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Assessment of the Ichthyofaunal diversity in relation to Physico-chemical attributes of River Asan in the Garhwal Himalaya, India

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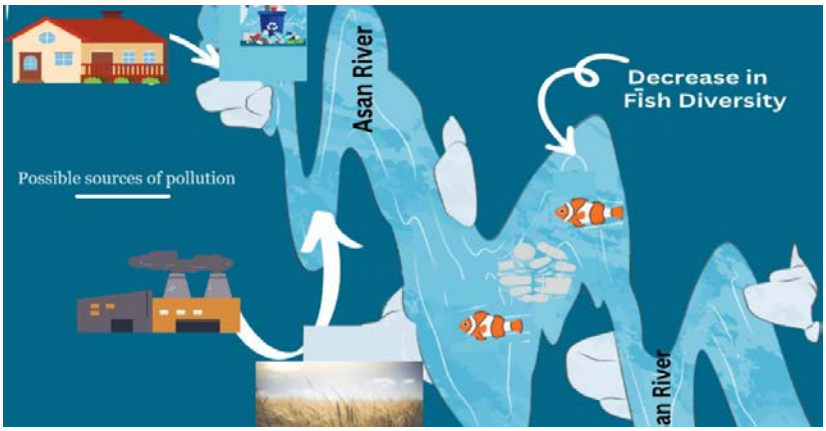
Abstract

The present study investigated the water quality of River Asan based on various physicochemical parameters and its freshwater fish fauna in lower Himalaya. In two sampling sites 95 fish specimens were collected, 13 fish species belonging to 1 class, 4 orders, 4 families, 9 genera were recorded from the river Asan during the present study. *Barilius bendelisis* constituted high percentage in fish composition. The water quality of River Asan is good, and no substantial pollution was observed. Main 4 different ecological indices applied to fish data shows that the change in fish number is the seasonal phenomenon. However, decline in many fish populations observed, possibly due to illegal fishing and disturbance through anthropogenic activities. There is a need to protect their natural habitats, execute policies and motivate people for the management and conservation of fish varieties in this river.



Keywords: Fish diversity, water quality, physicochemical, PCA, River Asan

INTRODUCTION

Water is one of the most important and most valuable compounds of the organism. Freshwater habitats occupy a small part of the Earth's surface, but they are more important to humans than their area.[1] All organisms on earth need water for their survival and growth Freshwater ecosystems are the most threatened ecosystem of the world. There is a greater decline in freshwater biodiversity when compared to the terrestrial biodiversity.[2] The water quality of groundwater and any surface water like river is either due to human activities or natural influences. Water quality of any water body is defined as its chemical, physical and biological properties according to its suitability for a particular use.

The invariant living components of water bodies are the fishes which are the important food resource and they also indicate the ecological health of the water body. India has heterogeneity in climatic conditions, therefore, has a large network of rivers, both in Himalaya and plains harboring 2500 fish species.[3] Physical change, habitat deprivation, disproportionate water withdrawal and pollution contribute directly or indirectly to the deterioration of fresh water biota. Due to increased population of humans, industrialization, use of fertilizers and pesticides in agriculture by man and several other man-made activities make water body highly polluted with different toxic contaminants.[4] To understand the ecology of freshwater systems, analysis of physico-chemical parameters is very essential. To detect the effects of pollution on water quality various physico-chemical methods were used[5]. Most of the references in fisheries research in Doon Valley remained are on eastern part, whereas the western part of Doon valley remained

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neglected due to its topography, in Eastern Doon valley it is easy to reach the river sites due to better road linkage and terrain. In Western Doon valley very less work has been done on fish taxonomy. The first report in Amalwa and Asan River was given by Singh.[6] He listed 8 species from Asan River and 4 species from Amalwa River, while Husain[7] studied the selected sites of Amalwa River. The fish fauna of India and around has fascinated the interest of various workers during the past.[5-19]

The fresh water fishes show variations in relation to habitat and geographical conditions. Enormous diversity in size, shape, colour and habitats is exhibited by fish fauna of India. The fish are reported from the Indian coast, coastal lagoons, beaches, coral reefs, rocks, sand, mud, dark caves, rivers and streams, lakes and ponds and almost all habitat[12]. Fishes are considered as an effective biological indicator of environmental quality and anthropogenic stress in aquatic ecosystems. However, many ecological disturbances in aquatic ecosystems linked to anthropogenic pressures resulted in loss of biodiversity, and decline in fisheries have been well documented[20]. Fishes are important, palatable, proteineous food for mankind. The present contribution is an attempt to study the ichthyofaunal diversity of River Asan in order to provide the information about their status in this river. Different indices were applied to evaluate fish diversity.

Materials and Methods

Sampling sites

The present research work is done in 'Doon Valley'= Dehradun valley, which is situated between outer and lesser Himalaya. Geographically lies between 29° 50'-30° 30' N Latitude and 77° 35'- 78° 20' E Longitude. The present study was conducted in River Asan, a tributary of River Yamuna in western part of Doon Valley. River Asan, has about 41 km course in the Western Doon, arises from a clayey depression situated to the West of Dehra-Asarori water divide and flows Westerly to meet Yamuna at Dhalipur. Sampling for the limnological study of river Asan, was conducted at two (02) designated sampling sites i.e. Asan Pul, Dharmawala (Upper Asan) (30.42° N and 77.69° E) and Asan Barrage (Lower Asan) (30.43° N and 77.66° E). Monthly sampling for collecting data on various physicochemical and biological parameters was undertaken during November 2017 to April 2018 (Figure 1).

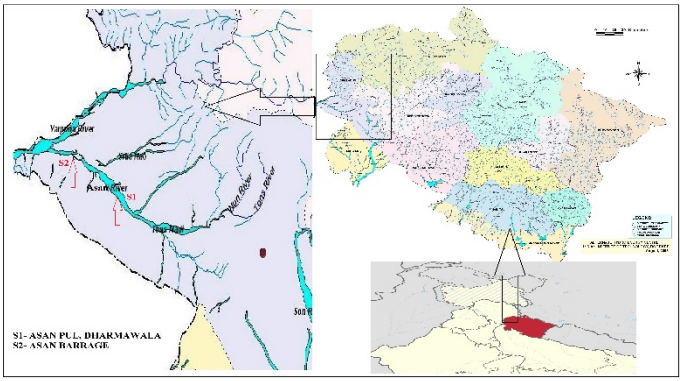

Figure 1. Location map for the river Asan in Garhwali Himalaya

Field and Habitat Sampling

Data on various physicochemical parameters [Air temperature (°C), water temperature (ºC), pH, dissolved oxygen (mg/l), free carbon dioxide (mg/L), alkalinity (mg/L), conductivity (mS/cm), chloride (mg/L) and total dissolved solids (ppt)] was measured at regular interval at the designated sampling sites along with the fish diversity of River Asan from November 2017 to April 2018. Standard methods defined in[21-24] were followed for the analyses.

Fish Sampling and Identification

Monthly fish collection was made personally by using different sized fishing nets at different sampling sites during November 2017 to April 2018. Fishes were examined in both fresh and preserved condition in the field and laboratory respectively. The fishes were classified according Nelson[21] with modification that of Talwar and Jhingran[22] and Jayaram.[23] The macro identification of fish samples was done with the help of earlier works reported.[27-31]

Data Analysis

The ANOVA test for physic-chemical parameters was run using the PAST version 2.17c[32] to show substantial difference among different physico-chemical parameters. Different ecological indices were also applied to the fish data i.e. Shannon-Weiner species diversity index[33], Species richness index,[34] evenness index[35] and Dominance index[32]. Percentage composition of fish communities between sections were calculated using MS Excel. Principal component analysis (PCA) was applied to explore relationships between environmental and fish communities variables during different seasons using PAST version 2.17.[32] Cluster analysis using the Euclidean distance as a measure of dissimilarity was used to explore the relationships between fish species. Environmental variables and fish communities were used as metrics.[32]

Results and Discussion

Physico-chemical parameters

The result of analysis of physicochemical parameter at preferred sampling sites was depicted in Table 1. The air temperature was minimum i.e., 11°C at upper Asan during November and maximum 30°C at lower Asan during April. The water temperature more or less fluctuated with the air temperature. The minimum water temperature recorded was 14°C at upper Asan during January and maximum 22°C at lower Asan during April. Water temperature of a water body shows the characteristic annual cycle, with higher values during the dry summer season and lower values in the winter season.[37] Similar trend was also observed during the present study period.

The minimum value of dissolved oxygen was recorded 8.8 mg/L at upper Asan in November and maximum 13.5 mg/L at lower Asan during December. The amount of Dissolved Oxygen in water is one of the most commonly used indicators of a water body's health. A sufficient supply of DO is dynamic for all higher aquatic life. Temperature is inversely proportional to the DO level in the water. Cold water holds more oxygen than warm water. The higher value of dissolve oxygen during winter was due to low atmospheric pressure and intensive photosynthetic activity by plants. The minimum values during summer was due to high atmospheric temperature and high metabolic activity of organism and decreased oxygen water holding capacity of water at higher temperature.[38]

Table 1. Monthly average variation of physicochemical parameters of river Asan during the study period (November 2017- April 2018) [Mean±SD].

Parameters/ Months	November	December	January	February	March	April
	Mean ±SD	Mean ±SD	Mean ±SD	Mean ±SD	Mean ±SD	Mean ±SD
Air temperature (ºC)	15.50 ±6.363	20.00 ±1.41	21.00 ±1.41	23.25 ±1.06	23.50 ±0.70	29.50 ±0.70
Water Temperature (ºC)	17.00± 0.00	17.00± 2.82	14.50 ±0.70	19.50 ±0.70	21.00 ±0.00	21.00 ±1.41
Dissolved oxygen (mg l^{-1})	9.00±0 .28	12.20± 1.69	12.90 ±0.42	12.06 ±0.14	10.94 ±0.57	9.70± 0.14
Carbon dioxide (mg l^{-1})	2.20±0 .00	2.20±0 .00	2.20± 0.00	3.30± 1.55	2.20± 0.00	2.20± 0.00
Alkalinity (mg l^{-1})	15.00± 7.07	17.50± 10.60	12.50 ±3.53	12.50 ±3.53	15.00 ±7.07	10.00 ±0.00
TDS (ppt)	0.21±0 .009	0.30±0 .033	0.27± 0.04	0.21± 0.001	0.25± 0.04	0.22± 0.02
pH	7.11±0 .261	7.34±0 .19	7.25± 0.35	7.32± 0.10	7.20± 0.03	7.10± 0.02
Conductivity mS/cm	0.27±0 .016	0.315± 0.004	0.31± 0.012	0.38± 0.004	0.27± 0.03	0.30± 0.008
Chloride (mg l^{-1})	42.10± 3.31	20.59± 3.01	19.72 ±0.22	20.59 ±1.00	24.85 ±13.0	17.76 ±2.99

Gayathri[39] recorded maximum dissolved oxygen during the winter and minimum during the summer in Shoolkere Lake, Bangalore. Similar result was recorded during the present study period. Free carbon dioxide was recorded minimum 2.2 mg/L at both upper and lower Asan and maximum 4.4 mg/L at lower Asan in February. Bhalla and Sekhon[40] observed minimum free CO_2 in winter while maximum during summer season in Godavri River. The total alkalinity was recorded minimum 10 mg/L at both upper and lower Asan and maximum 25 mg/L at upper Asan during December. Agarwal and Thapliyal[41] obtained maximum alkalinity during winter months in Bhilganga.

The value of total dissolved solids fluctuates from 0.21 ppt at upper Asan in February to 0.33 ppt at lower Asan in December. The pH of the water of river Asan was observed minimum 6.93 at upper Asan during November and maximum 7.48 at lower Asan in December. According to WHO[42] range of pH of drinking water is in between 6.5-8.5. In river Asan during the study period pH was observed within the permissible limits given by WHO. The E. Conductivity of water was recorded minimum 0.24 mS/cm at upper Asan during March and maximum 0.38 mS/cm at lower Asan during February. The Chloride of water was recorded minimum 15.62 mg/L at upper Asan in month of March and maximum 44.45 mg/L at upper Asan during January. If a conductivity of a water body increases abruptly, it indicates that there is a source of dissolved ions in the surrounding area. Therefore, conductivity measurements can be used as a quick way to locate water quality problems while, chloride concentration serves as an indicator of pollution[43]. The ANOVA test indicated no significant difference (F=0.040, p=0.99) for physicochemical variables.

FISH FAUNA

A total number of 95 specimens were collected and examined during the present study period (November 2017 – April 2018). 13 species were recorded from the river Asan consists of 1 class, 4 orders, 4 families, 9 genus and 13 species (Table 2). The percentage composition of fish species shows that most abundant fish species is *Barilius bendelisis* with 46% of total composition out of which *Barilius bendelisis* (female) is 28% and *Barilius bendelisis* (Male) is 18%, followed by *Gara gotyla gotyla* 11%, *Puntius sarana sarana* 9%, *Barilius Barna* 7%, *Xenthodon cancila* 6%, *Mystus tengara* 4%, *Puntius sophore* 4%, *Puntius chola* 3%, *Puntius ticto* 3%, *Devario devario* 2%, *Mastacembelu sarmatus* 2%, *Aspidoparia jaya* 2%, *Tor putitora* 1%.

Table 2: Systematic position (check list), diversity, preferential habitat and conservation status of fish fauna recorded at different sections in River Asan during the present study (November 2017 to April 2018).

Class	Order	Family	Genus	Species	Local Name	Preferential Habitat	IUCN Status
Actinopterygii	Cypriniformes	Cyprinidae	*Aspidopa ria*	*jaya*	Chilwa, Chal	Runs	Least Concerned
			Barilius	*bendelisis*	Chedra	Runs, pools	Least Concerned
			Barilius	*barna*	Dhaur, Childi	Pools, runs	Least Concerned
			Gara	*gotyla gotyla*	Dhanura, Gotla	Pools, runs	Least Concerned
			Devario	*devario*	Chand	Pools, runs	Least Concerned
			Puntius	*sarana sarana*	Puta	Runs, riffles	Least Concerned
			Puntius	*chola*	Katcha, Puti	Pools, rapids	Least Concerned
			Puntius	*ticto*	Bhuri, Puti	Pools, runs	Least Concerned
			Puntius	*sophore*	Puti	Pools, runs	Least Concerned
			Tor	*putitora*	Pila-par mahaseer	Rapid, riffles	Endangered
	Siluriformes	Bagridae	*Mystus*	*tengara*	Kater	Runs, riffes	Least Concerned
	Beloniformes	Belonidae	*Xenthodon*	*cancila*	Sua	Rapid, riffles	Least Concerned
	Synbranchiformes	mastacembelidae	*Mastacembelus*	*armatus*	Baam	Runs, riffles	Least Concerned

DIVERSITY INDICES

Shannon-Weiner species diversity index (H´) ranged between 1.34 and 2.85. The Evenness index (E) ranged between 0.58 and 0.95. The Margalef richness index (d´) varies from 1.36 to Dominance index (D) also varied from 0.92 to 0.99. Positive correlation was observed during the present study between the Shannon-Weiner Diversity Index and Evenness index with the value 0.86, whereas, negative correlation was also observed between Shannon-Weiner Diversity Index and Dominance Index with value -0.13. Similar positive correlation between the Shannon Diversity Index and Evenness index among the different fish species in the Neyyer River of the Western Ghats of India was observed by Nair.[44] Similar pattern of negative correlation between

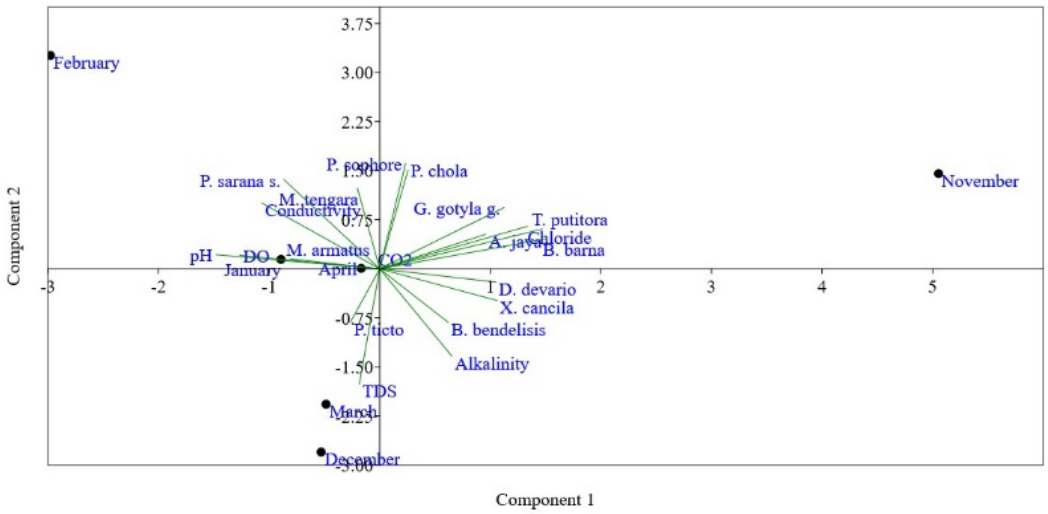

Figure 2: Ordination diagram of PCA of fish species and environmental variables in different months. The length of an arrow and its closeness to PCA axes is a measure of its strength.

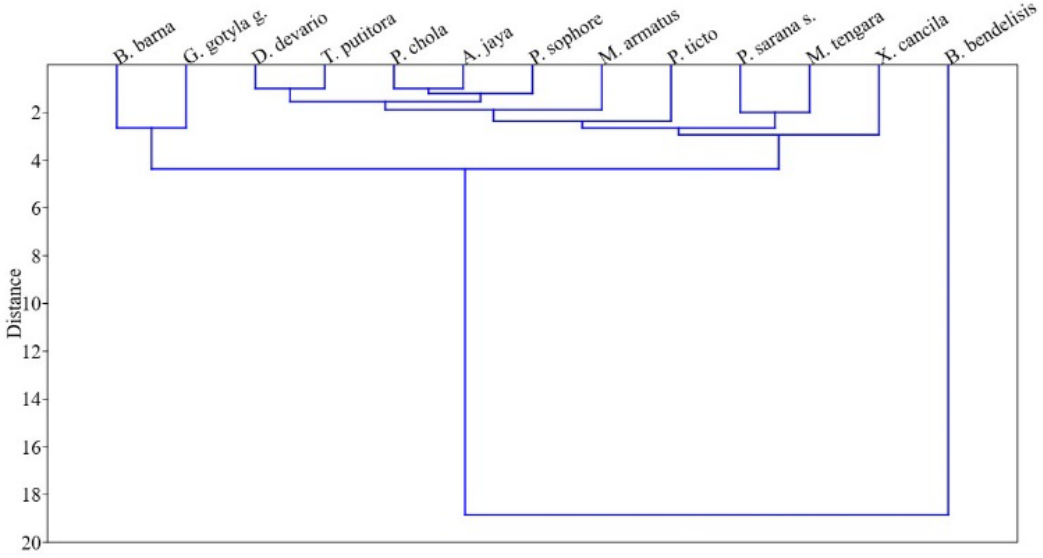

Figure 3: Cluster analysis based on number of fish species sampled across 2 river sites in River Asan using the Euclidean dissimilarity measures. The shorter the distance, the more similar are the fish species.

the Shannon's Index and Dominance Index was observed by Chowdhury[45] in the Naaf river estuary. No significant difference was observed in Shannon Weiner diversity index (H'), Evenness (e), Dominance Index (D) and Margalef richness index (d'). Therefore, it is concluded that differences in species diversity is a common phenomenon in the studied area.

PCA yielded different components showing clear allocation of fish species and environmental variables at different sections. The five axes explained the variance in the data with eigen values for Axis 1= 7.15 with variance 37.63% followed by for Axis 2= 4.98 with variance 26.21%, Axis 3= 2.96 with variance 15.61%, Axis 4= 2.16 with variance 11.39% and for Axis 5= 1.73 with variance 9.14%. The PCA showed distribution of fish species and environmental variables at different sections of the river were varied seasonally (Figure 2).

The 6 fish species i.e. *Puntius chola*, *Puntius ticto*, *Tor putitora*, *Barilius barna*, *Aspidoparia jaya* and *Gara gotyla gotyla* along with chloride associated with November month on upper right quadrant of biplot. The 3 fish species named *Xenthodon cancila*, *Barilius bendelisis*, *Devario devario* along with alkalinity and free CO_2 in bottom right quadrant. *Puntius ticto* along with total dissolved solids associated with month of March, December and April on bottom left quadrant of biplot. On upper left quadrant *Puntius sarana*, *Masatcembelus armatus* and *Mystus tengara* along with water parameters pH, dissolved oxygen and conductivity associated with January and February month.

Cluster analysis shows assemblage of fish species of River Asan. Cluster analysis using the Euclidean distance as a measure of dissimilarity was used to explore the relationships between various fish species (Figure 3). The shorter the distance more closely the relationship of fish species. The first assemblage comprises of *Barilius barna* and *Gara gotyla gotlya* at a distance more than 2. Second assemblage was formed between the *Devario devario* and *Tor putitora.* Third assemblage was formed between the *Puntius chola* and *Aspidoparia jaya. Puntius sophore* occur in association with the third assemblage. *Mastacembelus aramatus* formed an association with the fishes of second assemblage and another assemblage. *Puntius ticto* forms an association with this assemblage. *Puntius sarana* and *Mystus tengara* forms an assemblage together at a distance and this was also found in association with the previous assemblage. *Xenthodon cancila* also forms an association with the assemblage. First assemblage of fish species forms an association with all fishes except the *Barilius bendelisis. B. Bendelisis* forms a final assemblage with the all fish species at a distance more than 18.

The seasonal change in water quality of rivers, streams and lakes shows its effect on the population density of flora and fauna of particular ecosystem[46]. The water quality of that area is also affected by the geography and topography of that particular area. As a result of anthropogenic activity and natural processes the physical, chemical, and biological parameters also keep changing which in-turn influences the water quality. The vast support species-rich fish communities contribute to the overall high biodiversity of rivers/streams ecosystems[47]. A conventional use of fish habitat shows the physical and chemical characteristics of the environment, excluding biological attributes. Variety of fish species were found from the Asan River during the study period which indicates the good aquatic life. But, due to the illegal fishing and anthropogenic activities there is a decline in number of fishes, therefore different measure should be taken and fishing should be banned.

CONCLUSION

Based on the study results we concluded that the 13 fish species belonging to 1 class, 4 orders, 4 families, 9 genera were recorded from the river Asan during the present study. *Barilius bendelisis* constituted high percentage in fish composition. The water quality of River Asan is good, as there is no pollution. Many fish populations were declined due to illegal fishing and disturbance through anthropogenic activities and there is a need to protect their natural habitats, execute policies and motivate people for the management and conservation.

CONFLICT OF INTEREST

The authors do not have any conflicts of interest.

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