). *Dichrostachys cinerea* sub sp. *africana*, *P. africanum* and *Combretum imberbe* where the most preferred species due to their properties of dense wood and little smoke (Madubansi and Shackleton 2007, Maroyi and Rasethe 2015). Rules placed by the traditional authorities in the communities permits harvesting or pruning of dry thorny plant species for fuelwood irrespective of their edibility. These qualifies the preference of *D. cinerea* sub sp. *africana* and *S. ataxacantha*. *D. cinerea* sub sp. *africana* and *Terminalia sericea* again meet the criteria because they are reported to be some of the dominant species in bush encroachment (Stafford et al 2017). Plant species with large numbers of carbon content has great heating value, while high moisture and ash content reduces high heating value of fuelwood species (Sedai et al 2016). Species that produce low smoke or ash have high calorific value and durability (Martínez 2015).

The community members are aware of the environmental threats affecting biodiversity (Adam 2014). Mapulana people of Bushbuckridge agrees with Kirkland et al (2007) that there is depletion of bush in their area. Fields of natural vegetation within Mapulana communities has been turned into settlement areas filled with sprawling Reconstruction and Development Programme houses thereby resulting in communities purchasing fuelwood from the neighboring villages or farms. In Thaba Chweu, protected areas where fenced and the fencing was either stolen or removed. In Nigeria, communities believe that conservation of natural resources can be achieved only if the government

Table 2. Fuelwood tree species of Mapulana people

Local name	Scientific name	Family	Frequency index
Moreke	*Dichrostachys cinerea* (L.) Wight & Arn. subsp. *africana* Brenan & Brummitt var. *africana*	Fabaceae	51
Mogamuse	*Eucalyptus grandis* W. Hill	Myrtaceae	31
Mogaletlwa (Legaletlwa)	*Senegalia ataxacatha* (DC.) Kyalangaliwa & Boatwr. *	Fabaceae	28
Mosehla	*Peltophorum africanum* Sond.	Fabaceae	21
Semoto / Mokgwelere / Modiba/ Mokabe / Moduma	*Combretum imberbe* Wawra / *Combretu mmolle* R. Br. ex G.Don / *Combretum collinum* Fresen.	Combretaceae	21
Mopai	*Pinus patula* Schltdl. & Cham. var. *patula**	Pinaceae	16
Mogonono / Mososo	*Terminalia sericea* Burch. ex DC.	Combretaceae	15
Segoi / Semata / Senokomarope	*Zanthoxylum capense* (Thunb.) Harv.	Rutaceae	10
Sepalate / Morothomabela	*Albizia versicolor* Welw. Ex Oliv.	Fabaceae	10
Morotho	*Cussonia transvaalensis* Reyneke	Araliaceae	7
Mosabai / Mopayi	*Ficus glumosa* Delile	Moraceae	5
Moshiteshite	*Acacia cyclops* A. Cunn. ex G. Don*	Fabaceae	3
Sephashu se sekgolo	*Gymnosporia buxifolia* (L.) Szyszyl.	Celastraceae	3
Mokomo	*Rauvolfia caffra* Sond.	Apocynaceae	3

Plant status- * naturalized and the rest are native

can create more employment opportunities, resulting in public awareness and education that will assist the community in understanding the value of forests (Ifegbesan et al 2016).

Alternative tree species utilized as fuelwood: Mapulana communities resorted to the utilization of fruits tree species as fuelwood to curb scarcity or shortage, and collection is mainly done on communal lands, protected areas, neighboring farms and homesteads. Matsika et al (2013) observed three reasons that the communities of Athol and Welverdiend used to curb fuelwood shortages. They use electricity as an alternative, create fuelwood markets and also extend territory for fuelwood collection. Kirkland et al (2007) and Findlay (2013) however, reported that fuelwood shortage was caused by poverty, high unemployment rates, commercial gains and increased population size in some villages around Bushbuckridge municipality. Madubansi and Shackleton (2007) further elaborated that the preference of fuelwood species depends on the relative abundance or scarcity of specific species. Limited distribution of native species force communities to search for alternatives fuelwood (Kunwar et al 2018). The utilization of plant species used as fruits or spices or foliage trees through pruning is encouraged as alternative fuelwood (Cardoso et al 2017, Scheid et al 2018). Responding to fuelwood scarcity communities resolved to using transportation when collecting fuelwood, whereby large amounts of fuelwood is collected (Abdullahi and Oruonye 2009, Scheid et al 2018, Guild and Shackleton 2018) Preference of fuelwood species depended on quality of fuelwood collected (Joshi et al 2018)

Twenty-eight species used as fruits and fuel wood were identified (Table 3). Seventy-five percent (21 species) of the tree species are native while twenty-five percent (7 species) are naturalized species. Surprisingly fruit tree species listed by elders as non-wood are the preferred ones. *Parinari curatellifolia, Sclerocarya birrea* subsp. *Caffra* and *Trichilia dregeana* is used for fuelwood, Similar results were observed by Rasethe et al (2013) and Maroyi and Rasethe (2015), where *S. birrea* subsp. *caffra* was utilized as fruits and fuelwood. Rasethe et al (2013) further elaborated that despite its high utilization *S. birrea* subsp. *caffra* is a protected species in terms of National Forests Act of 1998 of South Africa. In central Argentina Martínez (2015) observed 75% of native and 25% naturalized plants species utilized for fuelwood.

Persea americana and *Psidium guajava* use were low in fuelwood only but higher on the second category of fruits and fuelwood, while for *Mangifera indica* the case was vice-versa. Municipal interventions on aspects of biodiversity such as fencing of prohibited areas and removal of naturalized species would be more effective if communicated with community members. The removal of *P. guajava* in some parts of Mapulana communities has left a complaining respond due to miscommunication by traditional leaders. *Diospyros mespiliformis*, *Strychnos spinosa*, *Strychnos madagascariensis* and *Syzygium cumini* are utilized as fruits and fuelwood. *S. birrea* subsp. *caffra*, *S. spinosa*, *D. mespiliformis* and *S. madagascariensis* has been utilized as fuelwood in some villages around Bushbuckridge municipality (Madubansi and Shackleton 2007). The utilization of fruit tree species as fuelwood has been recorded from different countries. *Prunus persica* and *Morus alba* were used for fuelwood in Kashmir, India (Islam et al 2018). *Schinus molle* used for fuelwood by small number of South African households (Shackleton and Shackleton 2018). *Annona senegalensis* sub sp. *senegalensis* and *D. mespiliformis* are used fuelwood in northern Ghana (Jasaw et al 2017). In Burkina Faso, *D. mespiliformis* is one of the preferred tree species sold as fuelwood (Puentes-Rodriguez et al 2017).

Rules and regulation of harvesting tree species: In almost all villages harvesting of wild fruits trees for fuelwood is prohibited as these are classed as food (Fig 2). The harvesting of live trees for fuelwood is also forbidden. There has been a tradition to only collect dry or dead wood as fuelwood and fruits from the wild. According to village culture or tradition certain plant species cannot be harvested conjunctionally, these applies to wild fruits and fuelwood. Failure to comply with the rules will result with a heavy fine from the traditional office. Rankoana (2016) reported an amount of $70.50 as the minimum applicable fine depending on the crime committed. indlay and Twine (2018) further elaborated that there is misunderstanding about the issue rules and regulation concerning harvesting of fuelwood within communities. Certainly, there are rule given by the traditional authorizes but it is not clear who is responsible for making sure the people adhere.

Forty four percent of participants are follow rules placed by the traditional leaders within their villages which are one's own village but not neighboring communities (Table 4). Traditional health practitioner (THP) are among the 44% specifying rules concerning medicinal tree species harvesting. THP are required to issue permits or certificates acquired from the traditional associations for collection of roots, leaves and barks from wild tree species. Unsustainable harvesting challenges have been created by THP assistants who are ill informed about conservation of the plants. THP assistants from neighboring villages tend to

uproot plant species. Bukuluki et al (2014) observed the same result in Uganda. Kurui et al (2016) explains how medicinal plants are conserved in Kenya. In disagreement with twenty nine percent of participants who strongly believe that there are no rules. Twenty seven percent of participants agree with the latter that there are no rules but were in the past. Reasons for this misconception is observed by responds received from traditional leaders when crime is reported, how members from other neighboring communities invade and harvest resources with no fear of punishment or fine as fines are subjected to certain village members but not all. Rasethe et al (2013) reported that rules where perceived not effective because of no compliancy by villagers of Limpopo. Shumsky et al (2014) observed that different

responds for use of wild plants and inability to understand policies stipulated by foresters has resulted in heavy penalties for community member of Kenya. In Nigeria traditional leaders determine the quantity of land a family can possess and the access these rights differs from men and women (Ifegbesan et al 2016). Findlay and Twine (2018) affirms that permits should be issued to everyone who wishes to harvest plants for fuelwood.

Species prohibited in fuelwood collection: Sixteen percent of participants which are mostly elders and traditional health practitioner, has listed 9 trees species which are not to be utilized as fuelwood (non-wood) (Table 5).

Eucleacris pa subsp. *crispa*, *Philenoptera violacea* and *Vangueria infausta* are the common species known to be

Table 3. Fruit tree species utilized by Mapulana people as alternative fuelwood

Common name	Scientific name	Family	Fuelwood only	Fuelwood + fruits
Mmilo	*Vangueriai nfausta* Baker	Rubiaceae	-	5
Mmola / Mopola	*Parinari curatellifolia* Planch. Ex Benth.	Chrysobalanaceae	16	4
Motjhidi	*Ximenia caffra* Sond var. *caffra*	Olacaceae	-	1
Mogo	*Ficus sur* Forssk.	Moraceae	-	5
Mogotlho	*Trichilia dregeana* Sond.	Meliaceae	9	-
Motlhakawume	*Flueggea virosa* (Roxb. ex Willd.) Voigt subsp. *virosa*	Phyllanthaceae	1	1
Motlhakolane	*Euclea divinorum* Hiern	Ebenaceae	4	-
Motlhatswa	*Litchi chinensis* Sonn.*	Sapindaceae	-	3
Motlhatswawatlhaga	*Englerophytum magalismontanum* (Sond.) T.D. Penn.	Sapotaceae	1	-
Motlho	*Syzygium cumini* (L.) Skeels*	Myrtaceae	-	7
Mogwagwa	*Strychnos madagascariensis* Poir.	Strychnaceae	-	11
Mokotapeni	*Persea americana* Mill.*	Lauraceae	3	7
Mokumo	*Ficus thonningii* Blume	Moraceae	2	-
Monamona	*Citrus sinensis* Pers.*	Rutaceae	1	1
Moneyi	*Berchemia zeyheri* (Sond.) Grubov	Rhamnaceae	-	1
Mongaba	*Psidiu mguajava* L.*	Myrtaceae	1	3
Mongosi	*Mangifera indica* L.*	Anacardiaceae	4	3
Mooka	*Vachellia nilotica* (L.) P.J.H. Hurter & Mabb. subsp. *Kraussiana* (Benth) Kyal. & Boatwr.	Fabaceae	1	1
Mopeta	*Prunus persica* (L.) Barsch*	Rosaceae	3	-
Morula	*Sclerocarya birrea* (A. Rich.) Hochst. subsp. *caffra* (Sond.) Kokwaro	Anacardiaceae	12	12
Moshala	*Strychnos spinosa* Lam. subsp. *spinosa*	Strychnaceae	-	11
Mothalo / Mokgalo	*Ziziphus mucronata* Willd. subsp. mucronata	Rhamnanceae	3	-
Mothokolo	*Carissa edulis* (Forssk.) Vahl	Apocynaceae	-	3
Motilwane	*Antidesma venosum* E. Mey. Ex Tul.	Phyllanthaceae	-	1
Motllepo	*Annona senegalensis* Pers. subsp. *senegalensis*	Annonaceae	-	4
Motsadi	*Ximenia americana* L. var. *americana*	Olacaceae	-	2
Motsere	*Bridelia micrantha* (Hochst.) Baill.	Phyllanthaceae	3	
Motsoma	*Diospyros mespiliformis* Hochst. ex A.DC.	Ebenaceae	-	13

Plant status- * naturalized and the rest are native

Table 4. Responds on adhering to rulesen forced by traditional leaders within villages

Parameter	Percentage %
Non-wood	16
Rules in immediate villages	44
No rules	29
No rules, but were in the past	27

Table 5. Species forbidden to be utilized as fuelwood

Species Name	Frequency Index
Mmilo (*Vangueria infausta* Baker)	36
Mogo (*Ficus sur* Forssk.)	27
Motjhidi (*Ximenia caffra* Sond var. *caffra*)	27
Motlhakola swifi (*Euclea crispa* (Thunb.) Gurke subsp. *crispa*)	45
Motlho (*Syzygium cumini* (L.) Skeels)	9
Mokomo *Rauvolfia caffra* Sond.	9
Mophata (*Philenoptera violacea* (Klotzsch) *Schrire*)	45
Mothalo / Mokgalo *Ziziphus mucronata* Willd. subsp. *mucronata*	18
Motllepo (*Annona senegalensis* Pers. subsp. *senegalensis*)	9

forbidden. Giannecchini et al (2007) observed the harvesting live trees species prohibition in some villages around Bushbuckridge municipality. Kirkland et al (2007) and Prinsloo (2014) reported the utilization of wild fruits trees species for fuelwood. The control over this issues has deteriorated from the traditional leaders due to the democratic change or political status of community members (Kirkland et al 2007, Shumsky et al 2014). It has been assumed that there are no more rules. Elderly people have revealed the latter as one of the causes of overexploitation of natural resources. Other reasons where large population size, high unemployment rates, faded respect for traditional leaders and behavioral life style of the younger generation. Findlay and Twine (2018) address that the faded respect is due to nepotism, corruption, bribery and traditional authorizes fearing for their lives.

CONCLUSION

Mapulana utilize few tree species as fuelwood. In supplementing these species fruit species are utilized as alternative fuelwood. As stipulated from the current study, that every community has rules to protect the biodiversity, but not adhered to. Mapulana require environmental awareness education on aspects of saving the biodiversity. Municipal intervention on aspects of biodiversity would be more effective if communicated with the communities in overall, which in turn will assist in vegetation protection.

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Recycling of Wood Bark of *Azadirachta indica* for Bio-oil and Chemicals by Flash Pyrolysis

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Abstract: In this study, flash pyrolysis of wood bark of neem tree (*Azadirachta indica*) was examined with an aim to analyze the effect of process parameters on pyrolysis yield, physical and chemical characteristics of bio-oil produced to determine its viability as a commercial fuel as well as chemical feedstock. Flash pyrolysis of wood bark was done in a laboratory scale fluidized bed reactor at a temperature ranges from 350 to 550 ºC, different particle sizes from 0.71 to 1.25 mm with a sweep gas flow rate of 1.25 to 2.25 m^3/hr. The maximum yield of pyrolysis bio-oil of 49.5wt% was obtained under the pyrolysis temperature of 450 ºC, 1.0 mm particle size and at the sweep gas flow rate2 m^3/hr. The FT-IR and GC-MS analysis of the bio-oil indicates that it mostly consists of phenolic and oxygenated compounds with alkanes, alkenes, ketones and carboxylic acids. Chromatographic studies on the bio-oil confirmed that the oil derived from neem wood bark can be used as a renewable fuel having calorific value of 22.7 MJ/kg and its elements can be used as valuable feedstock for chemical industries.

Keywords: Wood bark, *Azadirachta indica*, pyrolysis, fluidized bed, bio-oil, characterization

The reduction in fossil fuel resources such as coal, petroleum, and natural gas has encouraged research to develop new approaches to find or invent renewable fuel (Shafiee and Topal 2009). Due to the enormous availability of biomass resources, the focus isto obtain energy from biomass (Arul Kumar et al 2019). Biomass is the world's largest energy source and represents approximately 220 billion dry tons per annum. Pyrolysis is the basic thermo-chemical conversion process in the combustion of biomass and also in its conversion into bio-fuels and chemicals (Yu et al 2010). Biomass is a complex material, mainly consists of cellulose, hemicellulose and lignin in addition to extractives and inorganic salts. The main product of the pyrolysis process is bio-oil or pyrolytic oil. The pyrolytic oil is a hopeful contestant to replace petroleum fuels (Madhu et al 2015). It is a low grade bio-fuel and can be upgraded to higher value hydrocarbon fuels, it is composed of a very complex mixture of oxygenated organic compounds and its elemental. The aqueous phase of the bio-oil contains oxygenated and organic compounds and non-aqueous phase contains oxygenated compounds and aromatic hydrocarbons (Madhu et al 2018). Numerous researches are carried out on wood as a fuel, there is some growing interest in fast growing plants like barks. Wood barks are local resources and can be supported with local economic models.

India has a huge unused potential of non-edible oil bearing plants dispersed throughout the country. *Azadirachta indica* is commonly known as neem tree. It can be used in various industries such as pharmaceuticals, plant and animal nutrition, cosmetics, pest control and energy

generation. Its fruits and seeds are the source of neem oil. The wood has been separated from its bark and is mainly used in carpentry works. The wood bark is bulky to carry, it has poor shelf life and not preferred by customers for carpentry works. It is having 14% tannin, an amount comparable to that in conventional tannin-yielding trees. It yields a strong, coarse fibre commonly woven which gives higher bulk density. Generally these barks are having no market value and used for cooking purposes in Indian households. The open burning of these wood barks has some adverse effect on the environment. From the previous literatures it has been shown that the wood bark is also used as a suitable biomass material for pyrolysis and can produce bio-fuel with higher heating value. The literature available in the field of wood bark pyrolysis is minimum and particularly no data available for neem bark pyrolysis system. This work focuses on pyrolysis characteristics of wood barks of *Azadirachta indica*.

MATERIAL AND METHODS

The wood bark was sampled from Tirunelveli (8° 44' Nlatitude, 77° 44' E longitude) Tamilnadu, India. In order to remove the moisture content of the sample, it was crushed, dried in an open sunlight for four weeks and further dried in a vacuum oven at 40 ºC for 4 hours and stored in desiccators. The samples were ball milled to homogenize the composition to obtain four different sizes-0.6, 0.71, 1.0 and 1.25 mm. The proximate, ultimate and lignocellulosic content of the biomass sample is shown in Table 1. Proximate analysis of the sample and pyrolysis products were performed with the

Table 1. Proximate and ultimate analysis of the biomass

Parameters	Value (wt%)
Proximate analysis	
Volatile matter	69.8
Fixed Carbon[a]	15.7
Moisture Content	10.3
Ash	4.2
Ultimate analysis	
Carbon	41.51
Hydrogen	7.30
Nitrogen	5.41
Oxygen[a]	45.36
Sulfur	0.42
H/C molar ratio	2.096
O/C molar ratio	0.821
Empirical formula	$CH_{2.9}N_{0.11}O_{0.82}$
Lignocellulosic content	
Cellulose (± 0.05%)	17.58
Hemi-cellulose (± 0.05%)	42.56
Lignin (± 0.05%)	39.86

[a]by difference, [b]dry ash basis

ASTM standards, such as volatile matter - ASTM D3175, ash content - ASTM D3174, moisture content - ASTM D3173 and fixed carbon - by difference. ASTM D5373 test method was used for analysis of the sample and pyrolysis products by using Vario EL-III, Germany Elementar analyzer. Lignin, cellulose and hemicellulose content of the biomass mixture were measured by using traditional wet chemistry method (Jin et al 2017). The mixture contains more fractions of volatile matters which gives a hope for higher bio-oil yields.

Reactor setup: The experimental set up was as described by Madhu et al (2015). The experiments were carried out in a laboratory scale fluidized bed reactor which consists of stainless steel tube of 50 mm inner diameter and 1.0m height was externally heated by an electrical furnace. Temperature measurements were taken above the bed with five K type thermocouples which were located at five different points (at the interval of 150 mm) inside the reactor. The temperature in reactor was controlled by a PID controller. The outside of the reactor is well insulated with mineral wool and Chromel-Alumel. The reactor was heated using 2 kW electrical resistance heater. The reactor is vertical and nitrogen gas was allowed from the bottom of the reactor. Initially air was admitted till the reactor reaches the uniform temperature and then the flow of nitrogen replaces the air will allow the reaction under anaerobic condition. A rotameter set up is attached outside the reactor to measure the flow of nitrogen. A distributed valve at the bottom of the reactor was employed for the separation of air and nitrogen. The velocity of the fluidizing gas was approximately maintained two times

greater than the minimum fluidization velocity of 0.11 m/s. Pressurized gas or liquid enters the fluidized bed through numerous holes via a plate known as a distributor plate which has 75 holes with 3 mm diameter, located at the bottom of the reactor. The flow rates of the nitrogen were 1.25, 1.75, 2.0 and 2.25 m^3/hr. The sand particle of size 0.75 mm is used for all the experiments.The biomass particles are kept in the hopper and are fed into the reactor through screw feeder. The screw feeder is attached with reactor at the height of 600 mm through feeding port. At the desired pyrolysis temperature, the sample with different particle sizes was placed inside the hopper and fed into the reactor at the rate of 30 g/min. The effluent during the reaction including volatile compounds, gas and fine charcoal was quenched by the condenser by the circulation of cooled water maintained at 10 ºC. Experiments have been carried out in a temperature range from 350 to 550 ºC, under nitrogen gas atmosphere. The condensed bio-oil from the condenser was collected in a conical flask and weighed. The char was collected from the bottom of the reactor and weighed. The percent conversion of biomass sample to bio-fuels on weight ratio was calculated as total amount of bio-oil collected per batch/total amount of biomass sample fed. The yield of char was calculated as percent by the total amount of char collected /total amount of biomass sample fed. The uncondensable gas produced during the reaction was calculated by the overall material balance. The bio-oil used for characterization study was obtained under experimental condition that gives maximum bio-oil yield. Prior to the study, the bio-oil were poured and centrifuged for 20 min at about 1500 rpm in order to separate the organic phase from aqueous phase and char.

Experimental procedure: The experimental works are carried out in three series and the first part is to find out the effect of pyrolysis temperature on yield of pyrolysis products. The sample is heated to a final pyrolysis temperature of 350, 400, 450, 500, 550 ºC at the constant particle size of 0.71 mm and at the sweep gas flow rate of 1.75 m^3/hr. The particles are heated and held at that temperature for 30 min until no significant release of gas were observed. The effect of particle size on pyrolysis yield was conducted with four different particle sizes of 0.6, 0.71, 1.0, 1.25 mm with the optimum pyrolysis temperate of 450ºC and at the sweep gas flow rate of 1.75 m^3/hr. The effect of sweep gas flow rate during pyrolysis reaction was conducted by varying the flow rate as 1.25, 1.75, 2.0, 2.25 m^3/hrat the optimum pyrolysis temperature of 450ºC and at the optimum particle size of 1.0 mm. Each experiment was performed thrice. Table 2 shows the experimental conditions of this study.

Characterization methods: The physical characterizations of the bio-oil obtained from the pyrolysis of the sample were

estimated by using BROOKFIELD LV-DV-II Pro viscometer and Penskey Martein closed cup apparatus. The density of the bio-oil was measured by weighing the know volume of the sample and heating value of the bio-oil by Parr-6772 calorimetric thermometer. The pH value was determined by digital pH meter. The component analysis of the bio-oil was done by Elementar Vario EL-III instrumentations with WinWar software. The chemical investigation of the bio oil was performed via Fourier transform infra-red spectroscopy (FT-IR) by using Bruker Optik GmbH Tensor27 by Opus version 6.5. Each spectrum was registered over 64 scans, at resolution 4 cm^{-1} among 4000 to 400cm^{-1}. The volatile and semi volatile of the bio-oil and gas was analyzed by using Thermo MS DSQ II Gas chromatography–mass spectrometry. The organic mixture was separated by the capillary column of dimension 30 m x 0.25 mm diameter x 0.25 µm of DP-35. Helium was used as a carrier gas and allows at the rate of 10 ml/min. Initially the oven was set to 70 ºC for 3 min and then increased to 250 ºC at the rate of 10 ºC/min. Mass spectrometer was operated at a temperature of 200 ºC of range 40-600 m/z.

RESULTS AND DISCUSSION

Effect of temperature on product yield: The bio-oil yield increases from 33.6to 36.4wt% when the temperature was increased from 350 to 550ºC. The char yield decreases from 38.2 to 24.3wt% and the gas yield increases from 28.2 to 39.3wt%. At lower pyrolysis temperature (< 350 °C), the decomposition of the biomass mainly occurs at heteroatom within the structure which results in production of char(Tsai et al 2007). At the temperature of about 550 °C, enormous breakup of biomass species causes the high molecular disordering, producing numerous types of compounds. The

conversion efficiency of biomass into bio-oil remained very low when the temperature is maintained less than 350 °C. Massive conversion of biomass to liquid and its fragments typically occurs within the temperature range of 400-500ºC (Akhtar and Amin 2012). The conversion efficiency increases with increase in temperature because of the availability of extra energy inputs to break the biomass structure. Due to strong cracking, the yield of bio-oil was a maximum of 42.6wt% at the pyrolysis temperature of 450°C, when the temperature beyond 450 °C the yield of bio-oil decreases to 36.4wt%. This is due to the formation of secondary cracking reactions of the pyrolysis vapor. According to Keleş et al (2011) at elevated temperature, the secondary decomposition of the bio-char could produce non-condensable gases contributing an increase in gaseous products (Sohaib et al 2017). Abnisa and Daud(2014)observed the yield of palm oil 47.3 wt% at 500 ºC. Maximum bio-oil yield of 50.6 wt% was obtained for lemon grass at a temperature of 450ºC (Madhu et al 2018).

Effect of particle size on product yield: The size of the feed particles is considered important on the yield of bio-oil (Mohan et al 2006). The bio-oil yield is significantly increases as the particle size is increased from 0.6 mm to 1.0 mm and gas yield decreased. The bio-oil yield increases from 36.5 to 45.3wt% and the char and gas yield decreases from 29.3 to 24.9wt% and 34.2 to 29.8wt%, respectively when the particle size is increased from 0.6 mm to 1.0 mm. When the particle size further increases from 1.0 mm to 1.25 mm, the bio-oil yield decreased to 39.6wt%.The smaller particles can heat up uniformly than larger particles. The poor heat transfer to the inner surfaces of the larger particles will lead to the low average particle temperatures yielding lower bio-oil yield (Şensöz and Angın 2008). In this study, particle size of 1.0

Table 2. Experimental conditions and pyrolysis yield

Case	Temperature in °C	Particle size in mm	Sweep gas flow rate in m^3/hr	Char yield in wt%	Bio-oil yield in wt%	Gas yield in wt%
Run 1	350	0.71	1.75	38.2	33.6	28.2
Run 2	400	0.71	1.75	30.8	38.9	30.3
Run 3	450	0.71	1.75	24.8	42.6	32.6
Run 4	500	0.71	1.75	22.7	40.2	37.1
Run 5	550	0.71	1.75	24.3	36.4	39.3
Run 6	450	0.6	1.75	29.3	36.5	34.2
Run 7	450	0.71	1.75	24.8	42.6	32.6
Run 8	450	1.0	1.75	24.9	45.3	29.8
Run 9	450	1.25	1.75	27.8	39.6	32.6
Run 10	450	1.0	1.25	24.5	40.6	34.9
Run 11	450	1.0	1.75	24.9	45.3	29.8
Run 12	450	1.0	2.0	27.2	49.5	25.2
Run 13	450	1.0	2.25	28.5	42.6	29.4

mm seems to be good for the production of higher bio-oil yield.

Effect of sweep gas flow rate on product yield: The increase in nitrogen gas flow rate from1.25 to 2.0 m³/hr increased the bio-oil yield from 40.6 to 49.5wt% and the decreased to 42.6wt% when the sweep gas flow rate was increased to 2.25 m³/hr. The gas yield has decreased from 34.9 to 25.2 wt%. Increase of char yield of 24.5 to 28.5 wt% was observed with increase in gas flow rate from 1.25 to 2.25m³/hr. At a sweeping gas flow rate of 2.0 m³/h, the maximum yield of bio oil of 49.5wt% was obtained (Fig. 1). The increase in the nitrogen flow rate resulted in slight increase of char yield. The flow rate of sweep gas affect the residence time of the developed gases produced during the pyrolysis reaction (Zanzi et al 2002). In present study, the yield of bio-oil, char and gases are directly associated with the fluidization condition and vapour residence time (Dhyani and Bhaskar 2018). The rate of increase of the sweep gas flow increased the motion of the biomass particles inside the

reactor and the reactor becomes vigorous and then the mixing between the sand material and biomass is improved. The better mixing of these maximizes the heat transfer rate and enhances the production of volatiles. On the other side the shorter residence time of the biomass particle leading to lower prospect of the secondary tar cracking. The maximum yield of bio-oil, char and gas was 49.5,28.5 and 34.9wt% at the sweep gas flow rate of 2.0, 2.25 and 1.25 m³/hr respectively.

Product Characterization

Physical properties of the bio-oil: The bio-oil obtained was highly oxygenated with maximum oxygen content of 41.01wt%. The density and viscosity was 1015 kg/m³ and 8.1cSt respectively and were related to the ability to flow, which can considerably affect fluid atomizers when it used for the fuel for heating applications. The flash point of the bio-oil was 155ºC and indicates that it can be stored safely at room temperature. The pH value of the bio-oil is 3.7which is also reliable with the previous studies. The low pH value of the bio-

a) Effect of temperature

b) Effect of particle size

c) Effect of sweep gas flow rate
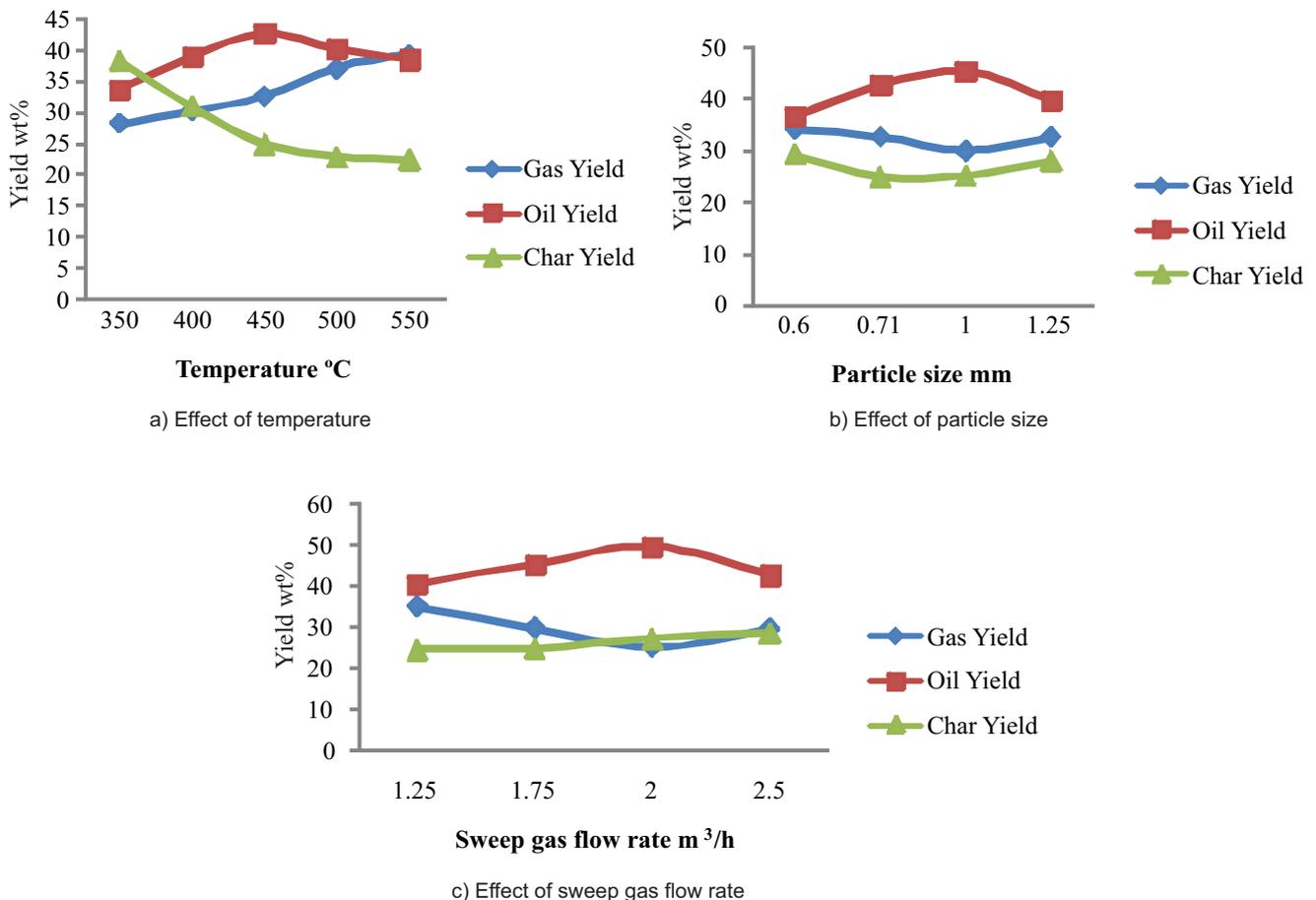
Fig. 1. Effect of process on different parameters on pyrolysis yield

oil indicates the presence of acidic compounds and it has to be treated before used for the specific applications because the bio-oil is corrosive to steel, aluminum and nickel based materials. The ash content of the bio-oil is less than 0.1 wt%. Due to the presence of oxygenated components, the heating value of the bio-oil is only as 22.7 MJ/kg which is half the value of the diesel fuels which is actually good enough for an agricultural waste. By comparing the physical properties of the bio-oil with transportation fuels, the neem bark pyrolysis oil is denser. Density and viscosity of the bio-oil can be reduced by blending it with transportation fuel. The comparison of physical properties of the obtained bio-oil is shown in Table 3.

Neem Bark oil: H/C molar ratio-2.223, O/C molar ratio-0.630, Empirical formula- $CH_{2.22}N_{0.014}O_{0.63}$

Chemical Characterization of the Bio-oil

FT-IR spectrum of the bio oil was given in Figure 2. The result shows that the entity of different organic compositions including aromatic, aliphatic and oxygenated functions (Table 4). It is a method of analysis that is based on the absorption of the functional groups.

The GC-MS analysis and various chemical compositions present in the bio-oil is represented in The most abundant components are phenolics and other aromatic compounds. The bio-oil contains different types of organic compounds such as phenols, alkanes, alkenes, fatty acids and esters. According to the area percentage recorded in GC-MS, the highest peak areas of the compounds were phenol, trimethylamine, 2-methylphenol, octadecane nitrile and stearic acid, methyl ester. The total area parentage of the phenol and its derivatives are 30. Phenols are used as a versatile precursor for many herbicides and pharmaceutical drugs (Madhu et al 2016). The obtained neem bark bio-oil products have compounds with carbon chain length ranging from C_5 to C_{47} which is similar to a mixture of gasoline and

Table 4. The FTIR functional group of the pyrolysis oil

Frequency range (cm^{-1})	Group	Class of compounds
3400-3200	OH-Stretching	Polymeric hydroxyl compound, alcohols
3000-2850	C-H bond	Alkyls
2260-2240	C≡N stretch	Nitriles
1600-1585	C-C stretching	Aromatics
1445-1400	–CH$_2$	Alkanes
1375-1000	C-O	Alcohols, carboxylic acids, esters, ethers
1000-650	=C-H bending	Alkanes
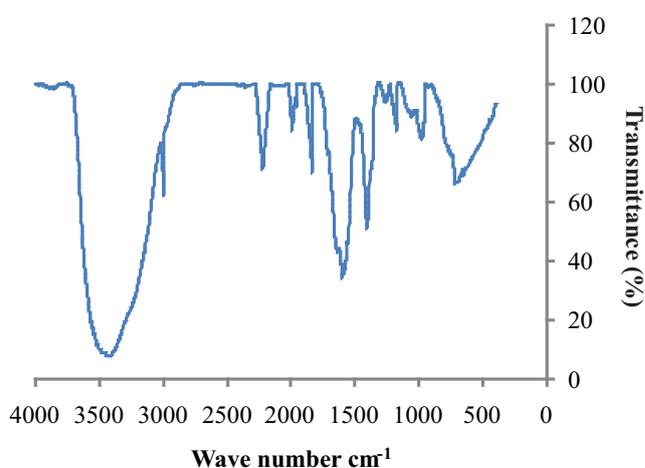
Fig. 2. FT-IR spectrum of the bio-oil

diesel fuels. Besides phenol and its derivatives, the bio-oil contains other compounds in moderate level such as ethanol, kaempferol, 1, 2-benzendiol, hexadecanenitrile, vanillin etc. These elements are used in various industries as a precursor for many industrial products (Weber et al 2004), pharmaceutical applications (Jadhav et al 2004) and, flavoring agents in food industries (Fahlbusch et al 2003).

Table 3. Comparison of physical properties of bio-oil (Solantausta et al 1993, Islam et al 1999Abnisa et al 2014, Ingram et al 2008, Sowmya Dhanalakshmi and Madhu 2018)

Properties	Neem bark bio-oil	Pine bark	Palm shell	Albiziaamara wood	Hard wood	Diesel	Unit
Density	1015	1170	1051	1050	1220	780	kg/m^3
Viscosity	8.1	70	3.2	4.2	13	1.3-3.3	cSt
Flash point	155	a	a	160	66	75	ºC
pH	3.7	3.2	2.5	3.6	a	a	-
Carbon	48.82	53.99	19.48	47.54	55.5	86.58	wt%
Hydrogen	9.1	6.97	8.92	7.8	6.7	13.29	wt%
Nitrogen	0.84	0.09	0.2	0.5	0.1	65 ppm	wt%
Sufur	0.23	0.035	0.04	0.1	0.0	0.11	wt%
Oxygen	41.01	38.21	71.40	44.06	37.7	0.01	wt%
Heating value	22.7	18.3	6.58	18.63	17.5	45.46	MJ/kg

Table 5. GC–MS analysis of the bio-oil

Compound name	Molecular formula	% area
1,4-Dimethoxybenzene	$C_8H_{10}O_2$	1.26
2-furanmethanol	$C_5H_6O_2$	0.20
Tridecane	$C_{13}H_{28}$	0.81
2-Isopropyl-2,5-dihydrofuran	$C_7H_{12}O$	3.75
4-ethyl-2 methoxy-phenol	$C_9H_{12}O_2$	1.55
Pyrogallol 1,3-dimethyl ether	$C_8H_{10}O_3$	0.99
n-Tetradecane	$C_{14}H_{30}$	1.52
Phenol	C_6H_6O	12.62
2-methylphenol	$C_7H_8O_2$	7.80
3-methylphenol	C_7H_8O	2.66
2-methoxyphenol	$C_7H_8O_2$	1.22
2,6-dimethylphenol	$C_8H_{10}O$	1.96
2,4-dimethylphenol	$C_8H_{10}O$	3.54
1,4-dimethoxy benzene	$C_8H_{10}O_2$	0.81
Octadecanenitrile	$C_{18}H_{35}N$	7.68
Stearic acid, methyl ester	$C_{19}H_{38}O_2$	5.24
Eugenol	$C_{10}H_{12}O_2$	0.63
5-hydroxymethylfurfural	$C_6H_6O_3$	0.10
Ethanol	$C_{13}H_{22}O_3$	2.12
Kaempferol	$C_8H_8O_4$	3.27
2,3,5-Trimethoxytoluene	$C_{10}H_{14}O_3$	2.25
1,2-benzendiol	$C_6H_6O_2$	4.25
Hexadecane nitrile	$C_{16}H_{31}N$	5.45
Trimethylamine	C_3H_9N	8.22
3-Acetoxy-24-methyl-5-cholest-5,22-dien-7-one	$C_{31}H_{48}O_3$	2.85
Stearic amide	$C_{18}H_{37}NO$	3.25
3,4-Altrosan	$C_6H_{10}O_5$	3.10
9-Octadecenamide	$C_{18}H_{35}NO$	5.46
4-Fluorophenyl	C_6H_5F	2.26
Vanillin	$C_8H_8O_3$	0.79
oleic acid	$C_{18}H_{34}O_2$	1.20
Stigmast-5-en-3-ol, oleate	$C_{47}H_{82}O_2$	0.67

CONCLUSION

Wood bark of neem tree (*Azadirachta indica*) is the promising feedstock for the production of bio-fuel. The maximum yield of bio-oil of 49.5wt% was under the pyrolysis temperature of 450ºC, particle size of 1.0 mm and the sweep gas flow rate of 2.0 m³/hr. The maximum conversion was achieved at the temperature 450°C. The most significant parameter to determine the product distributions. The bio-oil contains 32 types of compounds with carbon chain length in the range of C_5-C_{47}. The FT-IR and GC-MS analysis of the bio-oil shows the presence of various organic mixtures with phenols, alkanes, alkenes, fatty acids, esters, resulting in low pH values and high oxygen contents. The obtained bio-oil can be used as a renewable fuel with the heating value of 22.7 MJ/kg which is half the value of gasoline and diesel and valuable chemical feedstock. The Bio-oil may be used as a source of low-grade fuel directly or it may be upgraded to high quality liquid fuel.

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Studies on Intercropping of Maize (*Zea mays* L.) with Pea (*Pisum sativum* L.) Genotype

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Abstract: The field experiment was conducted at Khalsa College, Amritsar on sandy loam soil, low in organic carbon and available nitrogen and high in available phosphorous and potassium during the *rabi* season 2016-17. The yield was higher in sole maize (51.7 q ha^{-1}) but was at par with Maize+Pea$_{75AP-3}$, Maize+Pea$_{50AP-3}$ and Maize+Pea$_{50GS-10}$ but significantly higher than Maize+pea$_{100AP-3}$), Maize+pea$_{100GS-10}$ and Maize+Pea$_{75GS-10}$. The pod yield was maximum in sole pea$_{100GS-10}$ (65.4 q ha^{-1}) and minimum in maize+pea$_{50AP-3}$ (33.8 q ha^{-1}). The highest maize equivalent yield (84.5 q ha^{-1}) and land equivalent ratio (1.71) was observed with maize+pea$_{100AP-3}$ in intercropping system. Highest net returns of Rs.67169 ha^{-1} was in maize+pea$_{50AP-3}$ intercropping.

Keywords: Intercropping, Maize equivalent yield, Land equivalent ratio, Net return

To promote sustainability and achieve high productivity, adoption of crop rotation, multiple cropping and intercropping is essential. Intercropping is advanced management practices of soil fertility status, consisting of cultivating two or more crops in the same time. The most common advantage of intercrop is the production of greater yield on given piece of land by making more efficient use of available resource. By using a mixture of crops of different rooting ability, canopy structure, height and nutrient requirement based on the complementary utilization of growth resources by component crops. Moreover, intercropping improves soil fertility through atmospheric nitrogen fixation with the use of legumes, increases the soil conservation through greater ground cover than sole cropping. Cereal-legume intercropping has a pivotal role for increasing land use efficiency, Land productivity and atmospheric nitrogen fixation (Banik and Sharma 2009). Intercropping is considered as practical application of ecological principles such as diversity, crop interaction and other natural regulation mechanism. Intercropping maize and legume are able to reduce the amount of nutrient taken from the soil as compare to maize monocrop (Carlson 2008). Intercropping has some disadvantages such as selection of appropriate crop species, including extra work in preparing and planting mixture and also extra work during crop management practices.

Seed rate is an important agronomic parameter in intercropping system, which provides early canopy cover for maximum interception of solar radiation. Soomro et al (2009) mentioned that yield and all growth parameters were significantly affected by seed rate and planting method. Seed rate of field pea under maize-pea intercropping may affect the plant population, growth and development and ultimately the yield of pea crop. So keeping in view the above consideration an research is planned to analyze the performance and seed rate of component crops under maize+pea intercropping.

MATERIAL AND METHODS

The present investigation was conducted during the *rabi* season of 2016-17, Khalsa College, Amritsar. The soil of the experimental site was sandy loam in texture with normal soil pH and electrical conductivity, low in organic carbon and available N, high in available P and K. The experiment was planned to study the effect of intercropping of pea in winter maize with different varieties of pea at different seed rates. After pre-sowing irrigation, seed bed was prepared with help of bed planter of standard size of 67.5 cm. Maize was sown manually on the southern slope of beds in rows by dibbling method at the seed rate of 25 kg ha^{-1}. Similarly pea crop was sown in rows by *kera* method at seed rate of 100 kg ha^{-1} and 62.5 kg ha^{-1} for pea varieties AP-3 and GS-10 respectively. Pea crop was harvested for green pods manually by hand picking method and fresh weight of green pod was recorded as yield of intercrop. Maize crop was harvested manually when more than 80 per cent of the cobs turned yellowish brown and grains became hard. The experiment was laid out in randomized complete block design with nine treatments (Table 1) replicated four times.

RESULTS AND DISCUSSION

Growth of maize: The sole maize produced higher growth, whereas pea intercropping at 100 per cent seed rate of both

Table 1. Treatment detail of experiment

Treatments	Description
T$_1$: Maize+pea$_{100\ AP-3}$	Variety AP-3 of pea sown @ 100% seed rate in maize
T$_2$: Maize+pea$_{100\ GS-10}$	Variety GS-10 of pea sown @ 100% seed rate in Maize
T$_3$: Maize+Pea$_{75\ AP-3}$	Variety AP-3 of pea sown @ 75% seed rate with Maize
T$_4$: Maize+Pea$_{75\ GS-10}$	Variety GS-10 of pea sown @ 75 % seed rate with Maize
T$_5$: Maize+Pea$_{50\ AP-3}$	Variety AP-3 of pea sown @ 50% seed rate with Maize
T$_6$: Maize+Pea$_{50\ GS-10}$	Variety GS-10 of pea sown @ 50% seed rate with Maize
T$_7$: Sole maize	Sole maize
T$_8$: Sole pea$_{100AP-3}$	Variety AP-3 of pea
T$_9$: Sole pea$_{100GS-10}$	Variety GS-10 of pea

varieties (T$_1$, T$_2$) and 75 per cent seed rate of GS-10 variety significantly reduced the growth of maize as compared to the sole maize (Table 2). However sole maize treatment remained at par with pea intercropped at 50 per cent seed rate of both pea varieties and 75 per cent seed rate of AP-3 variety. The more growth in case of sole crop was attributed to comparatively better penetration of light, circulation of air and more nutrition availability. The decrease in growth in intercropped situation was ascribed to the fast growth of intercrops at an early growth stage and competition offered by intercrop for different environmental resources which suppressed growth of the companion crop.

Yield attributing characters: The bigger size of cobs not only provided sufficient space for accommodating maximum grains per cob but also offers sufficient space to increase their size. The number of cobs and cob length in sole maize was significantly higher than cob length of treatments where pea was intercropped at 100 per cent seed rate of both pea varieties and 75 per cent seed rate of GS-10 variety. However, these were at par with pea intercropped where 50 per cent seed rate of both pea variety and 75 per cent seed rate GS- 10 variety was used. The test weight and number of

grains per cob in sole maize was slightly higher from intercropped treatments but did not vary significantly. Current results were in accordance with Ali and Angelescu (2011).

Yield: The sole maize produces higher grain yield which was significantly better than T$_1$, T$_2$ and T$_4$ where intercrop was sown with 100 per cent seed rate of both pea varieties and 75 per cent with GS-10 variety (Table 4). However, performance of sole maize remained equal with 50 percent seed rate of both varieties of pea and 75 per cent seed rate of AP-3 variety. Higher yield of maize in pure stand and with 50

Table 3. Effect of intercropped pea on yield of maize during *rabi* 2016-17

Treatments	Grain yield (q ha^{-1})	Stover yield (q ha^{-1})	Harvest index
T$_1$: Maize+Pea$_{100\ AP-3}$	44.17	63.54	41.00
T$_2$: Maize+Pea$_{100\ GS-10}$	41.5	61.54	40.13
T$_3$: Maize+Pea$_{75\ AP-3}$	47.28	67.09	41.34
T$_4$: Maize+Pea$_{75\ GS-10}$	44.5	64.21	40.93
T$_5$: Maize+Pea$_{50\ AP-3}$	49.13	68.61	41.73
T$_6$: Maize+Pea$_{50\ GS-10}$	47.37	67.51	41.23
T$_7$: Sole maize	51.77	69.59	42.66
CD (p=0.05)	5.91	4.35	NS

Table 4. Effect of intercropping on growth and yield of intercropped pea during *rabi* 2016-17

Treatments	Plant height (cm)	Dry matter accumulation	Number of pods per plant	Pod yield (q ha^{-1})
T$_1$: Maize+Pea$_{100AP-3}$	57.55	6.80	5.8	43.7
T$_2$: Maize+Pea$_{100\ GS-10}$	65.25	7.92	9.2	58.17
T$_3$: Maize+Pea$_{75AP-3}$	64.67	6.86	5.0	37.9
T$_4$: Maize+Pea$_{75\ GS-10}$	69.17	8.12	8.4	48.82
T$_5$: Maize+Pea$_{50AP-3}$	64.32	7.02	5.6	33.8
T$_6$: Maize+Pea$_{50\ GS-10}$	73.22	8.20	8.4	44.25
T$_8$: Sole pea$_{100\ AP-3}$	61.17	7.08	6.4	50.6
T$_9$: Sole pea$_{100\ GS-10}$	66.47	8.12	10.8	65.45
CD (p=0.05)	4.10	0.84	3.2	8.69

Table 2. Effect of intercropped pea genotypes on growth and yield attributes of maize during *rabi* 2016-17

Treatments	Plant height (cm)	Dry matter accumulation (q ha^{-1})	Leaf area Index	No. of cobs per plant	Cob length (cm)	No. of grains per cob	Test weight (g)
T$_1$: Maize+Pea$_{100AP-3}$	136.8	103.0	3.48	1.18	17.21	432.6	20.29
T$_2$: Maize+Pea$_{100GS-10}$	131.6	97.8	3.34	1.16	16.08	401.3	20.06
T$_3$: Maize+Pea$_{75AP-3}$	142.1	109.5	3.76	1.26	17.89	468	20.41
T$_4$: Maize+Pea$_{75GS-10}$	139.2	105.9	3.61	1.20	17.41	436.6	20.19
T$_5$: Maize+Pea$_{50AP-3}$	148.6	112.7	3.98	1.28	19.12	486.2	21.19
T$_6$: Maize+Pea$_{50GS-10}$	144.2	109.8	3.81	1.26	18.51	453.3	20.96
T$_7$: Sole maize	154.3	116.3	4.06	1.30	19.95	494.4	21.64
CD (p=0.05)	12.50	7.01	0.33	0.10	2.20	49.20	NS

Table 5. Effect of intercropped pea genotypein maize on Land equivalent ratio and Economics during *rabi* 2016-17

Treatments	Land equivalent ratio	Maize equivalent yield (q ha^{-1})	Total cost (Rs ha^{-1})	Total income (Rs ha^{-1})	Net profit (Rs ha^{-1})	B:C ratio
T_1: Maize+Pea$_{100\,AP-3}$	1.71	84.5	45240	109861	64621	1.43
T_2: Maize+Pea$_{100\,GS-10}$	1.69	77.2	46134	100486	54352	1.18
T_3: Maize+Pea$_{75\,AP-3}$	1.66	82.2	41080	106944	65864	1.60
T_4: Maize+Pea$_{75\,GS-10}$	1.59	74.5	41764	96906	55142	1.32
T_5: Maize+Pea$_{50\,AP-3}$	1.61	80.3	37260	104429	67169	1.80
T_6: Maize+Pea$_{50\,GS-10}$	1.59	74.6	38350	96981	58631	1.52
T_7:Sole maize	1	51.7	24500	67275	42775	1.74
T_8:Sole pea$_{100\,AP-3}$	1	-	25670	60720	35050	1.36
T_9: Sole pea$_{100\,GS-10}$	1	-	26640	52360	25720	0.96

percent seed rate of pea intercrop was due to less intercrop competition between component crops. This might be due to more competition among plants due to higher plant population which might have caused reduction in availability of growth factors for the legume component and finally there was yield reduction. On the other hand, the sole crop enjoyed higher availability of nutrient, moisture, light, space etc and produced more number of cobs/plant and finally gave higher grain yield. This corroborates with the findings of Pandey et al (2003).

Studies on Intercrop

Growth of pea: Crop growth parameter like plant height and dry matter accumulation of both varieties of pea (AP-3 & GS-10) at various seed rates (100, 75 and 50 per cent) remained at par among all treatments. However, higher growth parameters were in sole pea treatment of AP-3 variety and minimum when pea intercropped at 100 per cent seed rate with GS-10 variety. Among varieties higher growth in GS-10 variety was due to long duration nature of GS-10 variety, which leads to vegetative growth of crop plants for longer period and ultimately resulted in higher dry matter accumulation per plant of GS-10 variety.

Pod yield and number of pods: Pod yield of pea GS-10 in sole was maximum and it was significantly higher than AP-3 sole treatment and was due to its genetic character supported by significantly higher number of pods per plant in GS-10 variety when 100, 75 and 50 per cent of seed rate was used (Table 5). Among intercropping, yield of GS-10 when intercropped with 100 percent seed rate was higher than other intercropping treatments and it was at par with sole AP-3 and GS-10. It might be due to 100 percent seed rate of GS-10. Over all yield GS-10 in intercropping remained higher than AP-3 in their respective seed rates. Similar trend was observed for the number of pods per plant which was in favor of pod yield. Reduction in yield of both varieties when intercropped at 100 per cent seed rate over sole crop was due to competition offered by base crop

(maize) for growth factors. However reduction in yield of both varieties in reduced seed rate treatments was due to less number of plants per unit area, which leads to fewer yields per unit area. Similar findings were given by Ahmad et al (2007).

Land equivalent ratio (LER): Among intercropping system, LER was higher with T_1 (maize + pea$_{100AP-3}$) and lower in treatment T_4 (maize+pea$_{75GS-10}$). LER increased with increase in seed rate of component crop i.e. from 50 per cent (T_5, T_6)< 75 per cent (T_3, T_4)< 100 per cent seed rate (T_1, T_2) which calculated as 1.60< 1.63< 1.70 respectively (Table 6). Among varieties, LER was higher in AP-3 i.e. 1.61, 1.66 and 1.71 at 50, 75 and 100 per cent seed rate, respectively than LER of GS-10 variety at their respective seed rates. Higher LER in intercropping treatments was also reported by Mandal et al (2014).

Maize equivalent yield (q ha^{-1}): The maize equivalent yield of maize was affected due to variation in the treatments (Table 6). The treatment T_1 (maize+pea$_{100\,AP-3}$) has maximum maize equivalent yield (84.5 q ha^{-1}) over the intercropping treatments T_2, T_4 and T_6, where maize was intercropped with GS-10 variety of pea. Higher maize equivalent yield in intercropped treatments with AP-3 variety (T_1) was due to higher green pod price of AP-3 variety as it become ready to harvest earlier than GS-10 variety. Similar findings on higher equivalent yields in intercropping treatments were given by Tripathi and Nath (2010). Maize as sole crop gave reasonable good yield and economic return but due to sustaining of soil fertility as well as ensures productivity from maize, intercropping with legumes is one of the ways which could help in yield stability.

Benefit:cost ratio: Benefit cost ratio was maximum in (T_5) where maize was intercropped with pea (AP-3 variety) at 50 per cent seed rate, followed by sole maize(Table 7). However The B:C ratio in sole pea (GS-10) was lower than all other treatments.Economic returns were greater for intercrops than for either sole crop (Kermah et al 2017).

CONCLUSION

The maximum grain yield of maize and pea pod yield were obtained from sole maize and pea respectively. However, maize equivalent yield and land equivalent ratio were higher in maize-pea intercropping system where AP-3 variety of pea was sown as intercrop at recommended seed rate. It is beneficial to grow AP-3 variety of pea at half of recommended seed rate as intercrop in maize.

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Assessment of Aboveground Biomass and Carbon Storage in Bamboo Species in Sub-Tropical Bamboo Forests of Mizoram, North-East India

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Abstract: Bamboo forests cover about 57% of the total forest area in Mizoram and most dominant bamboo species include *Melocanna baccifera*, *Dendrocalamus longispathus*, *Dendrocalamus hamiltonii*. The present study aims to determine aboveground biomass and carbon storage in five bamboo species viz. *M. baccifera*, *D. longispathus*, *D. hamiltonii*, *Bambusa tulda* and *Schizostachyu*m *dullooa* in Mamit district, Mizoram. A total of 33 sample plots were laid and aboveground biomass was studied using harvesting method. Diameter of bamboo was divided into three diameter classes as <3 cm, 3-5 cm and >5 cm. The culm density was highest in 3-5 cm diameter class. Total aboveground biomass in five bamboo species was *D. londgispathus* (214 Mg ha^{-1}) >*M. baccifera* (169 Mg ha^{-1})>*B. tulda*(111 Mg ha^{-1})>*D. hamiltonii* (101 Mg ha^{-1})>*S. dullooa* (41 Mg ha^{-1}). Aboveground biomass in <3 cm diameter class was highest in *D. longispathus* (23.82 Mg ha^{-1}) and lowest in *S. dullooa* (8.28 Mg ha^{-1}) whereas aboveground biomass in 3-5cm and <5cm ranged from 14.15 – 81.23 Mg ha^{-1} and 17.84 – 109.88 Mg ha^{-1} respectively. Carbon storage in >3 cm was (4-12 Mg ha^{-1}), 3-5 cm (7–41 Mg ha^{-1}) and > 5 cm (9–54 Mg ha^{-1}). This study demonstrates that bamboo has potential in enhancing carbon stock and important contribution in carbon stabilization to mitigate climate change impact efficiently.

Keywords: Bamboo, Biomass, Carbon, Climate change, Sub-tropical forest

Bamboo forest is an important forest type worldwide, mostly distributed in the tropical and subtropical regions of Asia, Latin America and Africa providing economic and ecological benefits. Global bamboo forest consists of 1,250 species within 75 genera, most of which are relatively fast growing, attaining maturity in five years (Yuming et al 2004). In India, a total of 136 bamboo species belonging to 23 genera are reported and bamboo diversity is relatively high in North-East India with 63 different species under 15 genera. Bamboo forest covers about 57% of the total geographical area of Mizoram found at an elevation ranging from 400m – 1500m. A total of 35 bamboo species are recorded under 8 genera in Mizoram with *Melocanna baccfiera* (Roxb.) Kurz., a monopodial bamboo covering an area about 95% of the total bamboo forest of the states. Bamboo has been recorded as an early colonizer in abandoned jhum land in this region (Hauchhum and Tripathi 2017). However, bamboo forests have faced extreme anthropogenic pressure since the last few decades as young shoots are harvested for consumption and mature culms are in great demand for household purpose and bamboo-based industries (Jha 2003). In addition, forest fire due to large scale slash and burn agricultural practices and unscientific management has significantly reduced bamboo growing stock of the state.

The growth rate of bamboos varied from those of timber species with their unique characteristics like fast growth, high biomass productivity and rapid maturation (Nath et al 2015). The harvest period for most bamboos ranged from 3-5 years in comparison to tree species (Desalegn and Tadesse 2014). As a consequence, bamboo appears to have high potential for biomass production and carbon sequestration (Yen et al 2010). With the ever increasing attention given to global warming, many countermeasures have been proposed to mitigate the trend of carbon increased in the atmosphere. Therefore, plantation of fast-growing species like bamboo having high potential for carbon sequestration and fixation is an important candidate to mitigate global warming (Nath et al 2009, Nath and Das 2012). Studies on bamboo biomass and carbon storage in Mizoram are very limited. Therefore, a precise estimation of bamboo carbon storage is needed to enlarge our knowledge on the potential of bamboo in carbon stabilization. This study aims to investigate the aboveground biomass and carbon storage in five village forest bamboos viz. *Melocanna baccifera*, *Dendrocalamus longispathus*, *Dendrocalamus hamiltonii*, *Bambusa tulda* and *Schizostachyum dullooa* in Mizoram, North-East India and to increase our knowledge and understanding on the role of different bamboo species in enhancing carbon stock.

MATERIAL AND METHODS

Site description: This study is carried out in Reiek and Ailawng villages situated in the eastern part of Mamit District,

Mizoram (41'03.29" – 47'04.24" N and 37'20.76" – 40'23.84" E). The study site belongs to a subtropical monsoon climate zone with mean annual rainfall from 1300 – 1500 mm and mean annual temperature 20°C. The topography of these two villages is characterized by moderate to steep slopes hilly terrain. Bamboo plays an important role in the socio-economic development in this village.

Sampling method: Biomass was estimated by harvesting randomly selected culms (diameter) of different sizes. Depending on the culm size, three different diameter classes were selected representing the whole diameter range like >3 cm, 3-5 cm > and <5 cm. We had selected 10, 7, 7, 6 and 3 sites for *Melocanna baccifera, Dendrocalamus hamiltonii, Dendrocalamus longispathus, Bambusa tulda* and *Schizostachyum dullooa* respectively with a total of 33 sites for all bamboo species studied. From each selected sites, 10 × 10 m plot for extensive study of aboveground biomass and carbon storage. Within each plot, two culms were harvested with two culms from each diameter class. Thus, a total of 198 culms were harvested to study its biomass and carbon storage. The ages of bamboo studied range from 2-4 years. The fresh weight and height of culms were measured at the field without separating it into leaf, branch and culm. A sub-sample of was brought to laboratory and oven dried at 70°C to constant weight to determined its biomass. The aboveground biomass was calculated as the ratio of absolute dry weight to fresh weight and then computed into hectare basis. A sub-sample of each species was brought to laboratory and powdered for analysis its carbon content. The ash content was estimated by heating 1 g of powdered sample at 550°C for 6 hours in a muffle furnace. A total of 50% of the ash free mass was calculated as the carbon content.

RESULTS AND DISCUSSION

Changes in culm density: The culm density of *D. longispathus* was highest for all three diameter classes compared to the other four species (Fig. 1.). The average number of culms in <3 cm diameter was 5970 culms ha^{-1} in *D.*

longispathus followed by *M. baccifera, D. hamiltonii, S. dulloa* and *B. tulda*. Similarly, in 3-5cm and >5 cm diameter class, the average culm per hectare ranged from 2375 – 7310 and 1450 – 6290, respectively (Fig. 1). Total number of culms including all diameter class was 18,77 culm ha^{-1} in *D. longispathus* followed by *D. hamiltonii, M. baccifera, S. dulloa* and *B. tulda*. Among the clump forming bamboos, the highest number of clump was recorded in *D. longispathus* (163 clumps/ha) and lowest in *B. tulda* with 145 clumps ha^{-1} (Fig. 2.). The mean diameter in <3 cm diameter class was highest in *B. tulda* (2.63 cm) and lowest in *S. dulloa* (1.97 cm). Similarly, mean diameter in 3-5 cm diameter class ranged from 3.33 – 4.47 cm and in >5 cm was 5.45 – 7.51 cm (Table 1). The average height recorded in <3 cm, 3-5 cm and >5 cm
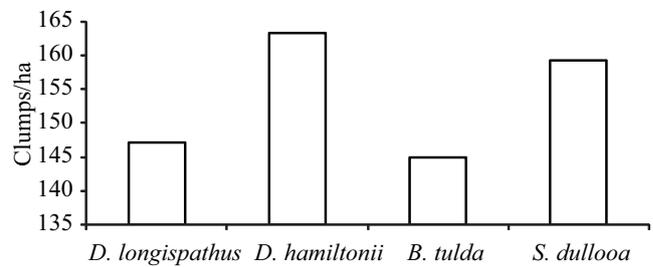
Fig. 2. Total number of clumps in four bamboo species in Mizoram

Table 1. Average diameter and height in three diameter class of different bamboo species in Mizoram

Class	*D. longispathus*	*M. baccifera*	*D. hamiltonii*	*B. tulda*	*S. dullooa*
Average diameter (cm)					
< 3 cm	2.47	2.40	2.46	2.63	1.97
3-5 cm	4.37	4.40	4.47	4.33	3.33
> 5 cm	7.83	6.63	6.57	6.53	5.45
Average height (m)					
< 3 cm	8.94	6.80	7.57	7.78	8.01
3-5 cm	11.33	9.50	12.43	10.55	11.22
> 5 cm	13.01	13.47	17.77	15.16	13.25
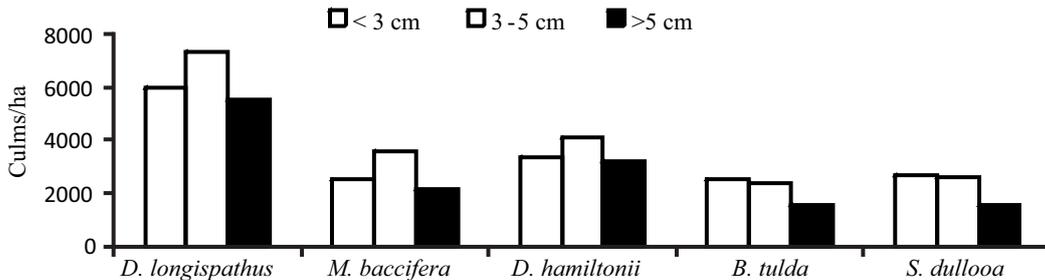
Fig. 1. Culm density of five different bamboo species in Mizoram

diameter class was 6.47 – 8.11 m, 9.41 – 11.84m 12.14 – 16.46m respectively (Table 1). Statistical analysis showed that diameter and height of each bamboo species significantly varied for all three diameter class.The result of culm density indicates that 3 years (3-5 cm diameter class) culm dominate the sites in *D. longispathus*, *M. baccidifera* and *D. hamiltonii*, but in 2 years the dominant species were *B. tulda* and *S. dullooa*. This result reveals that bigger culm size are decreasing which may be due to selective felling of matured culms by villagers to meet their requirement as well as adoption of rational harvesting by bamboo growers and buyers. On the other hand, decrease young bamboo culms (<3 cm) in *D. longispathus* and *M. baccifera* may be the result of over-harvesting of young shoots for consumption as food and selling in market as these two species are most favorite by the local people. Further, the main uses of bamboo in this region are making panel board, construction, paper and pulp, basket and other different household materials that play significant role for long term carbon sink. Thus, bamboo promotes the well-being of rural livelihood economically and ecologically who has a close relationship with forest and its products.

Changes in aboveground bamboo biomass and carbon storage

Aboveground biomass and carbon storage significantly differed in all three diameter class in all the five bamboo species (Table 2). The mean aboveground biomass in <3 cm diameter was highest in *D. longispathus* (23.82 Mg ha^{-1}) and lowest in *S. dullooa* (8.28 Mg ha^{-1}). Correspondingly, the aboveground biomass in 3-5cm and <5cm ranged from 14.15 – 81.23 Mg ha^{-1} and 17.84 – 109.88 Mg ha^{-1} respectively (Fig. 3). The total aboveground biomass (summing all the three diameter class) was highest in *D. longispathus* (214 Mg ha^{-1}) followed by *M. baccifera*, *B. tulda* , *D. hamiltonii* (and *S. dullooa*.Among the bamboo species studied, aboveground biomass and carbon storage was highest in *D. longisapthus* for all diameter classes which may be due to increase in

Table 2. Analysis of variance for different parameters in three diameter classes of five bamboo species

Species	Parameters	F-value	P-value
D. longispathus	Diameter	125.74	0.001
	Height	6.46	0.320
	Biomass	35.34	0.001
	Carbon	35.36	0.001
M. baccifera	Diameter	102.62	0.001
	Height	10.99	0.003
	Biomass	109.23	0.001
	Carbon	89.35	0.001
D. hamiltonii	Diameter	107.65	0.001
	Height	11.65	0.009
	Biomass	74.31	0.001
	Carbon	57.42	0.001
B. tulda	Diameter	86.35	0.001
	Height	18.73	0.003
	Biomass	25.04	0.001
	Carbon	31.52	0.001
S. dullooa	Diameter	29.97	0.001
	Height	26.6	0.001
	Biomass	2.41	0.177
	Carbon	3.57	0.125

number of clumps and culm density compared to other species. Further, variation in average diameter, height and culm density in the five bamboo species could be responsible for differences in the aboveground biomass.In the present study, although the culm density considerably reduced in larger diameter size, the aboveground biomass was comparatively high which may be the result of thick walled culm structure compared to thin wall culm in smaller diameter class. In addition, the present results indicate that aboveground biomass has positively significantly correlation with diameter size.
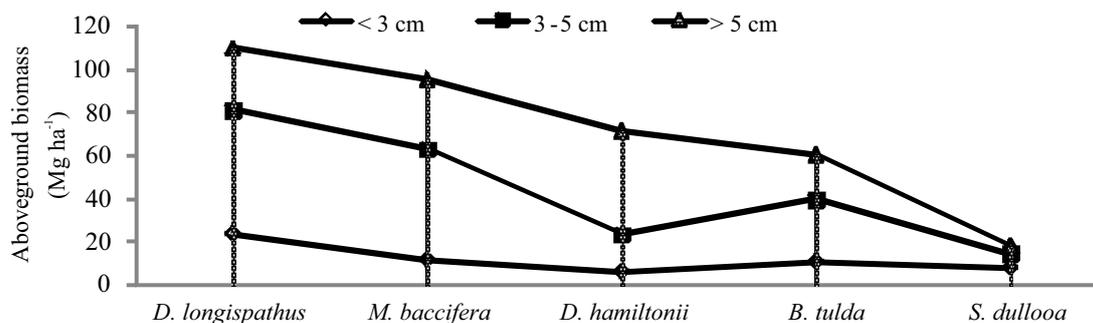
Fig. 3. Aboveground biomass in three diameter classes of five different bamboo species in Mizoram
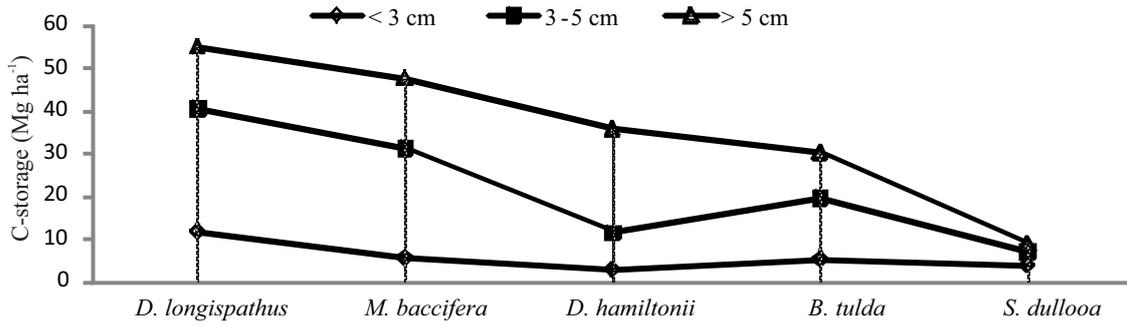
Fig. 4. Amount of C-storage in three diameter classes of five different bamboo species in Mizoram
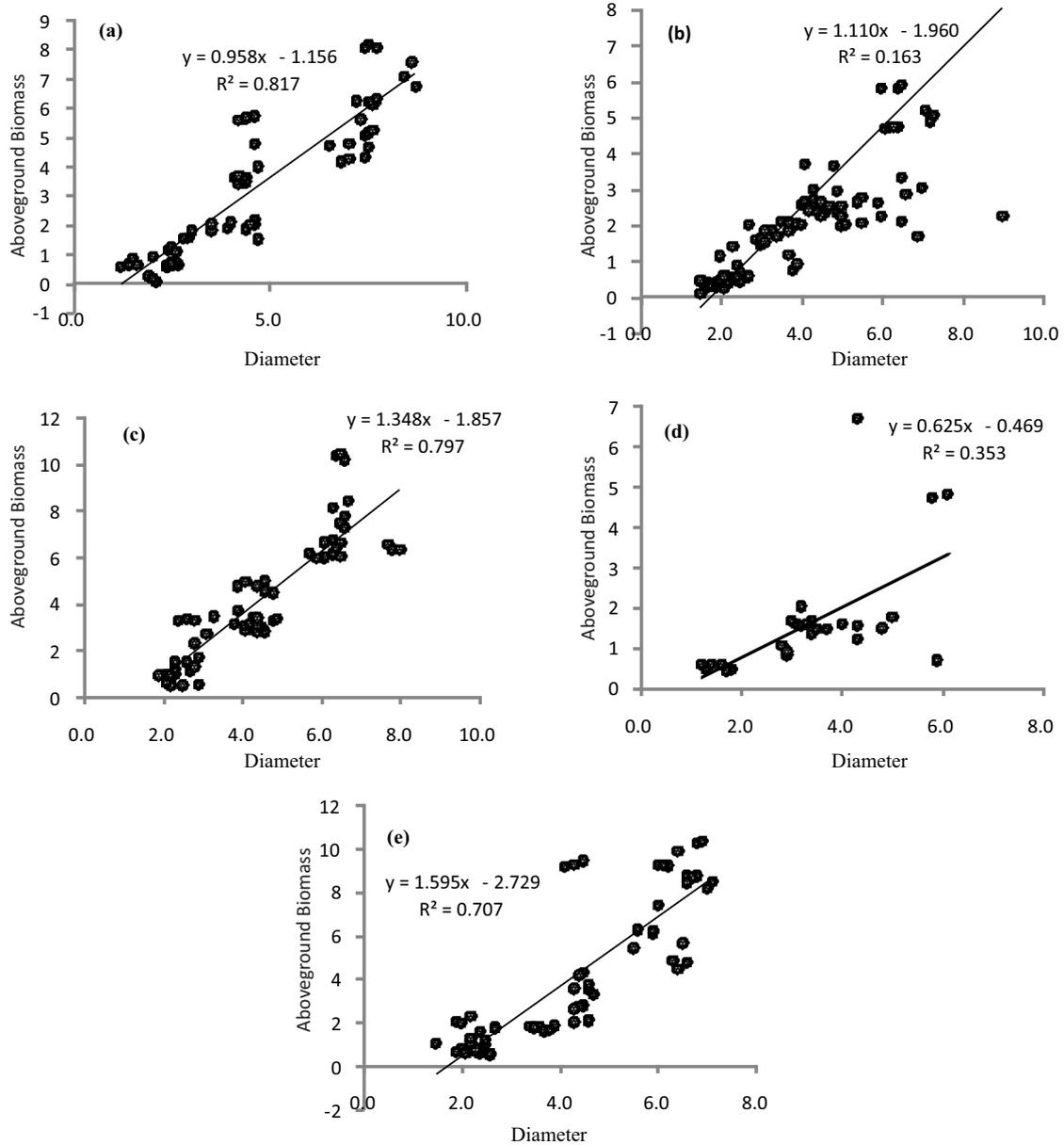
Fig. 5. Relationship between aboveground biomass and diameter in five different bamboo species (a) *D. longispathus* (b) *M. baccifera* (c) *B. tulda* (d) *S. dullooa* (e) *D. hamiltonii* in bamboo forests of Mizoram

The carbon storage in >3 cm was highest in *D. longispathus* (12 Mg ha^{-1}) and lowest in *S. dullooa* (4 Mg ha^{-1}). Similarly, in 3-5 cm and > 5 cm, the carbon storage ranged from 7 – 40 Mg ha^{-1} and 9 – 54 Mg ha^{-1} respectively (Fig. 4). The aboveground biomass and carbon storage in five different bamboo species showed the following trend: *D. londgispathus>M. baccifera >B. tulda>D. hamiltonii>S. dullooa*. The changed in aboveground biomass showed significant relationship with corresponding diameter-*D. longispathus* (R^2 = 0.817), *B. tulda* (R^2 = 0.797), *D. hamiltonii* (R^2=0.707), *S. dullooa* (R^2 = 0.353) and *M. baccifera* (R^2 = 0.163) (Fig. 5). The aboveground biomass and carbon storage in <3 cm and >5 cm diameter class is comparable in *M. baccifera* and *B. tulda* in 3 years age in Lengpui village, Mizoram(Devi et al 2018). The total aboveground biomass reported is within the range compared to other bamboo studied in different region, 105 Mg ha^{-1} in *Phyllostachys makinoi* in central Taiwan (Yen et al 2010), *Phyllostachys pubescens* (97-106 Mg ha^{-1}) in China (Wang et al2013) but greater than 22 – 77 Mg ha^{-1} in North East India (Nath and Das 2012).

CONCLUSION

D. longispathus and *M. baccifera* has greater aboveground biomass and carbon storage compared to other three bamboo species. On the other hand, thick walled bamboo like *B. tulda* and *D. hamiltonii* (with lower culm density) has comparatively high carbon storage. The present study shows that bamboo has significant contribution in carbon sequestration and has potential to mitigate global climate change.

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Impact of Land Use and Land Cover on Aquatic Macrophyte Community Composition in Small Streams: A Case Study from Cachar District of Assam in Northeast India

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Abstract: Land use and land cover (LULC) profoundly influence the aquatic ecosystems through runoffs. The runoffs comprising of nutrient, as well as propagule of aquatic macrophytes (AMs), are expected to determine the physicochemical and biological characteristics of the aquatic environment. We tested this proposition by comparing the assemblages of AMs as well as the water and sediment characteristics in two small streams, each flowing through two different types of landscape, i.e., agriculture and human settlements. The study was done for a period of two years, i.e., from 2014 to 2016. Seventeen species of AMs belonging to 14 families were recorded, of which 7 were invasive aquatic macrophytes (IAMs). Taxa richness and diversity of AMs was higher in the stream flowing through the agricultural landscape while density and dominance of AMs were higher in the stream flowing through the landscape dominated by human settlement. Multivariate analysis revealed that stream depth and input of nutrients and organic matter from the adjoining riparian region play significant role in modulating the stream environment and AM community composition and abundance.

Surrounding land use and land cover (LULC) profoundly influence the aquatic environment. Runoff of organic waste and chemical fertilizers is possibly one of the mechanisms that cause substantial variation in the abiotic conditions in the riparian area of the aquatic habitats, which in turn determine the plant species composition and diversity in such habitats (Rajbongshi et al 2018). However, the extent to which such runoffs cause variation in environmental conditions, as well as species assemblages, needs proper investigation. The phenomena of environmental parameters in any aquatic system and distribution of its biota are directly related to and influenced by each other and controlled by variety of natural regulatory mechanisms (Bhat et al 2009). Besides anthropogenic activities like input of domestic effluents, runoff from agricultural lands affects the diversity of the nearby aquatic ecosystem (Medona et al 2015, Marwein et al 2018). Many studies have been done on the relationship between aquatic macrophytes (AMs) and their environmental factors in big rivers (Bernez et al 2004, Hrivnak et al 2010) and lentic bodies such as lakes, wetlands, and ponds (Svitok et al 2011, Hrivnak et al 2013). However, understanding on this aspect in the smaller streams is limited (Riis et al 2000, Downes et al 2003). In present study, we hypothesize that variation in the ecological parameters such as water and sediment characteristics because of different LULC determine AM community composition, diversity, and abundance patterns in small streams located in the Cachar district of Assam in northeast India. The Cachar district is a part of the Barak river basin – which is a major river system in the northeastern region of India comprising of numerous tributaries such as Jiri, Siri, Madhura, Jatinga and Larang, Sonai, Ghagra, Katakhal, Dhaleswari, Singla, Longai with many other small streams. The objectives of the study are to characterize and compare the water and sediment properties in two small streams located under two different landscapes and, to study the community characteristics of AMs and their association with water and sediment parameters in the two small streams.

MATERIAL AND METHODS

Study area: The two small streams viz., Lakhichora (Stream1) (Longitude 092 ˮ47.578'E; Latitude 24 ˮ44.522'N) and Makrulchora (Stream2) (Longitude 092 ˮ46.340'E; Latitude 24 ˮ45.326'N) were selected for study in Cachar district of Assam in northeast India. The first stream flows through an agricultural landscape comprising of paddy fields, while the second stream flows through a landscape dominated by human settlements.

Vegetation sampling: Vegetation sampling was carried out at two months interval for a period of two years, i.e., from April 2014 to February 2016. During each sampling, 30 random quadrats of 1 x 1m size were laid in each of the streams.

Frequency, density, abundance, relative frequency, relative density, relative abundance, and importance value index (IVI) were calculated following standard methods (Misra 1968). The macrophytes were identified following standard taxonomic keys, relevant scientific literature (Biswas and Calder 1984, Cook 1996, Fassett 2000, Majid 2000), and online resources (www.kew.org and www.tropicos.org). The invasive species were identified using the global database on invasive species (www.issg.org/Database) and the ENVIS database (www.bsienvis.nic.in/Database). Indices of diversity, dominance, and evenness were calculated following standard methods (Kent and Coker 1992, Magurran 2013).

Sampling and analysis of water and sediment: Air temperature (AT), water temperature (WT), and sediment temperature (ST) of the selected streams were measured using a mercury bulb thermometer (0-100°C). Water depth (WD) was determined using a measuring pole. Transparency (Trans) was measured using Secchi disk. Water flow rate (WFR) was determined using float method (Hauet et al 2008). Three sets of representative surface water samples were collected from each stream in PVC bottles. They were then mixed to make composite sample for analyses of different chemical parameters. However, samples for dissolved oxygen (DO) and biological oxygen demand (BOD) were collected in BOD bottles separately. Besides water sample, three sets of sediment samples from a depth of 0-15 cm were collected using a soil corer. Subsequently, a composite sample was prepared by mixing the three sets of samples, which were then kept in polythene bags for analysis.

Laboratory analyses: A small fraction of the fresh sediment samples was used for analysis of pH, conductivity (SEC), and moisture content (MC). The rest of the sediment samples were air-dried, ground, sieved using 2 mm mesh size and kept in airtight polythene pockets for analysis of chemical properties. The pH and EC of the water sample were analyzed using pH meter and conductivity meter respectively. Samples for BOD were kept in an incubator at 20°C for three days. This was followed by analyses of the other chemical properties of water. DO and BOD (at 20°C for three days) was estimated following Winkler's method. Total alkalinity (TA) and free carbon dioxide (CO_2) were analyzed by titrating with strong acid and alkali, respectively. Other parameters like hardness (H) as $CaCO_3$, nitrate-N (NO_3-N) and phosphate-P (PO_4-P) were done following standard methods (Trivedy and Goel 1984, APHA 2012). For sediment, pH (SpH) and electrical conductivity (SEC) were analyzed by using pH meter and conductivity meter respectively. Moisture content (MC) was determined by oven

drying the samples at 105°C to a constant mass for 48 hours (Allen et al1974). Sediment texture was estimated following Anderson and Ingram (1993). Bulk density (BD) was determined by soil coring method (Anderson and Ingram 1993). Water holding capacity (WHC) was calculated by Keen's method (Piper 1942). Sediment nitrate-N (SNO_3-N) was estimated using phenol disulphonic acid method (Allen et al 1974), and sediment phosphate-P (SPO_4-P) was estimated using ammonium-molybdate blue method (Jackson 1962). Sediment organic carbon (OC) was analyzed following Walkley and Black rapid titration method (Walkley and Black 1934). Sediment organic matter (OM) content was determined by multiplying the OC values by a factor of 1.724 (Allen et al 1974).

Data visualization and statistical analysis: The level of heterogeneity in the selected environmental parameters was assessed using univariate (mean and SD, and t-test) and multivariate (principal component analysis, canonical correspondence analysis and multiple regression) statistics using SPSS software version 20 (Nie et al 2011). Computation of diversity indices and SIMPER analysis were done using PAST version 3.14 (Hammer et al 2001). The relationship of the AM assemblages with their habitat condition in the selected streams was determined by canonical correspondence analysis (CCA) using CANOCO software (version 4.5, TerBraak and Smilauer 2002, Trial version).

RESULTS AND DISCUSSION

Land use effects on the physicochemical properties of water and sediment: Physicochemical parameters of water and sediment of selected streams (Table 1) showed that WFR, EC, DO, NO_3-N, PO_4-P, MC, BD, WHC, SEC, SNO_3-N and OM were more in stream1. On the other hand, WT, ST, Trans, WD, pH, BOD, TA, CO_2, H as $CaCO_3$, SpH and SPO_4-P were more in stream 2. The sediment texture in stream1 was clayey whereas in stream 2 it was sandy clay. Among all physicochemical properties of water, stream2 had significantly more WD. On the other hand, amongst all the physicochemical properties of sediment in streams, OM was significantly higher in stream1.

PCA recognized six factors in the data set related to water parameters, which explained 85% of the total variance of water parameters (Table 2). The varimax factor (VF) containing a correlation higher than 0.70, were considered significant. The first VF accounted for 17.427% of the total variance and had greater loading score for WD and NO_3-N. The second VF explained 16.266% of the total variance and had greater loading score for WT and WFR. The third VF estimated15.894% of the total variance and had greater

Table 1. Physico-chemical properties of water and sediment in streams

Parameters	Stream1	Stream2	t- value
Physico-chemical properties of water			
Air temperature (AT) (°C)	27.03±5.42	26.82±5.38	0.094[ns]
Water temperature (WT) (°C)	28.81±4.44	28.89±3.92	-0.049[ns]
Water depth (WD) (cm)	32.50±15.17	63.40±14.90	-5.034[**]
Transparency (Trans) (cm)	[ᵠ]19.92±3.09	27.72±5.83	-
Water flow rate (WFR) (ms^{-1})	0.053±0.04	0.045±0.03	0.553[ns]
pH	5.48±0.90	5.54±0.80	0.178[ns]
Electrical conductivity (EC) (µScm^{-1})	73.59±32.69	72.32±33.52	0.094[ns]
Dissolved oxygen (DO) (mgl^{-1})	7.58±2.61	5.99±2.77	1.448[ns]
Biological oxygen demand (BOD) (mgl^{-1})	3.29±1.89	3.41±2.48	-0.134[ns]
Free carbon dioxide (CO_2) (mgl^{-1})	17.01±6.33	20.39±8.7	-1.087[ns]
Total alkalinity (TA) (mgl^{-1})	28.11±13.72	28.22±10.22	-0.022[ns]
Hardness (H) as $CaCO_3$ (mgl^{-1})	35.11±12.37	37.72±15.02	-0.465[ns]
Phosphate-P (PO_4-P) (mgl^{-1})	0.08±0.05	0.06±0.04	1.170[ns]
Nitrate-N (NO_3-N) (mgl^{-1})	2.99±1.70	2.39±1.30	0.980[ns]
Physico-chemical properties of sediment			
Sediment temperature (ST) (°C)	26.61±4.67	27.67±3.77	0.609[ns]
Moisture content (MC) (%)	28.58±5.01	25.60±6.23	1.296[ns]
[¶]Texture	Clay	Sandy Clay	-
[¶]Bulk density (BD) (gcm^{-3})	1.41	1.32	-
[¶]Water holding capacity (WHC) (%)	37.14	28.12	-
pH	4.66±0.61	4.71±0.74	-0.198[ns]
Electrical conductivity (SEC) (µScm^{-1})	53.24±29.93	51.45±21.13	0.169[ns]
Phosphate-P (SPO_4-P) (gkg^{-1})	0.29±0.20	0.34±0.22	-0.470[ns]
Nitrate-N (SNO_3-N) (gkg^{-1})	1.64±1.26	1.45±0.92	0.430[ns]
Organic matter (OM) (gkg^{-1})	9.72±4.41	6.65±2.51	2.097[*]

Mean±SD; n=12, [ᵠ] n= 7 as the reading was below the detectable limit during some sampling period; df=22;
'**' indicates $p<0.01$; '*' indicates $p<0.05$; '[ns]' indicates not significant; [¶] indicates that the data is based on one-time sampling

Table 2. Rotated principal components according to the Varimax method for physico-chemical parameters of water in streams

Parameters	Component					
	VF1	VF2	VF3	VF4	VF5	VF6
Physico-chemical properties of water						
WT (°C)	-.048	**.903**	-.019	.231	.016	.156
WD (cm)	**.780**	.146	-.171	.303	.270	.055
WFR (ms^{-1})	.065	**.748**	-.106	-.321	-.289	-.244
pH	.545	.581	.226	.199	-.259	.137
EC (µScm^{-1})	.221	-.270	.601	-.236	.503	.270
DO (mgl^{-1})	-.592	.016	.592	.161	-.061	-.242
BOD (mgl^{-1})	-.151	-.079	**.812**	.254	-.113	-.012
Free CO_2 (mgl^{-1})	-.011	.073	.095	**.926**	.052	-.017
TA (mgl^{-1})	.050	-.134	-.051	.089	**.947**	.039
H as $CaCO_3$ (mgl^{-1})	-.018	.054	-.094	-.010	.074	**.946**
PO_4-P (mgl^{-1})	.165	.322	.647	-.320	.079	-.367
NO_3-N (mgl^{-1})	**-.853**	.095	-.077	.356	.056	.247
Eigen value	2.091	1.952	1.907	1.528	1.407	1.330
Variance (%)	17.427	16.266	15.894	12.734	11.727	11.082
Cumulative variance (%)	17.427	33.693	49.586	62.320	74.047	85.129

VF - Varifactor; Bold values indicate strong loading

loading score for BOD. The fourth VF determined12.734% of the total variance and had greater loading score for CO_2. The fifth factor explained 11.727% of the total variance and had greater loading score for TA. The sixth VF observed 11.082% of the total variance and had greater loading score for H as $CaCO_3$. This, therefore, indicates that morphometry of streams in addition to the input of runoff water beside anthropogenic activities such as bathing, washing utensils, and cloths plays a dominant role in altering the water properties of the selected streams and hence the habitat condition for the respective AMs. Similarly, PCA recognized four factors in the data set related to sediment parameters, which explained 82% of the total variance of the sediment parameters (Table 3). The VF containing a correlation greater than 0.70, were considered significant. The first VF accounted for 23.161 % of the total variance and had greater loading for ST and SEC. The second VF explained 22.624% of the total variance and had greater loading score for MC and SpH. The third factor explained 19.884% of the total variance and had greater loading score for SPO_4-P and OM. The fourth factor explained 16.419% of the total variance and had greater loading score for SNO_3-N. This, therefore, indicates that input of agricultural residues, other allochthonous materials besides decomposition of OM plays a significant role in altering sediment properties of the selected streams.

Land use effects on community characteristics of stream vegetation: Overall, 17 species of AMs belonging to 14 families were recorded from the two streams. Amongst the 17 species, seven belonged to the category of invasive aquatic macrophytes (IAMs). Twelve species of AMs were from stream 1, i.e., the stream flowing through the agricultural landscape, while 10 species were recorded from stream2, i.e., the stream flowing through the landscape dominated by human settlement (Table 4). The species found exclusively in stream1 were *Limnophila sessiliflora, Marsilea quadrifolia, Monochoria hastata, Nymphoides indica, Persicaria barbata, Sacciolepis interrupta* and *Sagittaria sagittifolia*. The species found exclusively in stream2 were *Azolla pinnata, Euryale ferox, Salvinia cucullata, Trapa natans* and *Utricularia aurea*. The species common to both the streams were *Eichhornia crassipes, Ipomoea carnea, Ludwigia adscendens, Nymphoides cristata* and *Persicaria hydropiper* (Table 4). Overall, the SIMPER analyses revealed that there was 61.87% average dissimilarity in the compositions of AMs between the two streams (Table 4). Such variations in the distribution pattern and composition of AMs in the selected streams indicate the variations in the propagule distribution of the AMs and habitat conditions of the streams due to the variations in location of both the streams.

Table 3. Rotated principal components according to the Varimax method for physico-chemical parameters of sediment in streams

Parameters	Component			
	VF1	VF2	VF3	VF4
Loading scores				
ST (°C)	**.891**	.185	.221	-.110
MC (%)	-.086	**.901**	.091	.130
SpH	.351	**.800**	.017	.013
SEC (μScm⁻¹)	**-.826**	.001	.221	-.253
SPO$_4$-P (gkg⁻¹)	-.044	.071	**-.861**	.299
SNO$_3$-N (gkg⁻¹)	.095	.089	-.051	**.900**
OM (gkg⁻¹)	-.054	.290	**.736**	.397
Eigen value	1.621	1.584	1.392	1.149
Cumulative variance (%)	23.161	22.624	19.884	16.419
Variance (%)	23.161	45.785	65.669	82.088

VF -Varifactor; Bold values indicate strong loading

The IVI values showed that *E. crassipes* was the most dominant species in stream1 and co-dominant species in stream2 (Table 4). This might be due to its faster growth rate (Patel 2012), the ability for fast reproduction via its propagation through daughter plants (Tellez et al 2008*)* and also ability to successfully displace the other plants (Tellez et al 2008). CCA plot revealed a close association of free-floating macrophytes like *E. crassipes* with TA, CO_2, and H as $CaCO_3$ (Fig. 5). Contrastingly, *T. natans* was the most dominant AM in stream2 (Table 4). This might be due to its capacity to form a dense bed on the water surface that restricts the light penetration, which prevents other species from growing near it (Hummel and Findlay 2006). The dominance of *T. natans* in stream2 may also be attributed to greater WD, as revealed through the multiple regression analysis (Table 6). In stream1, the second dominant species was *M. quadrifolia* (Table 4)*.* Its dominance may be attributed to its ability to propagate through spores and its fast growth rate (Schneider-Binder 2014, Soni and Singh 2012). CCA plot revealed a close association of rooted floating macrophytes like *M. quadrifolia* with EC, NO_3-N, and OM present in the sediment (Fig. 5). *N. cristata* was the third dominant species in stream1 (Table 4). This might be attributed to its ability for greater reproduction via plant fragments, bulbils, and tubers (Willey and Langeland 2011). Also, their dense canopy reduces the amount of direct sunlight required by other aquatic plants (Anderson and Frank 2014) thereby suppressing the growth of the other AMs. Multiple regression analysis revealed that *N. cristata* is strongly associated with OM in the streams (Table 6)*. U. aurea was* the third dominant species in stream 2 (Table 4). This might be due to its rapid growth rate through the

production of stolons (Gordon and Pacheco 2007). In addition, *U. aurea* showed a strong relationship with WD as revealed by the multiple regression analysis (Table 6). The total density of AMs was higher in stream 2 (Fig. 1). This might be due to the resultant effect of the higher density of two invasive macrophytes viz., *E. crassipes* and *T. natans* in stream 2. The multiple regression analysis revealed a strong relationship between total density of AMs with an increase in SpH and decrease in BOD of water. This, therefore, indicates that an increase in sediment pH and reduction of organic matter in water facilitates better growth of AMs in streams.

Habit-wise distribution of the AMs in the selected
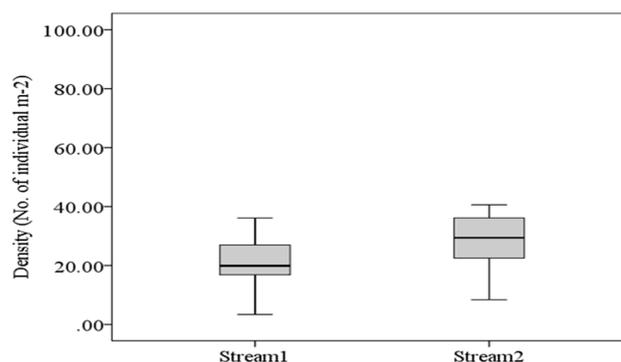
Fig. 1. Density (no. of individual m^{-2}) of aquatic macrophytes in the selected streams

Table 4. Distribution, density (no. of individual m^{-2}), IVI, taxonomic richness and dissimilarity of aquatic macrophytes in streams

Family	Species name/Habit	Stream 1		Stream 2	
		Density	IVI	Density	IVI
Azollaceae	**Azolla pinnata* R. Br. (Free floating)	-	-	2.16±6.29	16.28±39.79
Pontederiaceae	**Eichhornia crassipes* (Mart.) Solms (Free floating)	9.09±5.75	94.90±35.75	9.55±6.17	110.38±53.47
Nymphaeaceae	*Euryale ferox* Salisb. (Rooted floating)	-	-	0.33±0.51	7.42±9.92
Convolvulaceae	*Ipomoea carnea* Jacq. (Emergent)	0.90±1.00	16.29±13.74	0.21±0.39	4.85±9.22
Scrophulariaceae	**Limnophila sessiliflora* (Vahl) Blume (Submerged)	0.12±0.40	1.80±6.22	-	-
Onagraceae	*Ludwigia adscendens* (L.) Hara (Emergent)	1.69±0.97	34.23±15.24	0.13±0.32	2.73±6.69
Marsileaceae	*Marsilea quadrifolia* L. (Rooted floating)	8.50±18.95	42.92±54.54	-	-
Pontederiaceae	*Monochoria hastata* (L.) Solms (Emergent)	0.50±0.77	10.65±12.87	-	-
Menyanthaceae	*Nymphoides cristata* (Roxb.) Kuntze (Rooted floating)	2.98±3.33	40.99±44.91	0.68±0.83	18.46±28.73
	Nymphoides indica (L) Kuntze (Rooted floating)	0.50±1.26	7.54±21.65	-	-
Polygonaceae	*Persicaria barbata* (L.) H.Hara (Emergent)	0.20±0.38	3.24±6.12	-	-
	Persicaria hydropiper L. (Emergent)	1.18±1.69	14.36±20.09	0.18±0.41	4.06±9.57
Poaceae	*Sacciolepis interrupta* (Willd.) Stapf (Emergent)	0.83±1.09	24.18±28.21	-	-
Alismataceae	**Sagittaria sagittifolia* L. (Emergent)	0.44±0.68	8.94±11.89	-	-
Salviniaceae	*Salvinia cucullata* Roxb. (Free floating)	-	-	0.15±0.36	2.79±6.75
Trapaceae	**Trapa natans* L. (Free floating)	-	-	12.26±8.82	111.95±60.20
Lentibulariaceae	*Utricularia aurea* Lour. (Submerged)	-	-	1.40±1.76	21.09±18.02
Total family: 14 Stream 1: 9 Stream 2: 10	Total aquatic macrophyte species: 17	12		10	
	Total invasive aquatic macrophyte species: 7	5		5	
Dissimilarity of aquatic macrophytes in two streams: 61.87%					

Mean±SD; n=12; '-' indicates absence of the taxa concerned; '**' indicates that the taxa is reported as globally invasive species; '*' indicates that the taxa is reported as invasive species in India

Table 5. Canonical correspondence analysis (CCA) showing the strength of aquatic macrophytes habit-environment relationship in the selected streams

Axes	Axis-1	Axis-2	Axis-3	Axis-4
Eigen values	0.558	0.247	0.205	0.183
Species-environment correlations	0.984	0.959	0.963	0.929
Cumulative percentage variance of species data	31.2	45.0	56.4	66.7
Cumulative percentage variance of species-environment relation	34.8	50.2	62.9	74.4

streams revealed that in stream1 the density of rooted floating AMs was more followed by free-floating, emergent and submerged species (Fig. 2). The dominance of rooted floating AMs in stream1 may be attributed to the better habit condition characterized by shallow depth (Table 1). This facilitates the rooted floating AMs in better utilization of the available micro- and macronutrients as revealed by the CCA ordination plot (Fig. 5). Besides association of the rooted-

floating macrophytes with nutrients like nitrate-N and phosphate-P present in the stream water have also been observed (Fig. 5). In the case of stream 2, the density of free-floating AMs was more followed by submerged, rooted floating and emergent species (Fig. 2). The dominance of free-floating species in stream 2 might be attributed to its greater WD (Table 1) that helps the AM to float on water surface. Also, association of free-floating AMs with TA, CO_2,

Table 6. Results of multiple regression analysis for density and diversity index of aquatic macrophytes against the environmental parameters in the selected streams

Dependent variable	Predictor variable	Unstandardized coefficients		Standardized coefficients	t-value	Significance level	95% confidence interval for B	
		B	Std. error	Beta			Lower bound	Upper bound
Azolla pinnata	Constant	-25.582	4.982		-5.135	.000	-35.943	-15.221
	SpH	4.953	.969	.732	5.110	.000	2.937	6.968
	SCond	.066	.025	.372	2.598	.017	.013	.119
Euryale ferox	Constant	-1.507	.452		-3.335	.003	-2.450	-.565
	SpH	.556	.106	.944	5.264	.000	.336	.777
	MC	-.044	.012	-.653	-3.783	.001	-.069	-.020
	PO_4-P	3.661	1.383	.407	2.647	.015	.776	6.546
Ipomoea carnea	Constant	-.022	.316		-.070	.945	-.677	.633
	PO_4-P	7.734	3.680	.409	2.101	.047	.101	15.367
Limnophila sessiliflora	Constant	-.105	.095		-1.112	.278	-.301	.091
	WFR	3.309	1.566	.411	2.113	.046	.061	6.557
Ludwigia adscendens	Constant	4.493	.753		5.968	.000	2.923	6.064
	WD	-.038	.009	-.765	-4.379	.000	-.056	-.020
	NO_3	-.427	.123	-.605	-3.471	.002	-.684	-.170
	SPO_4-P	-1.969	.779	-.389	-2.527	.020	-3.595	-.344
Monochoria hastata	Constant	-.211	.222		-.953	.351	-.671	.249
	PO_4-P	6.193	2.585	.455	2.396	.026	.832	11.553
Nymphoides cristata	Constant	-2.533	.838		-3.022	.006	-4.271	-.795
	OM	.533	.093	.774	5.733	.000	.340	.726
Nymphoides indica	(Constant)	-.494	.399		-1.240	.229	-1.323	.335
	Cond	.018	.005	.641	3.570	.002	.007	.028
	BOD	-.169	.076	-.401	-2.233	.037	-.326	-.012
Persicaria barbata	Constant	.598	.153		3.897	.001	.279	.917
	WD	-.006	.002	-.488	-2.765	.012	-.011	-.002
	BOD	-.056	.023	-.427	-2.420	.025	-.105	-.008
Sacciolepis interrupta	Constant	-1.176	.449		-2.618	.016	-2.109	-.242
	PO_4-P	11.803	3.239	.595	3.644	.002	5.067	18.540
	TA	.025	.012	.345	2.114	.047	.000	.050
Sagittaria saggitifolia	Constant	.784	.235		3.331	.003	.296	1.272
	WD	-.012	.004	-.487	-2.614	.016	-.021	-.002
Salvinia cucullata	Constant	-.222	.118		-1.886	.073	-.467	.022
	Cond	.004	.001	.506	2.750	.012	.001	.007
Trapa natans	Constant	-5.411	3.642		-1.486	.151	-12.963	2.141
	WD	.241	.070	.594	3.463	.002	.097	.385
Utricularia aurea	Constant	-1.054	.608		-1.733	.097	-2.315	.207
	WD	.037	.012	.558	3.151	.005	.013	.061
Total density	Constant	-23.468	21.644		-1.084	.291	-68.478	21.542
	SpH	13.429	4.564	.498	2.943	.008	3.938	22.919
	BOD	-3.729	1.406	-.449	-2.653	.015	-6.652	-.806
Diversity index	Constant	1.148	.147		7.802	.000	.842	1.454
	SPO_4-P	-1.023	.282	-.551	-3.628	.002	-1.609	-.436
	PO_4-P	4.130	1.365	.459	3.025	.006	1.291	6.969

and H as $CaCO_3$ has also been observed (Fig. 5).

The diversity index of AMs was more in stream1 (Fig. 3) which may be attributed to its location near the agricultural field that facilitate in transport of propagule/seed of some weed species of the waterlogged paddy field like *E. crassipes, I. carnea*, *L. sessiliflora, L. adscendens*, *M. quadrifolia, M. hastata, N. cristata, P. barbata, P. hydropiper*, *S. interrupta* and *S. sagittifolia* into the adjacent stream. Besides, the entry of nutrients from the agricultural field to the nearby stream might have facilitated diverse AMs to grow in stream1. The multiple regression analyses also showed a strong relationship between diversity of AMs and the phosphate-P concentration in both water and sediment of the streams (Table 6). All the above results reveal that the dominant AM species have a differential pattern of resource utilization and sharing in the selected streams (Fig. 4). This is plausibly a function of the resource availability and environmental variation determined by the adjacent land use activities.

Fig. 4. Dominance-diversity curve of aquatic macrophytes in the selected streams
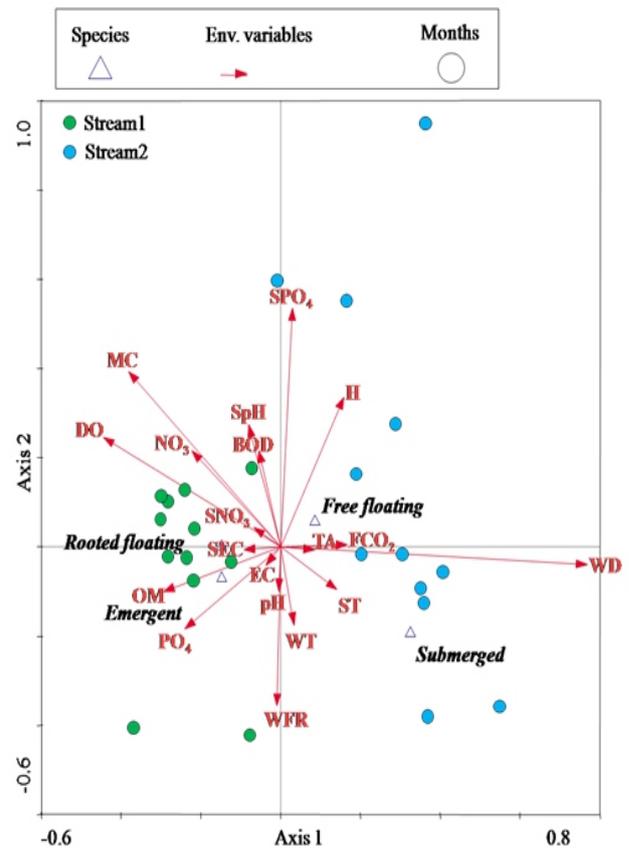
WT- water temperature; WD-water depth; WFR-Water flow rate EC- Electrical conductivity; DO-dissolved oxygen; BOD-biological oxygen demand; FCO_2 - free carbon dioxide; TA-total alkalinity; H (as $CaCO_3$)- hardness as $CaCO_3$; NO_3-nitrate-N; PO_4-phosphate–P; ST- sediment temperature; MC- Moisture content; SpH- Sediment pH; SEC- sediment electrical conductivity; SNO_3- sediment nitrate-N; SPO_4- sediment phosphate-P; OM- Organic matter

Fig. 5. CCA showing association of aquatic macrophytes under different habits with their habitat conditions in the selected streams

Fig. 2. Relative abundance (%) of aquatic macrophytes under different habits in the selected streams

Fig. 3. Diversity indices of aquatic macrophytes in the selected streams

CONCLUSION

The present study thus concludes that stream morphometry, the input of organic matter and nutrients, and the transport of propagules/seeds of AMs from the

surrounding riparian land use play a vital role towards the assemblages of AMs and their diversity in steams located under different land uses.

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Crop diversification for Sustainable Management of Blossom Midge (*Contarinia maculipennis* Felt) of Jasmine (*Jasminum sambac* L.)

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Abstract: A field trial was conducted to study the influence of crop diversification through intercropping on the incidence of blossom midge, *Contarinia maculipennis* of Jasmine. There was significant reduction in incidence of the pest in intercropped treatments over monocrop of jasmine. Marigold recorded significantly the lowest mean incidence of 15.37 per cent, followed by gingelly and coriander with jasmine as sole crop recorded highest blossom midge incidence (22.17 per cent). Among the intercrops, higher incidence of blossom midge was recorded in jasmine intercropped with fennel and fenugreek. Jasmine intercropped with marigold recorded 30.67 per cent reduced blossom midge incidence than sole jasmine crop.The population of natural enemies *viz.,*coccinellids, chrysopids, preying mantises and spiders were more recorded in marigold intercropped jasmine with 8.70, 3.60, 4.40 and 5.30 no's/five plants respectively. Moreover, the emergence of a specific midge predator, *Systatsis dasyneurae* were more encountered in jasmine intercropped with marigold (4.30 adults/50 infested buds) than sole jasmine crop. The pest defender ratio was highest in jasmine + marigold (1:3.50) and the order falls as jasmine + coriander (1:3.05) and jasmine + gingelly (1:2.34). The data indicated the supremacy of marigold in reducing the incidence of the blossom midge as well as attracting more natural enemy population, bagging the credit of eco-feast crop.

Keywords: Blossom midge, Jasmine, Crop diversification

Jasmine (*Jasminum sambac* L.) is traditionally as well as commercially cultivated for its sweet-scented flowers all over the world. The world production of jasmine concrete is around 20 tonnes per annum, out of which India is producing and exporting about 2 tonnes (Ray et al 2014). The largest area under jasmine cultivation is in Tamil Nadu and Karnataka from where it is distributed to metropolitan cities (Nimisha and Razia 2014). The production of jasmine is affected by various factors, among which, insect pests are the most devasting factor. The major pests affecting jasmine are jasmine bud worm (*Hendecasis duplifascialus* Hampson), blossom midge (*Contarinia maculipennis* Felt), leaf webworm (*Nausinea geometralis* Guenee), gallery worm (*Elasmopalpus jasminophagus* Hampson), leaf roller, (*Glyphodes unionalis* Hubner), and the two spotted mite (*Tetranychus urticae* Koch.). Of these, budworm and blossom midge gain major economic importance, as they cause excessive damage to the buds. Blossom midge has attained the status of a major pest causing severe economic loss by reducing the marketable quality of the flowers. Jasmine growers completely rely on synthetic chemicals in managing blossom midge of jasmine. In search of safer alternatives to chemicals considering their negative impacts, attention has been focused on exploration of diversified cropping system approaches, which is based on the principle of reducing pest incidence by increasing natural enemy activity through diversifying crop ecosystem. Intercropping bring reduction of pest populations in the main crop principally in three ways, by delaying the onset of pest incidence, by inhibiting pest build up above ETL and finally increasing the abundance of natural enemies.

Farooq et al (2011) indicated that some plants contained organic substances that act as pest repellent. Lakshminarayanan et al (2005) investigated the intercropping of leguminous vegetables in a pruned field of jasmine (*Jasminum sambac* L.) and indicated that intercropping pruned jasmine with double rows of cowpea (*Vigna unguiculata*) fetched the highest equivalent yield of jasmine land equivalent ratio, net returns and benefit-cost ratio with minimal pest incidence. Anburani and Priyadharshini (2011) explored the intercropping system with mullai (*Jasminum auriculatum*) and recorded the highest number of productive shoots per plant, flower yield per plant, flower yield per hectare and profitability in the mullai intercropped with cowpea trial and recorded minimum incidence of pests. Intercropping in jasmine ecosystem for pest management has not been experimented yet. Therefore, the present study was undertaken to explore and assess the influence of intercropping on the infestation of jasmine bud worm and the occurrence of natural enemies.

MATERIAL AND METHODS

A field experiment was conducted during July-November, 2015 at farmer's holding at Manjampati, Madurai district, India

in a randomized block design (RBD) with each treatment replicated thrice. Seeds of the intercrops were sown in a young jasmine plantation of two-year-old crop. All the standard package of practices recommended for the crops was followed except plant protection measures (Vanitha 2001). Nine intercropping systems were evaluated (Table 1). The intercropping system was planted at 4:1 ratio with recommended spacing (Sujayanand et al 2015). Observations on per cent infestation of blossom midge, *C. maculipennis* and its their natural enemies in five randomly selected jasmine plants in each treatment were recorded from flowering stage at ten days interval. Blossom midge incidence was recorded by counting the total number of buds and number of pink discoloured shrivelled buds. The defender to pest ratio per cropping system was calculated for each plot by dividing the total number of defenders per cropping system by the total number of pests per cropping system. Total number of pests and natural enemies observed by sweep net and in situ counts will be used for estimating P: D ratio (Lokesh et al 2017)

RESULTS AND DISCUSSION

Incidence of blossom midge in intercropping system: The incidence of *C. maculipennis* was significantly lower (15.37 per cent) in jasmine intercropped with marigold (4:1), whereas jasmine as sole crop recorded highest blossom midge incidence (22.17 per cent) (Table 1). The per cent incidence in jasmine intercropped with marigold decreased from 24.37 to 14.36 per cent on 20 and 70 days after sowing. The mean incidence of blossom midge in jasmine intercropped with marigold was 15.37 per cent with a 30.67 per cent reduction over jasmine sole crop. The intercrop with more efficacies falling next in the order was gingelly. Coriander crop intercropped in jasmine field also had

potential in minimizing blossom midge incidence. The order falls as   cluster bean>onion >cowpea > black gram fenugreek> fennel. Among the intercrops, jasmine + fennel recorded maximum blossom midge incidence (19.26 per cent), followed by jasmine + fenugreek indicating their poor efficiency in repelling the pest (Fig. 1).

Impact of intercrops on population of natural enemies in intercropping system (Table 2):

Coccinellid: The mean population of coccinellids (*Cheilomenes sexmaculatus*, *Coccinella transversalis*, *Brumus sutularis, Scymnus* sp.,) in various intercropping systems ranged from 3.2 (jasmine + fennel) to 8.70/5 plants (jasmine + marigold) while it was 1.10./5 plants in jasmine alone crop. The mean population of coccinellids was higher in jasmine intercropped with marigold which was on par statistically with jasmine + cowpea. Jasmine intercropped with fennel, gingelly and cluster bean recorded least coccinellid population (Plate 2).

***Chrysoperla zastrowi sillemi* (Esben-Peterson):** Jasmine intercropped with marigold recorded the highest mean population of *C. zastrowi sillemi*, followed by jasmine + coriander which was on par with jasmine intercropped with gingelly and onion. The jasmine pure crop recorded the least incidence.

Preying mantids: The mean population of preying mantids was highest in jasmine intercropped with marigold (4.40 /5 plants) followed by jasmine intercropped with gingelly, onion and cowpea.

Spider: Jasmine intercropped with marigold recorded maximum spider population of (5.30/5 plants), but there was no significant difference noticed among various intercropping systems on spider population, with the least population in jasmine sole crop.

Table 1. Incidence of blossom midge, *Contarinia maculipennis* in jasmine ecosystem as influenced by intercrops

T. No.	Intercropping system	Percent incidence*						Mean	PROC
		20 DAS	30 DAS	40 DAS	50 DAS	60 DAS	70 DAS		
T$_1$	Jasmine + Cowpea	23.41^a	18.24^d	15.40^{cd}	12.23^{bc}	16.47^b	19.14^b	17.49^{bc}	21.1
T$_2$	Jasmine + Black gram	25.31^a	20.41^{abcd}	16.63^{bc}	14.40^b	15.36^{bc}	19.36^b	18.59^b	16.14
T$_3$	Jasmine + Cluster bean	27.32^a	20.56^{abcd}	11.47^f	12.20^{bc}	13.68^{bc}	16.39^b	16.95^{bcd}	24.89
T$_4$	Jasmine + Coriander	26.20^a	19.40^{bcd}	14.36^{cde}	12.25^{bc}	14.35^{bc}	15.69^c	17.04^{cd}	23.14
T$_5$	Jasmine + Fenugreek	30.17^a	22.36^{abc}	15.23^{cde}	11.65^c	13.45^{bc}	16.74^c	18.27^{bcd}	17.59
T$_6$	Jasmine + Gingelly	28.41^a	18.69^{cd}	13.36^{def}	11.47^c	12.69^c	14.52^c	16.52^d	25.48
T$_7$	Jasmine + Fennel	27.36^a	24.36^a	19.36^{ab}	14.52^b	13.58^{bc}	16.39^b	19.26^{bcd}	13.12
T$_8$	Jasmine + Onion	23.78^a	18.36^d	14.52^{cde}	12.69^{bc}	14.27^{bc}	18.96^{bc}	17.10^{bc}	22.86
T$_9$	Jasmine + Marigold	24.37^a	17.36^d	12.34^{ef}	10.23^c	13.57^{bc}	14.36^c	15.37^d	30.67
T$_{10}$	Jasmine sole crop	21.41^a	23.45^{ab}	20.47^a	23.56^a	20.47^a	23.65^a	22.17^a	

Figures with same letters don't differ significantly.
In a column, means followed by common letter(s) are not significantly different by LSD (P= 0.05)

*Systatsis dasyneurae***:** The mean emergence of the predator, *Systasis dasyneurae* from fifty infested jasmine buds collected from jasmine intercropped with marigold was 4.30 adults as against 1.20 in jasmine sole crop. Jasmine intercropped with sesamum recorded 4.60 adults and Jasmine intercropped with cluster bean recorded 4.20 adults Jasmine intercropped with fennel and fenugreek (1.90 and 2.30 adults) registered the least parsitoid emergence among the intercrops examined (Fig. 2).

Pest defender ratio: The highest population of pests was in jasmine intercropped with fenugreek, blackgram and cowpea (11.33, 9.33 and 7.33 no's/5 plants). The least population of pests in intercrops was in fenugreek and coriander (no pest) and highest in jasmine intercropped with cowpea and

blackgram (Table 3). The total number of pests in jasmine and intercrops was more in jasmine + cowpea and jasmine + fennel intercropping system, and the least in jasmine + marigold, jasmine + onion and jasmine + gingelly. Among all the nine intercrops evaluated, the total natural enemy population was more in jasmine + marigold, followed by jasmine + cluster bean and jasmine + gingelly. The pest defender ratio was highest in jasmine + marigold (1:3.50) and the order falls as jasmine + coriander and jasmine + gingelly. The ratio was least recorded in jasmine + fennel (1:1.02) and jasmine + fenugreek (1:1.18) intercropping systems (Fig. 3). Marigold attracted lot of natural enemies and bagged the credit of ecofeast crop. Jasmine intercropped with marigold recorded the highest mean population of coccinellids (8.70/ 5

Table 2. Incidence of natural enemies in jasmine ecosystem as influenced by intercrops

Intercropping system	Number per five plants				No. emerged from 50 infested buds
	Cocinellids	Chrysopids	Preying mantids	Spiders	*Systasis dasyneurae*
T_1	7.50^b	1.30	3.70^{cd}	4.90^{ab}	1.70^e
T_2	4.60^d	1.40^d	3.30^{fg}	4.40^b	3.20^{bc}
T_3	3.70^e	1.70^c	3.10^{ef}	4.50^{ab}	4.20^a
T_4	4.90^d	3.50^a	3.50^{de}	4.80^{ab}	3.40^{bc}
T_5	4.90^d	1.90^c	1.90^g	4.90^{ab}	2.30^{de}
T_6	3.60^e	2.50^{ab}	4.20^b	5.40^a	4.60^a
T_7	3.20^f	1.30^d	2.70^g	4.30^b	1.90^e
T_8	6.10^c	2.30^{ab}	3.90^{bc}	5.10^{ab}	3.10^{bc}
T_9	8.70^a	3.60^a	4.40^a	5.30^a	4.30^a
T_{10}	1.10^e	0.20^f	0.20^h	1.30^c	1.20^f

In a column, means followed by common letter(s) are not significantly different by LSD (P= 0.05),. See Table 1 for treatment details
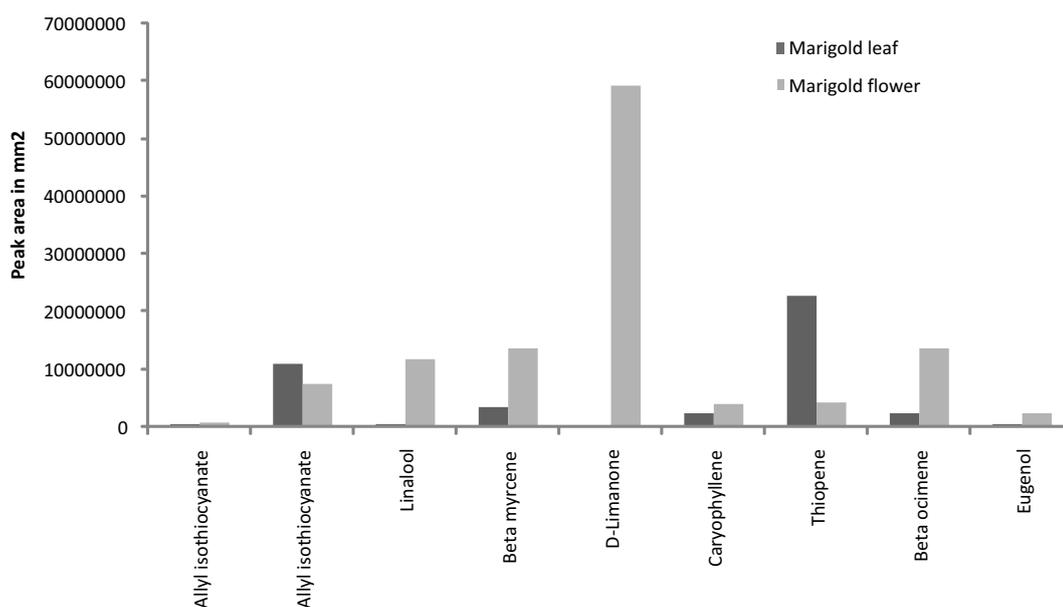
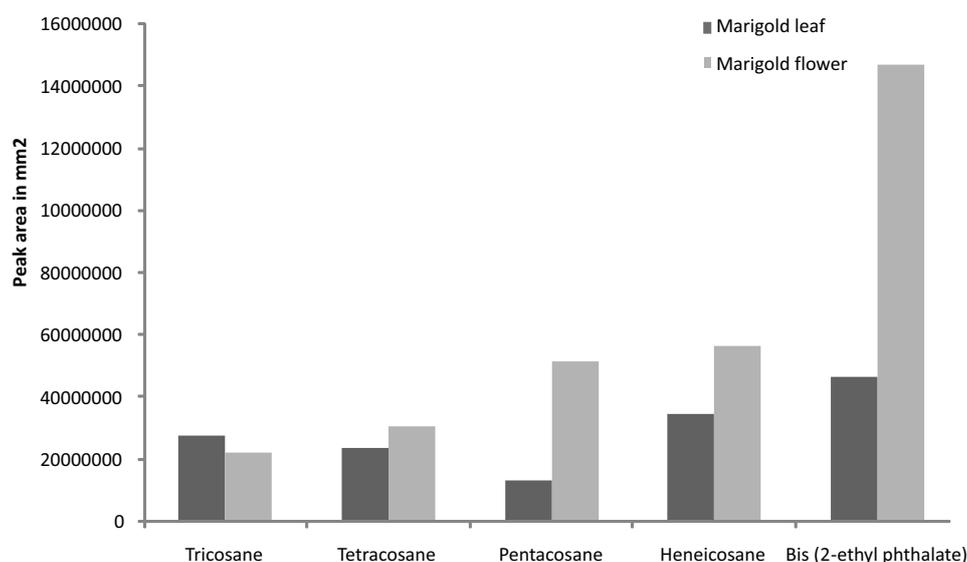**Fig. 1a.** Comparison of the common hydrocarbons presents in marigold (*Tagetus erecta*)

plants) followed by spider, preying mantises and *C. z. sillemi*. The mean emergence of the specific midge predator, *Systasis dasyneurae* from jasmine intercropped with marigold was highest (4.30 /50 infested buds).The total natural enemy population was more in jasmine + marigold (20.99/five plant) recording highest pest defender ratio (1:3.50).

The present study identified marigold as the eco-feast crop by reducing blossom midge incidence and increasing natural enemy population. Intercropping has been reported to reduce insect pest populations due to deterrence in crop fields with increased plant diversity that creates unsuitable habitat or unfavourable environment to pest species. Intercropping particularly with four rows of jasmine to one row of marigold developed less population of sucking and lepidopteran infestations. Sujayanand et al (2015) reported

that intercropping of eggplant with marigold is a successful strategy for reducing the fruit and shoot borer and sucking pest especially jassids and whiteflies. Marigolds have been shown promising results in companion planting (Hooks et al 2010) and behave as natural pest deterrents by secreting the toxic chemical α-terthienyl through their roots and thus fending of surrounding threats (Gommers and Baher 1988). Additionally, they give off a very pungent odour, which is thought to detract most above ground insects (Parker et al 2013). Allelochemicals emanated from parts of marigold (*Tagetes erecta* L.) in the intercrop might be responsible to repel the herbivores in jasmine ecosystem (Gomez et al 2003). The findings emerged from the present study is supported by Lakshminarayanan et al (2005) who explicated that raising intercrops in jasmine ecosystem recorded less incidence of pests with additional income in yield. Silveria et

Table 3. Total number of pests and natural enemies in intercropping system

Intercropping system	Number per plant						P:D ratio
	Pests in jasmine	Pests in intercrops	Total pests	Natural enemies in jasmine	Natural enemies in intercrops	Total natural enemies (Defenders)	
T_1	8.33[c]	5.33[d]	13.66[e]	4.33[c]	10.33[b]	14.66[de]	1:1.07
T_2	7.33[bc]	4.66[d]	11.99[e]	2.66[d]	9.66[c]	12.32[ef]	1:1.03
T_3	6.66[ab]	1.66[bc]	8.32[cd]	5.33[b]	13.66[a]	18.99[bc]	1:2.28
T_4	6.33[ab]	0.00[a]	6.33[ab]	5.66[b]	13.66[a]	19.32[ab]	1:3.05
T_5	9.33[c]	0.00[a]	9.33[d]	2.33[d]	8.66[d]	10.99[f]	1:1.18
T_6	6.66[ab]	1.33[bc]	7.99[bcd]	5.33[b]	13.33[a]	18.66[bc]	1:2.34
T_7	11.33[d]	0.33[ab]	13.66[e]	3.66[cd]	10.33[b]	13.99[de]	1:1.02
T_8	6.00[a]	1.33[ab]	7.33[abc]	4.33[bc]	11.33[b]	15.66[cd]	1:2.14
T_9	5.33[a]	0.66[ab]	5.99[a]	6.33[a]	14.66[a]	20.99[ab]	1:3.50

In a column, means followed by common letter(s) are not significantly different by LSD (P= 0.05). See Table 1 for trearment details

Fig. 1b. Comparison of the common hydrocarbons present in marigold (*Tagetus erecta*)

Pink discoloured buds

Pre-mature drying of buds

Adult midge   **Shriveled bud stalk**   **Maggot inside the shrivelled bud stalk**

Plate 1. Damage symptoms of jasmine blossom midge, *Contarinia maculipennis*

Plate 2. Natural enemies in marigold intercropped in jasmine

al (2009) also reported marigold is potentially useful to maintain arthropod biodiversity. Research works on intercropping to manage dipterans are very scarce. Dhawan et al (2013) corroborated that sorghum intercropped with leguminous plants has reduced sorghum shoot fly (*Contarinia sorghicola*) incidence.

To identify the compounds responsible for the repellence of pests and attraction of natural enemies, the marigold flower and leaf extracts were analyzed in GC-MS. The chemical profile of marigold flower and leaf extracts contributed 43 and 33 compounds respectively. Allylisothiocyanate, linalool, caryophyllene, beta myrcene, tumerone, D-limanone and trans beta ocimene were the compounds of interest present, of which, linalool, beta farnesene, alpha farnesene, allyl isothiocyanate and caryophyllene were present in marigold leaves also. Chemically complex plant volatiles have multiple ecological roles in plant-insect interactions including attracting pollinators, acting as cues for foraging herbivores as well as functioning as direct defense, indirect defense, or interplant priming. Caryophyllene is an active component of marigold flowers and leaves and its potential in attracting two types of herbivore enemies *viz.,* entomopathogenic nematodes and parasitic wasps in maize ecosystem was demonstrated by Kollner et al (2008). The chemical fraction containing (E)-β-caryophyllene attracts egg parasitoid, *Trissolcus basalis* females that parasitize *Nezara viridula* eggs (Colazza et al 2004; 2009). Comparing the compounds present in marigold leaves and flowers, 9 compounds were present in common *viz.,* allyl isothiocyanate*,* detected twice, linalool, beta myrcene, L-limanone, caryophyllene, thiopene, beta ocimene, eugenol, tetracosane, tricosane, pentacosane, heneicosane and bis (2 ethyl hexyl phthalate) with quantity in abundance in marigold flowers (Fig. 1).

CONCLUSION

Diverse environmental conditions would provide a greater diversity of habitats and victims to predators and parasitoids through time as well as alternate food sources such as pollen and nectar and so sustain more stable populations of natural enemies than monocultures. Jasmine intercropped with flowering plants increased the natural population thereby reducing blossom midge incidence. The study suggested that the plant biodiversity is an important factor that influences the presence of pests as well as natural enemies influencing the former negatively and the latter positively. Thus, habitat manipulations could be employed to reduce blossom midge incidence and conserve natural enemies in jasmine ecosystem.

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Rainfall Analysis of Ludhiana and Bathinda Districts using Markov Chain Model

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Abstract: The Markov chain model is a good tool to analyze the historical data to access and predict the forthcoming events. In the field of Soil and Water Engineering, use of Markov chain model gives a clear idea of rainfall pattern to grow crop as well as to conserve rainwater by installing soil and water conservation techniques. Punjab has divided into different climatic regions Bathinda and Ludhiana falls under South-west part of Punjab and Central part of Punjab. Ludhiana and Bathinda receives about 700 mm and 500 mm of annual rainfall. As the central part of the Punjab is facing problem of lowering groundwater so rainwater harvesting in this part is very important and south-western part is having mixed problem of brackish groundwater, rising water table and salinity in this region; so the study of the historical data is a great help for managing crop production in these areas. Out of 30 years rainfall data (1985-2015) for central region (Ludhiana), Markov chain model predicted that the probability of wet spell is considerable less as compared with dry spell throughout the year. The wet spell starts from the 26th SMW to 38th SMW whereas dry spell remain there from 39th SMW to 25th SMW. Similarly, for South West region (Bathinda), the wet spell started from 25th SMW to 38th SMW and rest of the part of the year remain as dry.

Keywords: Rainfall analysis, Markov Chain model, Wet spell, Dry spell

The Indian climate is mainly characterized by monsoon rainfall and Punjab, receives the most of the rainfall during monsoon season i.e. June to September. Major parts of Punjab are facing decline in precipitation during the monsoon and also the climate changes have put a massive pressure on water resources in Punjab leading to the rainfall analysis on a state as well as regional scale. The climate of Punjab is typically subtropical with ranging from 2°C in winters to 47°C in summers with an average annual rainfall in the range of 58 cm to 96 cm. The importance of rainfall is designing irrigation projects on a sound economic basis fixing cropping patterns and working out the irrigation requirements of crops (Biwalkar et al 2015, Vashisht et al 2013, Sharda et al 2012 and Singla et al 2011). Recharge can move excess salts that accumulate in the root zone to deeper soil layers, or into the groundwater system. Tree roots increase water saturation into groundwater reducing water runoff. Flooding temporarily increases river bed permeability by moving clay soils downstream, and this increases aquifer recharge. Artificial groundwater recharge is becoming increasingly important in India, where over-pumping of groundwater by farmers has led to underground resources becoming depleted.

Markov chain probability model has been extensively used to determine the long-term frequency behaviour of dry and wet spells (Senthilvelan et al 2012). A two-state Markov chain is a stochastic model for persistence of binary events. The occurrence/non-occurrence of precipitation on a given day is a simple meteorological example of a random binary event and a sequence of daily observations on precipitation/no precipitation for a particular location constitutes a time series of that variable (Dastidar et al 2010).The use of a two-state Markov chain to analyse data of this kind dates back as early as 1962 when Gabriel and Neumann (1962) fitted a two-state first order Markov chain to the daily rainfall occurrence at Tel Aviv. Several similar analyses have been attempted by many researchers. The present paper deals with the main objective related with problems of crop cultivation under changing climate and conservation of water resources by keeping in view the uneven distribution of rainfall in state of Punjab and to analyze the weekly rainfall in order to identify the pattern of occurrence of rainfall by applying a Markov chain probability model to the data on weekly rainfall occurrence for 33 years in Ludhiana and Bathinda region. The present study is important for deciding the irrigation scheduling for crops and time of cultivation round the year.

MATERIAL AND METHODS

The weekly rainfall data collected according to standard meteorological weeks from the observatory of Punjab Agricultural University, Ludhiana for a period of 1983 to 2016. Markov Chain model has been used and the threshold limits have been employed for estimating the weekly rainfall probability. As per the definition given by Indian Meteorological Department, a period is said to be wet when the parameter of that period exceeds 20 mm per week a

threshold limit and to be dry when under the limit. In Markov chain, followings are the governing equations;

Initial rainfall probability (%) (D): Initial probability indicates the minimum quantity of rainfall to be expected for a particular time series data. Initial rainfall probability of getting lesser than specific limit of rainfall is given by

P(D) = F(D)/n, P(D) = Probabilities of the week being dry, F(D) = Frequency of dry weeks

n= Number of years of data

Initial rainfall probability (%) (W): Initial probability indicates the minimum quantity of rainfall to be expected for a particular time series data. Initial rainfall probability of getting greater than specific limit of rainfall is given by

P(W) = F(W)/n, P(W) = Probabilities of the week being wet, F(W) = Frequency of wet weeks

Conditional rainfall probability (%) (D/D): Conditional rainfall probability (%) of getting rainfall lesser than specific limit during next week also, when rainfall was lesser than the specific limit during previous week

P(D/D) = F(D/D)/F(D), P(D/D) = Conditional probability of dry week preceded by a dry week, F(D/D) = Frequency of dry weeks preceded by another dry week

Conditional rainfall probability (%) (W/W): Conditional rainfall probability (%) of getting rainfall higher than specific limit during next week also, when rainfall was more than the specific limit during previous week

P(W/W) = F(W/W)/F(W), P(W/W) = Conditional probability of wet week preceded by a wet week, F(W/W) = Frequency of wet weeks preceded by another wet week

Conditional rainfall probability (%) (D/W): Conditional rainfall probability (W/D) of getting >specific limit of rainfall during next week when this week has been wet *i.e.*, the rainfall was <specific limit; then

P(D/W) = F(D/W)/F(D), P(D/W) = Conditional probability of dry week followed by wet week, F(D/W) =Frequency of dry week followed by wet week

Conditional rainfall probability (%) (W/D): Conditional rainfall probability (W/D) of getting <specific limit of rainfall during next week when this week has been dry *i.e.*, the rainfall was >specific limit; then

P(W/D) = F(W/D)/F(W), P(W/D) = Conditional probability of Wet week followed by dry week, F(W/D) =Frequency of Wet week followed by dry week.

RESULTS AND DISCUSSION

Probabilities of occurrence of dry wet spells at Ludhiana: Ludhiana is located at 30.9°N 75.85°E. It has an average elevation of 244 metres from mean sea level. The annual rainfall for the region is 700-800 mm from which 75% is received during rainy season (June-September) and rest is

during winter season through western disturbances .In central part of Punjab (Ludhiana) the probability of dry spell starts from the first standard meteorological week (SMW) that continuous for upto 22nd SMW with almost constant probability of about 90 per cent (Table 1). These trends start decreasing from the 23rd SMW and lasts upto 25th SMW and keep on reducing upto 28th SMW (rainy season). As the central part of the Punjab is facing lowering of groundwater so the practices may be adopted to conserve the runoff or overland flow in-situ or low water demanding crops must be sown during this period of time so that, the pressure on groundwater may decrease and replenishment of groundwater may be increased.

The probability of dry spell approached 100 per cent during 43rd to 48th SMW. In Ludhiana, the probability of having dry spell is very high throughout the year and it is almost 100 per cent from the 42nd SMW (93.94%) to 3rd SMW (87.88%). The probability of wet spell starts from 26th SMW (60.61%) to 34th SMW (57.58%). The probability of occurrence of wet spells start increasing from 23rd SMW. The chances of wet spells to occur were maximum 78.79 per cent during 28th SMW. The chances of dry spells are more prominent than the wet spells round the year.

The conditional probability (dry/dry) for SMW varied between 14.19 to 100 per cent, lowest probability was in the week 28th SMW which is 14.19 per cent and the highest probability calculated in the 43rd to 48th SMW i.e. 100 per cent (Table 2). The conditional probability (dry/wet) for SMW varied between 0 to 84.71 per cent, lowest in the week 43rd to 48th SMW and highest in the week 28th SMW. For dry SMW varied between 0 to 100 per cent, lowest in the 44th to 48th SMW. The conditional probability (wet/wet) for SMW varies between 0 to 76.92 per cent, highest in the 28th SMW. The probability of having dry week followed by dry week remained very high throughout the year except from 23rd SMW to 38th SMW. This shows the Ludhiana region is receiving good amount of rainfall during rainy season but there is a long dry spell after the rains.

The probability of occurrence of dry spell is initially high after 22nd SMW it starts decreasing and then increasing during later part of the season. The probability of dry spells is highest during 43rd to 48th SMW and lowest during 28th SMW (Fig. 1). The probability of having wet spell is less during the winter and summer season but after 23rd SMW to 37th SMW there is a good probability of having rains. The probability of occurrence of wet spell is initially low till 22nd SMW then increasing afterward and then decreasing during later part of the season from 39th SMW. The probability is minimum in 43rd to 48th and maximum in 28th SMW.

The conditional probability (D/D) remains initially high,

from 22nd SMW it starts decreasing and goes to the lowest point that is 14.79 per cent in 28th SMW due to the occurrence of wet period than it again starts increasing. The conditional probability (D/W) remains initially low, from 22nd SMW it starts increasing and goes to the highest point 28th SMW than it again starts decreasing due to occurrence of dry period. The conditional probability (W/D) remains initially high between the 75 to 100 per cent till 22nd SMW, except 2nd, 4th, 10th and 14th SMW (Fig. 3). After 22nd SMW it starts decreasing due to occurrence of wet spells and then it starts increasing followed up by the gradually decreasing due to the occurrence of dry period or spells. The conditional probability (W/W) remains initially low and then starts increasing due to occurrence of wet spells. After 38 SMW it starts decreasing and remains constant till 52nd, except 51st SMW.

Probabilities of occurrence of dry wet spells at Bathinda:
Bathinda is located in south part of western agro-climatic

zone at30.20°N 74.95°E and an altitude of 211 meters above mean sea level in Punjab. The average rainfall of this region is 350 mm, 80 per cent of which occurs during the southwestern monsoon season of June to September. The probability of occurrence of dry spell are more than 90 per cent from 1st standard meteorological week (SMW) to 23rd standard meteorological week (SMW) except for 6th, 7th, 8th and 11th SMW during which the probability is 87, 81, 84 and 87.5 per cent (Table 3). From 24th SMW, the probability of dry spell starts decreasing and reaches minimum 43 per cent during 31st SMW and increase thereafter. It approached 100 per cent during 43rd to 50th SMW.

The conditional probability (dry/dry) for SMW varied between 28.57 to 100 per cent, lowest was in the week 31st SMW which is 28.57 per cent and the highest is in the 10th, 12th, 16th, 41st, 43rd to 50th SMW i.e 100 per cent. The conditional probability (dry/ wet) for SMW varied between 0 to

Table 1. Initial probability of occurrence of dry-wet spell at Ludhiana

SMW	F (D)	P (D) (%)	F (W)	P (W) (%)	SMW	F (D)	P (D) (%)	F (W)	P (W) (%)
1	31	93.94	2	6.06	27	14	42.42	19	57.58
2	28	84.85	5	15.15	28	7	21.21	26	78.79
3	29	87.88	4	12.12	29	10	30.30	23	69.70
4	28	84.85	5	15.15	30	12	36.36	21	63.64
5	31	93.94	2	6.06	31	15	45.45	18	54.55
6	26	78.79	7	21.21	32	13	39.39	20	60.61
7	27	81.82	6	18.18	33	11	33.33	22	66.67
8	28	84.85	5	15.15	34	14	42.42	19	57.58
9	30	90.91	3	9.09	35	17	51.52	16	48.48
10	31	93.94	2	6.06	36	20	60.61	13	39.39
11	29	87.88	4	12.12	37	20	60.61	13	39.39
12	30	90.91	3	9.09	38	22	66.67	11	33.33
13	32	96.97	1	3.03	39	28	84.85	5	15.15
14	31	93.94	2	6.06	40	29	87.88	4	12.12
15	32	96.97	1	3.03	41	32	96.97	1	3.03
16	29	87.88	4	12.12	42	31	93.94	2	6.06
17	32	96.97	1	3.03	43	33	100.00	0	0.00
18	30	90.91	3	9.09	44	33	100.00	0	0.00
19	30	90.91	3	9.09	45	33	100.00	0	0.00
20	31	93.94	2	6.06	46	33	100.00	0	0.00
21	30	90.91	3	9.09	47	33	100.00	0	0.00
22	30	90.91	3	9.09	48	33	100.00	0	0.00
23	26	78.79	7	21.21	49	32	96.97	1	3.03
24	24	72.73	9	27.27	50	31	93.94	2	6.06
25	24	72.73	9	27.27	51	30	90.91	3	9.09
26	13	39.39	20	60.61	52	31	93.94	2	6.06

Table 2. Conditional probability of occurrence of dry- wet spell at Ludhiana

SMW	F (D/D)	P (D/D) (%)	F (D/W)	P (D/W) (%)	F(W/W)	P (W/W) (%)	F (W/D)	P (W/D) (%)
1	29	93.55	2	6.45	0	0	2	100
2	25	89.29	3	10.71	2	40	3	60
3	25	86.21	4	13.79	0	0	4	100
4	25	89.29	3	10.71	2	40	3	60
5	29	93.55	2	6.45	0	0	2	100
6	19	73.08	7	26.92	0	0	7	100
7	22	81.48	5	18.52	0	0	6	100
8	24	85.71	4	14.29	0	0	5	100
9	27	90.00	3	10.00	0	0	3	100
10	30	96.77	2	6.45	0	0	1	50
11	26	89.66	3	10.34	1	25	3	75
12	27	90.00	3	10.00	0	0	3	100
13	31	96.88	1	3.13	0	0	1	100
14	30	96.77	1	3.23	1	50	1	50
15	31	96.88	1	3.13	0	0	1	100
16	25	86.21	4	13.79	0	0	4	100
17	31	96.88	1	3.13	0	0	1	100
18	27	90.00	3	10.00	0	0	3	100
19	27	90.00	3	10.00	0	0	3	100
20	29	93.55	2	6.45	0	0	2	100
21	27	90.00	3	10.00	0	0	3	100
22	27	90.00	3	10.00	0	0	3	100
23	22	84.62	4	15.38	3	42.86	4	57.14
24	17	70.83	7	29.17	1	11.11	8	88.89
25	17	70.83	7	29.17	2	22.22	7	77.78
26	3	23.08	10	76.92	11	55	9	45
27	6	42.86	8	57.14	11	57.89	8	42.11
28	1	14.29	6	85.71	20	76.92	6	23.08
29	3	30.00	7	70.00	16	69.57	7	30.43
30	3	25.00	9	75.00	13	61.90	8	38.10
31	6	40.00	9	60.00	9	50	9	50
32	6	46.15	7	53.85	13	65	7	35
33	4	36.36	7	63.64	16	72.73	6	27.27
34	5	35.71	9	64.29	10	52.63	9	47.37
35	10	58.82	7	41.18	8	50	8	50
36	12	60.00	8	40.00	5	38.46	8	61.54
37	12	60.00	8	40.00	5	38.46	8	61.54
38	12	54.55	8	36.36	3	27.27	8	72.73
39	23	82.14	5	17.86	0	0	5	100
40	25	86.21	4	13.79	0	0	4	100
41	31	96.88	1	3.13	0	0	1	100
42	29	93.55	2	6.45	0	0	2	100
43	33	100.00	0	0.00	0	0	0	0
44	33	100.00	0	0.00	0	0	0	0
45	33	100.00	0	0.00	0	0	0	0
46	33	100.00	0	0.00	0	0	0	0
47	33	100.00	0	0.00	0	0	0	0
48	33	100.00	0	0.00	0	0	0	0
49	31	96.88	1	3.13	0	0	1	100
50	29	93.55	2	6.45	0	0	2	100
51	28	93.33	2	6.67	1	33.33	2	66.67
52	29	93.55	2	6.45	0	0	2	100

Soil Quality Indicators for Rice Based Cropping Systems
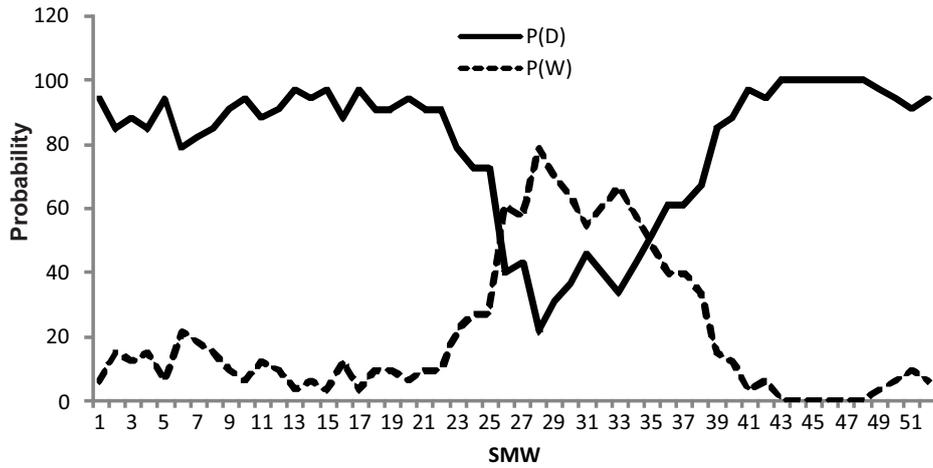
Fig. 1. Initial probability of dry spell and wet spell at Ludhiana
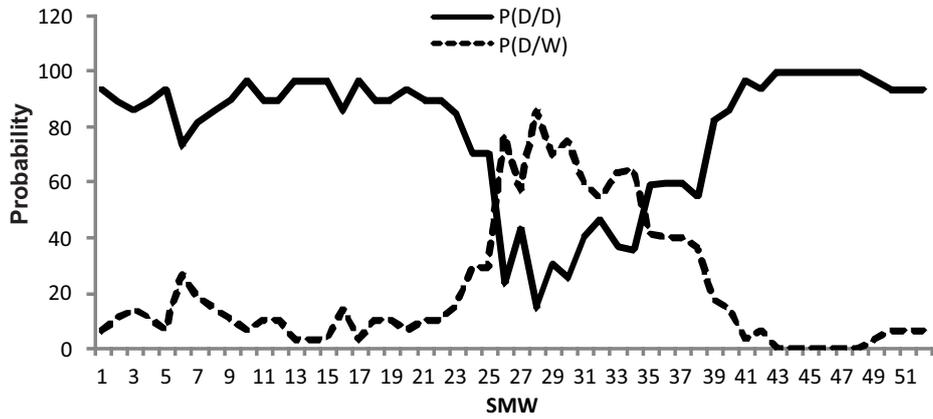
Fig. 2. Conditional probability of dry spell and wet spell at Ludhiana
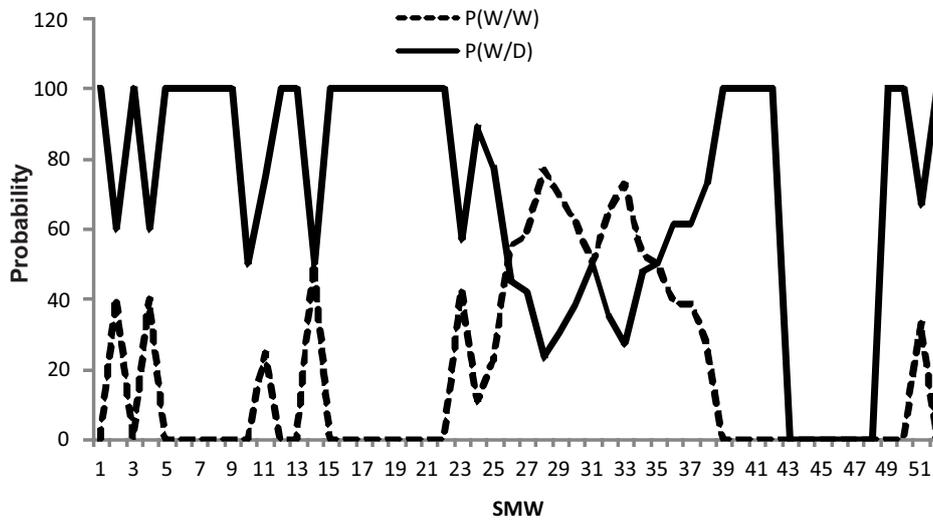
Fig. 3. Conditional probability of wet/dry and wet/wet spell at Ludhiana

Table 3. Initial probability of occurrence of dry-wet spell at Bathinda

SMW	Initial probability								
	F (D)	P (D)	F (W)	P (W)	SMW	F(D)	P (D)	F (W)	P (W)
1	30	93.75	2	6.25	27	18	56.25	14	43.75
2	31	96.875	1	3.125	28	21	65.625	11	34.375
3	30	93.75	2	6.25	29	16	50	16	50
4	29	90.625	3	9.375	30	17	53.125	15	46.875
5	31	96.875	1	3.125	31	14	43.75	18	56.25
6	28	87.5	4	12.5	32	19	59.375	13	40.625
7	26	81.25	6	18.75	33	24	75	8	25
8	27	84.375	5	15.625	34	24	75	8	25
9	30	93.75	2	6.25	35	23	71.875	9	28.125
10	32	100	0	0	36	22	68.75	10	31.25
11	28	87.5	4	12.5	37	21	65.625	11	34.375
12	32	100	0	0	38	23	71.875	9	28.125
13	30	93.75	2	6.25	39	29	90.625	3	9.375
14	30	93.75	2	6.25	40	29	90.625	3	9.375
15	31	96.875	1	3.125	41	32	100	0	0
16	32	100	0	0	42	28	87.5	4	12.5
17	30	93.75	2	6.25	43	32	100	0	0
18	31	96.875	1	3.125	44	32	100	0	0
19	30	93.75	2	6.25	45	32	100	0	0
20	30	93.75	2	6.25	46	32	100	0	0
21	29	90.625	3	9.375	47	32	100	0	0
22	31	96.875	1	3.125	48	32	100	0	0
23	30	93.75	2	6.25	49	32	100	0	0
24	24	75	8	25	50	32	100	0	0
25	21	65.625	11	34.375	51	30	93.75	2	6.25
26	22	68.75	10	31.25	52	31	96.875	1	3.125
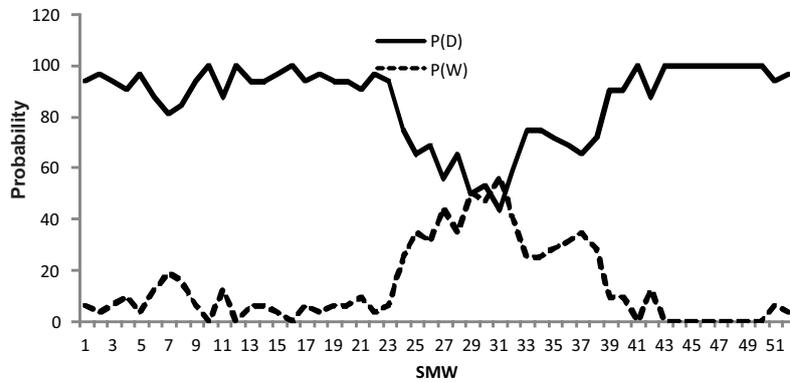
Fig. 4. Initial probability of dry spell and wet spell at Bathinda
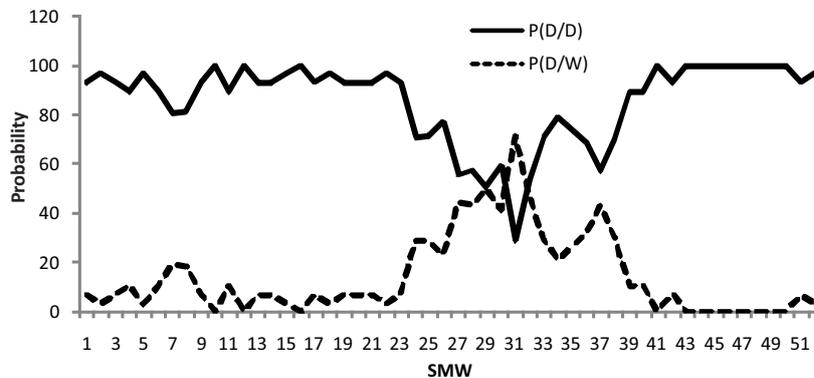
Fig. 5. Conditional Probability of dry spell and wet spell at Bathinda

Table 4. Conditional probability of occurrence of dry- wet spell at Bathinda

SMW	Conditional Probability							
	F (D/D)	P (D/D)	F (D/W)	P (D/W)	F (W/D)	P (W/D)	F (W/W)	P (W/W)
1	28	93.33	2	6.67	2	100	0	0
2	30	96.77	1	3.23	1	100	0	0
3	28	93.33	2	6.67	2	100	0	0
4	26	89.66	3	10.34	3	100	0	0
5	30	96.77	1	3.23	1	100	0	0
6	25	89.29	3	10.71	3	75	1	25
7	21	80.77	5	19.23	5	83.33	1	16.67
8	22	81.48	5	18.52	5	100	0	0
9	28	93.33	2	6.67	2	100	0	0
10	32	100.00	0	0.00	0	0	0	0
11	25	89.29	3	10.71	3	75	1	25
12	32	100.00	0	0.00	0	0	0	0
13	28	93.33	2	6.67	2	100	0	0
14	28	93.33	2	6.67	2	100	0	0
15	30	96.77	1	3.23	1	100	0	0
16	32	100.00	0	0.00	0	0	0	0
17	28	93.33	2	6.67	2	100	0	0
18	30	96.77	1	3.23	1	100	0	0
19	28	93.33	2	6.67	2	100	0	0
20	28	93.33	2	6.67	2	100	0	0
21	27	93.10	2	6.90	2	66.67	1	33.33
22	30	96.77	1	3.23	1	100	0	0
23	28	93.33	2	6.67	2	100	0	0
24	17	70.83	7	29.17	7	87.5	1	12.5
25	15	71.43	6	28.57	6	54.55	5	45.45
26	17	77.27	5	22.73	6	60.00	4	40.00
27	10	55.56	8	44.44	9	64.29	5	35.71
28	12	57.14	9	42.86	9	81.82	2	18.18
29	8	50.00	8	50.00	9	56.25	7	43.75
30	10	58.82	7	41.18	7	46.67	8	53.33
31	4	28.57	10	71.43	10	55.56	8	44.44
32	10	52.63	9	47.37	9	69.23	4	30.77
33	17	70.83	7	29.17	7	87.50	1	12.50
34	19	79.17	5	20.83	6	75.00	2	25.00
35	17	73.91	6	26.09	7	77.78	2	22.22
36	15	68.18	7	31.82	8	80.00	2	20.00
37	12	57.14	9	42.86	9	81.82	2	18.18
38	16	69.57	7	30.43	7	77.78	2	22.22
39	26	89.66	3	10.34	3	100	0	0
40	26	89.66	3	10.34	3	100	0	0
41	32	100.00	0	0.00	0	0	0	0
42	26	92.86	2	7.14	2	50	2	50
43	32	100.00	0	0.00	0	0	0	0
44	32	100.00	0	0.00	0	0	0	0
45	32	100.00	0	0.00	0	0	0	0
46	32	100.00	0	0.00	0	0	0	0
47	32	100.00	0	0.00	0	0	0	0
48	32	100.00	0	0.00	0	0	0	0
49	32	100.00	0	0.00	0	0	0	0
50	32	100.00	0	0.00	0	0	0	0
51	28	93.33	2	6.67	2	100	0	0
52	30	96.77	1	3.23	1	100	0	0
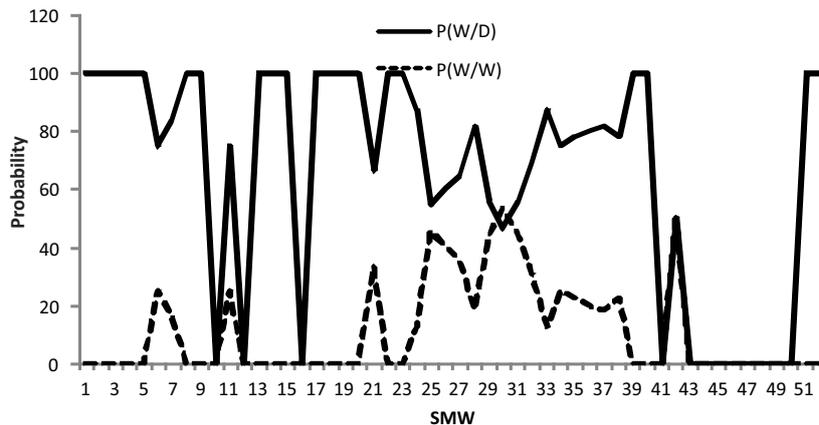
Fig. 6. Conditional probability of wet/dry and wet/wet spell at Bathinda

71.53 per cent, lowest in the week 10th, 12th, 16th, 41st, 43rd to 50th SMW and highest in the week 31st SMW.

The conditional probability (wet/dry) for SMW varied between 0 to 100 per cent. The conditional probability (wet/wet) for SMW varies between 0 to 53.33 per cent, highest in the 30th SMW. The probability of dry spells is maximum during 10th, 12th, 16th, 41st, 43rd to 50th SMW and minimum during 31st SMW (Fig. 4). The probability of occurrence of wet spells is initially low till 23rd SMW the increasing afterward and then decreasing during later part of the season from 38th SMW.

The Bathinda region is having very long dry spell followed by a short wet spell (Fig. 5).

The conditional probability (D/D) remains initially high, from 23rd SMW it starts decreasing and goes to the lowest point that is 28.57 per cent in 31st SMW due to the occurrence of wet period than it again starts increasing (Fig. 6). The conditional probability (D/W) remains initially low, from 23rd SMW it starts increasing and goes to the highest point 31st SMW than it again starts decreasing due to occurrence of dry period.

The conditional probability of wet spell followed by wet spell (W/W) is very less (Fig. 6). The conditional probability (W/D) remains initially high between the 75 to 100 per cent till 24th SMW, except 10th, 12th, 16th and 21st SMW. After 25th SMW it starts decreasing due to occurrence of wet spells and then it starts increasing followed up by the gradually decreasing due to the occurrence of dry period or spells. The conditional probability (W/W) remains initially low and then starts increasing due to occurrence of wet spells. After 38th SMW it starts decreasing and remains constant till 52nd SMW, except 42nd SMW.

CONCLUSIONS

The present analysis of daily rainfall data provides a wide range of probabilities i.e. initial probability, conditional probability, conditional probability of wet/dry and wet/wet. These probabilities are very much helpful for deciding the crop sowing and other related activities during crop growing season of any crop. This is also helpful to decide the irrigation scheduling of the crop at various stages.

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Analysing Drought and Wet Conditions Using Standardized Precipitation Index at Pantnagar

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Abstract: Drought is a natural event and significantly affects water resources sustainability, the environment and agricultural production. This study was conducted to characterize the meteorological drought and wet events using Standardized Precipitation Index (SPI) at Pantnagar located in Himalayan State of Uttarakhand, India. The SPI was calculated for 1-, 3-, 6-, 9-, 12- and 24-month time scales using monthly rainfall data of 56 years (1961-2016).The results of analysis revealed that there are 71% chances of normal condition for which no specific measures are required for water conservation or drainage. The occurrence of severe drought and severe and extreme wet events are also unlikely at Pantnagar. Therefore, the efforts must be made to harvest the excess water during the wet periods and utilize the same during the periods of moderate and extreme droughts for drinking, household activities and irrigation purposes in the study region.

Drought is a worldwide natural phenomenon, usually defined as the period of less than normal water availability and is one of the major weather-related hazards. It indicates a temporary reduction in water or moisture availability significantly below the normal or expected amount for a specific period. Drought events evolve slowly in time and their impacts generally last a long period of time. This condition is either due to inadequate rainfall or lack of irrigation facilities for meeting normal crop requirements in the context of the agro-climatic conditions prevailing in a particular area. Subsistence farmers are more likely to migrate during drought because they do not have alternative food sources particularly in the developing countries. In past few years, on global scale numerous studies have been conducted on meteorological drought analysis (Smakhtin and Hughes 2007; Raziei et al 2009; Edossa et al 2010; Pai et al 2011; Angelidis et al 2012; Dash et al 2012; Dogan et al 2012; Kaur and Kalra 2016; Mishra and Kumar 2018; Singh et al 2018; Vani et al 2018). In view of the above, this study was conducted to analysed the meteorological drought and wet patterns using the multi-temporal SPI and propose drought mitigation plan at Pantnagar, located in the foothills of the central Himalayan State of Uttarakhand, India.

MATERIAL AND METHODS

Study area and data acquisition: This study was conducted at Pantnagar, situated at the longitude of 79° 31' 0" E and latitude of 29° 3' 0" N in Uttarakhand, India. The area lies in the *Tarai* belt situated in the foothills of the Himalayas at an elevation of 243.8 m above the mean sea level. Its climate is sub-humid and sub-tropical. The region has winter season from October to January, a summer season from February to May and a rainy season from June to September. The yearly mean precipitation is about 1400 mm. The monthly rainfall data of 56 years (1961-2016) were collected from the climatic observatory at the Crop Research Centre of G. B. Pant University of Agriculture and Technology, Pantnagar, India.

Standardized Precipitation Index (SPI): The concept of SPI was introduced by McKee et al(1993) which is one of the most common climate drought indicators in the regional drought analysis. The probability density function for the gamma distribution is expressed as:

$$g(x) = \frac{1}{\beta^{\alpha}\Gamma(\alpha)} x^{\alpha-1} e^{-x/\beta} \quad x > 0 \qquad (1)$$

where α and β are the shape and scale parameters, and value always greater than zero; x is the value of precipitation; and (α) is gamma function obtained from the following equation:

$$r(\alpha) = \int_0^{\infty} y^{\alpha-1} e^{-y} dy \qquad (2)$$

In this regard, the parameters α and β are estimated by using the optimal maximum likelihood estimation method, using the following equation:

$$\alpha = \frac{1}{4A}\left(1 + \sqrt{1 + \frac{4A}{3}}\right) \qquad (3)$$

$$A = \mathrm{Ln}\left(\dot{X}\right) - \frac{\sum_{i=1}^{n} \mathrm{Ln}(X)}{n} \qquad (4)$$

$$\beta = \frac{\bar{X}}{n} \qquad (5)$$

where, *n* is the number of precipitation observations and X is the average of precipitation for a given period of several months. The resulting parameters are then used to find the cumulative probability of the observed precipitation for the given month and the specific time scale for each station. The cumulative probability assuming t = x/β becomes a defective gamma function.

$$G(X) = \int_0^x g(x)\ dx = \frac{1}{\Gamma(a)}\int_0^x t^{(a-1)} e^{(-t)} dt \qquad (6)$$

Since gamma function for X = 0 is not defined, If the distribution of the precipitation is zero, the cumulative probability is calculated as follows:

$$H(X) = q + (1-q)\,G(X) \qquad (7)$$

where, q is the probability zero precipitation, and computed by dividing the number of zeros (m) in a rainfall time series to the total number of observations (n). The cumulative probability, H(X) is then transformed to the standard normal distribution (Z) with the mean of zero and variance of one, which is the value of SPI.

$$z = \begin{cases} SPI = -\left[t - \dfrac{c_0 + c_1 t + c_2 t^2}{1 + d_1 t + d_2 t^2 + d_3 t^3} \right] & 0 < H(X) \le 0.5 \\[4mm] SPI = +\left[t - \dfrac{c_0 + c_1 t + c_2 t^2}{1 + d_1 t + d_2 t^2 + d_3 t^3} \right] & 0.5 < H(X) < 1 \end{cases} \qquad (8)$$

$$t = \begin{cases} t = \sqrt{Ln\left(\dfrac{1}{H(X)^2}\right)} & 0 < H(X) \le 0.5 \\[4mm] t = \sqrt{Ln\left(\dfrac{1}{(1-H(X))^2}\right)} & 0.5 < H(X) < 1 \end{cases} \qquad (9)$$

The values of coefficients for Eq. (8) are as c_0 = 2.515517; c_1 = 0.802853; c_2 = 0.010328; d_1 = 1.432788; d_2 = 0.189269; and d_3 = 0.001308. In this study, SPI was computed using gamma distribution. Based on the SPI values the drought and wet conditions, existing at a place can be identified and categorized with specific symbol as presented in Table 1. The characteristics of drought (SPI ≤ -1.0) and wet (SPI ≥ 1.0) conditions on multi-temporal scales of 1-, 3-, 6-, 9-, 12-, and 24-month are presented in Table 2 and 3, which provide information about total number of drought or wet months, number of consecutive drought or wet incidents, drought or wet percentage, average duration, and the longest duration of drought or wet with total severity, average intensity and category. The severity (S) of drought or wet condition was calculated as the cumulative sum of consecutive negative or positive SPI values with corresponding sum of durations (D); and the intensity (I) was calculated by dividing S with D. The SPI series are classified as short-term (SPI-1 and SPI-3), medium-term (SPI-6 and SPI-9) and long-term (SPI-12 and SPI-24) droughts or wets events. The pattern of occurrence of drought and wet events is described in the subsequent sections.

RESULTS AND DISCUSSION

Drought and wet pattern at Pantnagar: The general pattern of drought events indicates that out of total available

Table 1. Drought and wet events classification based on SPI values

SPI values	Category	Symbol
SPI ≥ 2.0	Extremely wet	C
1.50 ≤ SPI < 2.0	Severely wet	B
1.00 ≤ SPI < 1.5	Moderately wet	A
-1.0 < SPI < 1.0	Normal	N
-1.5 < SPI ≤ -1.0	Moderately drought	1
-2.0 < SPI ≤ -1.5	Severely drought	2
SPI ≤ -2.0	Extremely drought	3

Table 2. SPI-based drought pattern of rainfall series at Pantnagar

SPI category	Total months	No. of drought months	No. of drought incidents	Drought percentage (%)	Average duration (month)	Longest duration (month)	Period of longest drought	Drought severity	Average intensity	Drought category
SPI-1	672	51	46	7.59	1.11	4	May to August, 1978 June to September, 1979	-5.87 -6.60	-1.47 -1.65	1 2
SPI-3	670	109	81	16.27	1.35	6	June to November, 1979	-11.49	-1.91	2
SPI-6	667	104	82	15.59	1.27	8	June, 1978 to January, 1979 July, 1979 to February, 1980 June, 1992 to January, 1993	-12.89 -17.39 -9.47	-1.61 -2.17 -1.18	2 3 1
SPI-9	664	94	79	14.16	1.19	12	June, 1979 to May, 1980	-24.85	-2.07	3
SPI-12	661	87	76	13.16	1.14	26	May, 1978 to June, 1980	-47.98	-1.85	2
SPI-24	649	76	70	11.71	1.09	25	July, 1978 to July, 1980	-50.32	-2.01	3

months, the number of drought months were 51 (SPI-1), 109 (SPI-3), 104 (SPI-6), 94 (SPI-9), 87 (SPI-12) and 76 (SPI-24) (Table 2). The percentage of drought occurrence and average duration varied from 7.59 to 11.71 and 1.11 to 1.09 for SPI-1to SPI-24, respectively. The longest drought duration was found to be 26 months for SPI-12. Drought severity and average intensity were -5.87 to -6.60 and -1.47 to -1.65, -11.49 and -1.91, -12.89 to -9.47 and -1.61 to -1.81, -24.85 and -2.07, -47.98 and -1.85 and -50.32 and -2.01 for SPI-1, SPI-3, SPI-6, SPI-9, SPI-12 and SPI-24, respectively. Accordingly, the drought category varied from moderate to extreme drought for SPI-1 to SPI-24. Figure 1 (a to f) show the distribution of drought events for SPI-1 to SPI-24 at Pantnagar during 1961 to 2016.

The general pattern of wet events indicates that out of total available months, the number of wet months were 130 (SPI-1), 110 (SPI-3), 108 (SPI-6), 105 (SPI-9), 95 (SPI-12) and 72 (SPI-24) (Table 3). The percentage of wet occurrence and average duration varied from 19.35 to 11.09 %, and 1.24 to 1.06, for SPI-1 to SPI-24, respectively. The longest wet duration was found to be of 36 months for SPI-24. Wet severity and average intensity were found to be 4.78 to 5.55 and 1.59 to 1.85, 13.55 to 17.02 and 1.69 to 2.13, 19.70 and 1.79, 59.51 and 2.05, 60.76 and 2.34 and 82.02 and 2.28 for SPI-1, SPI-3, SPI-6, SPI-9, SPI-12 and SPI-24, respectively. Accordingly, the wet category varied from moderate wet to extreme wet for SPI-1 to SPI-24. Figure 1 (a to f) show the distribution of wet events for SPI-1 to SPI-24 at Pantnagar during 1961 to 2016.

Probability of occurrence of drought and wet events: The probability of occurrence of drought (moderate, severe and extreme) and wet (moderate, severe and extreme) events are given in Table 4, which indicates that the probability of occurrence of moderate, severe and extreme drought events
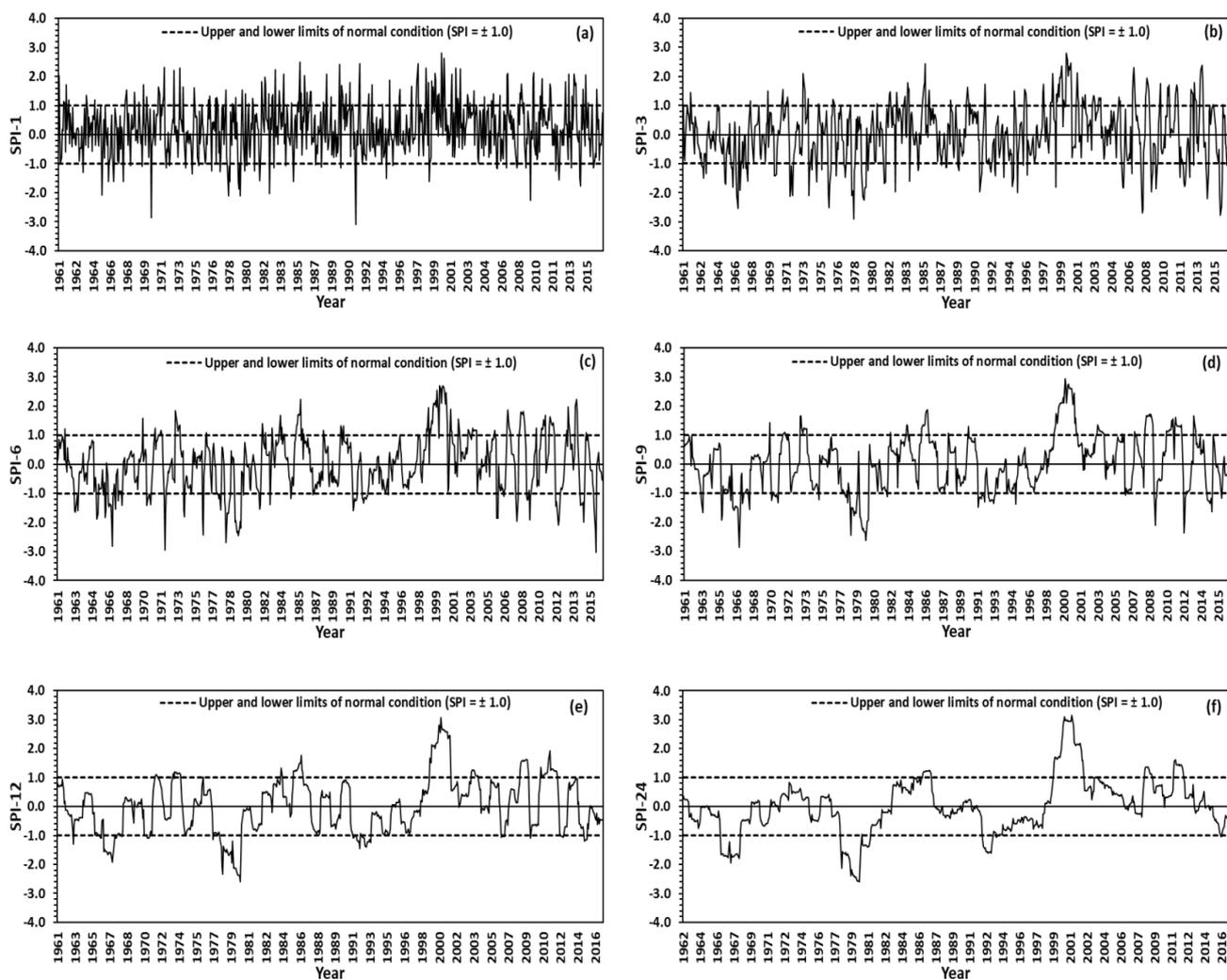
Fig. 1 (a to f). Drought and wet patterns for SPI-1, SPI-3, SPI-6, SPI-9, SPI-12 and SPI-24 at Pantnagar

Table 3. SPI-based wet pattern of rainfall series at Pantnagar

SPI category	Total months	No. of wet months	No. of wet Incidents	Wet percentage (%)	Average duration (month)	Longest wet pattern				
						Longest duration (month)	Period of longest wet	Wet severity	Average intensity	Wet category
SPI-1	672	130	105	19.35	1.24	3	September to November, 1971	4.78	1.59	B
							October to December, 1997	5.47	1.82	B
							June to August, 2008	4.41	1.47	A
							January to March, 2014	5.55	1.85	B
SPI-3	670	110	85	16.42	1.29	8	May to December, 1999	13.55	1.69	B
							April to November, 2000	17.02	2.13	C
SPI-6	667	108	86	16.19	1.26	11	May, 1999 to March, 2000	19.70	1.79	B
SPI-9	664	105	95	15.81	1.11	29	April, 1999 to August, 2001	59.51	2.05	C
SPI-12	661	95	87	14.37	1.09	26	July, 1999 to August, 2001	60.76	2.34	C
SPI-24	649	72	68	11.09	1.06	36	August, 1999 to July, 2002	82.02	2.28	C

Table 4. Probability of occurrence of drought and wet events at different SPI time scales for Pantnagar

SPI time scale	Drought events			Wet events		
	Moderate	Severe	Extreme	Moderate	Severe	Extreme
	1	2	3	A	B	C
SPI-1						
Event months	31	13	7	67	38	25
Total months	51	51	51	130	130	130
Probability	0.61	0.25	0.14	0.52	0.29	0.19
SPI-3						
Event months	62	28	19	63	32	15
Total months	109	109	109	110	110	110
Probability	0.57	0.26	0.17	0.57	0.29	0.14
SPI-6						
Event months	60	31	13	67	26	15
Total months	104	104	104	108	108	108
Probability	0.58	0.30	0.13	0.62	0.24	0.14
SPI-9						
Event months	61	21	12	65	21	19
Total months	94	94	94	105	105	105
Probability	0.65	0.22	0.13	0.62	0.20	0.18
SPI-12						
Event months	55	21	11	57	15	23
Total months	87	87	87	95	95	95
Probability	0.63	0.24	0.13	0.60	0.16	0.24
SPI-24						
Event months	25	38	13	35	14	23
Total months	76	76	76	72	72	72
Probability	0.33	0.50	0.17	0.49	0.19	0.32

varied from 0.61 to 0.33, 0.25 to 0.50, and 0.14 to 0.17 for SPI-1 to SPI-24, respectively. Similarly, the probability of occurrence of moderate, severe and extreme wet events varied from 0.52 to 0.49, 0.29 to 0.19, and 0.19 to 0.32 for SPI-1 to SPI-24, respectively.

CONCLUSION

The aim of this study was to characterized drought and wet conditions during 1961 to 2016 at Pantnagar situated in central Himalayan State of Uttarakhand, India, using standardized precipitation index at multi-time scales. This

study revealed there are more chances (71%) of normal condition, and the occurrence of extreme drought or wet events is unlikely at Pantnagar, which requires no specific measures for water conservation or drainage. There are relatively more chances of occurrence of moderate drought and wet conditions, and severe drought for SPI-24, which may be taken care of by adopting appropriate water/moisture conservation measures such as *in-situ* rainwater harvesting, mulching etc. for enhancing agricultural productivity in the region.

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Modeling of Tidal Inlet of Pulicat Lagoon

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Abstract: Tidal inlet is the portion of water body between the sea and a river that is subjected to ingress of tide during high tide and flushing during low tide. These inlets remain cut off from the ocean whenever sand bars form across their entrances. Such seasonal closure of inlet causes many issues to the mankind and ecosystem. Keeping the inlet permanently open, ensuring year around navigability and improving the flushing of the estuaries/ lagoon continue to evince the hydrodynamic flow model of Kondurupalem lagoonal inlet on South East coast of India. The present study on the hydrodynamic flow model of the inlet was formulated after a comprehensive survey on the subject for a decade. The numerical model used in the analysis of the hydrodynamics of the tidal inlet is a depth - averaged, two-dimensional modelling system. Standard numerical modelling procedures were applied to understand the hydrodynamics of the study area. High resolution bathymetric data collected in 2018 was used to study the hydrodynamic behaviour of the inlet. The bathymetry data, bed resistance coefficients, wind field, hydrodynamic boundary conditions and eddy viscosity were fed as basic inputs. The hydrodynamic module simulated water level variations and flows in response to a variety of forcing function in lakes, estuaries and coastal areas. The characteristics of waves during south west and northeast monsoon of Kondurupalem coast were measured and analysed. The significant wave height during south west monsoon period ranged from 0.3 to 0.8 m with an average value of 0.45 m. Frequency distributions of wave heights show that 50 % of significant wave heights are in the range of 0.3 - 0.5 m indicating low wave activity during the observation period. Numerical models for water surface elevation shows a correlation of 0.8. It is concluded that numerical modelling results confirm satisfactorily with the site monitoring observations.

Keywords: Tidal inlet, Hydrodynamic modelling, Bathymetry data, Significant wave height, Numerical models

Coastal lagoons, which occupy 13% of the world's coastline, are rich, but very fragile ecosystems (Gonenc and Wolflin 2005). Coastal lagoons support a rich biodiversity, like plants, animals or microbes act as a spawning ground for marine fish and invertebrates, and resting areas for many species of migratory birds. (Aliaume et al 2007, Garrido et al 2011). Tidal inlets are a common feature along major part of the Indian coastline (Vandhana Devi and Nagendran 2017). Modelling is a useful tool for engineering design and analysis and help in seamless management of lagoons by solving physical problems using appropriate mathematical equations. With the increase in computational technology, many numerical models have been developed for various engineering practices (Central Federal Lands Highway Division 2013). The accurate predictions of oceanographic variables such as water level, currents, temperature, and salinity by the models enable use of model output to make ecological forecast (NOAA 2013). Many of the species in the estuary are significantly affected by their environmental conditions, such as water temperature, salinity, and current velocity. The parameters and mixing processes of coastal lagoons can be simulated by the time-dependant, nonlinear equations of conservation of mass and momentum. These simulations help in impact analysis for various conditions, once the processes are established by measurements.

Considerable research has been conducted on hydrodynamics of lagoons independently. Limited research work has been done at Kondurupalem tidal inlet of Pulicat Lagoon, whereas, a large volume of work has been done on Pulicat mouth of the lagoon. Also there has been very limited research conducted on hydrodynamics of the tidal inlet. It is essential to understand the hydrodynamics of the tidal inlet for any engineering development to take place, to prevent the sea mouth closure and to solve the problems arising due to siltation and sea mouth closure, there is an urgent need to understand the hydrodynamics of Kondurupalem tidal inlet. The present study aims to address the hydrodynamics of inlet in order to keep it open to conserve the lagoon ecosystem since more than 50,000 fishermen, thousands of migratory birds and other biota are dependent on it for their very existence. Though reports and publications on eco-management of Pulicat lake ecosystem are available (Sanjeevaraj 2010) such studies have not been extended to Kondurupalem tidal inlet in spite of its known hydrological and economic importance. Assessment of socio-economic status of fishing community in the study area has been reported (Vandhana Devi and Krishnaveni 2012).

MATERIAL AND METHODS

The methodology for development of Hydrodynamic flow model is depicted in Figure 1. Wind and tide data for the hydrodynamic model were carried out and numerical models

were used to understand the hydrodynamic behaviour and wave transformations in the study area.

Study area: Pulicat lagoon is the second largest brackish water lake in India next to Chilika. It straddles the border of Andhra Pradesh and Tamil Nadu states on the Coromandal Coast of South India. The Pulicat lagoon is connected to the sea through three tidal inlets, one each at Kondurupalem, Rayadoruvu and Pulicat mouth from north to south, respectively (Sanjeevaraj 2010). Kondurupalem, one of the tidal inlets of Pulicat lagoon, is taken for this study. The lagoon's boundary limits range between 13.33° and 13.66° N and 80.23° and 80.25°E. The map of the study area is shown in Figure 2. The fish, prawns and migratory birds of the backwater lagoon flourish in the entrance channel of the Kondurupalem inlet. The tidal inlet of the lagoon was closed for about six months due to failure of monsoon, accretion at mouth by long-shore sediment transport, weak tidal current, reduced fresh water flow not strong enough to keep the sand out of the inlet. Periodic closure of these inlets is a phenomenon which takes place due to bar mouth formation every year.

Monitoring of coastal processes: The coastal processes along the Kondurupalem coast were monitored in two phases during 2018. The monitoring programme covered a coastal stretch of 5 km (2.5 km north and south of the inlet) and included the following: survey of offshore and the lake bathymetry, measurement of water level, waves, coastal and near shore currents, sediment sampling, shoreline and beach surveys. Data were recorded relative to World Geodetic System 84 (WGS) and depths were referenced to MSL (Fig. 3, Table 1). The boundaries of the study area were monitored by two stations along cross-shore transects (St-1 & St-3, St-2 & St-4) perpendicular to coast while the near-shore processes were monitored with one Acoustic Doppler Velocimeter (ADV) (St-5), the inlet process was monitored using another ADV (St-6). The wave and tide gauges were deployed along with current meters at all locations. The stations for measuring hydrodynamics were reduced in NE monsoon by restricting to near coast stations, as the variability between near coast and little offshore was not seen at study area.

The first phase measurements for the monsoon period of the year 2018 commenced on 23rd June and continued till 07th July 2018. Two sets of current meter and directional wave and tide gauge were deployed at a depth of 6m at north (St-1) and south (St-2) of the inlet and another set at a depth of 14m off Kondurupalem coast (St-3 & St-4), respectively. Two acoustic doppler velocimeters each at breaker zone at a water depth of 4.5m (St-5) and at inlet mouth at a depth of 2.5m (St-6) were deployed. Acoustic Doppler Velocimeter
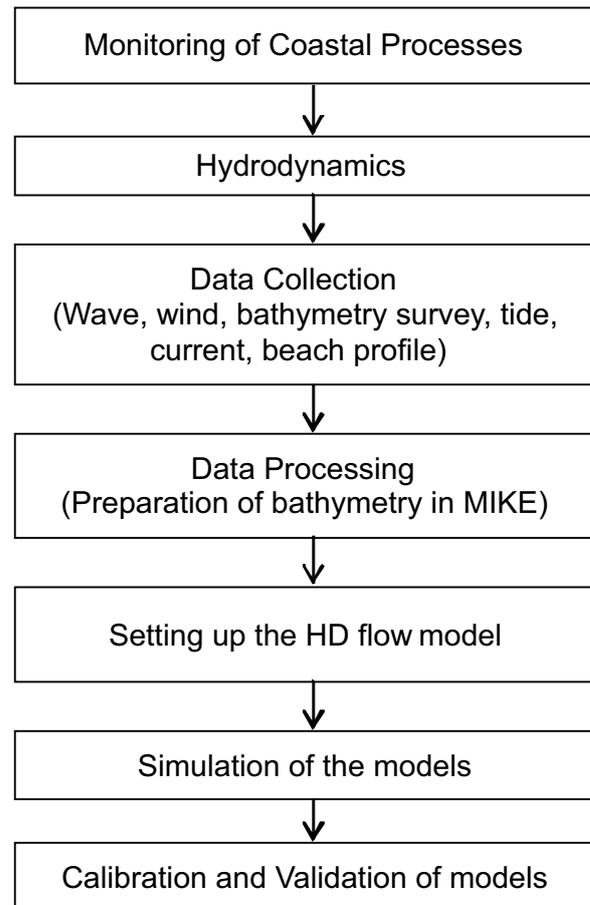
Fig. 1. Methodology for development of hydrodynamic flow model
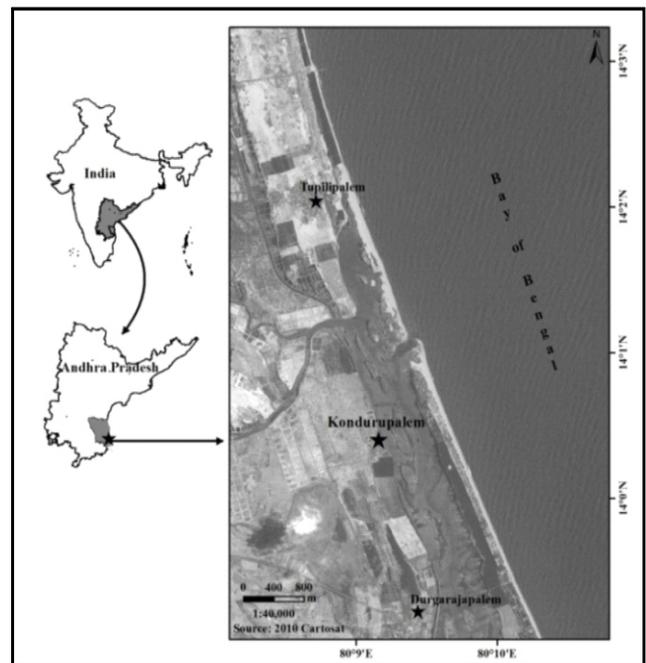
Fig. 2. Map of study area

(ADV) with a sampling frequency of 4 Hz with 1024 samples was used to measure near shore currents with an interval of 20 minutes in burst 2 mode. The pressure and velocity sensors were located at a distance of 1.1 m from sea bed. Near-shore currents were measured at two stations, namely station 1 (breaker zone), station 2 (inside the lake). Table 2 details the parameters and instruments used for monitoring coastal process.

The second phase measurements for the northeast monsoon period of the year 2018 commenced on 6th December and continued till 21st December 2018. Two sets of current meter and directional wave and tide gauge were deployed at a depth of 6m at north (St-1) and south (St-2) of the inlet and another set at a depth of 14m off Kondurupalem coast (St-3 & St-4), respectively while two acoustic doppler velocimeters were deployed each at breaker zone at a depth of 4.5m (St-5) and at inlet mouth at a depth of 2.5m (St-6).

The tides in Bay of Bengal are semidiurnal in nature as the sea level reaches its highest level in November and lowest in March along the south east coast of India. The tidal range in March varied between 0.5m (neap tides) and 0.7m (spring tides) whereas in November the range varied from 1.3 to -1.0m. Bathymetric surveys and near-shore profiles are direct measures of the boundary conditions for fluid motions, sediment transport mechanisms and shoreline changes. Seabed morphology was mapped from near-shore to 15m water depth using a single beam echo sounder during November 2017 and March 2018.

The bathymetry survey covered 5km along shore (north to south) and 5km cross-shore (east to west). The depth values were post processed, analyzed and interpolated using Hypack hydrographic software package. Topographic survey was carried out for Kondurupalem coast with 12 transects of 250 m horizontal spacing. Real Time Kinematic Global Positioning System (RTK-GPS) was used for near shore elevation data collection. The numerical model used in the analysis of the hydrodynamics of the Kondurupalem tidal inlet is a depth-averaged, two-dimensional modelling system. The standard numerical modeling procedures were applied to understand the hydrodynamics and sediment dynamics of the study area. Subsequently, the validated model was used to understand the hydrodynamics and sediment dynamics of the study area. This module calculates the flow field from the solution of the depth-integrated continuity and momentum equations. The governing equations are presented below using Cartesian coordinates (Polyanin et al 2002). The continuity equation is written as

$$\frac{\partial \zeta}{\partial t}+\frac{\partial p}{\partial x}+\frac{\partial q}{\partial y}=0 \qquad \text{Eqn 1}$$

$$\frac{\partial p}{\partial t}+\frac{\partial}{\partial x}\left(\frac{p^2}{h}\right)+\frac{\partial}{\partial y}\left(\frac{pq}{h}\right)+gh\frac{\partial \zeta}{\partial x}+\frac{gp\sqrt{p^2+q^2}}{C^2h^2}-\frac{1}{\rho_w}$$

$$\left[\frac{\partial}{\partial x}\left(h\tau_{xx}\right)+\frac{\partial}{\partial y}\left(h\tau_{xy}\right)\right]-\Omega q-fVV_x+\frac{h}{\rho_w}\frac{\partial}{\partial x}\left(p_a\right)=S_{ix} \qquad \text{Eqn 2}$$

$$\frac{\partial q}{\partial t}+\frac{\partial}{\partial y}\left(\frac{q^2}{h}\right)+\frac{\partial}{\partial x}\left(\frac{pq}{h}\right)+gh\frac{\partial \zeta}{\partial y}+\frac{gq\sqrt{p^2+q^2}}{C^2h^2}-\frac{1}{\rho_w}$$

$$\left[\frac{\partial}{\partial y}\left(h\tau_{yy}\right)+\frac{\partial}{\partial x}\left(h\tau_{xy}\right)\right]+\Omega p-fVV_y+\frac{h}{\rho_w}\frac{\partial}{\partial y}\left(p_a\right)=S_{iy} \qquad \text{Eqn 3}$$

Table 1. Station locations and depth details of moored instruments

Station ID	Total water depth (m)	Tide gauge depth (m) from surface	Current meter depth (m) from surface	ADV depth (m) from surface	Reference point
St-1	6.5	6.5	2.5	-	North of Inlet
St-2	7	7	6.5	-	South of Inlet
St-3	13	13	4	-	North of Inlet
St-4	13	13	6.5	-	South of Inlet
St-5	4	-	-	3	Breaker zone
St-6	2.5	-	-	1.5	Inlet mouth

Table 2. Details of the parameters and instruments used for monitoring

Parameter	Instrument	No. of locations
Tide	Directional Wave Recorder (Valeport)	4 (SW & NE monsoon)
Wave	Directional Wave Recorder (Valeport)	4 (SW monsoon) 2 (NE monsoon)
Coastal currents	Recording Current Meter (Aanderraa)	4 (SW monsoon) 2 (NE monsoon)
Nearshore currents	Acoustic Doppler Velocimeter (Sontek)	2
Bathymetry survey	Echo sounder (ODOM)	-

High resolution bathymetric data collected in 2018 was utilized to study the hydrodynamic behaviour at the lagoon inlet. The bathymetry data, bed resistance coefficients, wind field, hydrodynamic boundary conditions and eddy viscosity were fed as the basic inputs. The flow model (MIKE 21 HD) solves vertically integrated equations of continuity and momentum in two horizontal dimensions. After data collection and processing the three-dimensional (X, Y and Z) information of sea and estuarine bathymetry, shoreline and beach profiles were merged to a xyz file for model bathymetry. This file was brought into the MIKE Zero (bathymetry editor) where computational model area was discretized into mesh size of 50m grids. UTM 44 North (Universal Transverse Mercater) projection and WGS 84 (World Geodetic Datum) datum was used for editing all the data sets. The model was oriented to 334° from the North to make the computational grids parallel to the coast.

The Hydro Dynamic Module simulated water level variations and flows in response to a variety of forcing functions in lakes, estuaries and coastal areas. The simulations were done and the results were compared with the measurements.

Different boundary conditions were used for different modules in MIKE 21. The HD module, the model east boundary was fed with constant flux and tide data at model north and south (Fig. 4). Data collected at offshore 14 m depth data were used as boundary condition for the simulation of flow model.

In order to study the variation of coastal currents along Kondurupalem coast, current measurements were carried out using the RCM 9 self-recording current meters (Anderaa

Data Instruments) at four locations (S1, S2, S3 and S4) during South-west monsoon and at two locations (S1 & S2) during North-east monsoon. Current data were collected at every 10 minutes interval for a period of 15 days during both the seasons.

Fig. 3. Workstations established during 2018
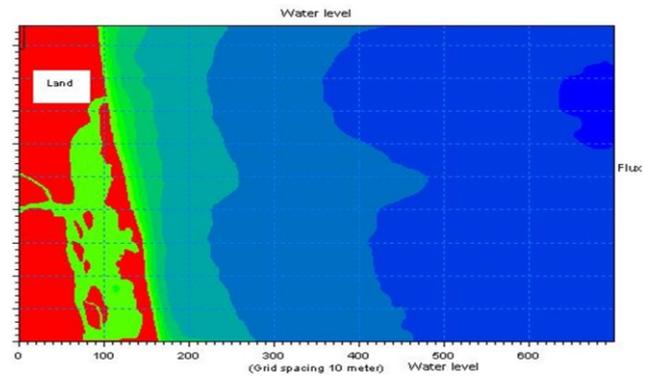
Fig. 4. Boundary conditions of hydrodynamic module
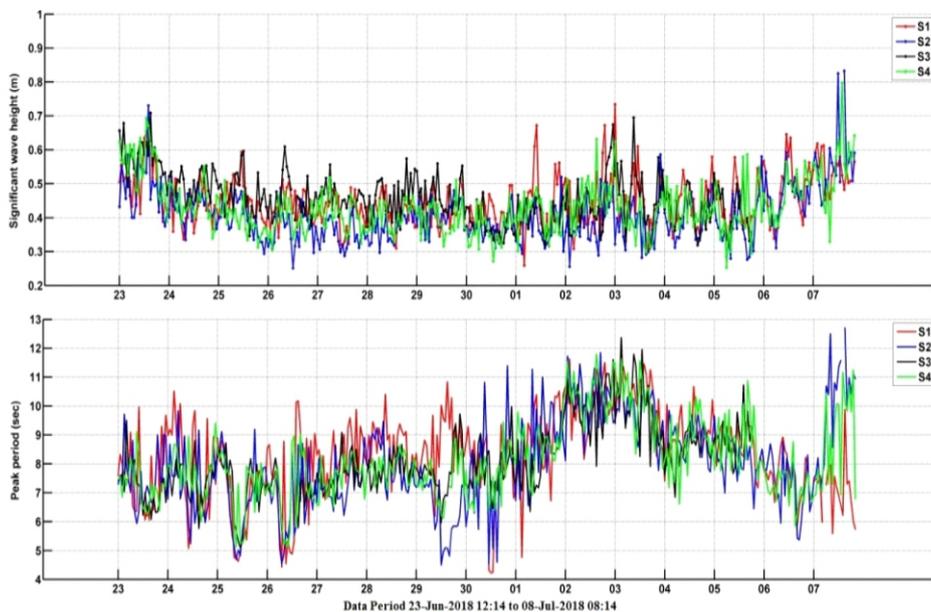
Fig. 5. Significant wave height & peak period during sw monsoon in Kondurupalem inlet

RESULTS AND DISCUSSION

The results were spatially interpreted using Geographical Information System (GIS). The hydrodynamic behaviour and wave transformation at Kondurupalem inlet were studied using two dimensional methods. Observations indicated that coastal circulation at the Kondurupalem tidal inlet had two distinct flow regimes viz. northerly (March-September) and southerly (October to February). The estuarine circulation was influenced by tides, and observations made during April, August and December 2018 indicated that tidal prism in the estuary was dependent on the dynamics of the sand spit and the extent of inlet opening. The maximum currents occur during March 2018 (inlet open condition) and minimum during September 2018 (mouth closure). The hydrodynamic model was executed for two seasons viz. June (mouth open - SW monsoon) and October (mouth closed- NE monsoon).The significant wave height during SW monsoon period ranged from 0.3 to 0.8 m with an average value of 0.45 m (Fig. 5). Frequency distributions of wave heights show that almost 50% of the significant wave heights are in the range of 0.3 - 0.5 m indicating low wave activity during the observation period. The peak period ranges between 5 s to 12 s with an average value of 8 s. The significant wave height during the NE monsoon period ranged from 0.25 to 1.50 m with an average value of 0.60 m. Frequency distributions of wave heights show that almost 50% of the significant wave heights were in the range of 0.5 - 0.7 m indicating moderate wave activity during the observation period (Fig. 6).

The wave rose diagram shows that during southwest monsoon, the waves approach the Kondurupalem coast from southeast with maximum significant wave height of 0.95 m at location S2 and from east during northeast monsoon with a maximum significant wave height of 1.56 m (Fig. 7). The wave periods ranged from 3 - 18 seconds at all the locations during southwest monsoon and 3-7 seconds
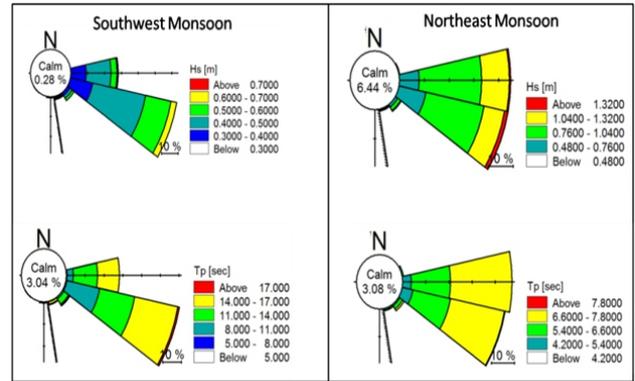
Source: National Institute of Technology, Chennai (NIOT)

Fig. 7. Wave rose diagram of Kondurupalem inlet during southwest and northeast monsoon

during northeast monsoon. The frequency distribution shows that more than 50% of the waves have T_z in the range of 8-10 seconds and 15% of the waves are above 10 s during the deployment period. Currents at each station were resolved into zonal (u-component) and meridional (v-component) directions (Fig. 8 & 9), with the flow to the east and the north being defined as positive. The measured current was up to 0.2 m/s with a mean value of 0.1 m/s during SW monsoon and about 0.3 m/s during NE monsoon. The v-component of current dominated the u-component at all the stations which results in large alongshore flow than the cross- shore flow.

Currents are northerly during SW monsoon whereas southerly during NE monsoon period (Fig. 10 & 11). The direction of near-shore currents at station 5 and 6 follow coastal currents, which is seasonal viz., northerly during southwest monsoon and southerly during northeast monsoon. Cross-shore currents are frequently directed offshore. Longshore currents are mostly parallel to the shore. In the near shore magnitudes and direction of wave-induced cross-shore mean currents are dependent upon the breaking of waves which is related to the significant wave height. The
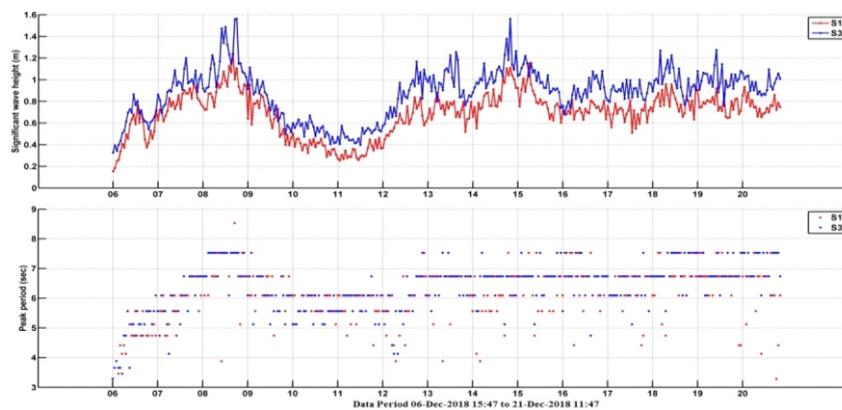
Fig. 6. Significant wave height & peak period during ne monsoon in Kondurupalem inlet
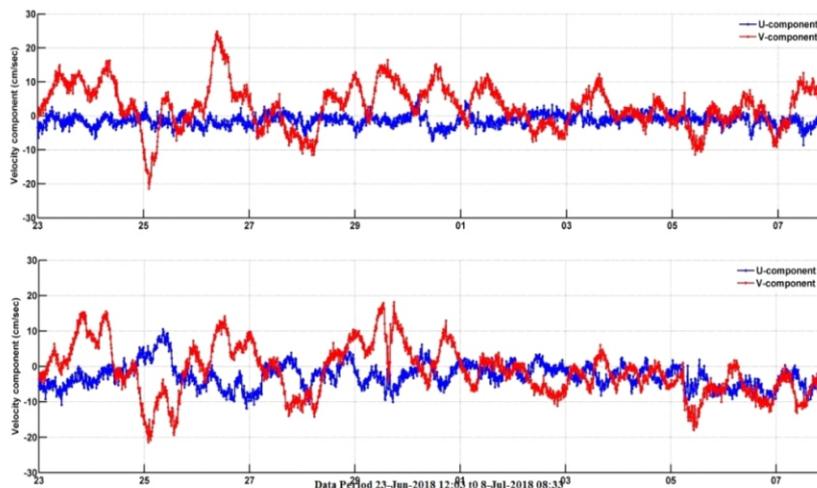
Fig. 8. Zonal (u) and meridional (v) component of coastal currents during SW Monsoon at stations S1 and S2 in Kondurupalem inlet
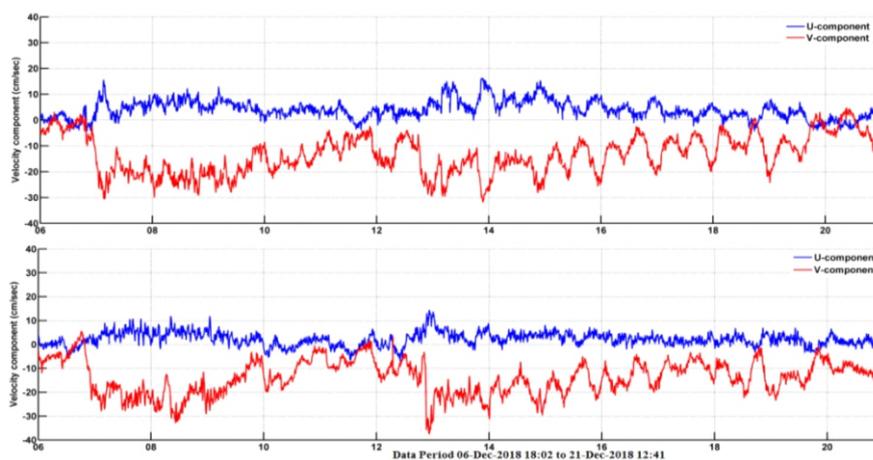
Fig. 9. Zonal (u) and meridional (v) component of coastal currents during NE monsoon at stations S1 and S2 in Kondurupalem inlet

Source: National Institute of Technology, Chennai (NIOT)
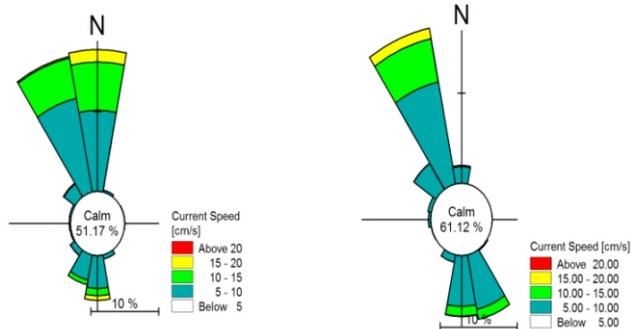
Source: National Institute of Technology, Chennai (NIOT)

Fig. 10. Current rose diagram during sw monsoon in Kondurupalem inlet
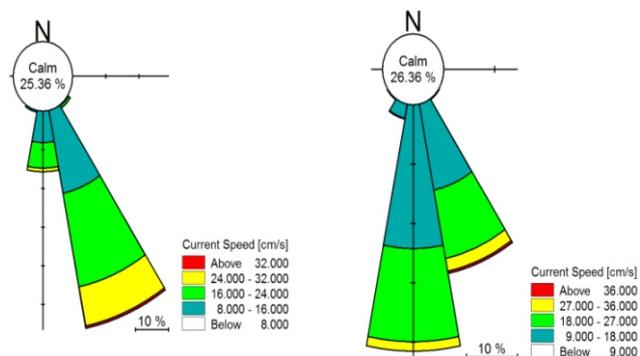
Fig. 11. Current rose diagram during ne monsoon in Kondurupalem inlet

magnitude and direction of the mean longshore current is related to the significant wave height and the incidence wave angle. For longshore currents, positive value indicates northward directed velocities and the opposite accounts for southward directed velocities.

The magnitude of near shore current at S5 was 0.2 m/s whereas at S6 it was 0.25 m/s during SW monsoon. The current at S5 during NE monsoon was 0.2 m/s and at S6 it was about 0.18 m/s. The mean cross (U) and longshore (V) currents (m/s) in the breaker zone during SW monsoon and NE monsoon in Kondurupalem inlet (Fig. 12 & 13). The mouth region was fully occupied with exposed sand. Distribution of depths indicated that in the northern part of the inlet, the deeper portion runs along the left bank of the inlet

whichis separated by an island from the channel running close to the right bank. The width of the overall water excursion varied between 200 and 400 m. In central portion, the inlet was occupied with a number of intricate network of canals. Here, there is no major water transport area. However, the deeper most channel with maximum depth 1.3 m runs close to the left bank. The right bank is occupied with very shallow depths of the order of 0.6m. In the central portion, the inlet is occupied with intricate network of canals with water depths varying between 0.2 to 0.5 m. In southern portion as in northern portion of the lake, the water course is well established with wide channel. Deeper channel running close to the right bank (looking north) has a maximum depth of 2.2 m. As the left portion is occupied with number of small
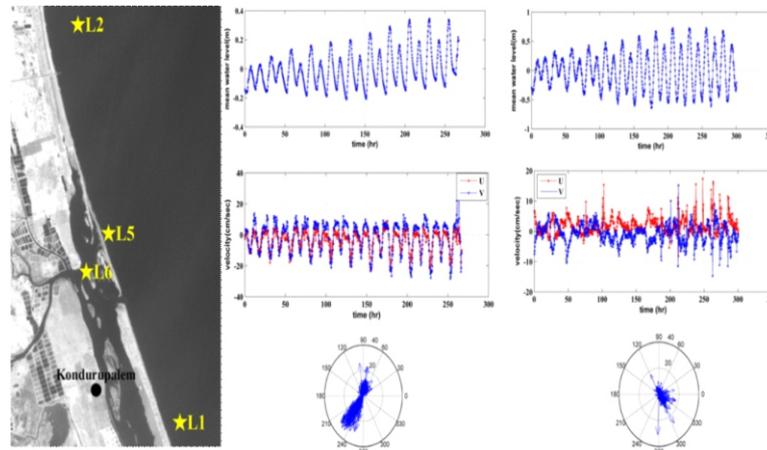
Fig. 12. Mean cross (U) and longshore (V) currents (m/s) in the breaker zone during SW monsoon in Kondurupalem inlet
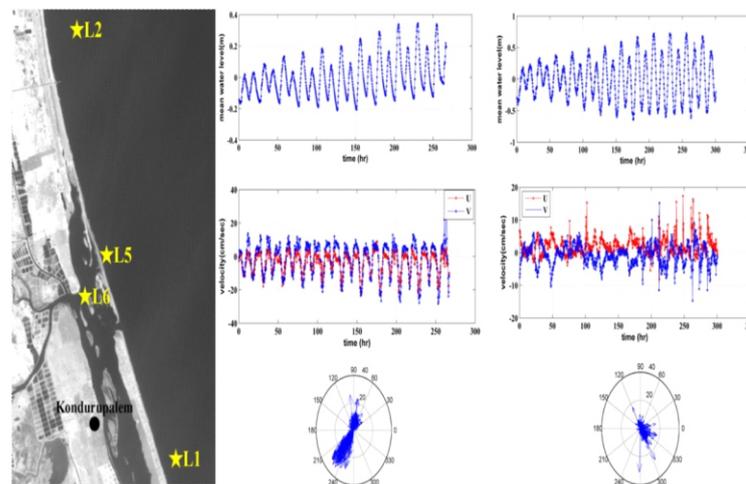
Fig. 13. Mean cross (U) and longshore (V) currents (m/s) in the breaker zone during NE monsoon in Kondurupalem inlet
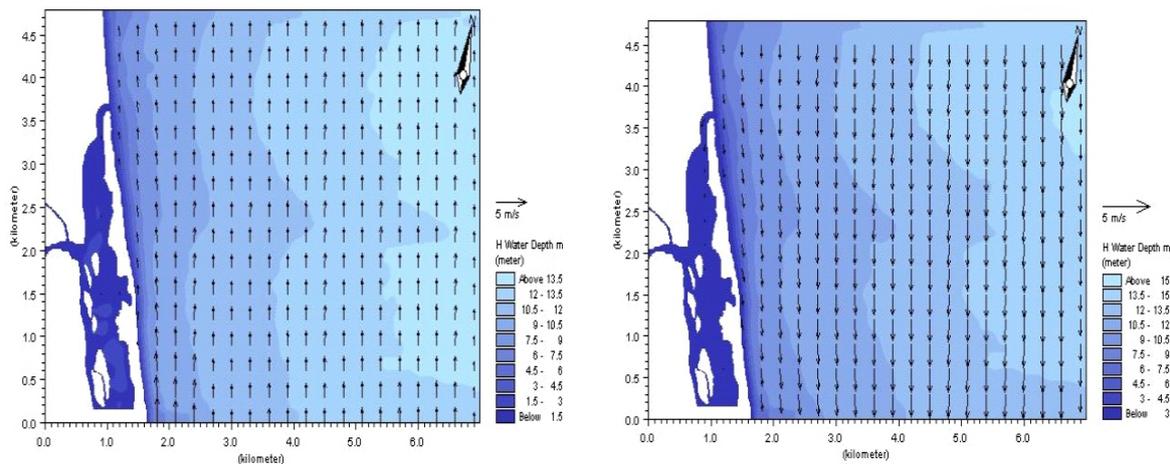
Fig. 15. Variation of water depth and flux during A) Southwest monsoon and B) North East monsoon
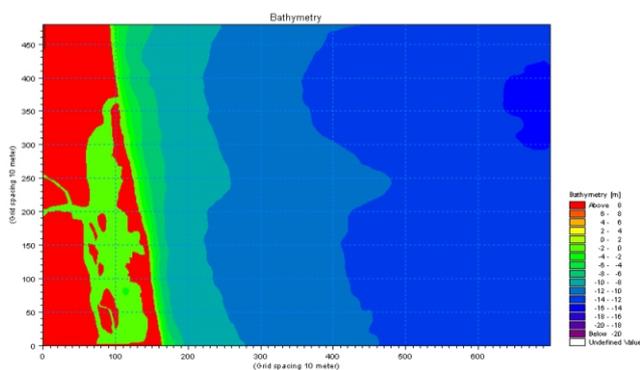
Fig. 14. Bathymetry/topography along Kondurupalem coast during 2017-2018

islands, an intricate network of shallow creeks of depths less than 0.5m are developed close to the left bank. Figure 14 shows the surveyed bathymetry/topography data along Kondurupalem coast during 2017-2018 (overall water excursion varied between 200 and 400 m). The results from hydrodynamic flow model for two typical wave regions July (SW monsoon season- 1.5 m to 13.5 m) and December (NE monsoon season- 3 m to 15 m) were shown in Figure 15 (A) and (B).

CONCLUSION

Modelling the hydrodynamics of Kondurupalem inlet is challenging because of the manpower constraints involved in the collection of the bathymetry data. The MIKE 21 model was calibrated and validated with water level, current and temperature measurements collected during the study period. Numerical models for water surface elevation shows a correlation of 0.8. Hence, the numerical modelling results confirm satisfactorily with the site monitoring observations. Hydrodynamic studies reveal that tidal action and effects are

the main driving forces that are responsible for the circulation patterns inside the lagoon. The time series variations in water surface elevation relative to the mean sea level reveal that water level varies between -0.6 and 0.6 m during spring and neap tides. Remote Sensing and Geographical Information System based studies reveal that the inlet gets shifted frequently in terms of its position and shape. The dredging at the closed bar-mouth may help in regulating the sediment accumulation at the inlet, enhancing the salinity and restoring the quality of the ecosystem to an extent.

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Study of the Adaptation and Gene expression in Coffee Beans after Exposure to Mutation

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Abstract: Two experiments were conducted to study the adaption of lines from coffee beans breed to cold environment after exposure of shoot apexes to different mutation treatments and its effective on gene expression. The first experiment included exposure cut shoot apexes to ultraviolet radiation in three wavelengths (220, 320 and 400 mm) with two exposure periods (2 and 4 hours per day). In the second experiment, the seeds were sown on five dates in 2016-2017 and 2017-2018. The results in first season showed that 30 January and 15 February sowing dates gave high yield traits in both seasons while 01March sowing provided biological yield in all seasons but it was not pods. The *atpA* gene was detected as genetic parameter, from leaves at end season 30 January and 15 February sowing dates while the gene was silent in leaves of 01 March, sowing date. This indicates that there were new lines of coffee beans suitable under Iraq conditions.

Keywords: *atpA* gene, Beans, Mutation, Ultraviolet

The plant adaptation essential for economic yield under specific environments. Among various factors plants growth depend on various climate factors: heat, rains, winds, soil and also on their biological factors. Most plant species grow under cold or hot environments (Jabbar 2019) and give yield according to the environment and applications (Al-Mohammad and AL-Khafaji 2018) and the stresses (AL-Salihy et al 2018). In Iraq, high temperature and lack in water irrigation in summer season are the most problems which identify of the cultivation of crop. Coffee cylindrical beans is one of the important summer plant species because it has high nutritional content from proteins, fibers, minerals and vitamins (Samuel and Ahiwe 2018). This is classified to many breeds like white beans, red beans, light and dark speckled kidney beans, black and coffee cylindrical beans. Coffee beans breed culture in the east Asia and other areas in the world. Iraq food diversity program, need adaptation in new environment, the adaptation can be achieved either production of genotypes that tolerance of less water or find a new breed grow early to avoid high temperature and lack in water in summer throw plant breeding programs or use one of biotechnology materials .

The mutation technique is one of bio-technology which use for getting on genetic variations. The UV light as physical mutant material effect on some chemical and growth traits in plants (Manaf et al 2016). If non-specialized cells exposure to external shock, it may be given differences in gene expression and morphological behaver compare to specialized cells in plant tissue (AL-Salihy and Jabbar 2017). Mapping genes in genetic material differ according to the species or genotypes , the most genes have activated under different growth stages but other genes have been silent under same conditions, shocks and mutation factors activate some silent genes by stopping dominant genes or allow to other metabolism genes to the continuous of activity under external stresses, morphological and quantitative traits affect from any change in gene expression , there are relationship between genetic and phenotypic traits (Jabbar 2019). The study was conducted to identify lines of coffee beans breed after exposure of shoot apexes to different mutation treatments and its effective on gene expression with study of the mutant lines adaptation under cold environment.

MATERIAL AND METHODS

Two experiments were conducted institute of genetic engineering and biotechnology of higher studies – University of Baghdad and college of sciences – University of Babylon. Field experiment was conducted in agricultural fields affiliated to Ministry of agriculture (Baghdad – Iraq). The the aim of study was to understand the ability of mutant lines of coffee beans to the adaptation under cold environments (5-20 ℃).

First experiment: Seeds were sterilized by ethanol 70% for 4 minutes and washed in sterilized distilled water, sterilized in sodium hypochlorite solution 5% with two drop of tween20 for 20 minutes, and washed in distill water for three times again, dry seeds were soaked in water over night for the germination and cultured in dishes, the dishes were incubated under 26 ± 2 ℃ with 14 light: 10 dark (Arias et al 2010, Jabbar 2018). After shoots were germinated, the apexes were cut and

cultured in dishes , the dishes were included media from 4.9 g/L of M.S salts, 100 mg/L of myo-inositol, 30 g/L sucrose, 7 g/L agar and plant hormones 5 mg/L N6-benzylamino purine with 1 mg/L 2,4-D for growth apexes (Alharby et al 2016, Murasgige and Skoog 62). After apexes were grew, the plant lets were incubated (Table 1). Itraviolet candles were used under three wavelengths (220, 320 and 400 nm) with two exposure periods (2 and 4 hours) after apex shoots cultured in media and incubated. The U.V. light candles connected with yellow candles of incubator, the exposure finished at Plantlets 15 cm .

Second experiment: This experiment was conducted in winter 2016-2017 and 2017-2018 , the seeds were sown in pots 50 cm, randomized complete block design was used with three replications, the treatments were five dates (Table 2). The fertilization was included nitrogen and phosphorus at 36,92 kg of N and P2O5/ha (Wondimu and Tana 2017). The data was collected on number of pods/plant , number of seeds/pod (mg) and plant seeds yield (g) .

DNA extraction and PCR: Total genomic DNA was extracted according to the standard procedure of (Spaniolas et al 2008) with some modifications by Hamorabi kit (product by the Institute of Genetic Engineering and Biotechnology-University of Baghdad). Type of PCR was Thermocycler PCR, Thermocycle PCR sample contents for gene transcription were master mix 10 μl, DNA 3 μl, forward primer 1 μl, reverse primer 1 μl and deionized distal water 5 μl, the PCR program was given from (Sang et al 2009), Primers of ATP synthase CF1 alpha subunit gene were *atpA* F: GGAATTGTGGTCTTTGG-TAGTG, *atpA* R: CCCCTCTTCCA-TCAATAGGTAC (Woloszynska et al 2006).

RESULTS AND DISCUSSION

The D1, D2 sown plants did not complete the growth because its weakness in growth from low temperatures, so all plants dead later , the D5 plants could give growth but it did not have yield Due to fall flowers from high temperatures at

Table 1. Heat degrees and quantity of lighting in different growth stages

Growth stages	Sites	Heat (ºC)	Light period (hour)
Culture apex in media	Incubator	10	10
Plantlets 2 cm	Incubator	14	11
Plantlets 4 cm	Incubator	14	11
Plantlets 6 cm	Incubator	16	12
Plantlets 15 cm	Incubator	18	12
Plantlets 20 cm	greenhouse	20±2	12
Plantlets 25 cm	greenhouse	24±2	14
Flowering 50%	greenhouse	26±2	14
Flowering 100%	greenhouse	28±2	
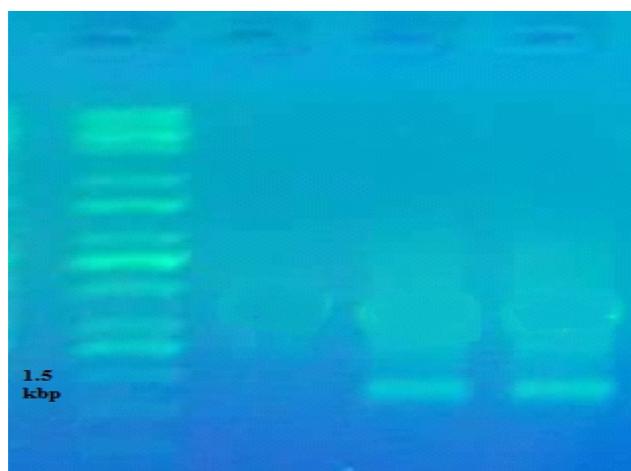
Fig. 1. Gel electrophoresis (1% agarose , 7 V/cm for 90 min) of *atpA* gene in coffee bean , first line : 100 bp DNA ladder, lines (2,3) positive results for *atpA* gene, line 1 : D5 , line 2 : D2 and line 3 : D3

end season, the D3,D4 plants gave biological and seeds yield .

Genetic parameters: The mutation affected on the gene detection, the gene expression of metabolism genes differed in expression with different conditions, *atpA* gene has been one of metabolism gene which detected in beans, it has responsible for transcription of ATP synthase CF1 alpha

Table 2. Effect dates of seedling in study traits

Sowing dates	2016-2017 season			2017-2018 season		
	No. of pods / plant	No. of seeds/ pod	Plant seeds yield (g)	No. of pods / plant	No. of seeds/ pod	Plant seeds yield (g)
D1 (30 December)	0	0	0	0	0	0
D2 (15 January)	0	0	0	0	0	0
D3 (30 January)	31.1	7.7	45.5	33.2	8.1	49.4
D4 (15 February)	26.33	6.9	36.7	24.67	7.3	37.9
D5 (01 March)	0	0	0	0	0	0
CD (p=0.05)	1.59	0.2	3.1	2.92	0.3	2.6

subunit enzyme, the *atpA* gene expressed in D3 and D4 treatments but it did not expressed in D5 treatment (Fig. 1), the D5 plants could not give yield, the detection of gene in D1 and D2 treatments did not take because all plants dead in early stage. The genes became silent or active by shock of exposure to mutation, in mutant plants, the genes could continue activity with the change of conditions of organism's environment and was in genes which responsible for action of protease and peroxidase enzymes which affected on growth (Peykarestan and Seify 2012), this result similar results of study.

The plants could not growth in wide range of temperatures (Esmaeilzadeh and Aminpanah 2015) , the mutation cause non-stability genetic material and give non-expectant results as changes in gene expression , so some genes could be active with change of the conditions which were in D3 and D4 treatments (Shaw and Chang 2005) .

CONCLUSION

The study gave relationship between phenotypic traits and gene expression in coffee beans mutant to the adaptation under cold stress conditions, the results confirmed that *atpA* gene expressed in D3 and D4 treatments, and gave seed yield, mutant coffee beans could growth in early date.

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Retrospective and Forecast of Heterochronal Climatic Fluctuations Within Territory of Dnieper Basin

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Abstract: The article presents a study of zonal (mixed forest zone, forest-steppe and steppe) patterns of long-term changes in climatic conditions over the past 200 years on the territory of the Dnieper transboundary basin using multivariate statistics, GIS technologies, and neurotechnologies. For a comprehensive analysis, assessment of series heterogeneity, determination of temporal and spatial patterns of formation and synchronicity of the dynamics of climatic parameters (air temperature, amount of atmospheric precipitation), the study applies the following methods of multivariate statistics: descriptive statistics, regression analysis, transformation of variables (T4253H-smoothen, method of difference integral curves of modular coefficients) and cross-correlation analysis. Climate change probability is predicted using the artificial neural network method. The findings show an increase in the average annual air temperature in three physical and geographical zones by 1.0-1.2°C in the period from the late 80's to the present. The largest proportion of abnormal manifestations of temperature changes is observed in the steppes (34.9%) and mixed forests (34.5%), and the greatest probability of abnormal precipitation changes is observed in the forest-steppe zone (30.3%). Long-term dynamics of intra-annual climatic changes reflect the 2°C warming during the first 10 months of the year, and an increase in average annual precipitation by 90 mm for the period from May to October. The forecasting results show that if the retrospective trend-cyclical tendency is preserved, by 2030 there will be zonal synchronicity of consistently unfavorable changes in climate indicators, characterized by an increase in the average annual temperature by 0.8 °C, and a decrease in annual precipitation amounts by 24 mm. The results and approaches to the multivariate processing of meteorological data presented can be used for spatiotemporal research on long-term regularities of changes in the state of hydrogeocosystems of river basins under the conditions of global climate change, as well as for the development of programs on adaptive and eco-friendly nature management in river basins.

Keywords: Climate, Air temperature, Atmospheric precipitation, Zonal patterns, Dnieper River basin, Multivariate statistics, Modeling, forecasting, GIS-technologies

A directed climate change is one of the most important global challenges of the 21st century, which goes beyond the framework of scientific research and represents a complex interdisciplinary problem covering ecological, economic and social aspects of global sustainable development (Bikbulatova 2013, Lisetskii et al 2011, 2017). Climate changes are diverse, being manifested, in particular, in the intensity, frequency of climatic abnormalities and extreme weather phenomena at different levels of the hierarchy in space and time. Over the past 20-30 years, the frequency and intensity of dangerous weather phenomena, which lead to significant economic damage and threaten the stable existence of ecosystems, as well as human health and life, have increased. The findings of many scientists suggest that continuing climate change may further lead to even more dangerous consequences if humanity does not take appropriate precautionary measures. Scientists of the world documented anthropogenic factor (Bikbulatov 2013; Lisetskii et al 2011, 2017), increase in the carbon dioxide cycle (Matveev et al 2011), radiation, warming of the atmosphere due to the absorption of infrared radiation under the dominant influence of convective heat transfer (Sorokhtin et al 1996), change of the currents in the Arctic Ocean (the cold Labrador current in the Greenland region and the warm Gulf Stream), leads to periodic catastrophic epochs of a steady decline and an increase in the temperature regime in the Northern Hemisphere (Karnaukhov et al 1997, Kreynin et al 2007). Climate at the regional level is formed under the influence of circulation of the atmosphere, solar insolation and surface pattern (Lisetskii et al 2014, 2017). The objective of the studies was to investigate the zonal peculiarities of long-term climate change in terms of air temperature and amounts of percipitation in the Dnieper River transboundary basin using multivariate statistics and GIS technologies.

MATERIAL AND METHODS

The research uses the climatic data of the open internet resources (http://meteo.ru/english/climate/cl_data.php; http://cliware.meteo.ru/meteo) and the actual data of the dynamics of the surface air temperature (T, °C) and precipitation (R, mm) by meteorological stations (MTS) of the three physical and geographical zones: the steppe zone -

MTS Kherson (1892-2014) – latitude: 46.63°, longitude: 32.60°; MTS Luhansk (1839-2003) – latitude: 48.60°, longitude: 39.30°; forest-steppe zone - MTS Kharkiv (1892-2008) – latitude: 49.90°, longitude: 36.30°; MTS Kyiv (1856-2003) – latitude: 50.40°, longitude: 30.40°; mixed forests zone - MTS Minsk (1810-2011) – latitude: 53.86°; longitude: 27.54°; MTS Smolensk (1910-2015) – latitude: 54.79°; longitude: 32.05°; MTS Kursk (1834-2015) – latitude: 51.60°; longitude: 36.20°; MTS Bryansk (1928-2015) – latitude: 53.30°; longitude: 34.20°. WorldClim (http://worldclim.org) global cluster climate data has been used for the spatial distribution of seasonal and annual air temperature and precipitation data for the period 1970-2000 with a spatial resolution of 380×240 m. For a comprehensive analysis, assessment of series heterogeneity, determination of temporal and spatial patterns of formation and synchronicity of the dynamics of climatic parameters, the study applies the following methods of multivariate statistics: descriptive statistics, regression analysis, transformation of variables (T4253H-smoothen, method of difference integral curves of modular coefficients) and cross-correlation analysis. For simulation and analysis of climate change, the study applies the following software products STATISTICA Advanced + QC for Windows v.10 Ru, MathWorks MATLAB 7.9 R2009b and *ArcGIS 10.1.*

RESULTS AND DISCUSSION

Climatic zones of the Dnieper basin are characterized by a rather high level of diversity. Transboundary basin is situated within three geographical zones: mixed forests (55% of the total area of the basin), forest-steppe (28.9%), and steppe (16.1%). The climatic indicators for individual MTS, established that the largest variational changes in the average annual air temperature (from 17.41 to 25.59%) are experienced by the ecosystem of the upper part of the Dnieper basin, which is located in the mixed forests zone. In the steppe zone, in comparison with the mixed forests zone, the value of the annual air temperature variation is 1.75-2.12 times less and makes 9.95-12.09 per cent. Negative values of the excess in most cases indicate a significant time heterogeneity in the annual range of the course of temperature changes. It is caused by instability of the temperature regime and the likelihood of significant response to global warming over the last 20-30 years. The reverse situation is observed with the spatio-temporal distribution of precipitation. The most heterogeneous dynamic changes occur in the steppe and forest-steppe zones: the level of variation ranges from 19.9 to 24.9 per cent, the mode value is less than 2-5 per cent of the norm (average value), indicating the instability of precipitation and the overwhelming frequency of manifestations of dry years in the period of observation. Eight zonal meteostations show rapid increase in annual average temperature by 1.0-1.2 °C in the instrumental period since the late 80's to present (Fig. 1). Also, there has been established a 90-year cycle, which identified two long-term periods of change in water availability: the I period of the 90's (1836-1925), the II period of the 90's (1926-2015). Beginning of the XXI century falls on the maximum of the 90-year cycle in terms of annual average rainfall changes. It may be followed by the next period of decrease in natural zonal water availability for the ecosystem of the Dnieper basin, which, subject to stable increase of
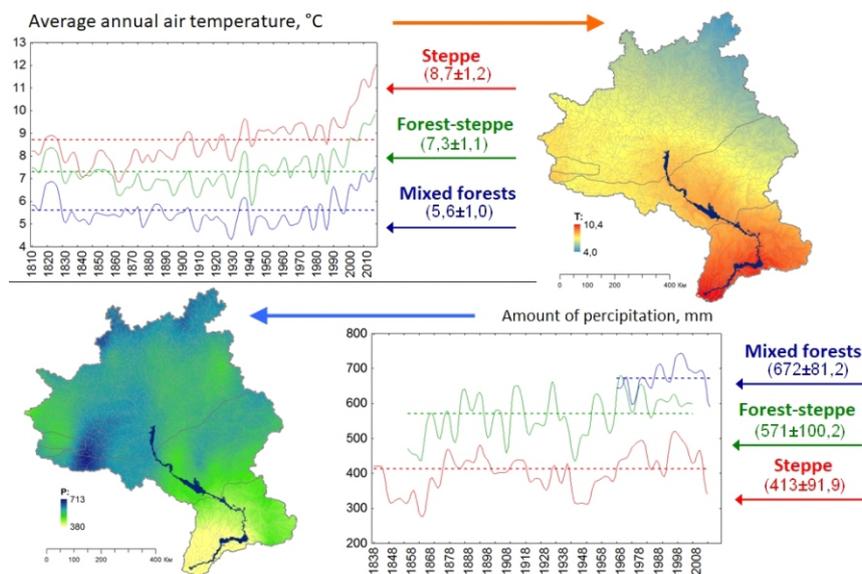
Fig. 1. Zonal regularities of long-term climate change in the territory of the Dnieper River basin

climatic temperature regime, may lead to an increase in the frequency of manifestations of arid periods during the next 90-year period.

Abnormal climatic conditions were determined by the following criteria: T, P ± - strong anomalies and T, P ±2 - very strong anomalies, where   is the value of the root-mean-square deviation. As a result of temporal analysis, it is determined that, depending on the physical and geographical zones of the Dnieper basin, the absolute value of the average annual air temperature does not exceed the abnormal values of ± in 65-68% of cases, i.e. over the 100-year period, there are 29.5 per cent of years with strong and 5.4 per cent - with very strong anomalies in the steppe zone, 27.7 per cent of years with strong and 4.7 per cent - with very strong anomalies in the forest-steppe zone, 30.4 per cent of years with strong and 4.1 per cent - with very strong manifestations of temperature anomalies in the mixed forests zone. The absolute value of the absence of anomalies in the amount of annual precipitation is 69.7-74.0 per cent: in the steppe zone, abnormal manifestations are observed in 22.3 per cent of years with strong and 5.4 per cent - with very strong manifestations; forest-steppe zone – 24,1 per cent of years with strong and 6.2 per cent - with very strong anomalies, mixed forest zone – 18.0 per cent with strong and 8,0 per cent - with very strong anomalies of natural water availability. That is, the greatest part of the abnormal manifestations of temperature changes is observed in the steppe and mixed forests zones, and the greatest probability of abnormal rainfall changes is observed in the forest-stepe zone.

Changes in the formation of climatic conditions in various physical and geographical zones of the transboundary river basin are caused by local forms of ground surface. It affects intra-zonal asynchrony and significant spatial heterogeneity of precipitation distribution the most. The value of the correlation of rainfall dynamics according to individual zonal meteorological stations ranged between 0.04-0.63. Changes in the air temperature are marked by a sufficient degree of synchronicity with the correlation 0.70-0.96, which makes it possible to assume the existence of uniform spatio-temporal regularities of the formation of the temperature regime within the territory of the Dnieper basin. The results of the analysis significantly simplify the task of studying, modeling, reconstructing missing data and forecasting climate change. Thus, having studied temporal patterns of formation according to one of the zonal meteorological stations, one can assume that such changes, first of all in the temperature regime, may occur throughout the Dnieper basin. Against the background of the average annual changes, there take place significant changes in the climatic conditions of the Dnieper River basin ecosystems in the middle of the year. As a result of the study, based on the example of MTS Kherson (steppe zone), it has been established that there is observed warming during the first 10 months of the year, on average by 2°C (from 10.4 to 12.4 °C), an increase in the amount of precipitation by 90 mm (from 314 to 404 mm) in the last 75 years. On the main background, an increase in the amount of precipitation in 75% of months shows negative abnormal phenomena of one-time fall of the monthly, and in some cases - semi-annual rate of precipitation, which leads to catastrophic underflooding and flooding of the territories at the local and regional levels, which determine the negative manifestations of erosion processes on agricultural land and increasing concentrations of nutrients in hydroelectric systems of the Dnieper basin (Pichura et al 2017).

The statistical characteristics of peculiarities of the spatial heterogeneity of the zonal distribution of climatic conditions are based on the raster models of open global climate data for environmental modeling and GIS - WorldClim, following the results of data selection at 2270 points in the basin of the Dnieper River. It has been established that for 30 years of general surveys (1980-2010) the distribution of the main climatic indicators, the average annual air temperature in the boundaries of the Dnieper basin ranged from 4.0°C on the northeast (head of the river) to 10.4°C in the southern part (estuary). The most standard deviation of the seasonal temperature dynamics is noted in the eastern part of the forest-steppe zone of the basin - up to 10.2°C, and at the border of transition of the steppe zone to the forest-steppe zone - within the range of 9.5-9.8°C. The smallest seasonal temperature fluctuations in the 30-years period were observed in the western and northwestern parts of the mixed forests and forest-steppe zonez respectively, within the range of 8.0-8.8°C.

Precipitation in the water supply area of the Dnieper River is distributed rather unevenly - their spatial trend-cyclical increase occurs from the southern (409 mm) to the northern (660 mm) part. The largest value of annual precipitation is recorded in the northwestern part of the forest-steppe zone - 713 mm. The northwestern and significant part of the forest-steppe and mixed forest zone have the high degree of variation of seasonal changes in natural moisture supply. The level of variation ranges between 30-42%. Southeastern part of the forest-steppe zone and the entire steppe zone have stable variation characteristics of precipitation changes - from 17 to 30%. The obtained results give a unique opportunity to trace and determine the spatial heterogeneity and the degree of availability of natural heat and water for the ecosystem of the Dnieper basin.

Markov Chain method has established the probability of changes in the annual climate inertia. Thus, the probability of repeating the air temperature above the average cyclic norm was $P_T = 0.54$, the sum of annual precipitation $P_P = 0.48$. The inertia probability of repeating hot (H) years is $P_{H1} = 0.48$, hot after cold years $P_{H2} = 0.60$. Therefore, the probability that a hot year will be followed by a cold one (C) is $P_{C1} = 0.52$, and similarly the probability that a cold year will be followed by a cold one is $P_{C2} = 0.40$. The inertia probability of repeating wet (W) years is $P_{W1} = 0.50$, wet years after dry ones $P_{W2} = 0.47$. Consequently, the probability that a wet year will be followed by a dry one (D) is $P_{D1} = 0.50$, and similarly the probability that a dry year there will be followed by a dry one is $P_{D2} = 0.53$. The chain of probability of changes in climatic conditions is presented on Figure 2.

The probability of hot and rainy periods in t years is equal to the probability of cold and dry years, respectively, repeated every ($t + 1$) years, that is:

$$P_{S(H;W)} = (1 - p_1)p_1^{t-1}$$
$$P_{S(C;D)} = p_2(1 - p_2)^{t-1}. \tag{1}$$

It is calculated that the probability of one isolated hot year equals $0.52p_1^{1-1}$, the probability of a three-year hot period equals 0.12, five-year - 0.03, etc. The probability of cold periods of the same duration is 0.60, 0.10, 0.02, respectively. The probability of one isolated wet period equals $0.50p_1^{1-1}$ the probability of a three-year wet period equals 0.12, five-year – 0.03, etc. The probability of dry periods of the same duration

is 0.60, 0.13, 0.04, respectively. Markov Chains are built on the basis of meteorological observation data, show that hot periods lasting 3-5 years are more likely than the same cold periods, and dry periods lasting 3-5 years are more likely than wet periods. This indicates a cyclical increase in the average annual air temperature and local reductions in the amount of annual precipitation in recent years on the territory of the Dnieper River basin. The probability of alternating hot-cold and wet-dry periods with different durations is determined by the formula:

$$P_{pt} = \frac{(1 - p_2)^{t-1} - p_1^{t-1}}{(1 - p_2 - p_1)} p_2(1 - p_1) \tag{2}$$

As a result of calculations, the probabilities of periods of different durations were obtained. Alteration of hot-cold periods: $t = 2$, $P_{pt} = 0.312$; $t = 3$, $P_{pt} = 0.275$; $t = 4$, $P_{pt} = 0.182$; $t = 5$, $p_{pt} = 0.107$; $t = 6$, $P_{pt} = 0.059$. Alternation of wet-dry periods: $t = 2$, $P_{pt} = 0.235$; $t = 3$, $P_{pt} = 0.242$; $t = 4$, $P_{pt} = 0.187$; $t = 5$, $p_{pt} = 0.129$; $t = 6$, $P_{pt} = 0.083$. The forecasting of climate change was carried out on the basis of data of *MTS* Smolensk (head of the river) and *MTS* Kherson (delta of the Dnieper River) using the method of neurotechnologies. According to the results of the simulation, artificial neural networks (*ANNs*) have been created for the three- and four-layer perceptron architecture (Table 1).

1. MTS Smolensk:
- air temperature forecast: four-layer perceptron with seven neurons in the first hidden layer and six neurons in the second hidden layer, learning
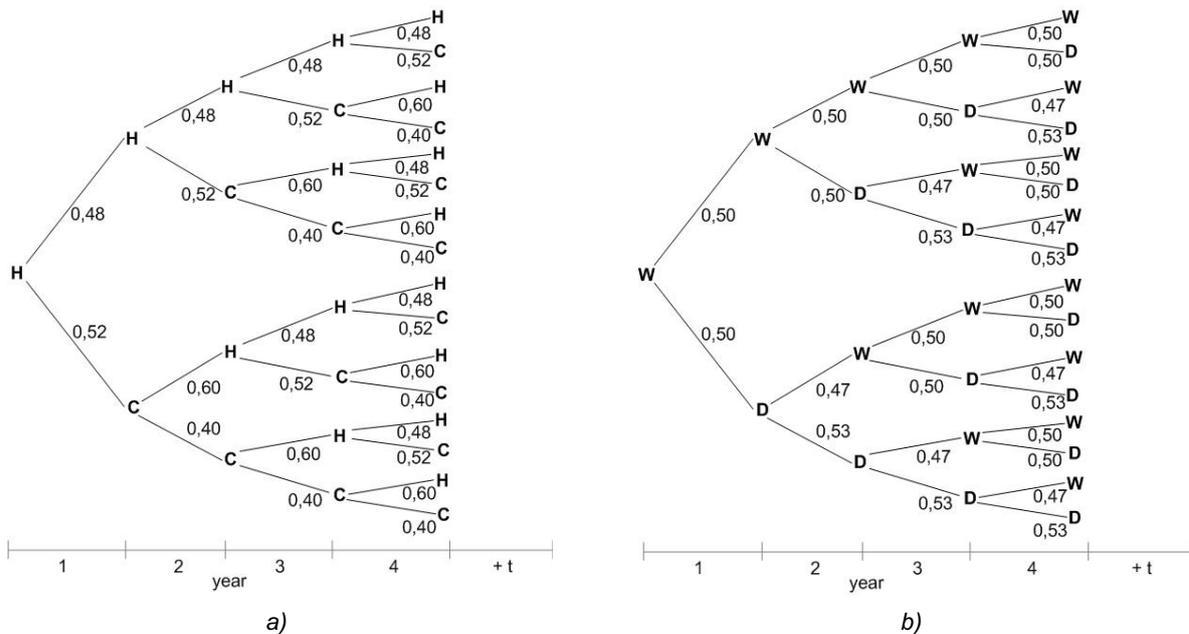
Fig. 2. Probability of changes in climatic conditions (hot – H, cold – C, dry – D, wet years – W) presented as schematic representation of the Markov chains: *a* – air temperature; *b* – annual amount of precipitation

Table 1. Key characteristics of the neural models for forecasting climate change on the territory of the Dnipro basin

Creteria of ANN	Parameters of approximation of ANN
MS Smolensk	
Average annual air temperature	
Weighting coefficients adjusting function	$$E(w(t)) = \frac{1}{2}\left(f(\sum_{m=1}^{6} w_m^{(3)}(t) f(\sum_{j=1}^{7} w_j^{(2)} f(\sum_{n=1}^{12} w_n^{(1)}(t) x_n^{(t)}))) - d^{(t)} \right)^2$$
Network response function	$$y_i(t) = f\left(\sum_{m=1}^{6} w_m^{(3)}(t) f(\sum_{j=1}^{7} w_j^{(2)}(t) f(\sum_{n=1}^{12} w_n^{(1)}(t) x_n^{(t)})) \right)$$
Learning algorithm	$$w_{ni}(t+1) = 0,09\delta_i x_n(t) + 0,4(w_{ni}(t) - w_{ni}(t-1))$$
Sum of annual precipitation	
Weighting coefficients adjusting function	$$E(w(t)) = \frac{1}{2}\left(f(\sum_{j=1}^{9} w_j^{(2)} f(\sum_{n=1}^{12} w_n^{(1)}(t) x_n^{(t)})) - d^{(t)} \right)^2$$
Network response function	$$y_i(t) = f\left(\sum_{j=1}^{9} w_j^{(2)}(t) f(\sum_{n=1}^{12} w_n^{(1)}(t) x_n^{(t)}) \right)$$
Learning algorithm	$$w_{ni}(t+1) = 0,16\delta_i x_n(t) + 0,4(w_{ni}(t) - w_{ni}(t-1))$$
MS Kherson	
Average annual air temperature	
Weighting coefficients adjusting function	$$E(w(t)) = \frac{1}{2}\left(f(\sum_{m=1}^{8} w_m^{(3)}(t) f(\sum_{j=1}^{8} w_j^{(2)} f(\sum_{n=1}^{12} w_n^{(1)}(t) x_n^{(t)}))) - d^{(t)} \right)^2$$
Network response function	$$y_i(t) = f\left(\sum_{m=1}^{8} w_m^{(3)}(t) f(\sum_{j=1}^{8} w_j^{(2)}(t) f(\sum_{n=1}^{12} w_n^{(1)}(t) x_n^{(t)})) \right)$$
Learning algorithm	$$w_{ni}(t+1) = 0,07\delta_i x_n(t) + 0,4(w_{ni}(t) - w_{ni}(t-1))$$
Sum of annual precipitation	
Weighting coefficients adjusting function	$$E(w(t)) = \frac{1}{2}\left(f(\sum_{j=1}^{7} w_j^{(2)} f(\sum_{n=1}^{12} w_n^{(1)}(t) x_n^{(t)})) - d^{(t)} \right)^2$$
Network response function	$$y_i(t) = f\left(\sum_{j=1}^{9} w_j^{(2)}(t) f(\sum_{n=1}^{12} w_n^{(1)}(t) x_n^{(t)}) \right)$$
Learning algorithm	$$w_{ni}(t+1) = 0,22\delta_i x_n(t) + 0,4(w_{ni}(t) - w_{ni}(t-1))$$

Note:

t – discrete time ser ies value;

w – matrix of weight coefficients ;

$x_n^{(t)}$ – n-a the coordinate of the input vector at a certain point in time t;

$y_i(t)$ – i-a the coordinate of the output vector created by the neural network at a certain point in time t;

$d_i^{(t)}$ – i-a the coordinate of the actual output vector at a ce rtain point in time t;

$f(s_i)$ – activation function of the hidden layer neurons : $f(s) = \dfrac{1}{1 + e^{-s}}$ – sigmoid with data conversion range [0, 1];

η – speed of training of neural networks coefficient ;

α – coefficient of training moment (coefficient of inertia) neural networks .

method: reverse distribution (370 epochs), the *ANN* matrix consists of 132 weighting coefficients;

- atmospheric precipitation forecast: three-layer perceptron with nine neurons in the hidden layer, learning method: reverse distribution (184 epochs), the *ANN* matrix consists of 117 weighting coefficients.

2. MTS Kherson:

- air temperature forecast: four-layer perceptron with eight neurons in the first hidden layer and eight neurons in the second hidden layer, learning method: reverse distribution (450 epochs), the *ANN* matrix consists of 168 weighting coefficients;
- atmospheric precipitation forecast: three-layer perceptron with seven neurons in the hidden layer, learning method: reverse distribution (100 epochs) and associated gradients (28 epochs), the *ANN* matrix consists of 91 weighting coefficients.

The researches have determined that the optimum values of the parameters of *ANN* learning algorithm for forecasting climatic indicators are: the rate of learning speed within $\eta = 0.07\text{-}0.22$; coefficient of moment of learning (inertia coefficient) $\alpha = 0.4$; number of iterations (epochs) prior to memorization within $N = 30\text{-}40$; the number of iterations (epochs) prior to *ANN* learning within $N = 130\text{-}170$ (depending on the sample array and the complexity of the development of the forecasted indicators). The number of hidden layers and network neurons is determined for each temporal series individually. The activation function of the neurons is sigmoid. The reliability of *ANN* for forecasting climatic indicators based on an independent (test) sample has made: for the average annual air temperature - 84-86%, for the amount of precipitation - 78-83%.

CONCLUSIONS

Estimation of zonal peculiarities of long-term climatic changes in the Dnieper River basin showed a stable dynamic increase in the average annual air temperature throughout the entire water supply area by 1.0-1.2°C for the last 200 years. There are two sinusoid 90-year cycles of variation in the amount of annual precipitation. If the retrospective trend-cyclical tendency is preserved, by 2030 there will be consistently unfavorable changes in climate indicators: increase in the average annual temperature by 0.8°C, and a decrease in annual precipitation amounts by 24 mm. This will lead to an increase in the percentage of manifestations of dry periods and will contribute to the reduction of soil and climatic potential.

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Evaluation of Carp Gut Isolated Probiotic Bacteria *Lactobacillus Plantarum* FLB1: Hematological and Biochemical Alterations in Rohu *Labeo rohita* (Ham.)

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Abstract: Feeding trial (120 days) was conducted to evaluate the effects of dietary supplementation of probiotic bacteria *Lactobacillus plantarum* FLB1, isolated from the intestine of Indian major carp (*Labeo rohita*) on the hematological and biochemical parameters of *L. rohita* fingerlings. Six experimental diets were formulated containing basal diet as control (T1) and five graded levels of *L. plantarum* at 10^4, 10^5, 10^6, 10^7, 10^8cfu g^{-1}(T2-T6) basal diet. Seven hundred and twenty fingerlings (mean body weight 5.9g) were distributed randomly in cemented tanks ($20m^2$) and fed with different experimental diets. Hb content, TEC, and Ht of fish fed with *L. plantarum* at 10^6 and 10^8cfu g^{-1} diet were significantly higher as compared to other experimental diets and control. Likewise, TLC values improved in probiotic fed fish, however, the differences were insignificant. Significantly decreased values for ESR and improved red cell indices viz., MCV, MCH and MCHC too revealed positive effect in probiotic fed fishes. There were significant difference (P≤0.05) in the serum biochemical parameters with maximum values for protein and globulin in T6 and minimum value for Alb/Glb in T5 and T6. Hence,it can be concluded that dietary supplementation of *L. plantarum* @ 10^8cfu g^{-1} diet is effective in enhancing the immunity and overall health status of *L. rohita.*

Keywords: *L. rohita,* Probiotics, *Lactobacillus plantarum,* Fish health, Hematology

Aquaculture in India has grown over six and half fold in the last two decades with freshwater aquaculture contributing over 95% of the total aquaculture production. The three Indian major carps, namely catla (*Catla catla*), rohu (*Labeo rohita*) and mrigal (*Cirrhinus mrigala*) contribute as much as 87% of total fresh water aquaculture production (Paul and Giri 2015). Among these three Indian major carps, *L. rohita* is one of the popular fish of Southeast Asia and is widely and intensively cultured in Indian subcontinent due to its high consumer preference and fast growth rate. In total world aquaculture production, rohu contributed 3% of total inland fin fish production with 1843 thousand tonnes during 2016 in comparison to 1133 thousand tonnes during 2010. The increase in production due to ever increasing demand, resulting in intensified and commercialized aquaculture operations. Increasing intensification and commercialization of aquaculture production has led to stress on organisms, which make them susceptible to number of diseases and has become a major problem in the fish farming industry. Bacterial originated diseases are more prevalent in these conditions, which cause poor growth performance, fish diseases and ultimately mass mortality. Several instances of infections with *Aeromonas hydrophila* in India have been reported in Indian major carps (Shome et al 2005), which has led to an increase in the use of antimicrobials. Done et al

(2015) too reported multiple negative impacts of using antibiotics, which include evolution in bacterial resistant strains due to excessive application of antimicrobial agents and chemical drugs. Use of alternative strategies including vaccinations, antitoxins and probiotics has been highlighted by many workers and has been suggested as an alternative way for the immunity enhancement, prevention and control of disease outbreaks (Verschuere et al 2000, Irianto and Austin 2003, Giri et al 2013) with sustainability, responsibility, quality and safety. The research on the use of probiotics in aquatic animals is increasing with the demand for eco-friendly aquaculture and probiotic is anticipated for the prevention of infectious microbial diseases and to replace antibiotics and chemotherapeutics. The common probiotics used in carp culture belongs to *Lactobacillus spp*., *Bacillus spp*., *Saccharomyces cerevisiae*, and *Lactococcus spp* (Dharmaraj and Rajendren 2014).

L. plantarum is known to produce antimicrobial substances like plantaricin that are active against certain pathogens, and is used as a probiotics (Mokoena 2017). Son et al (2009) demonstrated that probiotic *L. plantarum* can promote the growth, with enhanced immunity and resistance against *Streptococcus* infection. Many findings indicated that *L. plantarum* and its cellular components strongly inhibited the growth of fish pathogen. However, little information is

available on the immuno-modulatory effects of *L. plantarum* and especially of autochthonous origin on the Indian major carp rohu, *L. rohita*. Therefore, the present study was conducted to evaluate the effect of dietary administration of *L. plantarum* FLB1 on hematological and biochemical response of *L. rohita* under semi-intensive culture system.

MATERIAL AND METHODS

Preparation and maintenance of experimental tanks: The study was conducted in outdoor cemented tanks ($20m^2$). 1-2 inch soil was spread on the bottom of all the tanks to provide natural conditions along with liming @ $300kg\ ha^{-1}$ for disinfection and as per requirement (pH balance) throughout the experimental period. $1/4^{th}$ of water from experiment tanks was exchanged with freshwater once a week.

Procurement, conditioning and stocking of experimental fish: Fingerlings of rohu, *L. rohita* (720 nos.) were conditioned for one week in outdoor tanks under flow through condition and were fed with basal diet. After proper conditioning, fishes were distributed randomly in all experimental tanks (40/tank) in triplicate.

Preparation of Experimental diet: For the preparation of probiotic supplemented diets, *L. plantarum* FLB1, isolated from fish gut and screened for its probiotic properties was grown in MRS broth (Hi Media, India) in an incubator at 37° C. After incubation, the cells were harvested through centrifugation (2000xg) to obtain microbial pellet. The pellet was washed three times with phosphate buffered saline (pH 7.2), then count adjusted through spectrophotometer and mixed with basal diet @10^4cfu g^{-1} (T2), 10^5 cfu g^{-1} (T3), 10^6cfu g^{-1}(T4), 10^7cfu g^{-1} (T5), 10^8cfu g^{-1} (T6) cfu g^{-1}feed (Table 1).

To achieve accurate final concentrations in the diet, the bacterial suspension was slowly added to feed pellets with a hand sprayer for uniform distribution in the laminar airflow chamber under sterilized conditions. The resultant feed was stored at 4° C in sealed plastic ziploc bags until used. To ensure high probiotic level in the supplemented feed, fresh diets were prepared on weekly basis. Proximate analysis of ingredients, basal diet and experimental diets (Table 2) with respect to crude protein, ether extract, crude fibre, ash, and nitrogen free extract content was performed according to the AOAC (2015).

Table 2. Proximate composition (% DM basis) of ingredients, basal diet and experimental diets

Ingredients / Experimental diets	Crude protein	Ether extract	Crude fiber	Ash	NFE
Rice Bran	12.35	1.29	15.65	11.53	59.18
Mustard Meal	39.95	1.92	11.55	8.17	39.54
Experimental diets					
T1 (Control)	25.43	4.10	18.43	8.92	43.11
T2	25.67	4.20	18.40	8.67	43.02
T3	25.70	4.07	18.37	8.66	43.21
T4	25.77	4.23	18.40	8.67	42.93
T5	26.13	4.03	18.37	8.72	42.75
T6	25.90	4.17	18.43	8.68	42.82

Feeding of fish: Feeding was done with probiotic supplemented pelleted diets @ 5% fish body weight, with the daily ration divided into two equal parts and fed twice a day at 10:00 and 16:00 hrs.

Water quality parameters: Water samples were collected fortnightly in the morning hours for the analyses (APHA 2012) of physico-chemical parameters viz. temperature, pH, dissolve oxygen (DO), total alkalinity (TA), total hardness (TH), orthophosphate (PO_4^{-2}) and ammonical nitrogen (NH_3-N).

Blood and serum collection: Blood was collected by 1.0 ml sterile disposable insulin syringe (30G) through peduncle vein and pooled from a random sample of five fish from each replicate after anesthetized by clove oil @ 30-50 mg l^{-1} (1 part clove oil and 9 parts 94% ethanol) on day 120.For serum collection, the blood was collected without heparin and transferred to 2.0 ml eppendorf tube and kept overnight in a refrigerator in slanting position. The blood clots separated from a straw colored supernatant at the top were then centrifuged at 2000 rpm for 10 min at 4° C. The supernatant was collected, transferred to new eppendorf tube and stored at −20° C for further biochemical analysis as per standard protocol.

Hematological and biochemical parameters: The blood (heparinised 150 IU ml^{-1}) collected from each group was analyzed for hemoglobin (Hb), total erythrocyte count (TEC), total leukocyte count (TLC), Hematocrit (Ht) and Erythrocyte sedimentation rate (ESR). Hemoglobin (Hb) concentration was estimated by acid haematin method (Sahli 1962). MCV,

Table 1. Details of treatments for experiment

			Treatments		
Control diet	Basal diet supplemented with *L. plantarum* FLBI culture				
T1	T2	T3	T4	T5	T6
Basal diet*	Basal diet + *L. plantarum* FLB1 @ 10^4cfu g^{-1} feed	Basal diet + *L. plantarum* FLB1 @ 10^5cfu g^{-1} feed	Basal diet + *L. plantarum* FLB1 @ 10^6cfu g^{-1} feed	Basal diet + *L. plantarum* FLB1 @ 10^7cfu g^{-1} feed	Basal diet + *L. plantarum* FLB1 @ 10^8cfu g^{-1} feed

*Rice bran[1] (49%) + Mustard meal[1] (49%) + Vit-Min. mixture (1.5 %) + Salt (0.5%)[1] De-oiled

MCH and MCHC were calculated using the formulae (Haney et al 1992) as given below.

MCV (μm^3) = Ht / RBC x 10, MCH (g%) = Hb / RBC x 10, MCHC (g%) = Hb / Ht x 100

For serum biochemical parameters, Erba Kits, Erba Mannheim (Germany) was used to estimate total proteins (TP) and albumin (Alb) in blood serum by following the principle of Biuret reaction (Gornall et al 1949) and Globulin (Glb) and Alb/Glb ratio was calculated as

Glb (gdl^{-1}) **=** Total protein (gdl^{-1}) – Alb. (gdl^{-1}), Alb/Glb ratio = Alb/Glb

RESULTS AND DISCUSSION

Physico-chemical parameters of water: During the experiment, water quality parameters viz. temperature (28.97-34.69^{0}C), pH (7.50-7.81), DO (5.93-6.83 mgl^{-1}), TA (155.33-169.33 mgl^{-1}), TH(255.00-273.33 mgl^{-1}), orthophosphate (0.069-0.083 mgl^{-1}) and NH_3-N (0.033-0.076 mgl^{-1}) were under optimal range (Boyd and Tucker 1998) and differences in treatments were insignificant.

Hematological parameters: The Hb level increased among the probiotic fed treatments (with increasing probiotic dose 10^4-10^8cfu g^{-1} feed) with significant increase in T4-T6 as,compared to control (Table 3). Marzouk et al (2008) reported that fish fed diet supplemented with probiotics showed the highest values of Hb, RBCs and WBCs in *Oreochromis niloticus*. Firouzbakhsh et al (2012) too revealed significant difference in Hb concentration of probiotic fed fish and control in rainbow trout (*Oncorhynchus mykiss*). The present results are in accordance with the findings of Kumar et al (2006) in context to increase in Hb content of Indian major carp, *L. rohita* fed with *Bacillus subtilis*. TEC ($x10^6$ mm^{3-1}) increased significantly with increasing probiotic dose (10^4-10^8cfu g^{-1} feed) with maximum count in T6 (2.06) followed by T5, T4, T3, T2 and minimum in T1 (1.76) after 120 day of probiotic feeding. The blood

properties of fish vary with seasons and the number of teleost erythrocytes varies with species and is also affected by stress and environmental temperature, but they usually range between 1.05 × 10^6 μl^{-1} and 3 × 10^6 μl^{-1} (Roberts and Ellis 2001). In the present investigation, the TEC count significantly higher in all the experimental groups than control and was also in accordance with Hb content, which may be attributed to the fact that in most teleost, as in other vertebrates, the hemoglobin is contained in the erythrocytes (Roberts and Ellis 2001). Similarly, increased TEC were observed in *L. rohita* fed with *Bacillus subtilis* supplemented diets (Kumar et al 2006). The TLC was observed with insignificant difference in different treatments however, with lowest count in T1 (4.54x10^4 mm^{-3}), while highest in T6 (4.70 x $10^4$$mm^{-3}$). Similar result was reported by Nayak et al (2007) in terms of higher TLC in rohu, treated with probiotic bacterium *B. subtilis*. Non-specific immunity is mediated by leukocytes, and raised TLC is an evidence of immune stimulation, which confirm that probiotics could boost the immune system.

The Ht showed increasing trend with increasing level of *L. plantarum* in feed and was significantly higher than the control in T6 and T5 followed by T4 and T3 and T2 and T1 respectively, which indicates the efficiency of *L. plantarum* in improving the health status of the fish at higher doze. Increased levels of Ht and Hb in fish fed with *L. plantarum* revealed that probiotics improved the immune system of the fish. Irianto and Austin (2003) reported a similar increase in Ht of fish fed with diets fortified with probiotic bacteria. Nikoskelainen (2003) too observed that probiotic bacteria may have an impact on the specific and innate immunity of *O. mykiss*. Studies by Panigrahi et al (2005, 2007) and Aly et al (2008) also corroborated the effect of probiotics on enhancing immunity in fishes.The red cell indices like MCV, MCH and MCHC showed improvement in terms of increased values at higher probiotic dozes (10^6-10^8cfu g^{-1} feed), however, the differences were insignificant.

Table 3. Hematological parameters of rohu, *L. rohita* (Ham.) in different treatments at the completion of experiment

Parameters	Treatments					
	T1	T2	T3	T4	T5	T6
Hb (g %)	4.26[c]	4.38[c]	4.53[c]	5.03[b]	5.63[a]	5.58[a]
TEC ($x10^6$ mm^{3-1})	1.76[c]	1.86[b]	1.88[b]	1.92[b]	2.05[a]	2.06[a]
TLC ($x10^4$ mm^{3-1})	4.54[a]	4.66[a]	4.69[a]	4.61[a]	4.63[a]	4.70[a]
Ht (%)	24.03[c]	24.43[c]	26.00[b]	26.92[b]	28.53[a]	28.94[a]
MCV (μm^3)	136.38[ab]	131.39[b]	138.54[ab]	139.95[a]	139.01[ab]	140.68[a]
MCH (g %)	24.17[b]	23.54[b]	24.15[b]	26.15[ab]	27.45[a]	27.13[a]
MCHC (g %)	17.72[c]	17.92[c]	17.43[bc]	18.67[ab]	19.74[a]	19.29[ab]
ESR (mm hr^{-1})	2.42[a]	2.39[a]	2.38[a]	2.31[b]	2.27[b]	2.17[c]

*Values with same superscript (a,b….c) in a row do not differ significantly (p≤0.05)
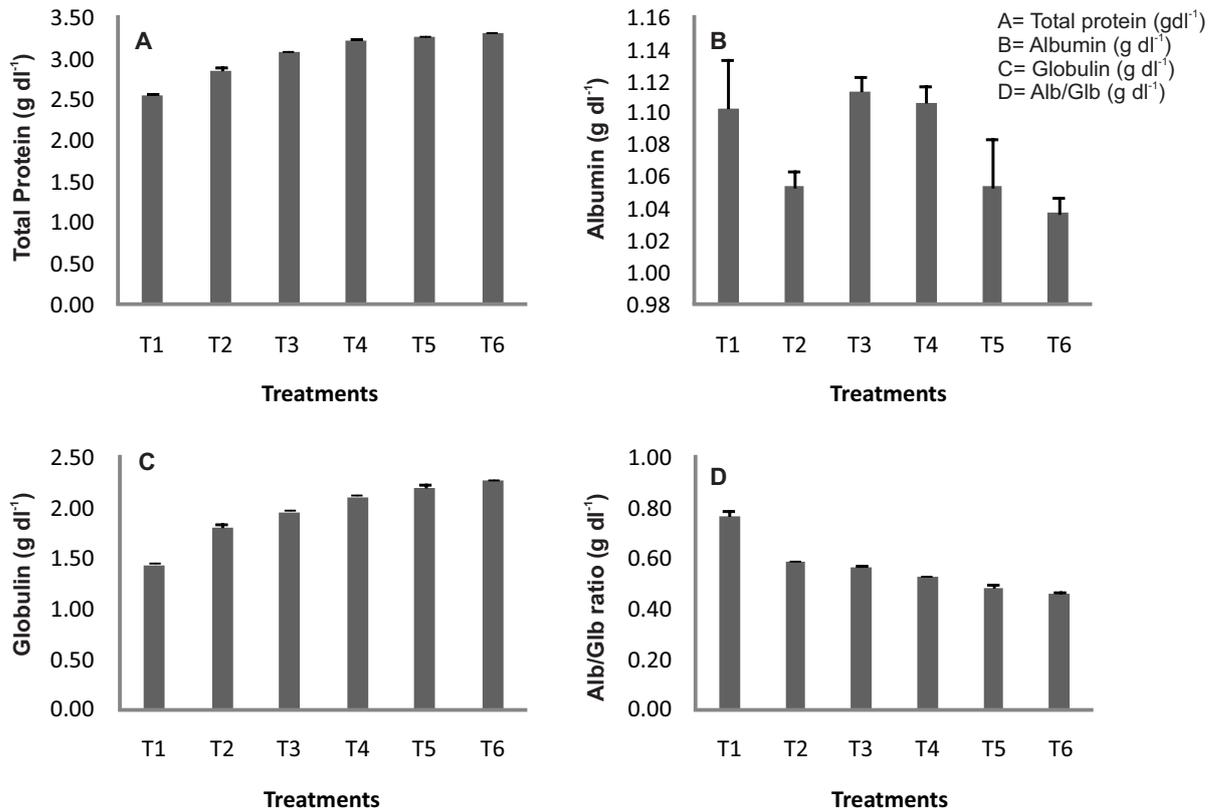
Fig. 1. Comparative biochemical parameters of *L. rohita* (Ham.) in different treatments at the completion of the experiment

Mean ESR (mm hr^{-1}) differed significantly among the treatments with significantly low ESR in T6 (2.17) as compared to other treatments and control (Table 3). The reduced ESR is indicative of the positive effect of *L. plantarum* fishes at particular concentration, because a faster-than-normal rate indicates inflammation in the body. This may be due to the immune-modulation response in the probiotic fed fishes (Nayak et al 2007, Al-Dohail et al 2009).The variation in hematological parameters could be attributed to the fact that, the probiotic supplemented feed improve the health status of fish as a result of hematopoietic stimulation. These results of the present study are in accordance with the findings of Manohar (2005) and Kumar et al (2006).

Biochemical Parameters: The blood serum protein (g dl^{-1}) varied from 2.54 in T1 to 3.30 inT6 and the difference among treatments were significant (Fig. 1) with increasing trend with increasing probiotic dose. The albumin (g dl^{-1}) level in blood serum of fish did not revealed any particular trend. The serum globulin (g dl^{-1}) level was significantly higher in all the treated groups compared to control with highest value in T6 followed by T5, T4, T3, T2 and T1, respectively. Since the gamma fraction makes the largest portion of globulin, it can be suggested that putative *L. plantarum* enhanced the immune system of *L. rohita* revealed in terms of enhanced globulin

level. The Alb/Glb ratio (g dl^{-1}) in blood serum decreased significantly due to increased globulin (p≤0.05) with increasing probiotic dose. Nayak et al (2007) too observed increased serum protein and globulin content and a lower Alb/Glbratio in *L. rohita* fed with *B. subtilis* supplemented feed. The increased serum protein, albumin and globulin levels coupled with decreased Alb/Glb ratio are indicative of stronger innate immune response of fish.

CONCLUSION

The putative bacteria *L. plantarum* FLB1 at higher doze (10^{-6}cfu g^{-1} feed) enhanced the hematological and serum biochemical parameters of *L. rohita* leading to improved immune and overall health status. However, field trial need to be conducted for better understanding and confirming the effect of putative *L. plantarum* FLB1 on fish health status in natural environment in combination with number of other factors for carp polyculture systems.

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Detection of Enzymes and Proteins Produced From Some Algae Isolated from Iraqi Aquatic Environment

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Abstract: The research was carried out to detection of enzymes (protease, amylase, beta-alkaline, phosphatase, and alkaline phosphatase) and proteins**,** detect two enzymes (protease, amylase) and proteins in ten local algae isolates, nine that belong to the blue-green algae and one to the green algae. The algae isolated from Tigris River in Iraq have been developedin BG-11 enrichment culture media. The result nine isolated algae (*Anabaena variabilia, Lyngbya digueti, Lyngbya limnetic, Microcystis aeruginosa, Oscillatoria limosa, Oscillatoria sancta, Phormidium mucicola, Spirulina laxissima, Westiellopsis prolific*) had the capability to produce the enzymes protease and amylase. The efficiency of the protease enzyme for green blue algae was 10.115-13.3 u ml^{-1} and the amylase enzyme activity was 0.112 - 0.562 u ml^{-1}, either the algae *Chrococcum sp*. The yield of the Green Algae Division was as high as the protease and amylase activity was 3.7 and 0.374 u ml^{-1}, respectively).The result indicated the capability to produce the proteins from the 10 isolates after development within a biomass ranged from 0.0607-0.5380 mg l^{-1} and protein content of 2.280-9.950 mg l^{-1} for algal. The *Chrococcum* sp. that belong to Green Algae produced protease, amylase, and betaalactase with concentrations of 3.7, 0.374 and 26.7 u ml^{-1}, respectively, and its production capability was 4.210 mg l^{-1}. The productivity of the phosphatase enzyme was0.06 and 0.03 u ml^{-1} *Anabaena variabilia* and *Lyngbya digueti* respectively, while the alklin phosphates enzyme was not produced in all studied algal isolates.

Keywords: Enzymes, Proteins, Algae and enzymes effect

Industrial biotechnology application for industrial manufacturing and energy of biomaterials, researchers believe that industrial biotechnology represents the next stage of biotechnology. One of the important aspects of industrial biotechnology in various products and industrial processes is the wide application of enzymes, such as chemical industries, detergents, textiles, food, animal feed, leather, pulp and paper industries. Micro algae can be use in various industries, including food for human consumption, animal feed and aquaculture. Microscopic algae have characteristics compare with others microbial cells for containing enzymes derived from synthetic microorganisms cellulases, galactosidases, proteases, lipases, phytases, laccases and a mylases, antioxidant enzymes, carbohydrate-related enzyme and carbon concentration. Algae is a rich source of proteins and enzymes, which are dietary supplements and contain bio-fertilizers (Padmapriya and Anand 2010). It contains a wide range of enzymes such as amylase, protease, alkalin phosphates, betalactimes, endonuclease, desaturase, peptide synthetase, cyclase, ribonuclease, phosphoglycerate kinase ,amino acids andoxidases enzymes (Thajuddin and Subramanian 2005). The purpose of the research is to detect the enzymes and proteins produced from local algal isolates and to evaluate their effectiveness in the production of large amounts of future enzymes.

MATERIAL & METHODS

Identification of isolated algae: The algae isolated were identified by using heamocytometer slide and observed it under the compound microscope X400 power (Desikachary1959, Edward 2010, Felisberto 2004, Al-Hussieny2018).

Development of algae: Ten genus of algae were isolated from the Iraqi aquatic environment. nine of which belong to the division of blue-green algae (*Anabaena variabilia, Lyngbya digueti, Lyngbya limenetic, Microcystis aeruginosa, Oscillatoria limosa, Oscillatoria sancta, Phormidium mucicola, Spirulina laxissima, Westiellopsis prolific*), one belonging to the green algae division *Chrococcum sp*., the algal isolates in culture media modified BG-11 were grown in 1 L volume per isolation under suitable environmental conditions of 25 ± 2° and illumination density (300µE/m²/s)by 16: 8 (light: dark) according to (Al-Hussieny 2014).

Isolation of algae: The following steps are followed:

• Preparing the solid medium BG-11 by adding 2%Agar-Agar sterilized with autoclave device, then poured into sterile Petri Few drops from the sample were transferred on the surface of the solid media. The dishes were then placed in controlled conditions of 300µE/m²/s and 25±2 °C for a period of 7-14 days. The development of algal species was followed by microscopic examination, transferring part of the colonies of developing algae to

Petri dishes containing the BG-11 medium and left to grow under the same conditions for the purpose of obtaining a single-algaeisolate (Unialgal culture). This process was repeated until a single pure culture was obtained.

- Transfer part of the colony after confirming that it contains only one type of algae to the BG-11 liquid medium in 250 ml glass flasks in sterile conditions. The vials were placed in the same previous development conditions for two weeks to obtain appropriate growth. The liquid culture was examined microscopically to ensure that it was free from other types of algae and the culture was renewed every two weeks to preserve the purity of the culture.

Purification: Axenic culture method was used to obtain pure isolation not contamination with bacteria and fungi by take 50 ml of the culture kept in a dark place for 24 hours at room temperature then placed in 10 ml of sterile medium for 2-3 hours. The culture was centrifugation 2000 cycles / min for three minutes. Take the deposit and wash with sterile distilled water repeat this process 10-15 times. Grown a small portion of the deposit in the sterile culture media for the purpose of stimulating growth. A drop from the previous culture was taken and spread on the Nutrient Agar medium, incubated at 37°C for 18 hours to ensure purity and to test the culture not contamination with bacteria.

Detection of extracellular enzymes produced from blue-green algae: Detection of extracellular enzymes amylase, protease betalactemase and phosphatase produced from green algae and green blue were estimated by standard methods of Bernfeld (1955), Manachini (1989) Novick (1962) and Lee (2000). The Laurie method was used to determine the concentration of protein produced from algal isolates (Lowry 1901).

RESULTS AND DISCUSSION

The 9 algae The nine green blue algae (*Anabaena variabilia, Lyngbya digueti, Lyngbya limnetic, Microcystis aeruginosa, Oscillatoria limosa, Oscillatoria sancta, Phormidium mucicola, Spirulina laxissima, Westiellopsis prolific*) and *Chrococcum* sp. of the green algae division were collected from different places of the Tigris River.

To detect the effectiveness of the following enzymes (protease, amylase, beta-alkaline, phosphatase, and alkaline phosphatase) and proteins. The result showed that of study the isolates of the green blue algae division on protease and amylase enzymes were effective and variable. The efficiency of the protease enzyme for green blue algae was 10.115 - 13.3 u ml^{-1}and the enzyme activity was 0.112 - 0.562 u ml^{-1}, either the algae *Chrococcum* sp. The yield of the Green Algae Division was as high as the protease and amylase activity was 3.7 and 0.374 u ml^{-1}, respectively). The
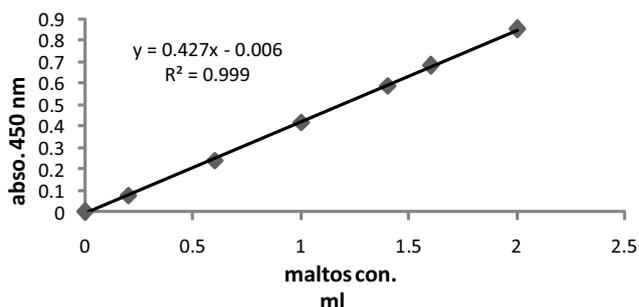
Fig. 1. Standard curve of estimating the effectiveness of enzymes extracted from algae
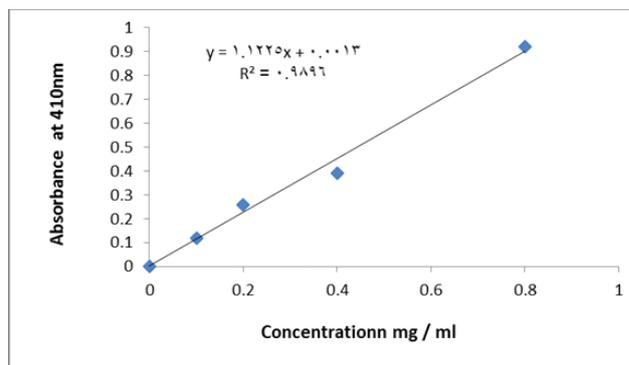
Fig. 2. Standard curve of estimate the effectiveness of phosphatase enzyme
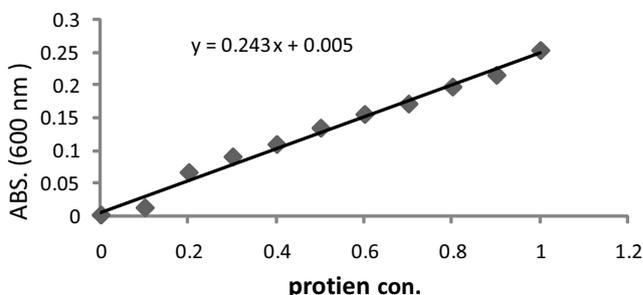
Fig. 3. Standard curve for estimating protein (protein used for bovine serum albumine solution)

results in Table 1 showed the presence of protease, beta lactamase and amylase enzyme and its variable effectiveness in green algae *Chrococcum* sp. The activity was 26.7 u / ml because green algae from the most algae aggregates consumed nutrients, including nitrates and nitrite, which accelerate the process of photosynthesis by converting solar or light energy into energy in the form of secondary metabolites, including enzymes (Inokuchi et al 1999) The presence of phosphatase inanabaena variabilia and *Lyngbya digueti* algae is due to the blue-green algae division represented by the with an activity of 0.06 and 0.03 u ml^{-1}, respectively. Due to these isolates, the appropriate pH is

within pH 8.3 up to alkalinity. This helped to secrete the phosphatase enzyme to the outside, which is also An environmental monitoring indicator because algae are very sensitive to phosphorus because each type of algae has an environment that is different from the rest of the species through which the secondary metabolic compounds are released to the medium surrounding the algae (Hernández et al 2002), while the alkaline phosphite enzyme was not shown in all algal isolates.

The results in Table 2 showed that the proteins produced from the 10 isolates after development within a biomass ranged from 0.0607 - 0.5380 mg l^{-1} and protein content of 2.280 - 9.950 mg l^{-1} for algal isolates, the highest algal isolates produced a protein amount of 9.950 and 6.275 and 5.030 mg l^{-1} for *Westiellopsis prolific, Spirulina laxissima and Phormidium mucicola*, respectively.

Some of kind algae give protein at higher concentrations than traditional plant and animal proteins. Bioactive peptides have been identified as antioxidants, anti-cancer, anti-hypertensive, immunosuppressive, atherosclerotic, and hepatic (Fan et al 2014). Researchers said that algae contain high quality proteins from Essential Amino Acid content.

Spirulina laxissima recorded a protein content of 6.275 mg l^{-1} during a 14-day development period in the culture media. Studies indicated that algae contained 69.3% protein, 17% carbohydrate, vitamin A, C and E at 1.81, 0.39 and 1.72%, respectively. The mineral content was iron, zinc, calcium, selenium 2.1, 0.12, 2.6 and 0.05% respectively; linolenic acid was 2.91%.(Santillan1974) reported that the protein content of *Spirulina* is 50-70% dry weight, more than the weight of meat, eggs, powdered milk, grains and soybeans, as well as a high quality protein containing all essential amino acids, leucine, valine and isoleucine , And has a very high digestion rate of 83-90% due to lack of cellulose in the cell walls. Unlike other microorganisms proposed as protein sources (*Chlorella*, *Scenedesmus*)

Table 2. Determination of concentrations of proteins product from algae

Algae isolates	Biomass (mg l^{-1})	Protein (mg l^{-1})
Anabaena variabilia	0.3732	3.89
Lyngbya digueti	0.3698	3.86
Lyngbya limnetic	0.2949	2.28
Microcystis aeruginosa	0.0607	4.13
Oscillatoria limosa	0.2308	3.59
Oscillatoria sancta	0.9063	4.94
Phormidium mucicola	0.2347	5.03
Spirulina laxissima	0.5380	6.275
Westiellopsis prolific	0.4959	9.59
Chrococcum sp.	0.0127	4.21
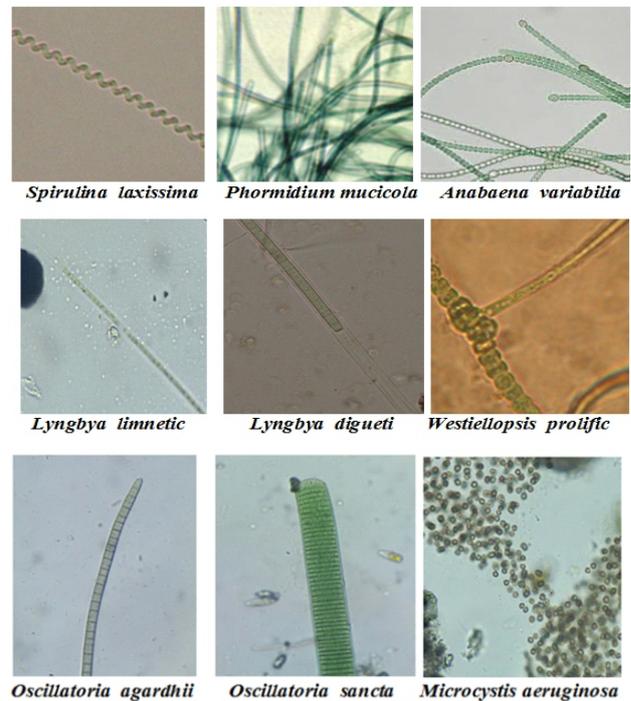
Plate 1. Algae isolates producing enzymes and proteins

Table 1. Effect of enzymes in some of kinds algae

Algae isolates	Amylase enzyme activity u ml^{-1}	Protease enzyme activity u ml^{-1}	Beta-lactamase enzyme activity u ml^{-1}	Phosphatase enzyme activity u ml^{-1}
Anabaena variabilia	0.447	11.766	-	0.06
Lyngbya digueti	0.330	12.783	-	0.03
Lyngbya limnetic	0.112	10.115	-	-
Microcystis aeruginosa	0.126	12.983	-	-
Oscillatoria limosa	0.126	12.983	-	-
Oscillatoria sancta	0.114	13.3	-	-
Phormidium mucicola	0.372	11.783	-	-
Spirulina laxissima	0.402	11.083	-	-
Westiellopsis prolific	0.562	11.95	-	-
Chrococcum sp.	0.374	3.7	26.7	-

which have cellulose walls .(Al-yassiry, 2014) reported that mineral levels in *Spirulina* algae such as iron 0.58-1.8, calcium 1.3-14, phosphorus 6.7-9.0 and potassium 6.4-15.4 g / kg, making them a suitable dietary supplement for vegetarians. *Spirulina* moss is considered an iron-rich food with iron content ten times higher than iron-rich foods. In addition to iron absorption *spirulina* is more than 60% of iron sulphates (found in iron supplements). *Westiellopsis prolific* contains protein substances such as Phycobili proteins, which are soluble proteins and are present in most blue-green algae, oxidizing and anti-aging substances (Sonani 2015).

CONCLUSION

In recent decades, the increasing availability of biocatalysts and developments in related biochemical knowledge have led to the investigation of new sources for enzyme production. Algae have unique properties and could be explored for the large-scale production of enzymes as future biocatalyst factories. Algae enzymes and proteins are environmentally friendly and highly efficient in reducing pollutants by having rapid dispersion in surrounding areas. Nowadays, cyanobacteria and algae are viewed as increasingly attractive cell factories for producing renewable biofuels and bioactive chemicals due to their ability to capture solar energy and their relatively simple genetic background for genetic manipulation. Algae possess the advantages of low-cost production, without the need to use fresh water and high-value arable land. Moreover, they show potential as a future source of enzymes. Algae, as an extremely diverse group of photosynthetic organisms, have a wide range applications from human and animal nutrition to cosmetics and the production of high-value molecules such as fatty acids, pigments, and stable isotope biomolecules.

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Bioaccumulation of Anionic and Nonionic Surfactants in *Ceratophyllum demersum* Plant in Tigris River, Baghdad, Iraq

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Abstract: Detergents (surfactants) are one of the environmental risks that cause adverse effects on aquatic ecosystems.The objective of this study to detect the ability of *Ceratophyllum demersum* plant to accumulate the detergents (surfactants) from the river water. Four sites were selected along the Tigris River within Baghdad City from upstream, midstream and downstream. The analyses of detergents are based on ultrasonic extraction of river sediment, then the analysts were measured by colorimetric determination photolab S12 and HPLC device. The only nonionic surfactant detected in both sites and seasons with few variations between the measurement methods, which assume the high washing activities that release directly to the river thus absorbed and accumulate at the *C. demersum* plant for long time. The surfactant (anionic) are undetectable by PhotolabS12 device for both sites and seasons, but it was detected by HPLC. The results revealed that the *C. demersum* plant has ability to absorb and accumulate this type of pollutants with high efficiency. This macrophyte can be used to detect the surfactant present in the aquatic environment and as removal agent (phytoremedation) from the environment with lowest cost.

Keywords: Detergents, Lotic ecosystem, Macrophyte, Ultrasonic extraction, Multivariate analysis

Surfactant compounds are one of the organic pollutants that seeps into the aquatic systems significantly as a result of domestic and industrial waste, these compounds are causing many health problems, which have become one of the major concerns in today's world (Schmitt 2001). Surfactants are widespread use for washing purposes and other applications, for detergent formulation as emulsifiers, pesticide formulations, treatment of textiles, fibers, wetting agents and cosmetics, to name a few (Kreisselmeier and Durbeck 1997). Olkowska et al (2011) reported that the surface active agents (surfactants) are organic compounds (have one or more hydrocarbon chains) with the specific chemical structure of these molecules, first called hydrophilic part which is soluble in polar medium while the second called hydrophobic in nonpolar medium. The surfactants are classified according to its hydrophobic/hydrophilicity features into: anionic, cationic, nonionic and amphoteric compounds based on a charge of hydrophilic part. Because of the specific structure of surfactant molecules are used in different fields of human activity (industry, household).Most of these compounds are dispersed into different environmental compartments (soil, water, sediment, plant), where they can undergo numerous physic-chemical processes (sorption, degradation) and freely migrate (Madsen et al 2001,Olkowska et al 2014). The surfactants are released effluents into rivers and after passing the wastewater treatment plants they disposed the sludge on land. Depending on their behavior and fate of the surfactants, the presence of its types varies in the environment (Lechuga et al 2016).

Bioaccumulation of surfactants is considered as environmental risks, which cause a negative impact on the ecosystem biological components (e.g., toxicity, endocrine balance disorder). These compounds are caused an increase melting of organic pollutants in water that can lead to migration and accumulation in various environmental compartments like sediment and plant. In addition, synthetic detergents are not only toxic but carcinogenic, even in the lowest permitted concentrations (Ying 2006). Aquatic plants have the ability to absorb the essential nutrients from the water column and these certain explains their ability to absorb nano particles that suspension in the water system and this helps their transmission through the food chain. Because of the uptake of the surfactants through the roots in the plants lead to the low efficiency of photosynthesis process and cause a defect in all its vital functions that affect the growth of the plant. When long-exposure to the surfactants leads to denaturation of existing proteins and inhibit the work of enzymes involved in different metabolic processes (Bhairi 2001).

One of the longest rivers in Western Asia is Tigris River. Its length is approximately 1800 km and an area about 473,103 square kilometers. The total drainage area of the Tigris River is 235,000 km^2, which is17, 2, 29 and 52 percent in Turkey, Syria, Iran and Iraq (Al-Ansari 2013). Flow of the Tigris River is affected over time by the construction of dams

and climate change. Where the drainage was 1,207 m^3/s within Baghdad city for the period 1931-1960 and become 522 m^3/s for 2000 onwards (Al-Ansari et al 2018). In addition to, Iraq is suffering from the effects of climate change like the rest of the world (Abbas and Hassan 2018), which was evident in the emergence of global warming and rising sea level. The reasons for the deterioration of water in Iraq are increasing temperatures, Low precipitation rates, and distribution patterns have changed with increasing evaporation (Adamo et al 2018). Anionic surfactants (AS) as well as nonionic surfactants (NS), which represent the second largest group of surfactants(Schmitt, 2001), have been of the basic interest in this study. Therefore, their concentration of these compounds in macrophytes, is very important in estimating the potential risks to aquatic organisms.

MATERIAL AND METHODS

Study area: The study was carried out along Tigris River within Baghdad city for the period from February 2017 to February 2018. Submersible plant (*Ceratophyllum demersum*) was collected on monthly basis for 5 months of the wet season and 8 months of the dry season (between 8.30 am to 2.30 pm hours. Four sites were selected for sample collection; one site upstream: Al-Muthanna bridge (site 1), two sites midstream: Al-Sarrafia Bridge (site 2) and Al-Shuhada Bridge (site 3) and one site downstream: Al-Dora bridge (site 4). Global Positioning System (GPS) (Table 1) determined the positions of the study sites.

Plant sampling, extraction and analysis: The submersible plant *C. demersum* was collected once per months for wet and dry seasons. The macrophyte was saved in plastic bags even transported to the laboratory for analysis. For anionic surfactants the macrophyte samples were cut into small pieces and grinding by ceramic mortar 2-3 g of plant. The sample was weighed into 100ml beaker and added 10-15 ml of methanol then placed into an ultrasonic water bath for 1 hour, the water temperature was setunder 40ºC by adding ice. The elute was transported to 10 ml centrifuge tube for centrifuging for 5 minutes in 4000 rpm. The supernatant liquid was transported to glass vials (30 ml). A 5 ml methanol was added to the centrifuge tube, for rinsing procedure and has been repeated three times, thence the supernatant was collected in the same vials and the combined extract was condensed to 1 ml under nitrogen flow then reconditioned to 2 ml methanol (Ou et al1997). For nonionic surfactants the same procedure was followed in anionic surfactant for plant but used dichloromethane instead of methanol through ultrasonic bath devise. The elutes were evaporated with a gentle stream of nitrogen gas and reconstituted with

Table 1. Geographical positions (GPS) of the study sites

Site number	Site name	Coordinates	
		Longitude (E)	Latitude (N)
1	Al-Muthanna Bridge	44°34'55.50"	33°42'83.22"
2	Al-Sarrafia Bridge	44°37'36.01"	33°35'37.53"
3	Al-Shuhada Bridge	44°38'79.03"	33°33'79.59"
4	Al-Dora Bridge	44°45'02.84"	33°28'96.82"

dichloromethane to 1 ml after that elutes were analyzed by HPLC device. After extraction, both AS and NS were measured by both photometer photolab S 12 (PHD) (Operation manual, 2014) and High Performance Liquid Chromatography system model (HPLC) (Syknm-S1122.Germany). The standard solutions used in this study were 4-dodecylbenzene sulfonic acid for AS and 4-nonylphenyl-polyethylene glycol for NS.

Statistical analysis: The multivariate statistical methods were applied in research, such as cluster analysis (CA) (temporal and spatial variation), principle component analysis (PCA) and factor analysis (FA). The statistical analysis of the results were used the program of multivariate analysis methods (Statistica Release 7 software) (McGarial et al 2000, Mckenna 2003).

RESULTS AND DISCUSSION

For Photolab S12 device, the anionic surfactant was not detectable during the study period for both seasons and sites. The nonionic surfactant ranged from 47.86 µg g^{-1} in wet season to 191.19 µg g^{-1} in dry season. The minimum value of AS was 20.99 µg g^{-1} in dry season and the maximum 191.86 µg/g in wet season. The NS ranged from 21.46 µg/g (wet season) to 669.38 µg g^{-1} (dry season). The AS by PHD was not detected in both seasons (wet and dry), while AS by HPLC was detected in both season, this belonged to the charge of surfactant hence it was not detected by PHD (Table 2). This indicated that surfactants were not adsorbed on surface of plant but accumulate inside the plant. The high concentration of AS recorded in wet seasons. These results caused by a long expouser of macrophyte to long-term exposure period to surfactants throughout dry season. Radeef et al (2013) reported that the aquatic plants have ability to accumulate the heavy metals from their environment, they are excellent organism for the study of some long-term changes of heavy metals in the environment. While for NS for both PHD and HPLC were detected in wet and dry season and the lowest value was in wet season and the highest value in dry season and this lead to increase the discharge this pollutants into river. Domestic and industrial detergents have contain up to 40% phosphate (Bhairi 2001),

Table 2. Surfactant concentrations in *C. demersum* plant during the study period

Parameters	Range		Mean*	Standard deviation
	Minimum	Maximum		
PHD (µg/g)				
AS	ND (W&d)	ND (W&d)	ND	ND
NS	47.86 (W)	191.19 (D)	103.81	41.72
HPLC (µg/g)				
AS	20.99 (D)	191.86 (W)	74.38	48.98
NS	21.46 (W)	669.38 (D)	301.59	203.30

-=not applicable or available. ND: no detectable,W= wet season, D= dry season.
*= no permissible limits for anionic and nonionic surfactants in Iraqi river maintaining system (Law 25/1967) and CCME for Rivers

which the plant uptake these compounds as nutrients through root or surface absorption. Then these nutrients are used in all metabolic processes of plant as an energy which diverted to reproductive structures (Kagalwala and Kavitha 2012). Forni et al (2008) observed the effect of sodium dodecyl sulphate (SDS) as AS on two aquatic macrophytes (*Azolla* and *Lemna*) and concluded that bioaccumulation of SDS was after 3 days in the plant grown with 50 and 100 ppm of SDS and with 10, 25, 50 and 100 ppm SDS after 7 days. Al-Awady et al (2018) observed that the *C. demersum* have efficiency in removing some heavy metals from treatment of wastewater.

The first cluster is composed of three sub-clusters (Fig. 1): (i) 1. A single sub-cluster of May 2017 in dry season with highest concentration (669.38 µg g^{-1}) for NS.(ii) Pair of April-June 2017 in dry season with the highest concentration for NS (570.90 and 514.79 µg g^{-1}). (iii) 3. A single pair of March 2017 in wet season and the high concentration for NS (467.07 µg g^{-1}) was observed. Second cluster included two sub-clusters, Pair of August-September 2017 in dry season with lowest concentration for AS (21.92 and 20.99 µg g^{-1}) and a single sub-cluster of July 2017 in dry season with values for NS by PHD (98.36, 72.10 and 62.17 µg g^{-1}). While third cluster contained pair of January 2018 in wet season- November 2017 in dry season, a single sub-cluster of February 2018, pair of December in wet season - October 2017 in dry season and a single sub-cluster of February 2017 in wet season. All these sub-clusters were recorded not detectable for AS by PHD. There is a clear variation between wet and dry season. There was a clear variation for NS by HPLC, in which recorded the three high values in March 2017 (wet season) and May and August 2017 (dry season) were observed (Fig. 2). The lowest value was noticed in February 2017 (wet season) for NS by HPLC. While NS by PHD the highest value was recorded in April 2017 (dry season). In

March and April 2017 (wet and dry season, respectively) were recorded the highest two values for AS by HPLC. While for AS by PHD was observed not detectable for both two seasons (Fig. 2 and Table 2).

The CA (Fig. 1) and temporal variation (Figure 2) illustrated that the most polluted months were March, April, May, June and August 2017, that suggest the highest pollutant (surfactants) occurs in dry season, that due to the river receive wastewaters discharged from all human activities especially in dry season. The tree dendrogram (Fig. 3) shows two clusters during the study period. The first cluster is consisted of one single sub-cluster; S3. At this site was recorded the lowest concentration for NS by PHD 91.59 µg g^{-1}, AS by HPLC 47.87 µg g^{-1} and NS by HPLC 169.92 µg g^{-1}.

Second cluster was included two sub-clusters: pair of S1 - S4. In which S1 was recorded the highest concentration for NS by PHD 127.68 µg g^{-1} and AS by HPLC 114.39 µg g^{-1} while at S4 recorded the highest concentration for NS by HPLC 390.33 µg g^{-1} and a single sub-cluster of S2. At this site a lowest concentration (267487.5 µg g^{-1}) for NS by HPLC was observed. The highest values of NS (by PHD) and AS (by HPLC) at S1 and for NS (by HPLC) at S4 (Fig. 4). TheS1 and S4 are most study sites contaminated with AS and NS in *C. demersum*. The CA and spatial variation (Fig. 3 and 4) for the concentrations of AS and NS illustrates that S1 and S4 were the highest polluted sites during the study period that may be S1 (Al-Muthanna Bridge) located near the tourist island of Baghdad, which is increasing tourist activity by the population during the summer period, which leads to increased discharge of waste to the river directly or indirectly, the S4 (Al-Dora Bridge) located near the discharge of the Al-Rasheed thermal power station south of Baghdad and the effluent of the vegetable oil plant.

Then the correlation matrix results was recorded only four the following strong correlations (Table 4). EC and TDS showed strongly negative correlation with AS (HPLC) (r= -0.989), and (r= -0.970) respectively. There was strong negative correlation observed for PO4 and TOC with NS (HPLC) (r= -0.974) and (r= -0.964), respectively.

Farhood (2017) studied the bioaccumulation of some heavy metals (Pb, Cu, Cd) of two types of aquatic plants (*C. demersum, Phragmites australis*) and suggested to use them as bio indicators for pollution. However, the results showed that the *C. demersum*has ability to accumulate all metals more than *P. australis*. Furthermore, they concluded that the *C. demersum*a great ability to accumulate these elements and can be considered as a good biological indicators for this type of pollutants. More recently, the aquatic weed *Ceratophyllum sp.* has been used as food for fish (Laining et al 2016). The *Ceratophyllum* weed meal (CWM) contains the

Ceratophyllum herbaceous meal (CWM) contains 23 protein, 4 fat and 15 percent fiber (Laining and Kristanto 2015). Kagalwala and Kavitha (2012) studied morphology and physiology of macrophyte *Hydrilla verticillata* after treatment with sodium lauryl sulphate (surfactant), thus the results noticed a significant effect of sodium lauryl sulphate on

morphology of plant, chlorophyll and protein content at concentrations 4, 8, 12, 16 and 20µg ml^{-1}. Anionic and nonionic surfactants are very toxic to plants that cause delays in growth, variation in roots elongation, less photosynthetic efficiency and activated oxygen species which are released from mitochondria and chloroplasts thus cause damage to

Table 3. Person's correlation coefficient of surfactants in *C. demersum* plant during the study period

Parameters	AS (µg g⁻¹) PHD	NS (µg g⁻¹) PHD	AS (µg g⁻¹) HPLC	NS (µg g⁻¹) HPLC
AS (µg g⁻¹) PHD	1.000			
NS (µg g⁻¹) PHD	-	1.000		
AS (µg g⁻¹) HPLC	-	0.123	1.000	
NS (µg g⁻¹) HPLC	-	0.032	0.477	1.000

No significant correlation. r ≤ 0.3= weak correlation; r between 0.5 and 0.7= moderate correlation; r > 0.7= strong correlation (Wang *et al* 2007)

Table 4. Correlation between Physicochemical Tigris River water and surfactants in *C. demersum* plant for all period study

Parameters	EC (µs cm⁻¹)	TDS (mg l⁻¹)	PO₄ (mg l⁻¹)	TOC (%)
NS (µg g⁻¹) PHD	-0.895 P=0.105	-0.659 P=0.341	-0.230 P=0.770	-0.631 P=0.369
AS (µg g⁻¹) HPLC	-0.989 P=0.011	-0.970 P=0.030	-0.502 P=0.498	-0.778 P=0.222
NS (µg g⁻¹) HPLC	-0.647 P=0.353	-0.738 P=0.262	-0.974 P=0.026	-0.964 P=0.037

Correlation marked was significant at p<0.05
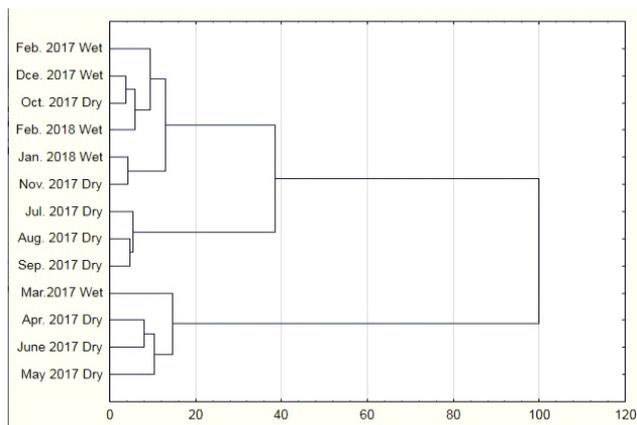
Fig. 1. Dendrogram of temporal clustering of sampling period during the study period
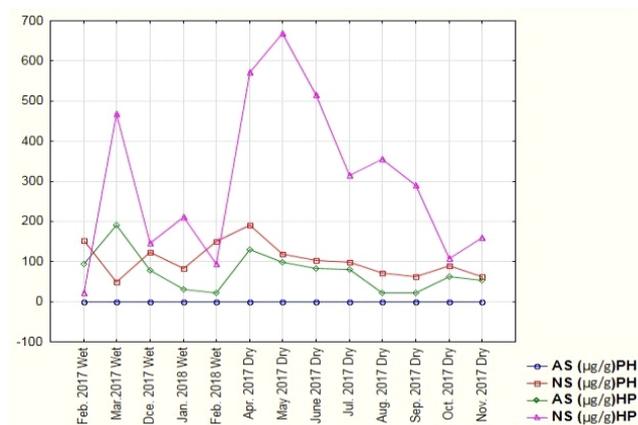
Fig. 2. Temporal variation of surfactants in *C. demersum* plant during the study period
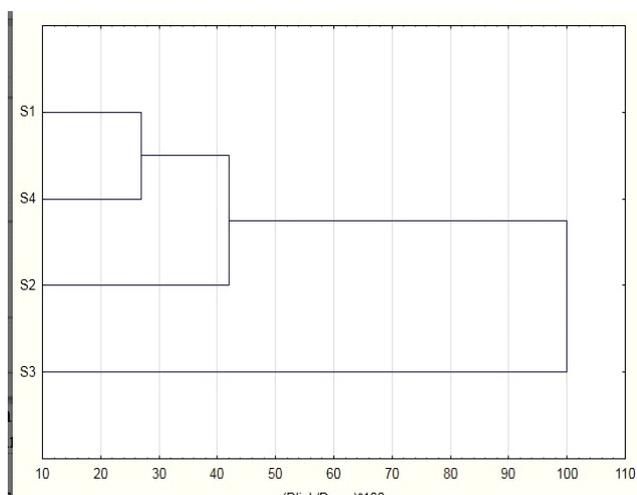
Fig. 3. Dendrogram of spatial clustering of sampling period during the study period
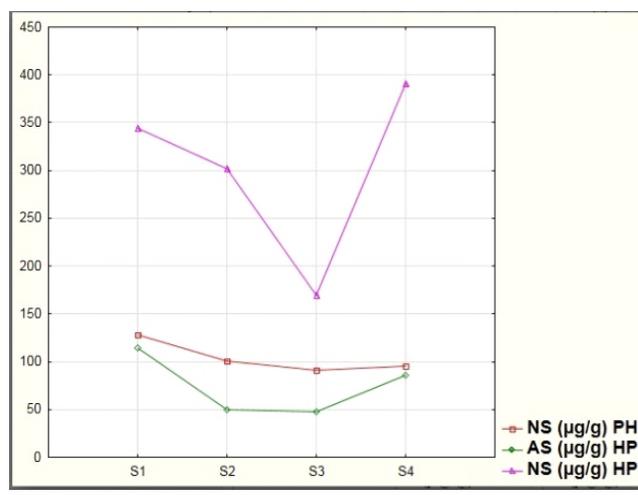
Fig. 4. Spatial variation of surfactants in *C. demersum* plant during the study period

metabolism by oxidation of lipids, proteins and nucleic acids (Zhao et al 2008). The t-test analysis was used to compare the two measurement methods (PHD and HPLC). The results showed significant differences at P<0.05 (t= 0.0001) between the results obtained by the two devices for AS measurement, also significant differences were obtained at p<0.05 (t= 0.004) for NS measurement.

CONCLUSION

The anionic and nonionic surfactants were detected in *C. demersum* of Tigris River for both seasons and sites by two measurements methods except for AS by PHD, which suggest that the *C. demersum* acts as a bio indicator for this type of pollutant. Second, *C. demersum* can be used as a phytoremediation for AS and NS for removing from river with less cost especially the *C. demersum*is present over the year. Finaly, HPLC can be used due to high efficiency and sensitive to measure AS and NS in river plant than PHD.

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Histological Alterations in the Gills of Crab, *Paratelphusa jacquemontii* after Chronic Exposure to Silver Nanoparticles (AgNP)

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Abstract: Histological changes in gills are used to evaluate the effects of chronic exposure to AgNP in freshwater crab, *Paratelphusa jacquemontii*. The acute toxicity study was carried out for 96 hours LC_{50} value and showed 0.71 mg/l. The LC_{50} is a measure of concentration of the toxin, which killed 50% of population in given time. The crabs were exposed to sub lethal concentration of LC_0 and LC_{50} of AgNP for 15 and 30 days. The most common morphological abnormalities observed in the gills morphology during the study were irregular structure of lamellae, fusion, hypertrophy, mucus secretion and necrosis, distorted central axis with an accumulation of haemocyte, circulatory disturbances, deformed lamella, and epithelial hyperplasia. The results showed that the AgNP could cause foremost histomorphological changes in the gills exposed with declining its gas exchange capacity. Moreover, our the finding indicates that the toxic effects increased with the concentration and time period of exposure.

Key Words: AgNP, Crab, Gills, Histology, Toxicity

Silver nanoparticles (AgNPs) are the most generally used metallic nanoparticles, observed in the number of consumer products (Walters et al 2016). In general, the size of these fine particles considers between 1 to 100 nanometers (Singh et al 2008). In the recent years, the use of nanotechnology has additionally expanded, with the utilization of silver nanoparticles (AgNPs) (Lindgren et al 2014). The worldwide manufacturing of AgNPs is approximately 500 tons for every year and amongst others, the application of AgNPs is growing rapidly (Aerle et al 2013). AgNP study confirmed that around 317 commodities contain nanoparticles, and of these 313 holds AgNPs. As per the guidelines of European Union, AgNPs are considered as extremely toxic chemicals to aquatic organisms. Silver nanoparticles have toxic effects on aquatic organisms regardless of the method used for synthesis, and so, their accidental or intentional entry into the aquatic ecosystems should inhibit for the protection of aquatic life (Johari et al 2013). The silver nanoparticles toxicity mechanism have not clearly understood but can include destabilisation of outer-membrane integrity, membrane potentialdisruption, cytotoxicity, genotoxicity, interruption of energy transduction, and formation of reactive oxygen species (Baptista et al 2015). In the aquatic environment, AgNPs negatively affect prokaryotes, invertebrates, and crabs. Freshwater crab assumes an imperative component in the maintenance, adjustment, and regulation of the environment by affecting both biotic and abiotic segments. They are plenteous and serve both as predator and prey and subsequently are situated at various trophic levels in the biological system (Maharajan et al 2015). Therefore, the study was carried out to know histological alterations in gills of the crab, *Paratelephusa jacquemontii* after exposure to AgNP doses which can be applicable while evaluating effects of AgNP in human and other organisms.

MATERIAL AND METHODS

Material synthesis and characteristics: Green synthesis method was used to preparation of silver nanoparticles. The aliquot containing 10gm of sugar with 200 ml deionised water used for preparation of AgNP. Solution was mixed vigorously and was maintained at 70-80^{0}C in water bath under magnetic stirring condition. Added 5 ml aliquot of the silver solution (10^{-1} molar $AgNO_3$), to the reducer aqueous solution. The colloidal solution heated up to yellow colour appears which requires around 30 minutes. The obtained silver nanoparticles were characterised by following techniques: UV-Vis Spectrum scanned from 800 to 200 nm using a spectrophotometer (Schimadzu UV 1800). The concentration of AgNP solution was measured with Inductive Coupled Plasma Atomic Emission Spectroscopy (ICP - AES) (SPECTRO Analytical Instruments GmbH, Germany). The size and distribution of AgNPs were confirmed with dynamic light scattering DLS (Malvern).

Experimental design: The Animal model used for study was crab, *Paratelphusa jacquemontii*. The crabs were purchased from local market with mean total length of 6 - 8 cm and mean weight 80-120 gm. Prior start to the experiment, crabs were acclimatized to laboratory conditions for 48 hrs and then exposed with AgNP to find out LC_{50} as per OECD guidelines. Natural light was used to conduct the experiment, which was available at laboratory during the daytime. Five experimental groups were made with each group containing ten crabs. An experimental groups comprises of, control group, group with LC_0 (0.01mg l^{-1}) and group with $1/10^{th}$ of LC_{50} (0.07mg l^{-1}) and exposed for 15 and 30 days respectively. All experimental groups were studied in triplicates. Single trey contains 3 litres of tap water and addition of AgNP solution was done to maintain concentration of exposure solution. The static experimental protocol was adopted with water was changed once every day. After 15 and 30 days of the exposure period, five healthy crabs were randomly sampled to assess effects on the gills and were fixed in Boiun's fixative. After fixation tissues were dehydrated using a series of graded ethanol solutions. They were cleared in xylene and embedded in paraffin wax. Slices of 5 μm were taken from paraffin blocks with the help of rotary microtome. These slices were spread on glass slides and then stained with haematoxylin-eosin and examined microscopically.

Data analysis: Mortality observations were made every day upto 96 hrs. For the calculation of LC_{50} value Trimmed Spearman-Karber computer programme (V 1.5) used which was developed by Ecological Monitoring Research Division of USEPA and Biostat v5 software.

RESULTS AND DISCUSSION

The UV-Vis spectroscopic results showed sharp peak with maximum absorbance at 415 nm (Fig. 1). ICP-AES analysis peak confirmed the concentration of AgNP with 0.031 ppm (Fig. 2). With the application of dilution factor and multiplication, it was confirmed that the original sample contained 248 ppm of AgNP. These findings confirmed that the synthesised material is AgNP. This also confirmed a homogeneous dispersion of the AgNPs in aqueous solutions. The DLS measurements exhibited that the hydrodynamic diameter of the AgNP ranged from 60 to 120 nm, with an average value of 65.76 nm (Fig. 2).

Study of LC_{50} for 96 hours: The AgNP toxicity examined through acute toxicity test for 96 hrs. The LC_{50} was, 3.62, 2.70, 1.88, 0.77 ppm after 24,48,72 and 96 hours, respectively. This study is the evidence of toxicity of colloidal AgNP to the freshwater crab. Behaviour of the control animals was found normal throughout the study but the crabs introduced with AgNP's showed abnormal behaviour. In crustaceans, the
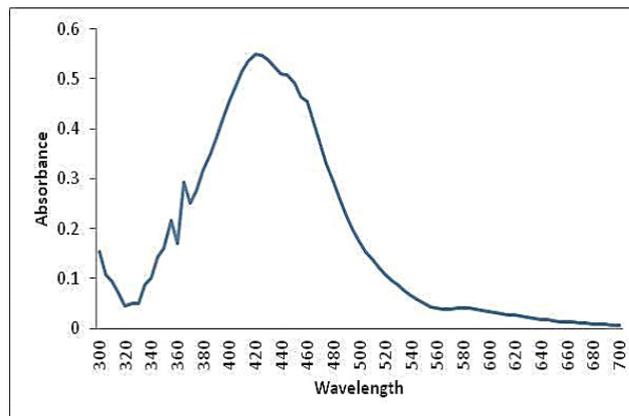
Fig. 1. UV–Vis spectrum of synthesized AgNP
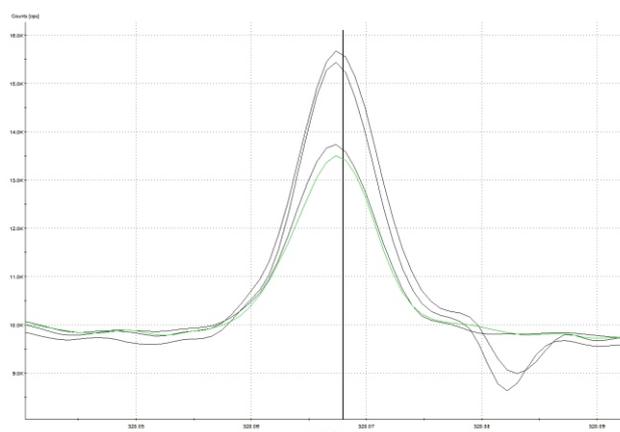
Fig. 2. ICP-AES analysis peak the confirmation and concentration of Ag NP

exposure routes are mainly passing through ingestion and adsorption to surface epithelia such as gills. The toxic effects of AgNP occurred higher with the dose and time.

Gills histopathology: Gills of the control crab is showed various lamellae which arranged serially in pairs along a central gill stem. They are flattened plate-like supported by the gill stem from which afferent and efferent blood vessels pass (Fig. A). The complete external surface of the gill is enclosed with a thin coating of chitinous cuticle beneath is a chitinous lining of epithelial cells. Lamella is flat, thin walled vascular structure containing blood. Epithelial cells of the lamellae are continual as the lining of the gill stem. There are also few pillar cells which helps in connecting two faces of lamellae (Fig. B). As study, the chronic exposure with AgNP for LC_0 concentration about 15 days period the gills showed rachis filled enormously thickened large mass of granular haemocyte. The gill lamellae were also affected showing accumulation of haemocyte resulting in swelling and enlargement of lamellae (Fig. C). The clumping of gill lamellae was also noted (Fig. D). The chronic exposure to

LC_0 concentration for 30 days period with AgNP's the gills showed rachis filled enormously thickened with bulky mass of granular haemocyte (Fig. E). The gill lamellae were affected showing accumulation of haemocyte resulting in swelling and enlargement of lamellae. The clumping of gill lamellae was also seen (Fig. F). The higher dose of AgNP tochronic exposure i.e. LC_{50} for 15 days period the gills showed large mass of granular haemocytein rachis (Fig. G). Affected gill lamellae were observed with circulatory disturbances, epithelial cells lifting and accumulation of haemocyte which cause to swelling and bulging of lamellae. The clumps formed by the lamellae were seen in Fig.H. The chronic exposure to LC_{50} concentration for 30 days period with AgNP the gills showed irregular structure of lamella and distortion of central axis filled extremely thickened with granular haemocyte (Fig. I). Gill lamellae were showing circulatory disturbances, deformed and degenerated lamellae, epithelial hyperplasia, as well as epithelial desquamation. The clumping of gill lamellae was seen at this exposure (Fig. J).

Gill can be used as an indicator of the aquatic environment quality, making it appropriate for environmental toxicology studies. Due to environmental toxins, reversible and irreversible structural alterations can be observed in the gills. Degeneration and necrosis are examples of irreversible changes whereas cellular hyperplasia is a reversible damage in gill structure (Bhagwant et al 2002).Metal and nanomaterial toxicity study and its accumulation in gills are carried out by many researchers in fishes, but very few studies are found metal and nanomaterial toxicity with crustaceans (Kadam et al 2018). Metals are one of the toxicants, which showed major environmental problems causing long-term effects on aquatic ecosystems (Paruruckumani et al 2015). Curvature occurred in secondary gill lamellae is the first change resulted due to ambient pollutants. Further damage includes oozing of mucus, tenderness and hyperplasia of gill tissue (Mansouri et al 2016, Hassaninezhada et al 2014). Morphological damages of the gills indicated that impairment in gaseous exchange efficiency of the gills lamella and hyperplasia were observed and this was comparable to the observation of Omoniyi et al (2002), Neelima et al (2015). The gills have been showed cellular damages in terms of epithelium proliferation and necrosis can affect the gas exchange and ionic regulation (Adinarayana et al 2017). As per the outcome of study AgNPs could cause major histomorphologiacal changes in the gills of crab, it leads to declining of gas exchange capacity in gills. These effects ranged from low concentration to high concentration with respect to exposure period. During study, various histological alterations were measured, like mucus production, epithelial hyperplasia, lamellar fusion, and swollen epithelium in the gills of AgNPs exposed gills. Similar study has been carried out in the fish gills with nanoparticles uptake by the gills have been demonstrated and which increased mucus layer with cell hyperplasia may constitute a barrier (Yuan et al 2013).

The secondary lamellar epithelium was simple, consisting of a thin single or double layer of epithelial cells, blood vessels and a row of pilaster cells but severe changes noticed due to the toxicity of metals to gills Patnaik et al (2011). In study of the fish collected from polluted water gill lamella showed cytoarchitectural distortion with overlapping of primary and secondary lamella Poleksic et al (1993). In the current study severe alterations were noticed with distortion of central axis and irregular structure of lamellae with accumulation of haemocytes. Higher severity was noticed in the higher concentration i.e. LC_{50} 30 day's exposure period than the control and sublethal concentration of LC_0 for 30 days period. A similar study with fish was conducted by Joseph et al (2018) showed absolute interrupted primary gill structure, marked hyperplasia of the bronchial arch, pilaster cell vacuolization and congestion of blood vessels were well marked. The main response of gill epithelium was decreased in permeability. The toxicity mechanism and actions of nanoparticles in the presence of other particles or environmental pollutants are dissimilar. The heavy metals toxicity in the occurrence of a variety of nanoparticles like C nanotubes, Ce, TiO_2 and Al_2O_3 nanoparticles is alike with the findings of studies (Hu et al2012;Yu et al2013). The histopathological changes in the gill tissue of crab may induce a hypoxic state under which oxidative stress was concomitantly generated.
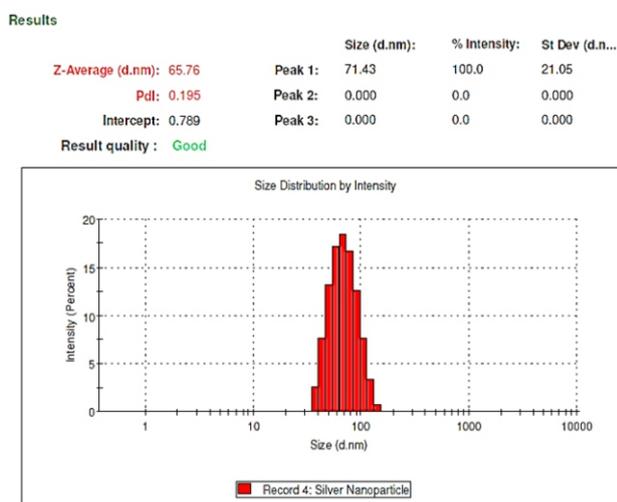
Results

		Size (d.nm):	% Intensity:	St Dev (d.n...
Z-Average (d.nm): 65.76	Peak 1:	71.43	100.0	21.05
Pdl: 0.195	Peak 2:	0.000	0.0	0.000
Intercept: 0.789	Peak 3:	0.000	0.0	0.000
Result quality : Good				

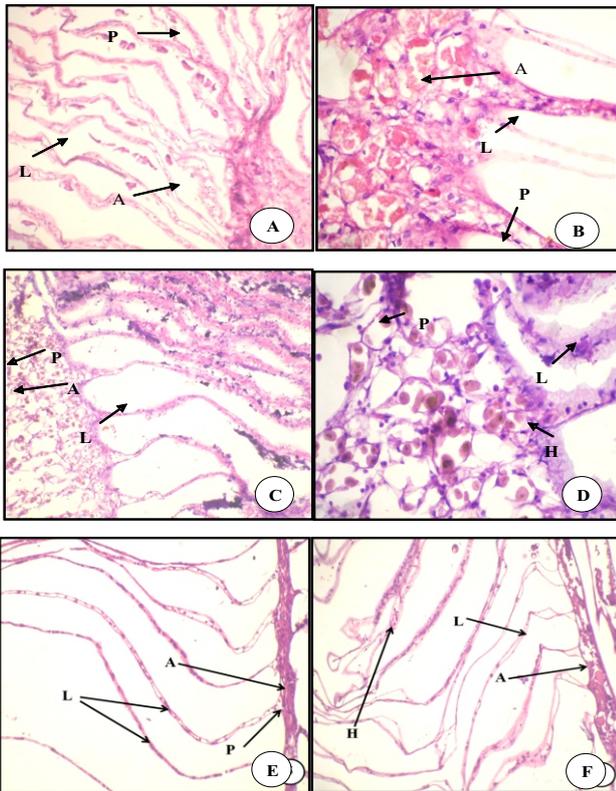**Fig. 3.** DLS measurements of synthesized AgNP

Fig. A, B. Light photomicrograph of gills of the control crab, *Paratelphusa (Barytelphusa) jacquemontii* (Rathbun) showing central axis (A), series of lamellae (L) and pillar cells (P). X25, X40
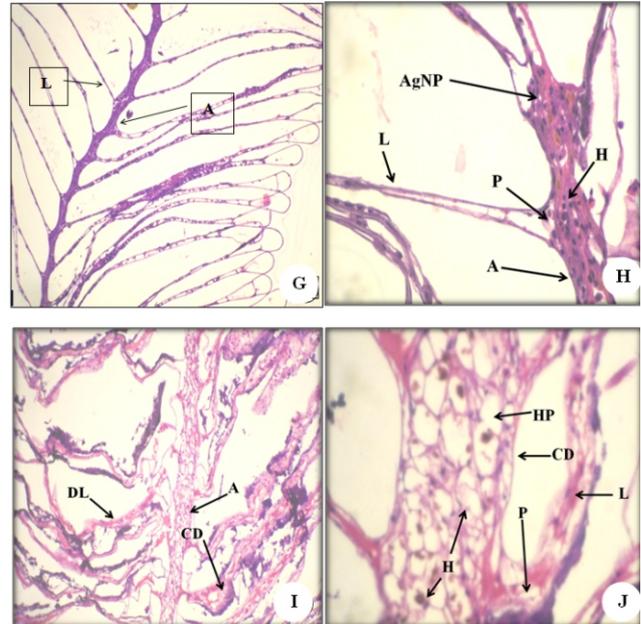
Fig. C, D. Light photomicrograph of the gills of the crab, *Paratelphusa (Barytelphusa) jacquemontii* (Rathbun) exposed to AgNP concentration LC_0 for15 days showing central axis (A), series of lamellae (L) and pillar cells (P). Note irregular structure of lamellae and presence of haemocytes (H). X25, X40

Fig. E, F. Light photomicrograph of the gills of the crab, *Paratelphusa (Barytelphusa) jacquemontii* (Rathbun) exposed to AgNP concentration LC_0 for 30 days showing central axis (A), series of lamellae (L) and pillar cells (P). Note irregular structure of lamellae and distorted central axis with accumulation of haemocytes (H). X25, X40

Fig. G, H. Light photomicrograph of the gills of the crab, *Paratelphusa (Barytelphusa) jacquemontii* (Rathbun) exposed to AgNP concentration LC_{50} for 15 days showing central axis (A), series of lamellae (L) and pillar cells (P). Note irregular structure of lamellae and distorted central axis with accumulation of haemocytes (H). X25, X40

Fig. I, J. Light photomicrograph of the gills of the crab, *Paratelphusa (Barytelphusa) jacquemontii* (Rathbun) exposed to AgNP concentration LC_{50} for 30 days showing central axis (A), series of lamellae (L) and pillar cells (P). Note irregular structure of lamellae and distorted central axis with accumulation of haemocytes (H) Circulatory Disturbances (CD) Deformed Lamella (DL), Epithelial Hyperplasia (HP). X25, X40

CONCLUSION

This study shows that the sublethal dose of LC_{50} of AgNP's indicates severe toxic effects on the gills of freshwater crab, *Paratelphusa jacquemontii*. The histological study of gills shows necrotic changes which have added to reduction in surface area and thus affecting the level of oxygen leading to anaerobic condition. These necrotic changes are the signs of toxic activity going on at the cellular level. More extensive studies are recommended for deeper understanding of the mechanisms and effect of nanomaterial hazards when other nanoparticles and environmental pollutants are present in the environment.

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A Case-Study of Uranium and Heavy Metal Detoxification

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Abstract: Uranium pollution has been reported in many countries and present study is a case study to record the affects of radioactive waste on human health. It has been recorded that the uranium accumulation in the body can be affecting the lungs. However, affect can be successfully detoxified and eliminated through a combination of acupuncture stimulation of pressure points.

Keywords: Uranium, Depleted uranium, Gulf War Syndrome, Balkan Syndrome

In this day and age of exposure to many toxins in the environment ranging from chemical pesticides to radioactive heavy metals, the role of clinical detoxification has become an issue of considerable importance. It is something of note not only for official governmental agencies dealing with environmental pollution issues and setting regulatory health standards, but for individuals seeking to improve their own health when chancing upon such hazards in their surrounding environment. Many parts of the world have been contaminated with radioactive waste from depleted uranium bombs and projectiles including the Arabian Gulf, Iraq, Syria, Bosnia, Serbia and Afghanistan. Depleted uranium is a by-product of the uranium enrichment process employed in nuclear reactors. It has been used to make depleted-uranium bombs and to coat bullets, which are effective armour-piercing projectiles. Other areas of the globe have been contaminated by nuclear testing sites, such as Nevada, and accidents at nuclear power plants, such as Three Mile Island, Chernobyl, and Fukushima. Heavy metal exposure can occur in humans potentially through the air, water, and food via soil. However, depleted uranium exposure is most likely to occur via inhalation (Bleise et al 2003). Thus, the unwary traveler travelling to such places can suddenly find oneself victim to unusual health disorders typified regionally in extreme cases by the Gulf War Syndrome and Balkan Syndrome, the symptoms of which are not readily recognized by the ordinary medical practitioner (Durakovic 2001).

In this study, the subject was a vegetarian female aged 51 years of Indian [Asian] descent with minor allergies and a history of asthma on her father's side of the family. Her body weight was 45.3 kilograms (100 pounds) and height was 167 cm (5 feet and 5 ¾ inches). She started to experience strange, unfamiliar symptoms after a two-day visit to Bosnia and Herzogovina that included dizziness, fatigue, a feeling of heaviness, digestive dysfunction, and unusually heavy nasal and chest congestion bordering on asthmatic attacks in response to old allergens two weeks following her trip. Despite these complaints, her kidney, liver, thyroid and heart function tests were all normal. Her red and white blood cell counts were also within normal limits. A chest X-ray was clear of any unidentified spots.

Since dizziness and fatigue are two of the classical signs of heavy metal poisoning, a metal toxicology test was eventually undertaken involving the analysis of a hair sample. The results showed that she had accumulated the maximum normal limit of uranium [90 ug] in her body [0.002 ug g^{-1} of body weight] during the period of her visit to Bosnia and Herzogovina [WHO]. There is no reason to suppose she ever had any prior exposure to this metal since she had never travelled to areas of uranium mining or anywhere associated with nuclear warfare. Moreover, the sample which represented the most recent hair growth taken from near the scalp, fixed the time of uranium exposure to this latest trip abroad.

Thus, a combined program of acupuncture detoxification treatment, which acts upon key meridians and points, possibly corresponding to the neurolymphatic system (Bradstreet et al 2015) with electrical correlates displaying conductance (Becker et al 1976), and metal chelation therapy was undertaken for a period of three months and three weeks, consecutively, following uranium exposure. Previously, the subject had found acupuncture to be helpful in relieving allergy and mildly asthmatic symptoms and was the reason for the choice of this dual treatment. Recently, in scientific studies, acupuncture has been demonstrated to excite receptors or nerve fibres in the stimulated tissue in a similar way to strong muscle contractions and the effects on certain organ functions are analogous to those produced by heavy exercise. The resulting rhythmic discharges in the nerve fibres cause the release of endogenous opioids and

oxytocin essential to producing functional changes in various organ systems. Experimental and clinical evidence suggests that acupuncture may have an effect at the hypothalamic and brainstem levels (Andersson and Lundeberg 1997; Pomeranz and Berman 2003).

The first metal chelation therapy treatment involved the oral administration of DMSA (500 mg) followed by an intravenous skin infusion of EDTA (1900 mg). The second treatment followed in five days and also included oral administration of DMSA (500 mg) and a skin infusion of EDTA (1900 mg). Standard Vitamin supplements (Vitamins A, B1, B6, B12, C, E, and folic acid) were included with the latter intravenous skin infusion to offset dilution of the blood and resulting deficiency of essential nutrients and micronutrients in the body. An oral powder containing mainly the minerals calcium, magnesium, zinc and Vitamin D, Vitamin K2 and CoQ10 was also administered with treatments to offset any deficiency or muscle cramping due to dilution of the blood, particularly since the patient had inherited Thalassemia minor from her mother's side of the family. In addition, amino acid supplements (2000 mg) were administered daily during the entire treatment to ensure sufficiently healthy enzyme and protein production by the body during detoxification.

EDTA (ethylenediaminetetraacetic acid) is a synthetic amino acid food preservative that binds to various heavy metals in the body and removes them through the urine. It is administered intravenously and has been in use for nearly 50 years to treat heavy metal toxicity (Dean 2018A). Na-Ca-EDTA chelates are rapidly excreted and, generally, cause greater losses of essential minerals from the body than DMSA. EDTA has been found to be most effective in removal of lead, cadmium, and mercury (Sears 2013).

DMSA (meso-2,-3-dimercaptosuccinic acid) is a sulfhydryl-containing, water-soluble, non-toxic, orally administered metal chelation agent. It has been used to treat heavy metal toxicity, particularly lead and mercury poisoning, since the 1950s. The low toxicity and efficacy of DMSA makes it the primary metal chelator of choice for removal of mercury and other heavy metals. It is also very safe and causes few side-effects. The DMSA-metal conjugates are expelled through the urine (Dean 2018B).Oral absorption of DMSA is approximately 20% with most DMSA in the blood plasma being bound to protein, mainly albumin (95%). Ten to twenty-five percent of orally administered DMSA is excreted in the urine, mostly within 24 hours of administration. Excretion of trace elements including zinc, iron, calcium and magnesium is much less than with Na-Ca-EDTA. Copper may be an exception (Sears 2013).

Chelating agents are rapidly excreted from the body over a period of a few hours or days. Typically, a chelating

agent will mobilize the most easily accessible metals in the blood plasma, kidneys, and liver first. Toxic metals in the bones and central nervous system are targeted to a lesser extent. Moreover, toxic elements sequestered in bone and soft tissues are not completely mobilized and migrate back into the bloodstream following metal chelation therapy. Thus, hair analysis combined with urine analysis pre- and post-treatment may be a more accurate indicator of heavy metal status in the body. Interim measurements may also reflect heavy metal excretion provoked by the chelation therapy and/or redistribution of toxic elements from less accessible to more accessible body compartments following treatment (Sears 2013).

By the time she had completed a course of acupuncture detoxification treatment at the China Acupuncture & Herbal Center in Canada and the first metal chelation therapy treatment had been initiated in Germany (the subject was the first depleted uranium case to be treated at the Dr. Von Rosen

Table 1. Pre-treatment hair analysis (Metal toxicology results)

Metal	Standard Value (ug g^{-1})	Test Value (ug g^{-1})
Arsenic (AS)	< 0.14	0.016
Lead (Pb)	< 3.0	0.22
Mercury (Hg)	<3.0	<0.03
Cadmium (Cd)	<0.20	<0.009
Chromium (Cr)	<0.85	0.55
Beryllium (Be)	<0.050	<0.01
Cobalt (Co)	<0.15	0.003
Nickel (Ni)	<1.0	0.04
Zinc (Zn)	<300	300
Copper (Cu)	<70	12
Thallium (Tl)	<0.005	0.001
Barium (Ba)	<8.0	0.13
Cesium (Cs)	<0.010	<0.002
Manganese (Mn)	<1.5	0.07
Bismuth (Bi)	<5.0	0.061
Vanadium (V)	<0.20	0.034
Silver (Ag)	<1.6	0.05
Antimony (Sb)	<0.12	0.017
Palladium (Pd)	<0.015	<0.004
Aluminum (Al)	<19	2.9
Platinum (Pt)	<0.010	<0.003
Tungsten (W)	<0.015	0.002
Tin (Sn)	<1.0	0.05
Uranium (U)	<0.20	0.002
Germanium (Ge)	<0.045	0.035
Titanium (Ti)	<2.0	0.33

Table 2. Initial provoked post-treatment urine analysis (Metal toxicology results – EDTA/DMSA)

Metal	Standard Value (ug g^{-1} creatinine)	Test Value (ug g^{-1})
Arsenic (AS)	<15	3
Lead (Pb)	<5/22 [CS]	34
Mercury (Hg)	<1/3.5 [CS]	0.66
Cadmium (Cd)	0.8/1.3 [CS]	1
Chromium (Cr)	0.55-4.8	2.26
Beryllium (Be)	<1.2	<DL
Cobalt (Co)	<5	1.9
Nickel (Ni)	<3/14.8 [CS]	18.7
Zinc (Zn)	0.78/19.5 [CS]	19.6
Copper (Cu)	<60	30.8
Thallium (Tl)	<0.6	0.22
Barium (Ba)	<5.7	12
Cesium (Cs)	<11	2.2
Manganese (Mn)	<4.5/35 [CS]	44
Bismuth (Bi)	<0.15	0.19
Vanadium (V)	<1	4.5
Silver (Ag)	<1.4	<DL
Antimony (Sb)	<1	<DL
Palladium (Pd)	<1.4/1.8 [CS]	0.84
Aluminum (Al)	<40	38
Platinum (Pt)	<0.6	-
Tungsten (W)	<0.79	<DL
Tin (Sn)	<2.0	0.35
Uranium (U)	<0.06	<DL
Germanium (Ge)	<1.5	0.28
Titanium (Ti)	<13	<DL

*<DL = below detection limit; CS = chelator-specific orientation range

Table 3. Final provoked post-treatment urine analysis (Metal toxicology results-DMSA)

Metal	Standard Value (ug g^{-1} creatinine)	Test Value (ug g^{-1})
Arsenic (AS)	<15	4.7
Lead (Pb)	<5/22 [CS]	31
Mercury (Hg)	<1/3.5 [CS]	3
Cadmium (Cd)	<0.8/1.3 [CS]	0.3
Chromium (Cr)	0.55-4.8	0.7
Beryllium (Be)	<1.2	<DL
Cobalt (Co)	<5	0.8
Nickel (Ni)	<3/14.8 [CS]	
Zinc (Zn)	0.06-0.78	0.37
Copper (Cu)	<60	46
Thallium (Tl)	<0.6	0.2
Barium (Ba)	<5.7	8.4
Manganese (Mn)	<4.5/35 [CS]	3.6
Bismuth (Bi)	<0.15	0.10
Vanadium (V)	<1	0.08
Silver (Ag)	<1.4	<DL
Antimony (Sb)	<1	<DL
Aluminum (Al)	<40	10
Platinum (Pt)	<0.6	-
Tungsten (W)	<0.79	<DL
Tin (Sn)	<2.0	0.3
Uranium (U)	<0.06	<DL
Germanium (Ge)	<1.5	0.9
Titanium (Ti)	<13	<DL

*<DL = Below detection limit; CS = Chelator-specific orientation range

Clinic), the uranium levels in her urine were below detectable levels. However, this preliminary urine analysis undertaken a few hours after provocation with Na-Ca-EDTA and DMSA also indicated slightly higher than normal levels for lead, nickel, vanadium, bismuth, and barium (Table II) that did not correspond with the initial hair analysis (Table I) suggesting that exposure to these elements may have occurred later. A final urine analysis after provocation with DMSA [500 mg] was conducted ten months following metal chelation therapy and it supported the previous results for significantly reduced uranium body burden (Table 3). In addition, nickel, vanadium, and bismuth levels were restored to normal levels. Lead and barium levels were reduced, but still somewhat higher than normal.

Another interesting parallel point to emerge in this study was that zinc levels were also noticeably high according to both hair and initial provoked urine analysis. In the absence

of oral zinc supplementation, this was most likely due to the fact that the subject used a zinc oxide sunscreen (9.5%) daily (Table 1 & 2). However, when the subject stopped sunscreen use during the course of her therapy, normal zinc levels were restored as evidenced by the final provoked urine analysis suggesting that zinc absorption may have occurred through the skin (Table 3). Previously, it has been reported that zinc absorption can occur through oral administration of zinc citrate, zinc gluconate, and zinc oxide in young adults (Wegmuller et al 2014). This observation is of interest in relation to the finding in rats that elevated zinc levels in the mammalian body may protect against depleted uranium toxicity (Hao et al 2012). Thus, the regular use of a zinc oxide-based sunscreen may be beneficial in helping to reduce heavy metal toxicity in individuals exposed to contaminated environments by facilitating zinc absorption.

The main results of this case-study indicate, firstly, that

the effects of even small amounts of uranium accumulation in the body can be debilitating, especially to individuals genetically predisposed to respiratory disorders such as asthma or emphysema since the lungs are one of the primary target organs of this toxic element. Secondly, small amounts of uranium in the human body can be successfully detoxified and eliminated through a combination of acupuncture stimulation of pressure points, possibly corresponding to a previously unrecognized neurolymphatic system in mammals, and EDTA- and DMSA-coupled heavy metal chelation therapy. Finally, it is recommended that metal chelation therapy and acupuncture be made widely available to the people of those countries that have suffered from depleted uranium and/or nuclear weapons attacks. Patients with genetic predispositions to respiratory disorders should be given priority in accessing treatment.

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Eco-friendly Arecanut Leaf Sheath Products: An Economic Analysis

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Abstract: The rising demand for biodegradable and eco-friendly areca leaf generated net returns of Rs. 17800 ha^{-1} to arecanut growers. The manufacturer invested Rs. 13.42 lakhs for establishment of unit. Leaf products *viz.*, 30 cm, 25 cm, 20 cm of plates and 15 cm and 11 cm of bowls are manufactured in the unit. The per unit cost inclusive of variable and fixed costs came to Rs. 2.21, Rs. 1.62, Rs. 1.15, Rs. 0.73 and Rs. 0.51 for30 cm, 25 cm, 20 cm plates, and 15 cm and 11 cm bowls, respectively. Correspondingly, manufacturer realized profit of Rs. 0.64, Rs. 0.23, Rs. 0.25, Rs. 0.47 and Rs. 0.29. Capital budgeting analysis indicated economic viability of investment with high Net Present Worth (NPW) of Rs. 46, 83,397, Benefit Cost Ratio (BCR) of 1.42 and Internal Rate of Return (IRR) of 212.90 percent. The unit has got enormous employment potential of 3344.6 mandays per annum. The percentage value addition to the raw material ranged between 374 percent in case of 25 cm plates to 900 percent in case of 11 cm bowls. Further, the study indicated price spread of Rs. 1.65, Rs. 1.15 and Rs. 1.1 in case of 30 cm, 25 cm and 20 cm plates, respectively and Rs. 0.8 and Rs. 0.6 for 15 cm and 11 cm bowls, respectively.

Keywords: Area leaf sheath products, Capital budgeting, Eco-friendly

Arecanut is cultivated extensively in the state of Karnataka in an area of 2.61 lakh hectares with annual production of 3.82 lakh tons (Directorate of Economics and Statistics, Bangalore). About three million farmers are dependent on arecanut directly/ indirectly for their livelihood. It generates enormous employment and income for the people who are deriving livelihood from this enterprise (Prakash 2012). Arecanut takes seven years for its complete establishment and remains in the field for eighty years and even beyond. During its life period, arecanut not only produces main product (Betel nut) but also by-products (leaf sheath and arecanut husk). The main product is marketable while by-product goes waste if not properly utilized for making usable commodities. On an average there would be 1600 palms ha^{-1}. Each palm produces on an average 10 leaf sheaths per year (Bhargav and Gaikwad 2012). During earlier days, leaf sheaths used as mulching material or source of organic matter. Of-late due to technological innovations, it has become possible to put leaf sheaths for better use for manufacturing leaf plates, bowls and spoons of different dimensions. These products are biodegradable and eco-friendly. As plastic based goods are banned in many states, arecanut based products are gaining importance and penetrating deeper into the consumer market. It has been observed that units manufacturing arecanut leaf plates and bowls on small scale as well as large scale have emerged in arecanut growing belts in few numbers. This has given rise to new class of entrepreneurs in the society. The units are capital and labour intensive, generates substantial employment opportunities for the people living around.

Keeping in view the economic significance, social and environmental importance of this vital rural based industry, the present study envisages detailed investigations on economic aspects of arecanut leaf plate and bowl manufacturing. The overall objective was to throw light on by-product utilization for economic development of the region.

MATERIAL AND METHODS

Ten arecanut leaf plate and bowl manufacturing units were selected for the present study. The relevant information was gathered from the units using interview schedule by personally contacting the entrepreneurs. The information includes capital investment made on land, buildings, machineries, equipments, water supply, and particulars of raw materials, labour, electricity, water, packing and packaging of finished products. The information pertinent to marketing of finished areca leaf products were elicited from wholesalers (n=10) and retailers (n=10). The data were analyzed using descriptive statistics, budgeting technique, discounted and undiscounted cash flow measures, market efficiency measures, simple ratios and percentages to draw meaningful inferences.

Manufacturers procured raw material from arecanut growers of surrounding regions at farm gate price of Rs.1.20 per leaf sheath. Wastage of 8.75 per cent of leaf sheath was noticed and accounted as cost in the manufacturing process. Valuation of plates and bowls was done on sq. cm basis by multiplying leaf sheath area in sq.cm with per sq. cm cost. The total procurement cost of raw material inclusive of wastage was divided by available leaf sheath area for

manufacturing of plates and bowls in sq. cm to arrive at cost of raw material. Labour used in the industry was valued using wage rates provided locally at Rs. 300/ manday and apportioned on the sq.cm basis. Similarly, electricity charge/sq.cm area of leaf sheath was estimated by dividing total electricity charges by total leaf sheath area used for plates and bowl manufacturing. Valuation of packing and packaging materials was done taking into consideration the market price of materials used. Twines used for tying the small packets of plates and bowls were valued by considering the quantity of twines and market price. The cost incurred on packing and packaging materials were apportioned on per plate/bowl basis. The actual cost incurred on repairs of machines, motors and other accessories were taken into consideration. An interest rate of 12 percent was charged on working capital and included as cost component. Depreciation on machineries and equipments was estimated using straight line method. The estimated depreciation amount was apportioned across five products based on capacity utilization (capacity utilization expressed in percentages was arrived at by dividing number of plates of 30 cm, 25 cm, 20 cm and bowls of 15 cm and 11 cm by total number of plates and bowls manufactured in the unit). The capacity utilization were in the order of 25, 33.34, 8.33, 16.67 and 16.66% in 30, 25, 20, 15 and 11 cm, respectively. Contribution of land was accounted for in the form of rental value considering the foregone returns from competing enterprise *i.e.*, paddy. Similar was the procedure involved in computing interest on fixed capital. The interest was estimated on investment at an interest rate of 12 percent and included as cost item for each product on the basis of capacity utilization.

Finally returns was computed at selling price of Rs. 2.85, Rs. 1.85, Rs. 1.40, Rs. 1.20 and Rs. 0.8 in 30, 25, 20, 15 and 11 cm, respectively. Economic feasibility of investment on areca leaf plate manufacturing unit was assessed employing discounted and undiscounted cash flow measures (Shinojet al 2010) such as net present worth (NPW), benefit-cost ratio (BCR) and internal rate of return (IRR).

The percentage value addition was estimated considering percentage change in the value of commodities at different stages (raw and finished forms). [(Price of finished good - price of raw material)/ price of raw material]×100. An attempt was made to study marketing pattern of products by tracing marketing channels and working out marketing costs, margins and price spread.

RESULTS AND DISCUSSION

Income generation to arecanut growers: Each hectare of land accommodates about 1600 palms at the spacing of 2.5

meters apart (Table 1). There would be 16000 leaf sheaths hectare^{-1} annum^{-1} @ 10 leaf sheaths palm^{-1}. Entrepreneurs have set up industries in arecanut growing belts for efficient utilization of by-product for manufacturing of plates and bowls. Manufacturers procured raw material from arecanut growers on paying Rs. 1.2 per leaf sheath. Farmers incurred an expenditure of Rs. 1400 towards collection and bundling of leaf sheaths in their gardens. Arecanut growers realized net returns of Rs. 17800 ha^{-1} after making provision for expenditure. The net income per leaf sheath worked out to Rs. 1.11.

Capital investment on areca leaf plate making unit: The buildings and machineries accounted for 89.04 per cent of the total investment (Table 2). The remaining 10.96 per cent was shared by water supply unit (6.1%) and motors meant for running machineries (4.86%) (Table 2). Plate and bowl manufacturing machines connected with dies of different dimensions accounted for 48.39 per cent of the total investment. The 10 hp motor was used to run machineries for plates and bowls while 2 hp motor was used to run washing gun for cleaning arecanut leaf sheaths. The water supply unit was installed to ensure constant water supply to the manufacturing unit.

Table 1. Income accrued to areca farmers from sale of by-products

Particulars	Value
Number of palms ha^{-1}	1600
Number of leaf sheaths ha^{-1}	16000
Expenditure towards collection of leaf sheaths ha^{-1} (Rs.)	1400
Price per leaf sheath (Rs,)	1.2
Gross returns per ha (Rs.)	19200
Net returns ha^{-1} (Rs.)	17800
Net returns per leaf sheath (Rs.)	1.11

Table 2. Capital investment on areca leaf product manufacturing unit

Particulars	Quantity (No.)	Value (Rs.)	% Share
Buildings machineries	2	545668	40.65
5 dies machine	1	362500	27.00
3 dies machine	1	181350	13.51
Bowl making machine @ Rs. 26440 machine^{-1}	4	105760	7.88
10 hp motor	1	42350	3.15
2 hp motor with washing gun	1	22800	1.70
Borewell and irrigation pumpset	1	75720	5.64
Sintex tank	1	6235	0.46
Total capital investment		1342383	100.00

Economics of areca leaf plates and bowl manufacturing: The variable cost ranged from 80.32 percent in 20 cm plates to 90.78 percent in 30 cm plates. The cost was 66.17 and 76.27 percent in case of 11 cm and 15 cm bowls, respectively. The remaining percentage was contributed by fixed costs. Among variable costs, labour cornered major share ranging from 34.45 per cent in 20 cm to 40.17 per cent in 30 cm plates. The share of labour was 24.49 per cent to 30.51 percent in case of 11 and 15 cm bowls. Electricity share was around 10 per cent in plates and ranged between 6 to 8 per cent in bowls. Interest on working capital was calculated as a proxy for opportunity cost of working capital. It varied from 19.68 per cent in 20 cm plates to 9.22 per cent in 30 cm plates. Among fixed costs, depreciation and interest on fixed capital cornered major share in case of bowls and plates. Net returns accrued from production of plates varied from 0.27 to 2.07 lakh and Rs. 0.27 to Rs. 1.02 lakh for bowls, respectively.

Packing operation followed at areca leaf plates and bowls manufacturing units: Packing and packaging was meant for preparing finished products for marketing. The materials used for packing included small polythene covers, while packaging required large sized covers of 42 inches and 43 inches size, twines and stitching thread. Packaging prevents likely damage to the products during transit, eases handling and enhances shelf life. Hence, quality packing materials had been used to reach the destination with minimum or no loss. An amount of Rs. 29,052, Rs. 34,416 and Rs. 6,732 for 30 cm, 25 cm and 20 cm plates and Rs. 14,544 and Rs. 12,672 for 15 cm and 11 cm bowls was incurred on packing operation (Table 4).

Per unit costs and returns: Table 5 indicates per unit costs and returns of plates and bowls. The per unit cost inclusive of variable and fixed costs came to Rs. 2.21, Rs. 1.62, Rs. 1.15, Rs. 0.73 and Rs. 0.51 in case of 30 cm, 25 cm, 20 cm plates and 15 cm and 11 cm bowls, respectively. The profit realized per unit was the highest in case of 30 cm plates (Rs. 0.64) and lowest in case of 25 cm plates (Rs. 0.23). As regards bowls, profit per unit was highest in case of 15 cm (Rs. 0.47) and lowest in case of 11 cm (Rs. 0.29).

Table 3. Economics of areca leaf plates and bowls (Rs.)

Particulars	30 cm	25 cm	20 cm	15 cm	11 cm
I. Variable cost (VC)					
Raw materials	183825 (25.67)	170208 (24.39)	27233 (22.00)	30637 (19.49)	17234 (15.64)
Labour	287643 (40.17)	266321 (38.16)	42635 (34.45)	47961 (30.51)	26990 (24.49)
Packing materials	29052 (4.06)	34416 (4.93)	6732 (5.44)	14544 (9.25)	12672 (11.50)
Electricity charges	78035 (10.90)	72255 (10.35)	11560 (9.34)	13006 (8.27)	7316 (6.64)
Annual repairs	1814 (0.25)	2418 (0.35)	605 (0.49)	909 (0.58)	909 (0.82)
Interest on working capital @ 12% annum[-1]	69644 (9.73)	65474 (9.38)	10652 (8.61)	12847 (8.17)	7815 (7.09)
Sub total	650013 (90.78)	611092 (87.56)	99417 (80.32)	119904 (76.27)	72936 (66.17)
II. Fixed cost (FC)					
Depreciation	24397 (3.41)	31802 (4.56)	9587 (7.75)	9099 (5.79)	9099 (8.26)
Rental value of land	1350 (0.19)	1350 (0.19)	1350 (1.09)	1350 (0.86)	1350 (1.22)
Interest on fixed capital @ 12 % annum[-1]	40272 (5.62)	53706 (7.69)	13418 (10.84)	26853 (17.08)	26837 (24.35)
Sub total	66019 (9.22)	86858 (12.44)	24355 (19.68)	37302 (23.73)	37286 (33.83)
Grand total (VC+FC)	716032	697950	123772	157206	110222
Total returns	923400	799200	151200	259200	172800
Net returns	207368	101250	27428	101994	62578

Note:
1. Price per sq cm of raw material (areca leaf sheath) =0.000611
2. Electricity charge to press one sq cm of areca leaf sheath = 0.000259
3. Quantity of areca leaf sheath used in manufacturing 30 cm plates (301005849 sqcm), 25 cm plates (278709120 sqcm),20cm plates (44593459sqcm), 15 cm bowls(50167641sqcm) and 11 cm bowls(28219298.4sqcm)
4. Figures in the parentheses indicate percentage to the total

Table 4. Cost of packing materials in areca leaf plates and bowls manufacturing units

Packing materials	30 cm			25 cm			20 cm			15 cm			11 cm		
	Qty	Rate	Value	Qty	Rate	Value	Qty	Rate	Value	Qty	Rate	Value	Qty	Rate	Value
Twines to bundle plates and bowls	6480	0.4166	2700	8640	0.4166	3600	2160	0.4166	900	8640	0.4166	3600	8640	0.4166	3600
Packing materials for making small packets of 50 plates each and 25 bowls each with polythene covers (kg)	64.8	140	9072	86.4	140	12096	21.6	140	3024	72	100	7200	72	100	7200
Packing materials required for packing the above packets (No.)	720	22	15840	720	24	17280	108	24	2592	144	24	3456	72	24	1728
Stitching material	720	2	1440	720	2	1440	108	2	216	144	2	288	72	2	144
Total			29052			34416			6732			14544			12672

Economic feasibility of investment on areca leaf plate unit: Economic feasibility of investment on areca leaf plate industry was examined using discounted and undiscounted cash flow measures (Table 6). NPW was obtained by deducting discounted costs from discounted returns, which came to Rs. 46 lakh. Since, NPW is positive, the investment on areca leaf plate industry was economically worthwhile. This indicates the amount of wealth generated by the unit over its life period after duly accounting for inflation. BCR was obtained as the ratio of discounted returns to the discounted costs, at 1.42 indicating that every rupee of investment on leaf plate manufacturing unit would generate returns of Rs. 1.42. Another discount rate higher than the previous discount rate was selected and discounting procedure was repeated until negative NPW was obtained. IRR was estimated using interpolation method. IRR came to 212.90 per cent indicating the rate of returns on investment. As the IRR was quite high, entrepreneurs can borrow credit from commercial banks or cooperatives at the rate of 12 percent and invest on areca leaf plate unit to reap returns at the rate of 212.90 per cent over investment. In addition to these, profitability index was constructed by taking the ratio of NPW and initial investment

Table 5. Unit costs and returns of areca leaf plates and bowls (Rs.)

Particulars/Dimensions	Plates			Bowls	
	30 cm	25 cm	20 cm	15 cm	11 cm
Raw material	0.57	0.39	0.25	0.14	0.08
Labour	0.89	0.62	0.39	0.22	0.12
Packing materials	0.09	0.08	0.06	0.07	0.06
Electricity charges	0.24	0.17	0.11	0.06	0.03
Annual repairs	0.01	0.01	0.01	0.00	0.00
Interest on working capital @ 7 % per annum	0.21	0.15	0.10	0.06	0.04
Variable cost	2.01	1.41	0.92	0.56	0.34
Fixed cost	0.20	0.20	0.23	0.17	0.17
Total cost	2.21	1.62	1.15	0.73	0.51
Sale price	2.85	1.85	1.4	1.2	0.8
Profit	0.64	0.23	0.25	0.47	0.29

Table 6. Economic feasibility of investment on areca leaf product manufacturing unit

Particulars	Value
Net Present Worth (NPW) @ 12%	4683397
Discounted Benefit Cost Ratio (DBCR)	1.42
Internal Rate of Return (IRR) %	212.9
Profitability index	3.49
Pay Back Period (PBP) in years	2.68
Proceeds per rupee of outlay	1.48
Average proceeds per rupee of outlay	2.19

made on the project. The index worked out to 3.49. Undiscounted measures such as payback period, proceeds per rupee of outlay and average annual proceeds were worked out. Payback period was 2.68 years suggesting that initial investment made on the unit could be recovered within 2.68 years. Proceeds per rupee of outlay and average annual proceeds per rupee of outlay worked out to 1.48 and 2.19.

Employment potential of areca leaf plate making unit: Table 7 indicates employment potential of arecanut leaf plate manufacturing industry. On an average 3344.6 mandays of labour employment was generated annually. Men were employed to perform operation of drying and stocking of raw materials in godown. About 395 mandays of employment was generated per annum. The women labour was employed to perform operations such as washing of leaf sheaths, manufacturing of plates, bowls and packing/packaging of finished products. A total employment of 3687 woman days was generated for women folk per annum. This being a rural industry served as a persistent source of employment for women to a greater extent thereby preventing migration of rural labour force to nearby cities and towns. Setting up of such industries not only utilize by-products efficiently but also provides livelihood to many landless families.

Marketing costs, margins and price spread: Costs incurred and margins realized by wholesalers and retailers in moving finished areca leaf products to consumers is presented in Table 8. The total marketing costs of wholesalers and retailers put together was Rs. 0.83 plate^{-1} for 30 cm plate and marketing margin was Rs. 0.82 plate^{-1}. Similarly, marketing costs incurred and margins realized by the above intermediaries in case of 25 cm and 20 cm plates worked out to Rs. 1.15 and Rs. 1.10 plate^{-1}. In case of 15 cm and 11 cm bowls, the total of marketing costs and margins came to Rs. 0.80 and Rs. 0.60, respectively. It could be observed that price spread decreased with decrease in the dimension of areca leaf products. Price spread was substantial across leaf products indicating that intermediaries have cornered major share in consumer rupee leaving negligible amount to producers and consumers.

Value addition: The results pertaining to value addition has been worked out and presented in Table 9. Value addition

was 400 percent in case of 30 cm plates. Raw material worth of Rs. 0.57 was purchased by the manufacturer to prepare 30 cm plate. This was sold at Rs. 2.85 plate^{-1}. Thus, value addition in absolute terms came to Rs. 2.28 and percent value addition came to $[(2.85-0.57)/(0.57)]*100 = 400$ percent. Similarly, percent value addition for 25 cm and 20 cm plates was 374 and 460 percent, respectively. In case of 15 cm and 11 cm bowls, the value addition was 757 and 900 percent, respectively.

Constraints

Defective raw materials: The manufacturer procures raw materials directly from arecanut growers. Farmers gather fallen leaf sheaths in the garden and bundle them into 25 numbers. In the process of gathering and bundling, there is a possibility for inclusion of broken/ defective/infested/ undersized leaf sheaths in the bundle. These defective leaf

Table 8. Marketing costs, margins and price spread in marketing of areca leaf products

Particulars/ Dimension	Plates			Bowls	
	30 cm	25 cm	20 cm	15 cm	11 cm
Manufacturer's selling price to wholesaler (Rs.)	2.85	1.85	1.4	1.2	0.8
Wholesaler's cost (Rs.)	0.18	0.12	0.09	0.08	0.05
Wholesaler's margin (Rs.)	0.22	0.13	0.11	0.12	0.15
Retailer's Cost (Rs.)	0.65	0.4	0.3	0.3	0.2
Retailer's margin (Rs.)	0.6	0.5	0.6	0.3	0.2
Consumer price/Retail Price (Rs,)	4.5	3	2.5	2	1.4
Total marketing cost (Rs,)	0.83	0.52	0.39	0.38	0.25
Total marketing margin (Rs.)	0.82	0.63	0.71	0.42	0.35
Price spread (Rs.)	1.65	1.15	1.1	0.8	0.6

Table 9. Value addition in areca leaf plate and bowl manufacturing unit

Particulars/Dimension	Plates			Bowls	
	30 cm	25 cm	20 cm	15 cm	11 cm
Farmers price (Rs.)	0.57	0.39	0.25	0.14	0.08
Manufacturer's cost (Rs.)	2.21	1.62	1.15	0.73	0.51
Manufacturer's margin (Rs.)	0.64	0.23	0.25	0.47	0.29
Manufacturer's selling price (Rs.)	2.85	1.85	1.4	1.2	0.8
Value addition %	400	374.00	460	757	900

Table 7. Employment potential of areca leaf plate manufacturing unit

Operations	Men labour	Women labour	Mandays
Drying of leaf sheaths and piling of dried leaf sheaths in go down	395		395
Washing of leaf sheaths and readying it for plate/bowl making		365	292
Pressing of leaf sheaths into plates/bowls		2592	2073.6
Packing of plates and bowls (bundling of plates, packing, packaging and stitching)		730	584
Total	395	3687	3344.6

sheaths have to be discarded in the process of manufacturing as the products produced out of such raw materials will have poor consumer preferences. It is likely that about 10 per cent of the raw material procured goes waste thereby adding to the cost of raw material and consequently rises cost of production.

Competition from large units: Due to stiff competition posed by large manufacturing units of areca leaf plates and bowls for export, the cost of raw material has gone up in the recent past. This hinders the emergence of rural based small and medium scale units as they cannot thrive in the competition.

Irregular power supply*: Irregular power supply has affected functioning of areca leaf sheath manufacturing units in rural area. Due to erratic power supply especially during day time, production of leaf products gets affected. Under such circumstances, the owner of the unit fails to comply with the promises made to the purchasers. This calls for government's attention to ensure continuous power supply during day time to encourage rural industries.

Labour scarcity: Lack of skilled labour in the rural area is another problem confronting the entrepreneurs. Even if few labour are available with skill to run machineries, they demand higher wages and consequently results in increased cost of production.

Huge initial investment: Establishment of areca leaf plate manufacturing unit requires huge investment. The entrepreneurs with little means cannot afford huge investments. Hence, in order to encourage the upcoming entrepreneurs from rural areas, subsidies should be given on plant and machineries as these enterprises are eco-friendly and utilize by-products of arecanut gardens efficiently.

CONCLUSIONS

The foregoing discussion indicated that the

establishment of areca leaf plate and bowl manufacturing unit on small scale requires an investment of Rs. 13.42 lakhs. The net returns per plate came to Rs. 0.64, Rs. 0.23, Rs. 0.25 and Rs. 0.47 and Rs. 0.29 in case of bowls. The manufacturing unit generated 3344.60 mandays of employment for rural labour. Further, the study indicated economic viability of investment on the unit by assuring IRR of 212.90 per cent. The initial investment could be recovered in 2.68 years as indicated by payback period. The percentage value addition ranged from 374 per cent in 25 cm plates to 460 per cent in 20 cm plates and 757 per cent in 15 cm to 900 per cent in 11 cm bowls. As the investment is huge, the rural entrepreneurs with little financial back up cannot venture into this kind of business. Hence, the government/ District industries centres/ Department of small scale industries should come forward to subsidize to an extent of 50 per cent to encourage small scale rural industries. Promotion of cooperatives in this field would help both producers and consumers. Possibility of usage of solar energy instead of electricity may be explored to ensure continuous functioning of the units.

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Ethnomedicinal Plants used by the Halam Tribe of North Tripura, Northeast India

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Abstract: Documentation of ethnobotanical knowledge of indigenous communities is vital for conservation and sustainable utilization of biodiversity. Traditional beliefs, concepts, knowledge and practices for preventing, lessening, and curing disease are still witnessed among the Halam tribe of North Tripura, northeast India. Extensive field visits and household surveys were carried out in three villages *viz. Noagaon*, *Zuithung*, and *Baghbasha* of Dharmanagar, North Tripura district following standard protocol during February 2012 to January 2014. Findings revealed the use of 52 medicinal plants comprising of trees, herbs, shrubs, bushes, and climbers for treating 30 different ailments mainly abdominal pain, cough, dysentery, jaundice, intestinal worms . Usage of herbs was highest (48.08%), followed by trees (21%). Utilization of different plant parts viz., seed, flower, leaf, stem, bark, root, rhizome, and, even the whole plant in some cases was observed, amongst which usage of leaves was highest (41%), followed by fruits (19%) amongst all plant forms. We also reported usage of two important medicinal plants *Alstonia scholaris* (L.) R. Br. and *Cissus quadrangularis* L. plant for treating snakebite and healing bone fracture respectively, which also resonates with the findings of other workers from different parts of India. However, such immense knowledge of the Halam tribe is rapidly declining due to rapid modernization and adaptation to changing lifestyle by the younger generation. Hence, there is an urgent need to document traditional knowledge on the medicinal plants of the Halam tribe before such valuable knowledge vanishes.

Since time immemorial, human are using plants for medicinal purpose and are continuing to be used by large tribal and poor communities especially in developing countries like India (Abu-Rabia 2005, Kagyung et al 2010). Thus, the studies of the tribal indigenous knowledge of plants constitute an important and preliminary aspect of ethnobotanical research. Documentation of the ethnobotanical-knowledge and practices of indigenous communities is vital for the conservation and sustainable utilization of biodiversity (Nizar et al 2015). In developing countries, medicinal plants are used as sources of medicine in virtually all cultures because of their lesser side-effects and better compatibility with the human body. According to the World Health Organization (2001), herbal medicines serve the health needs of about 80% of the world's population, especially for millions of people in the rural areas of developing countries. Northeast India comprising of eight different states are inhabited by more than 200 tribal groups with distinct socio-cultural aspects (Mao et al 2009). The use of plants as food and medicines is common among the ethnic groups of Northeast India (Kagyung et al 2010, Rajkumari et al 2013, Debbarma et al 2017). However, in comparison to the diversity of tribal communities residing in northeast India, studies conducted so far can be considered as in the preliminary stage.

The Halam tribe living in close proximity of the forests has mesmerizing culture and tradition. They have their own practice of traditional herbal medicines inherited from their forefathers and they have deep faith upon their old treaties and tradition gained through generations. Majority of them are dependent on herbal practices using traditional knowledge for preventing, lessening and curing diseases. Thus, the indigenous system of treatment based on medicinal plants is still an important part of social life and culture among the Halam. Hence, it is very important to document the traditional knowledge on ethnomedicinal use of Halam tribe of Tripura. Considering this, the present study was carried with an objective to explore and document the medicinal plants used by the Halam tribe of north Tripura, northeast India. The findings of the study will be helpful in adopting better conservation strategies of the valuable plants used as ethnomedicine for sustainable use of these natural resources.

MATERIAL AND METHODS

Study area: The study area comprised of three villages viz., *Noagaon*, *Zuithung* and *Baghbasha* located in Dharmanagar, North Tripura district of Tripura state in northeast India (24°37′ North latitudes and 92°17′ East longitudes) , with an average elevation of 21 meters (68 feet). North Tripura is home to a majority of the *'Korborok'* speaking tribes though Bengali is mostly spoken here. The main tribes

inhabiting this region are *Chakma, Halam, Koloi* and *Tripuri*.
Collection of ethnobotanical data: The survey was conducted for the period two years from February 2012 to January 2014, and for this prior informed consent and permission was obtained from the village heads and each participant verbally. For the household interviews, we used an open-ended questionnaire comprising various aspects of ethnomedicinal uses including plant species used as ethnomedicines, plant parts used, dosage preparation, ailments/diseases treated etc. The interviews were conducted in Bengali language, and the responses were recorded in English on the questionnaire. To gather information on the ethno-medico-botanical aspects of the Halam tribe, extensive field surveys were conducted using standard approaches and methodologies (Schultes 1960, 1962, Jain 1987, 1989). The tribal medicine practitioners, aged and experienced people, and forest dwellers, who have the knowledge of utilizing the plants as medicines were mainly interviewed to record the required information. Information was obtained from 72 randomly selected residents comprising 56 men and 16 women. The age range of the interviewees varied from 22 to 76 years. Only participants over 20 years of age were considered as respondents. Collections of the medicinal plants were done following the routine method and herbariums of the collected plants were prepared following standard protocols (Jain and Rao 1977). The plants were collected in its flowering and fruiting stage as far as possible from the natural habitat. Queries have been made repeatedly, occasionally asking help from interpreters for confirmation of data on each medicinal plant. Information regarding vernacular names, plant/plant part(s) used for treatment, the process of the preparation of medicine for the treatment of particular diseases were recorded. For authentic identification, several Floras and Monographs have been consulted (Hooker 1872-1897, Kanjilal et al 1934, 1936, 1938, 1940, Bor 1940, Deb 1981, 1983, Sharma et al 1993, Das et al 2010). Besides, online website i.e., http://www.theplantlist.org (retrieved on December 17,2018) was consulted to know the updated name of the flora recorded during the study. Specimens were authenticated with the consultation of Herbarium maintained at Botanical Survey of India, Shillong. Identified herbarium sheets were deposited in the Department of Ecology and Environmental Sciences, Assam University, Silchar, India for future references.

Besides, the use value (UV) for each medicinal plant species was calculated using the equation as follows (Phillips et al 1994):

$$\text{Use value (UV)} = \frac{U}{n}$$

Where, 'U' is the number of times a species was cited and, 'n' is the number of total respondents. UV is a quantitative method for evaluating the relative importance of each medicinal species based on its relative use by the respondents. All the collected data were analyzed using Microsoft Office Excel 2007.

RESULTS AND DISCUSSION

The Halams manifest various cultural features including supernatural beliefs and practices which signify a primitive level of socio-cultural existence in their society (Plate 1). Plant diversity profile and usage of different ethnomedicinal plants by the Halam tribe are represented in Table 1. Total of 52 medicinal plants belonging to 52 genera of 39 families were recorded (Table 1). Usage were highest for the families- Poaceae (4 species) and Asteraceae (3 species) (Fig 1). Ten common ethnomedicinal plants namely *Aegle marmelos* (L.) Corrêa, *Andrographis paniculata* (Burm.f.) Nees, *Averrhoa carambola* L., *Azadirachta indica* A.Juss., *Cajanus cajan* (L.) Millsp., *Cissus quadrangularis* L., *Justicia adhatoda* L., *Momordica charantia* L., *Ocimum tenuiflorum* L., *Terminalia chebula* Retz. were used by all the respondents of the Halam tribe since generations. Climbers were represented by five genera of 4 families, herbs by 25 genera of 19 families, sub-shrubs by 4 genera of 4 families, shrubs were by 6 genera of 6 families, and tree species by 12 genera of 11 families. These plants were used in treating 30 different ailments/diseases such as cough, dysentery, malarial fever, jaundice, abdominal problems, bone fracture, gynaecological problems, intestinal worm, snake bite, diarrhea, blood coagulation etc. (Table 1). Out of the 52 plant species, abdominal problems were treated by the maximum number of plants (7 species), and at least with one species each for 17 diseases among others (Table 2). Usage of herbs was highest (48.08%) among all the plant forms, followed by trees (21%) (Fig. 2). Utilization of leaves was highest (41%), followed by fruits (19%) (Fig. 3). For ethnomedicinal uses, the Halams mainly used the plant leaves as this part was used maximum with 22 species, followed by the fruits, bark, whole plants. Amjad et al (2015) and Bose et al (2015) also reported the highest use of leaves of the medicinal plants in the majority of remedies. Besides, Biswakarma et al (2015) and Anand and Deborah (2016) also reported the dominant use of fruits of the medicinal plants as remedies.

Use value: The use value of plant species ranged between 0.01–0.96 (Table 1). The highest use value was estimated for *Zingiber officinale* Roscoe (0.96), followed by *Andrographis paniculata* (Burm.f.) Nees, *Azadirachta indica A. juss*. These mostly used species with high use values were abundant in the wild and some were also grown in the homegardens by the Halams. Saxena et al (2012) suggested that *Alstonia*

Table 1. Medicinal plants used by the Halam tribe to treat various ailments, and use value of the medicinal plants

Species name	Common/ English name (Vernacular name)	Family	Habit	Plant parts used	Ailments/diseases treated	Use value
Acmella paniculata (Wall. ex DC.) R.K.Jansen	Panicled spot flower (*Ansa*)	Asteraceae	Herb	Whole plant	Piles	0.17
Alstonia scholaris (L.) R. Br. (Plate 1; B)	Devil tree (*Lethuang*)	Apocynaceae	Tree	Bark	Snake bite	0.11
Aegle marmelos (L.) Corrêa	Bael (*Bel*)	Rutaceae	Tree	Fruit	Dysentery	0.42
Allium sativum L.	Garlic (*Porungui*)	Alliaceae	Herb	Fruit	High blood pressure, Stomach Pain.	0.19
Aloe vera (L.) Burm.f.	Aloe vera (*Kumthumbang Par*)	Liliaceae	Herb	Whole plant	Wound, headache, nerve problem, primary burned skin	0.85
Amaranthus spinosus L.	Spiny amaranth (*Cheaksentai*)	Amaranthaceae	Herb	Leaf	Wound	0.58
Ananas comosus (L.) Merr.	Pineapple (*Morto*)	Bromeliaceae	Herb	Stem	Toothache	0.28
Andrographis paniculata (Burm.f.) Nees (Plate 1; F)	King of bitters (*Chirata*)	Acanthaceae	Herb	Leaf	Abdominal problems, Malarial fever	0.94
Averrhoa carambola L.	Star fruit (*Theimeurkoi*)	Averrhoaceae	Tree	Fruit	Jaundice	0.86
Azadirachta indica A.Juss.	Indian *Lilac* (*Neem*)	Meliaceae	Tree	Leaf, Fruit	Jaundice, Intestinal worm	0.92
Bambusa sp.	Bamboo (*Row*)	Poaceae	Herb	Bark	Blood clotting	0.26
Bryophyllum pinnatum (Lam.) Oken (Plate 1; C)	Air plant (*Nadapak*)	Crassulaceae	Herb	Leaf	Kidney stone, Diabetes	0.36
Cajanus cajan (L.) Millsp.	Pigeon pea (*Khakleing*)	Papilionaceae	Under shrub	Leaf, Root	Jaundice	0.22
Calotropis gigantea (L.) Dryand. (Plate 1; A)	Crown flower (*Lepol*)	Asclepiadaceae	Shrub	Leaf	Dysentery	0.11
Carica papaya L. (Plate 1; E)	Papaya (*Koipol*)	Caricaceae	Herb	Fruit, Flower	Dog-bite	0.25
Catharanthus roseus (L.) G.Don	Madagascar periwinkle (*Skoolpar*)	Apocynaceae	Herb	Leaf	Abdominal problems	0.19
Centella asiatica (L.) Urb.	Asiatic pennywort (*Nadapak*)	Apiaceae	Herb	Leaf	Blood pressure	0.44
Chenopodium album L.	Pigweed (*Bathua*)	Chenopdiaceae	Herb	Leaf	Abdominal problems	0.25
Chromolaena odorata (L.) R.M.King & H.Rob.	Siam weed (*Damkoldon*)	Asteraceae	Herb	Leaf	Itching	0.51
Cissus quadrangularis L.	Veldt Grape (*Harjura*)	Vitaceae	Climber	Whole plant	Bone fracture	0.07
Citrus maxima (Burm.) Merr.	Pomelo (*Matu*)	Rutaceae	Shrub	Fruit	Intestinal worm	0.22
Clerodendrum infortunatum L.	Hill Glory Bower (*Zuthur*)	Verbanaceae	Herb	Leaf	Vomiting, blood clotting	0.39
Clitoria ternatea L.	Asian pigeonwings (*Moipar*)	Papilionaceae	Climber	Root	Gynecological problems	0.36
Cocos nucifera L.	Coconut (*Dab*)	Arecaceae	Tree	Tender fruit	Primary burn	0.33
Colocasia esculenta (L.) Schott.	Taro (*Bathuang*)	Araceae	Herb	Stem	Snake bite	0.17
Combretum pilosum Roxb. ex G.Don	The bushwillows (*Chwaklong*)	Combretaceae	Shrub	Leaf	Abdominal problems	0.11

Cucurbita pepo L.	Pumpkin *(Maibal)*	Cucurbitaceae	Climber	Fruit	Diarrhea	0.31
Curcuma longa L. (Plate 1; D)	Turmeric *(Yang)*	Zingiberaceae	Herb	Rhizome,	Gynecological problems	0.64
Cuscuta reflexa Roxb.	Amar Bel *(Sornalota)*	Cuscutaceae	Climber	Whole plant	Body ache, fever	0.26
Cymbopogon citratus (DC.) Stapf	Lemon grass *(Ramjaipuram)*	Poaceae	Herb	leaf	Cough	0.17
Cynodon dactylon (L.) Pers.	Bermuda grass *(Durpa)*	Poaceae	Herb	Leaf	Menstrual problem	0.32
Hibiscus rosa-sinensis L.	China-rose *(Nipuipar)*	Malvaceae	Shrub	Flower	Jaundice	0.24
Justicia adhatoda L.	Malabar nut *(Basok)*	Acanthaceae	Shrub	Leaf	cough	0.85
Mangifera indica L.	Mango *(Aam)*	Anacardiacaee	Tree	Bark	Gynecological problems	0.24
Melastoma malabathricum L.	Indian rhododendron *(Murkum)*	Melastomaceae	Shrub	Seed	Abdominal problem	0.31
Mentha arvensis L.	Wild mint *(Padina)*	Lemiaceae	Herb	Leaf	Liver problem	0.28
Mikania micrantha Kunth	Bitter vine *(Chiaktharparang)*	Asteraceae	Under shrub	leaf	Wound	0.40
Mimosa pudica L.	Touch-me-not *(Cheikanleita)*	Mimosaceae	Undershrub	Root	Boils on skin	0.49
Moringa oleifera Lam.	Drumstick tree *(Sajona)*	Moringaceae	Tree	leaf	Wound	0.25
Momordica charantia L.	Bitter gourd *(Kangkala)*	Cucurbitaceae	Climber	Leaf	Malaria and purification of blood	0.36
Musa × paradisiaca L.	Banana tree *(Moot)*	Musaceae	Herb	Stem	Clotting of blood, abdominal problems	0.40
Ocimum tenuiflorum L.	Holy basil *(Tulsi)*	Lamiaceae	Herb	Leaf	Cough	0.71
Oxalis corniculata L.	Creeping wood sorrel *(Kakluangopoa)*	Oxalidaceae	Herb	Whole plant	Abdominal problems, Blood clotting	0.24
Psidium guajava L.	*Common guava (Soviri)*	Myrtaceae	Tree	Leaf	Dysentery	0.31
Saccharum officinarum L.	Sugarcane *(Meso)*	Poaceae	Herb	Stem	Jaundice	0.72
Scoparia dulcis L.	Goat weed *(Harjura)*	Scrophulariaceae	Herb	Leaf, Root	Bone fracture	0.01
Solanum torvum Sw.	Turkey Berry *(Daidil)*	Solanaceae	Under shrub	Fruit	Abdominal problems	0.13
Streblus asper Lour.	Siamese rough bush *(siyor)*	Moraceae	Tree	Bark	Gynecological problems	0.43
Tamarindus indica L.	Tamarind *(Thentherei)*	Caesalpiniaceae	Tree	Fruit	Vomiting	0.71
Terminalia chebula Retz.	Chebulic Myrobalan *(Horthoki)*	Combretaceae	Tree	Bark, Fruit	Liver problem	0.83
Zingiber officinale Roscoe	Ginger *(Ada)*	Zingiberaceae	Herb	Rhizome	Cough, lactation problem after delivery	0.96
Ziziphus mauritiana Lam.	*Chinese date (Boroi)*	Rhamnaceae	Tree	Bark	Dysentery	0.36
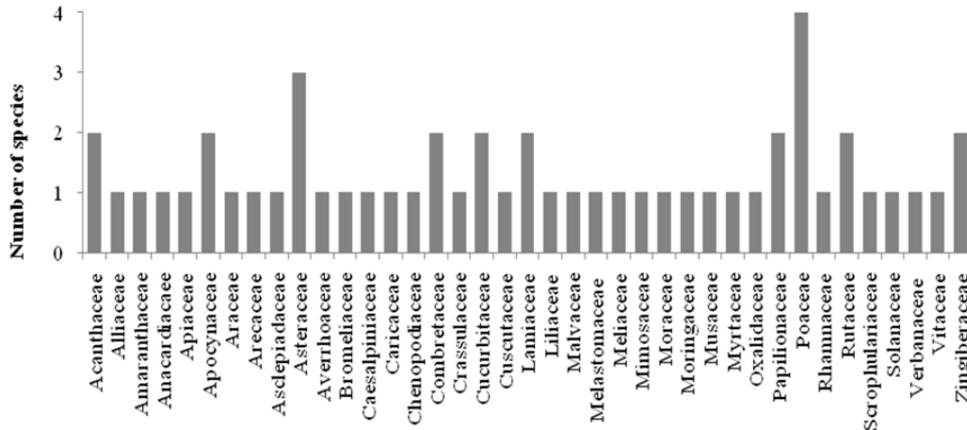
Fig. 1. Number of medicinal plant species under different families of medicinal plants used by the Halam tribe
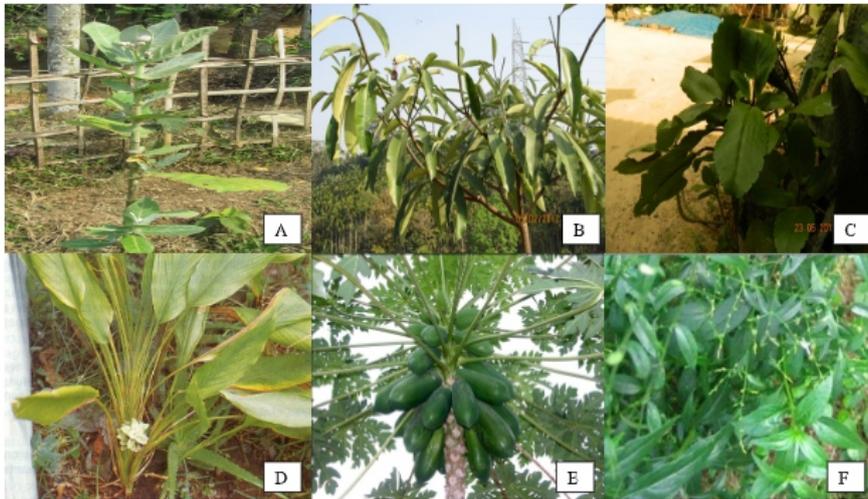
Plate 2. Some medicinal plants used by the Halam tribe (A-*Calotropis gigantea* (L.) Dryand; B-*Alstonia scholaris* (L.) R. Br.; C- *Bryophyllum pinnatum* (Lam.) Oken; D- *Curcuma longa* L.; E- *Carica papaya* L.; F- *Andrographis paniculata* (Burm.f.) Nees)

Plate 1: The socio-cultural aspects of the Halam tribe (A- A typical house of Halam; B- Traditional attire of Halam women; C- Various bamboo containers prepared by the Halam tribe; D- Traditional cooking method of the Halams

Table 2. Number of species used by the Halams as ethnomedicine against a particular disease/ailment

Ailments/disease treated	Species used
Abdominal problems	7
Blood clotting, jaundice	6
Gynaecological problems	5
Cough, dysentery and wound	4
Malarial fever	3
Snake bite, burn, intestinal worm, bone fracture, liver problem and vomiting	2
Blood purification, piles, itching, high blood pressure, head ache, neurological disorder, dog bite, diarrhoea, body ache, general fever, kidney stone, diabetes, skin disease, lactation problem, menstrual problem and toothache	1
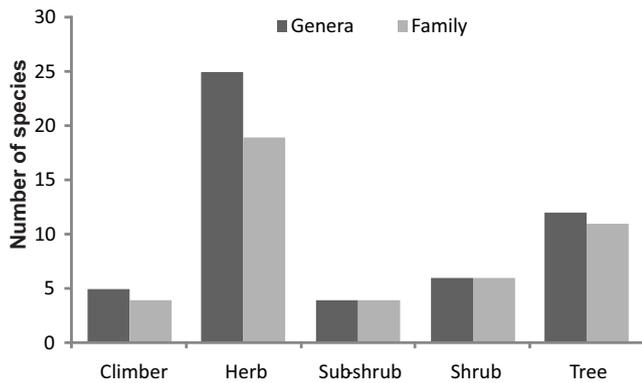
Fig. 2. Number of medicinal plants under genera and family on the basis of their life form
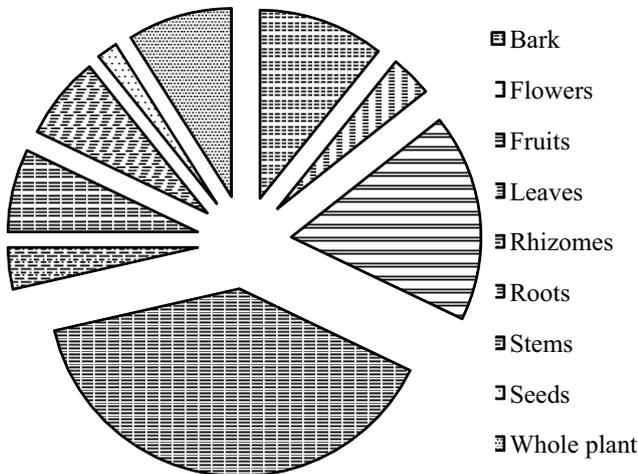
Fig. 3. Usage of different parts of the medicinal plants

scholaris (L.) R. Br. serves as one of the important sources of folklore medicines. In the present study, the Halam tribe used the bark of *Alstonia scholaris* (L.) R. Br. for treating snakebite (Table 1), which resonates with the findings of some workers reporting the use of *Alstonia scholaris* (L.) R. Br. against treating snakebite (Verma et al 2007, Mollik et al 2010), due to the presence of compound like pentacyclic triterpenes (free or as glycosides) (Meenatchisundaram et al 2008). Usage of *Cissus quadrangularis* L. by the common folk for treating against bone fracture is an old practice in India (Mishra et al 2010) and similar trend was observed in the present case.

CONCLUSION

The present study highlighted the rich ethnobotanical knowledge of the Halam tribe of North Tripura in treating various ailments. The Halams of north Tripura are dependent on the domesticated as well as wild plant resources for their personal health care on day-to-day basis. The calculated use values of the medicinal plants revealed that most of the species with high Use Value (UV) are grown in their home gardens. Thus, it can be concluded that the Halam tribe are utilizing the medicinal plants in sustainable manner, and posing minimal pressure on the wild local flora. However, the claimed medicinal values of the reported species are to be critically studied to establish their safety and effectiveness.

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