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Assessment of Fish Diversity in Relation to Water Quality in Ramganga River, India

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Abstract: The Ramganga River is comparatively cleaner in the hills (upper stretch) than the plains (middle and lower stretches) where it faces fragmentation, water abstractions, municipal sewage as well as industrial pollution from the industrialized and urban districts of Moradabad, Rampur and Bareilly. The water quality index (WQI) values are calculated for four sites in the middle and lower stretches using 15 water quality parameters (pH, EC, TDS, TSS, TS, Alk, Cl^-, $NO3^-$, $NO2^-$, NH_4^+, PO_4^{-3}, SO_4^{-2}, DO, BOD, COD). Excellent water quality is not reported at any location during the sampling. Katghar in Moradabad (RRG2) has the lowest water quality and low fish diversity indicating a loss of suitability for sustaining aquatic life due to the destruction of natural habitats, increased level of pollution, and over-exploitation of the species. The habitat type at RRG2 is dominated by pools that are not suitable for sustaining ample diversity. Chaubari in Bareilly (RRG3) has a great ichthyofaunal diversity because of the variety of habitats at this site from pools to rifles, runs, grassed banks and backwaters which provide suitable habitats for sustaining a good diversity. This study will serve as a baseline study for the fish diversity status of River Ramganga and its relation to water quality.

Keywords: Ramganga River, Fish diversity, Water quality index, Anthropogenic pollution, Heterogenous pollution sources

Freshwater is important for all forms of life on earth; however, it comprises less than 3% of the total available water on the planet (Slathia and Langer 2022). Freshwater habitats cover less than 1% of the global expanse and provide shelter to greater than 7% species of the total available species on the earth (Dudgeon et al 2006). Approximately 29,000 species of fish have been already identified; however, researchers believe that the number could be higher (Stendera et al 2012). Almost 13,000 species, 2513 genera of freshwater fish have been reported recently (Leveque et al 2008). Most fish belong to a few groups like *Cypriniformes, Clupeiformes, Osteoglossiformes, Beloniformes, Synbranchiformes, Siluriformes,* and *Perciformes*. The freshwater ichthyofaunal population in the tropical and subtropical regions is very diverse (Aguirre et al 2021). However, the temperate and polar regions are less diverse as cold-water conditions prevail. Because of their unique distribution patterns and habitat structures, riverine (stream) habitats harbour diverse biological communities and warrant extensive study of the patterns and drivers of community structure. These habitats occupy less than 1% of the earth's surface and are comprised of a variety of habitat types, harbour a disproportionately large number of species (Dudgeon et al 2006, Vorosmarty et al 2010).

The ichthyofaunal diversity is an important indicator of the ecological significance and understanding of a river, as sentinels of ecological integrity can be used for the endorsement of specific environmental flows (Jyothirmaye et al 2022). Because of comparative durability and agility, fish are regarded as valuable indicators for estimating the effect of many years in a riverine ecosystem. The extreme low flows (baseflow) conditions determine the hydraulic habitation and also the life cycle phases needed by various species of fish whereas the high flows determine the life cycle indications or habitat necessities. Throughout the phases of the life cycles in some distinct habitats, certain fish require permanent base flows whereas the others require high flows for migration and spawning. Such flows in a high quantity are also required for starting the development of the gonads and cleaning spawning beds and nursery areas. Various benthic fauna inclusive of the ichthyofauna gets a habitable environment due to diverse bedload materials that are responsible for the formation of pools, riffles, and bars. The spawning habitats and promising nursery grounds determine the species richness and fish community structure. Comparatively greater densities, higher biomass, and diversity as well as an abundance of species are present in the natural unaffected pristine channels (Dutta et al 2018). Damming, water abstractions, over-fishing, illegal fishing methods (use of dynamites) and the introduction of exotic fish species are some of the reasons behind declining fish diversity (Sarkar and Pal 2021).

River Ramganga is a good habitat for the Golden Mahseer (*Tor putitora*) fish which is found in the upper segment of the river. This river is also a favourable habitat for several species of Indian Major Carps (*Labeo calbasu, Labeo rohita, Labeo bata*), turtles (*Geoclemys hamiltonii, Melanochelys trijuga, Batagur dhongoka*), gharial (*Gavialis gangeticus*) and dolphins. The Ramganga is comparatively clean in the hills than the plains where it faces fragmentation at Kalagarh Dam, water abstractions at the Hareoli Barrage, municipal sewage as well as industrial pollution from the industrialized and urban districts of Moradabad, Rampur and Bareilly. The groundwater over-abstraction, floodplain encroachment and wetlands deterioration lead to reduced recharge and base flows. However, before its confluence with River Ganga, the Ramganga replenishes its health which is evident from Dabri that serves as favourable habitat for some of the endemic aquatic species of the Ramganga.

MATERIAL AND METHODS

Study area: With a catchment area of 24340.82 km^2, the Ramganga River is the first major tributary of the river Ganga (Khan et al 2016). The river originates in the form of a tiny spring in Diwali Khal from Namik glacier located in the Dudhotali range in Gairsain village of Chamoli district, Uttarakhand. The river passes through the Western Kumaon Himalayas before the confluence with the Ganga on its left bank in Farrukhabad district. It traverses 158 Km in the Western Himalayas before coming out through a U-shaped valley from the mountains in the most fertile Ganga Alluvial Plains (GAP). The river also covers the well-known Jim Corbett National Park where it placates the water requirements of the park. After covering a distance of 158 km, the river emerges out at the famous Kalagarh dam at an elevation of 365 m above mean sea level (MSL) in Kalagarh town. The river is a major water source fulfilling the daily water demands of two densely populated states of Uttarakhand and Uttar Pradesh. The river flows through Chakhutia, Bhikia Sain, Darchula, and Kalagarh areas in Uttarakhand and through Bijnor, Moradabad, Rampur, Bareilly, Shahjahanpur, Hardoi and Farrukhabad districts of Uttar Pradesh which are thickly populated and exploit the water from Ramganga for various agricultural, industrial and domestic needs (CWC 2012). The river also takes away the treated as well as untreated effluents load from highly industrialized districts of Moradabad, Rampur and Bareilly situated along the banks. Binao, Gagas, Mandal, Deota, Kosi, Kho, Phika, Dhela, Bhakra, and Baigul are the tributaries draining into this spring-fed river (Khan et al 2016). The details of the sampling sites and related features are given in Table 1 and the map of the study area is shown in Figure 1.

Water sampling: Water samples were collected from the sampling sites in the month of June 2019 for the water quality analysis. The water samples were collected at approx.1-foot depth in 1.5 L plastic bottles previously treated with 0.01 N nitric acid followed by washing with distilled water and

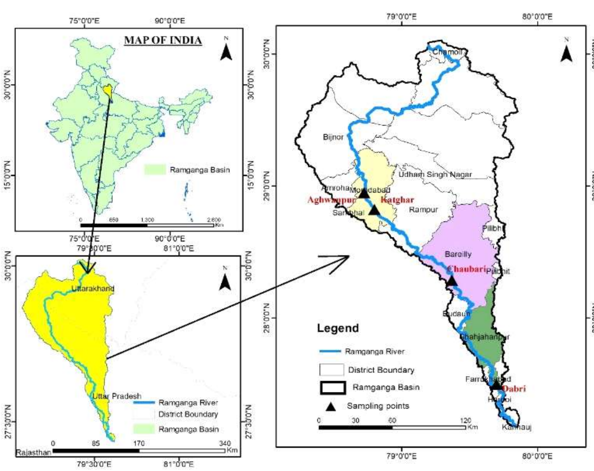

Fig. 1. Study area map of the Ramganga River Basin

Table 1. Detailed description of the sampling sites

Segment	Midstream	Midstream	Midstream	Downstream
Station name	Aghwanpur (Moradabad)	Katghar (Moradabad)	Chaubari (Bareilly)	Dabri (Shahjahanpur)
Sample Id	RRG1	RRG2	RRG3	RRG4
Pollution sources and features	Agricultural run-off (pesticides and fertilizers) from the nearby fields, sugar mill discharge, fishing, low velocity	Sewage discharge, waste dumping, illegal sand mining, thickly populated banks, low river velocity, domestic sewage and effluent discharge, urban effluents – e.g., domestic and industrial effluents, no riparian vegetation	Washing clothes/utensils, ritual activities, agricultural run-off, low flow velocity, decreasing riparian vegetation	Illegal fishing, agricultural run-off, body disposal, moderate velocity, decreasing riparian vegetation
Land use	Agriculture	Residential	Agriculture	Agriculture
Canopy	Shaded	Open	Mostly open	Open
Human settlement	Present	Present	Absent	Absent

brought to the Department of Environmental Sciences, BBAU for laboratory analysis under preserved conditions according to standard protocols. The samples were analysed for the physico-chemical parameters as per standard protocols (APHA 2017).

Water quality index: WQI is a mathematical tool that yields a single numerical figure from large water quality data. The data of the physicochemical parameters are calculated and a number is generated utilizing the values (Dutta et al 2018, Iqbal et al 2019). The water quality index is developed by the weighted arithmetic index method using 15 physicochemical parameters (pH, EC, TDS, TSS, TS, Alk, Cl^-, $NO3^-$, $NO2^-$, NH_4^+, PO_4^{-3}, SO_4^{-2}, DO, BOD, COD) that are of paramount interest while studying the freshwater ecosystems. The generated WQI value is classified in different ranges and allotted a definite class on the basis of the WQI value (Table 2). The Weighted Arithmetic Water Quality Index (WAWQI) was generated using the following equations (1-4) (Goel et al 2018).

$$Qn = 100\,(Vn - Vi)/Vs - Vi \qquad (1)$$

where Vs is the standard value and Vi is the ideal value

$$Wn = k/Sn \qquad (2)$$

$$K = \sum 1/Sn \qquad (3)$$

$$WQI = \frac{\sum QnWn}{Wn} \qquad (4)$$

Fish sampling: Experimental fishing was done from morning to late evening during the month of June 2019 in five different habitats (pool, run, riffle, rapid, and cascade) at each site with the help of expert local fishermen. Fish were caught with gill nets of different sizes (mesh size 2 × 2 cm, 3× 3cm) and cast net (sized 6 m diameter, mesh size 1-1.8 cm) with heavy iron sinkers so that the net settles down quickly in fast flowing water. The nets were positioned at sampling points to obtain the maximum number of fish samples from particular habitat. The collected fishes were preserved in 10% formaldehyde solution and brought to the laboratory for species-level taxonomic identification. Taxonomic identification was done on the basis of morphometric and meristic characters using standard keys (Jayaram 1994) with the help of experts in NBFGR (National Bureau of Fish Genetic Resources). The ecological diversity indices of each sampling site were calculated using PAST (Paleontological Statistics) software (VERSION 4.03) that included: Shannon index, Simpson index, Species richness, and evenness, Berger-Parker index, etc.,

Cluster analysis: Cluster analysis is a form of multivariate statistical technique that categorizes the complete data into various classes called clusters. The set of variables organized in groups or clusters is similar to each other than the variables of the other cluster. In the hierarchical agglomerative clustering analysis (HCA), the variables are classified into clusters on the basis of their inherent properties resulting in a tree-like structure called the dendrogram. In this study, the squared Euclidean distance technique and Ward's method were used. Statistical and computational analyses were performed using Microsoft Excel 2016 with XLSTAT (Student trial version) and IBM SPSS 20 software.

RESULTS AND DISCUSSION

Spatio-temporal variations in water quality: The pH ranged from 7.63 at RRG3 to 8.16 at RRG4. EC varied from 182.16 to 348.16. Dissolved oxygen (DO) is an important variable of water quality as it is required by the living organisms to sustain their life in water bodies ranged from 1.20 mg/L at RRG2 to 5.90 mg/L at RRG3. The biochemical oxygen demand (BOD) represents the organic matter load in the water body and was the lowest at RRG4 (7.43 mg/L) while it was the highest at RRG2 (33.35 mg/L). Fluoride in river water is mostly of geogenic origin and the level was comparatively high at RRG2, RRG3 and RRG4 except at RRG1 (0.12 m/L). Chemical oxygen demand (COD)

Table 2. Description of water quality index values with usage possibilities and health effects

Values	Water quality ranking	Usage possibilities and health effects
WQI < 25	Excellent	Quality of water is pristine; good for drinking, recreation, bathing, washing, crop irrigation, industrial purposes with no adverse health effects
26 ≤WQI < 50	Good	Quality of water closes to pristine but with little threat; conditions rarely depart from desirable levels; can be used for drinking after treatment but for all other purposes without treatment. No adverse health effects.
51 ≤ WQI < 75	Poor	Quality rarely threatened and usually protected; requires proper treatment before consumption, bathing or washing; can be used for crop irrigation and industrial purposes. Potential adverse health effects.
76 ≤ WQI < 100	Very poor	Quality is frequently impaired and the levels are undesirable; requires proper treatment so that it could be used for useful purposes. Potential adverse health effects.
WQI ≥ 100	Unfit for living being consumption	Water quality is continuously threatened; requires immediate curative action for improving the water quality; can be used only after proper treatment. Can adversely affect health

represents the organic as well as the inorganic load in the water bodies and it varied from 52.31 mg/L at RRG4 to 84.70 mg/L at RRG2 (Table 3).

Water quality index: WQI enables us to understand the extent to which the water body has been impacted by anthropogenic activity (Ustaoglu et al 2021). Excellent water quality is not reported at any locations during the sampling. The WQI values varied from 85.43 at RRG1 to 239.70 at RRG2 (Table 4). All the sites except RRG1 fall under the "Unfit for living being consumption" category which means that the water is heavily polluted with various pollutants from heterogeneous pollution sources. Anthropogenic disturbance and land use are quite probably important factors affecting the spatial patterns of water quality in rivers (Wu et al 2021). RRG1 falls under the "Poor" category as it has a comparatively lower pollutant load than the other sites. Human activities strongly affected the water quality of the Ramganga River. At RRG2, the WQI was 239.70 as this place receives pollution from domestic wastewater drains and municipal sewage. This place also receives the heavy industrial effluent load from the industries via drains. At RRG3, the WQI is reported to be 179.19 as this place receives a huge pollutant load from agricultural run-off and domestic wastewater drains from nearby villages. RRG3 is also an important religious spot as many rituals are performed on the banks of Ramganga at Chaubari, hence the ritual remains are directly thrown into the river. The WQI at RRG4 was 112.47 where the most dominant source of pollution is agricultural run-off from the nearby fields that use chemical fertilizers, pesticides as well as insecticides. The dead bodies are also cremated on the banks of the Ramganga River and the wastes are washed away from the banks of the river. The villages also discharge their household wastewater into the river directly through drains. The expanding practice of agriculture and the amount of sewage was probably the causes of gradual changes in water quality in the Ramganga River.

Fish diversity: A total of 19 fish species from 8 families were recorded from the study area. *Cyprinidae* was found to be the dominant family followed by *Bagridae, Ambassidae, Belonidae, Channidae, Cobitidae, Heteropneustidae, Mastacembelidae* (Table 5). The species richness in the four sampling sites exhibited substantial differences (Table 6, Fig. 2). Maximum species richness was found in RRG3 (18 species) while lowest in RRG2 (7 species). This is justified by the fact that RRG2 faces severe anthropogenic pollution. The human settlements at the bank of the Ramganga river discharge their domestic sewage into the river directly. The municipal drains as well as the industries also discharge their

Table 4. WQI of the study region using the weighted arithmetic method

Site	WQI	Status
RRG1	85.43	Very poor
RRG2	239.70	Unfit for living beings
RRG3	179.19	Unfit for living beings
RRG4	112.47	Unfit for living beings

Table 3. Physiochemical parameters of water quality at the studied sites

Parameters	RRG1	RRG2	RRG3	RRG4
pH	7.98±0.277	8.05±0.133	7.63±0.126	8.16±0.145
EC(micro mhos/cm)	187.48±0.585	348.16±0.579	208.60±2.067	182.16±2.367
TDS (mg/L)	288.50±6.557	520.26±0.451	345.02±23.889	273.39±0.899
TSS (mg/L)	64.59±0.866	74.52±0.487	50.86±2.478	57.41±0.515
TS (mg/L)	353.09±6.076	594.78±0.458	395.88±25.204	330.80±1.198
Alkalinity (mg/L)	176.88±1.035	358.64±0.338	187.75±6.497	191.37±0.446
Nitrate (mg/L)	3.11±0.019	2.77±0.029	2.88±0.086	1.95±0.030
Nitrite (mg/L)	5.31±0.050	4.99±0.081	3.86±0.090	3.21±0.064
Phosphate (mg/L)	2.33±0.043	2.77±0.022	0.72±0.033	1.27±0.220
Sulphate(mg/L)	31.47±0.071	43.86±0.030	37.38±0.804	29.06±0.155
DO (mg/L)	1.78±0.171	1.20±0.141	5.90±0.319	4.42±0.045
BOD (mg/L)	25.76±0.346	33.35±5.075	9.69±0.545	7.43±0.046
COD (mg/L)	71.68±0.454	84.70±0.136	59.69±0.986	52.31±0.298
Cl- (mg/L)	31.57±0.270	38.87±0.031	29.29±0.470	26.44±0.310
F- (mg/L)	0.12±0.005	0.19±0.008	0.29±0.008	0.33±0.01

Table 5. Fish species composition and distribution recorded from the four sampling locations in river Ramganga

Fishes Name	Common name	RRG1	RRG2	RRG3	RRG4	IUCN Status	Habitat	Type	Economic importance	Food items
Ambassidae										
Parambassis ranga (Hamilton 1822)	Indian glassy fish			✓		Least Concern	Freshwater, brackish	Demersal	Ornamental	Feeds on crustaceans, annelid worms, and other invertebrates
Bagridae										
Hemibagrus menoda (Hamilton 1822)	Belawna, Belaunda	✓	✓			Least Concern	Freshwater	Demersal	Food and Ornamental	
Mystus bleekeri (Day 1877)	Day's mystus			✓		Least Concern	Freshwater	Demersal	Food and Ornamental	
Mystus cavasius (Hamilton 1822)	Gangetic mystus		✓	✓	✓	Least Concern	Freshwater, brackish	Demersal	Food and Ornamental	Phytoplankton, zooplankton, insects, their larvae, worms and molluscans
Mystus vittatus (Bloch 1794)	Striped dwarf catfish	✓	✓	✓	✓	Least Concern	Freshwater, brackish	Demersal	Food and Ornamental	Zoobenthos, benthopelagic crustaceans, insects and fish
Belonidae										
Xenentodon cancila (Hamilton 1822)	Freshwater garfish			✓	✓	Least Concern	Freshwater, brackish	Pelagic-neritic	Food and Ornamental	Zoobenthos, benthopelagic crustaceans, and insects
Channidae										
Channa punctata (Bloch 1793)	Spotted snakehead	✓	✓	✓	✓	Least Concern	Freshwater, brackish	Benthopelagic	Food and Sports	Crustaceans, insects, molluscs
Cobitidae										
Lepidocephalichthys guntea (Hamilton 1822)	Guntea loach	✓		✓	✓	Least Concern	Freshwater, brackish	Demersal	Ornamental	Feeds on small crustaceans, insect larvae, worms and bottom detritus
Cyprinidae										
Bangana dero (Hamilton 1822)	Kalabans	✓		✓	✓	Least Concern	Freshwater	Benthopelagic	Food	Feeds on insect, larvae, molluscs, algae, zooplankton and detritus
Barilius bendelisis (Hamilton 1807)	Khoksa/Indian Hill Trout	✓		✓	✓	Least Concern	Freshwater	Benthopelagic	Ornamental	
Cabdio morar (Hamilton 1822)	Morari	✓		✓	✓	Least Concern	Freshwater	Benthopelagic	Food and Ornamental	Omnivore with a higher feeding preference for phytoplankton
Cyprinus carpio (Linnaeus 1758)	Common carp			✓	✓	Vulnerable	Freshwater, brackish	Benthopelagic		
Labeo boga (Hamilton 1822)	Boga	✓		✓	✓	Least Concern	Freshwater	Benthopelagic	Ornamental	Grazers and detritivores and feeds on algae and invertebrates
Pethia conchonius (Hamilton 1822)	Rosy barb		✓	✓		Least Concern	Freshwater	Benthopelagic	Ornamental	Zoobenthos, benthopelagic crustaceans, detritus, debris, insects, worms and other aquatic organisms
Puntius chola (Hamilton 1822)	Swamp barb	✓	✓	✓	✓	Least Concern	Freshwater	Benthopelagic	Ornamental	Zoobenthos, worms, insects, detritus, debris, benthic algae and weeds
Puntius sophore (Hamilton 1822)	Pool barb	✓	✓	✓	✓	Least Concern	Freshwater, brackish	Benthopelagic	Food and Ornamental	

Cont...

Table 5. Fish species composition and distribution recorded from the four sampling locations in river Ramganga

Fishes Name	Common name	RRG1	RRG2	RRG3	RRG4	IUCN Status	Habitat	Type	Economic importance	Food items
Osteobrama cotio (Hamilton 1822)		✓		✓	✓	Least Concern	Freshwater	Benthopelagic		
Heteropneustidae										
Heteropneustes fossilis (Bloch 1794)	Stinging catfish			✓	✓	Least Concern	Freshwater, brackish	Demersal	Food	Small fishes, zoobenthos, insects, worms and crustaceans
Mastacembelidae										
Macrognathus pancalus (Hamilton 1822)	Barred spiny eel	✓		✓		Least Concern	Freshwater, brackish	Benthopelagic	Food and Ornamental	Zoobenthos, benthopelagic crustaceans, shrimps, prawns, nekton, mollusks, other cephalopods, worm, insects, fish

effluents into the river with partial or without treatment. Maximum richness was recorded in RRG3 which is downstream of RRG2. By the time, the river reaches this place; it modifies itself due to its self-replenishing abilities as the Ramganga River at this place flows at a good velocity. RRG3 has a great ichthyofaunal diversity because of the variety of habitats found at this site from pools to rifles, grassed banks, and backwaters. The downstream before the confluence of the Ramganga with the Ganga, RRG4 is located which showed a richness of 14 species. This place receives agricultural run-off from both sides of the banks as large croplands are located at this site. This site, being a rural region receives organic pollutant load from the animal manure and human excreta. RRG4 also faces the problem of heavy illegal fishing for commercial purposes. The WQI of RRG4 is 112.47 which is comparatively lower than RRG3 signifying that RRG4 is less polluted than RRG3. The Shannon and Simpson fish diversity index (H) of the sites ranged from 1.71-2.59 and 0.80-0.91 respectively. The Shannon and Simpson fish diversity index of all the sites is in the order RRG3>RRG4>RRG1>RRG2 signifying that RRG3 has the highest and RRG2 has the lowest fish diversity among all the studied sites. The Berger-Parker Dominance index ranged from 0.176 at RRG4 to 0.31 at RRG2 denoting that RRG4 has the lowest while RRG2 has the highest dominance of the common fish species. The species evenness showed variation among the sites with values of 0.79 (RRG2), 0.74 (RRG3), 0.73 (RRG1) and 0.72 (RRG4). Even though RRG2 has a low richness but has the highest evenness (Fig. 3). Diversity indices showed that RRG3 followed by RRG4, RRG1, and RRG2 are the most preferred habitats as they show the highest number and diversity of fish species. It may be due to abundant food resources present in these sites like benthic organisms, algae, and planktons. Fish feed on various trophic levels, therefore, there is a significant positive correlation between their abundance and food resources. Low diversity was observed at site RRG2, indicating loss of its suitability for sustaining life due to destruction of natural habitats, increased level of pollution, and over-exploitation of the species.

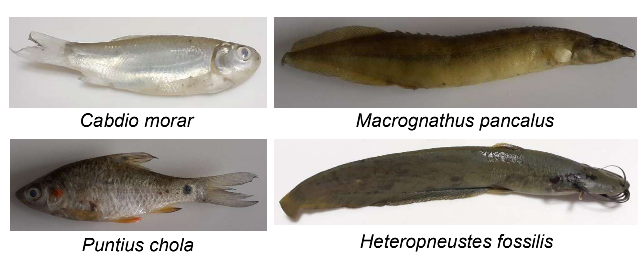

Fig. 2. Photographs of some fish species of the Ramganga River

Table 6. Diversity indices at various stretches of the river

Indices	RRG1	RRG2	RRG3	RRG4
Taxa_S	12	7	18	14
Individuals	117	158	395	221
Dominance_D	0.13	0.20	0.09	0.11
Simpson_1-D	0.87	0.80	0.91	0.89
Shannon_H	2.17	1.71	2.59	2.31
Evenness_e^H/S	0.73	0.79	0.74	0.72
Brillouin	2.04	1.65	2.51	2.22
Menhinick	1.11	0.56	0.91	0.94
Margalef	2.31	1.19	2.84	2.41
Equitability_J	0.87	0.88	0.90	0.87
Fisher_alpha	3.35	1.50	3.89	3.32
Berger-Parker	0.26	0.31	0.177	0.176
Chao-1	12	7	18	14

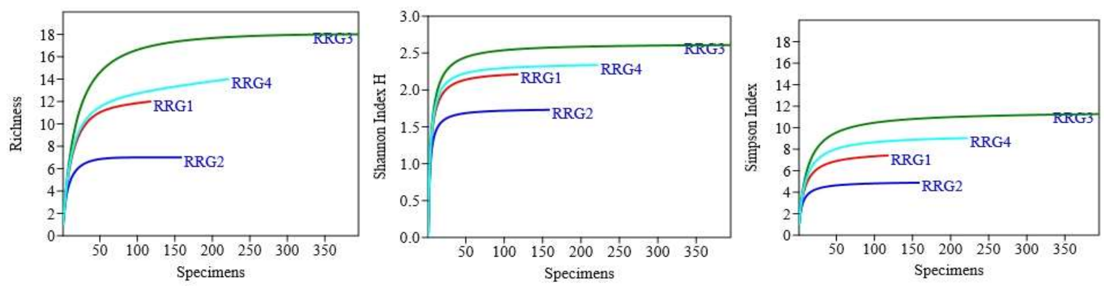

Fig. 3. Richness, Shannon index and Simpson index of the fishes at the sampling sites

Cluster analysis: In the dendrogram obtained by performing hierarchical agglomerative cluster analysis using Ward's Linkage, similar observation sites were grouped in separate clusters (Fathi et al 2019). The two separate clusters are formed (Fig. 4). In cluster one, RRG1 and RRG2 are present while in the second cluster RRG3 and RRG4 are present representing the same level of fish diversity which is evident from the fact during sampling, RRG1 faced rural pollution including agricultural run-off from the adjoining fields, and RRG2 faces the problem of urban pollution from industrial, municipal as well as domestic sources and the reduced flows from the dams augments the problem of pollution. The reduced oxygen levels and increased BOD are the issues that make the aquatic environment unsuitable for the fish thereby causing fish mortality and decreased diversity. At RRG3 and RRG4, there is less urban pollution stress and moderate agricultural pollution. The river moves away from pollution sources, the intensity of pollution decreases. So, these places don't suffer from severe pollution problems, hence the diversity here is similar to these two sites.

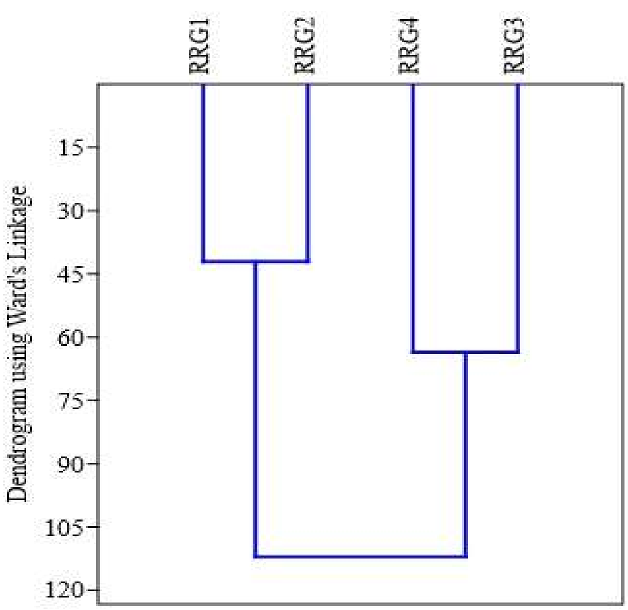

Fig. 4. Hierarchical agglomerative clustering on the basis of fish diversity

CONCLUSION

The spatial fish diversity and associated variability in the River Ramganga were evaluated in this study along with its relationship with water quality and habitat types. There was a drastic change in the WQI and fish diversity from the middle to lower stretches of the Ramganga River. The possible reason for this could be that at the time of sampling, there was not enough water flowing in the river. The Kalagarh Dam controls the water of the river in the reservoir due to which there is not enough water flow in the river in June. The water quality is not good enough to support rich ichthyofaunal diversity. The physicochemical parameters of water were proven to shape the fish diversity patterns. The increased human activities may accelerate species loss because high levels of disturbance result in reduced immigration of fishes at the local habitat scale. Over the last few decades, streams all over the country are under pressure from immense anthropogenic disturbances along with dam construction, industrialization near streams, illegal sand mining, illegal fishing, and mismanaged agricultural practices. The study suggests that the Moradabad stretch (RRG2) needs appropriate management and conservation strategies to prevent the further loss of ichthyofaunal populations.

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