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Fish-diversity in relation to physico-chemical characteristics of river Devaha, District Pilibhit (U.P.), India

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ABSTRACT

In the present study, the fish diversity was examined in relation to physico-chemical parameters of river Devaha, District Pilibhit, U.P., INDIA. The samples of water and fish species were collected in summer, rainy and winter seasons from site I (Doony dam), site II (premerger site of river Khakra) and site III (post merger point of river Khakra) from June 2010 to December 2012. Fish species belonging to 15 families and 26 genera were collected in the laboratory and identified. Cyprinids formed the most dominant group and were represented by 13 species belonging to 7 genera, followed by Bagridae (3 species). The distribution of fish showed interesting patterns about the species which were common to all the three sites. The Shannon-Weiner diversity index, ranged from 1.82 to 3.06 (lowest in May and highest in October), during the study period. The study showed that out of 34 species recorded 16 could be identified as at lower risk, 12 as vulnerable and 06 as endangered. The study showed that the river supports considerable diversity of fish fauna, about 52.94% fish being either vulnerable or endangered and are important for conservation. The river supports considerable percentage of food fish (86.5%), ornamental fish (4.92%) and sport fish (5.9%) and remaining of unidentified characteristics. The pollution potential of river was investigated by various physico-chemical parameters viz., water temperature (^{0}C), turbidity (NTU), conductivity (µmhocm^{-1}), pH, TDS (mg/L), DO (mg/L), BOD (mg/L) and COD (mg/L).

This study would be useful for conservation, planning and management of fish fauna by reducing the pollution potential of the river.

1) INTRODUCTION

Fish community is one of the most significant aquatic fauna which is directly or indirectly related with human health and wealth. Hence biodiversity and its conservation are regarded as the major issues enabling sustainable use of natural resources. It seems necessary and today's most urgent and significant need to protect ichthyofaunal diversity [1] in their natural habitat. Over the last century, river ecosystems have suffered from intense human intervention resulting in habitat loss and degradation and as a consequence, many fish species have become highly endangered, particularly in rivers where heavy demand is placed on fresh waters. The main causes are habitat destruction and defragmentation, industries and private use [2, 3] pollution stress [4] and global climate change impacts [5, 6]. Freshwater fish fauna is one of the most threatened taxonomic groups due to high sensitivity to qualitative alteration of aquatic environment. Fish are often used as bio-indicator for the assessment of water quality or increasing pollution potential.

The fish diversity and associated habitats management are a great challenge. The fish fauna of a river is highly threatened due to the presence of dams and water diversions, resulting fragmentation of habitat [7, 8, 9]. The pollution potential of river Devaha is gaining momentum day by day [10]. Keeping this in view, the present study was undertaken to determine the physico-chemical characteristics of water and fish species of river Devaha.

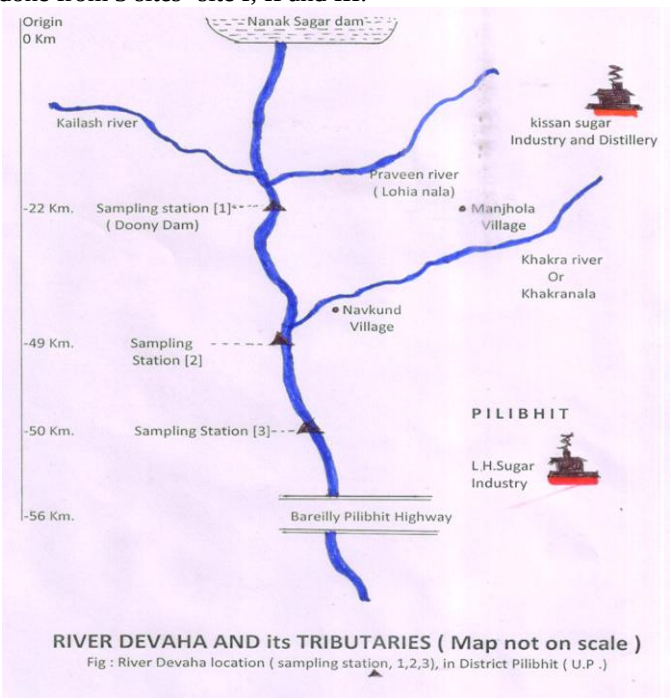
2) MATERIAL AND METHODS

Study Area: Pilibhit lies between the parallels of 28^{0}64' and 29^{0}53' North latitude and meridians of 79^{0}57' and 81^{0}37' East longitudes. The north side of Pilibhit is bordered by Udham Singh Nagar of Uttarakhand state. The river 'Devaha', an important perennial tributary of the river Ramganga, has its source at Nanak Sagar Dam, near Nanakmatta (Sitarganj, District Udham Singh Nagar, Uttarakhand) in Tarai region of Himalayas. At a distance of 22 Km. of its origin, the Doony Dam is situated on this river in Manjhola town of district Pilibhit. Two more rivulets- Kailash and Praveen (Lohia Nala) discharge their water in Doony dam. During its downward flow, after entering Pilibhit city, another river Khakra also join river Devaha. There are two sugar factories in this area, one Kisan sugar factory and Distillery (at Manjhola) and other

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Lalit Hari sugar factory in Pilibhit city. Sampling has been done from 3 sites- site I, II and III.



Site I: Doony dam (12Km. from Manjhola town).

Site II: Premerger site of Khakra River, where the river enters in to Pilibhit.

Site III: Post merger point of Khakra river, located at a distance about 1 Km away from merger point of Khakra river.

Collection of samples and analysis: The random samples of water were collected from the three sites in morning hours on observation day of first week of every month during June 2010 to December 2012.

The physico-chemical parameters viz., water temperature (^{0}C), turbidity (NTU), water flow (m sec^{-1}), conductivity (µmhos cm^{-1}), total dissolved solids (mg/L), pH, dissolved oxygen (mg/L), biochemical oxygen demand (mg/L), chemical oxygen demand (mg/L), total hardness (mg/), Chloride(mg/L), Phosphate (mg/L), Nitrite (mg/L), Calcium (mg/L) and Magnesium (mg/L) were determined by standard methods [11,12]. Water temperature (^{0}C) was measured by a sensitive mercury thermometer (1/10 ^{0}C). The electrical conductance was measured by a conductivity bridge (type Nalco; Dip type conductivity cell; cell constant = 1.0 ± 0.01cm^{-1}). Water velocity was measured by flow meter.

Collection of fish species and their identification: The fish were collected from three sampling sites, as well as from other areas of the river by using the expertise of local fisher folk. The sampling of various fish species was carried out in daytime (08.00am to 05.00pm) and in night (9.00pm to 11.00pm) on monthly basis during the study period.

Different types of gear including cast nets (9'.1"; 9',1/2"), gill nets (75 × 1.3m, 2"; 50 × 1m, 3" ; 30 × 1m, 2.5") drag nets (with varying mesh sizes) and other local contrivances were used for collecting the fishes allowing us to sample a range of fish sizes and minimize the basis due to the specifics gears.

Table-1: Seasonal variations of physico-chemical parameters of river 'Devaha' (Sites I, II, III)

S. No.	Parameters	Site I			Site II			Site III		
		Rainy	Winter	Summer	Rainy	Winter	Summer	Rainy	Winter	Summer
1	**Water Temperature (^{0}C)**	29.7 ±1.85	18.3 ±2.69	31.0 ±3.46	31.0 ±2.26	19.4 ±2.41	31.6 ±3.35	30.7 ±2.39	19.0 ±2.62	31.4 ±3.41
2	**pH**	7.87 ±0.13	8.09 ±0.06	8.16 ±0.01	7.51 ±0.10	7.76 ±0.13	7.63 ±0.06	7.7 ±0.11	7.78 ±0.07	7.84 ±0.04
3	**Turbidity (NTU)**	17.84 ±8.52	2.74 ±1.19	3.21 ±0.73	25.26 ±7.64	10.53 ±1.45	21.34 ±5.04	25.56 ±10.04	8.09 ±1.49	14.64 ±2.64
4	**Conductivity (µΩ^{-1}cm^{-1})**	295.47 ±19.70	166.39 ±5.13	200.58 ±18.77	831.43 ±8.56	1333.4 ±46.44	1023.04 ±195.5	417.2 ±5.94	667.24 ±22.64	511.38 ±97.38
5	**Flow Velocity (msec^{-1})**	0.73 ±0.09	0.65 ±0.03	0.57 ±0.05	0.41 ±0.09	0.36 ±0.02	0.32 ±0.05	0.55 ±0.07	0.48 ±0.01	0.43 ±0.02
6	**TDS (mg/L)**	169.04 ±12.44	94.5 ±3.43	114.1 ±10.88	515.7 ±6.43	826.9 ±30.33	633.93 ±121.15	249.04 ±5.23	399.69 ±14.09	306.55 ±59.38
7	**DO (mg/L)**	6.56 ±0.23	7.86 ±0.36	7.38 ±0.16	2.03 ±0.01	0.023 ±0.004	1.29 ±0.91	4.85 ±0.71	2.45 ±0.24	3.95 ±1.56
8	**BOD (mg/L)**	2.03 ±0.12	1.20 ±0.14	1.29 ±0.04	16.04 ±4.33	34.08 ±2.44	25.41 ±6.31	9.03 ±2.60	18.45 ±1.47	14.8 ±3.63
9	**Total hardness (mg/L)**	107.69 ±18.29	74.94 ±8.49	80.79 ±9.27	140.2 ±10.22	265.03 ±56.60	196.36 ±72.45	121.3 ±8.18	123.95 ±7.11	113.88 ±6.91
10.	**COD (mg/L)**	12.01 ±5.93	6.11 ±1.02	6.37 ±0.32	60.07 ±29.35	137.71 ±19.01	117.63 ±29.49	42.82 ±6.46	81.05 ±6.75	73.41 ±15.96
11	**Chloride (mg/L)**	10.01 ±0.89	7.57 ±0.72	7.85 ±0.49	100.84 ±14.73	142.89 ±22.06	132.27 ±12.11	40.08 ±5.96	63.75 ±10.12	54.76 ±5.92
12	**Phosphate (mg/L)**	0.37 ±0.50	0.07 ±0.01	0.08 ±0.01	2.60 ±0.12	5.49 ±1.09	4.02 ±1.27	1.04 ±0.05	2.14 ±0.37	1.6 ±0.45
13	**Nitrite (mg/L)**	BDL	BDL	BDL	0.13 ±0.03	0.23 ±0.02	0.24 ±0.04	BDL	0.13 ±0.02	0.16 ±0.03
14	**Calcium (mg/L)**	32.68 ±4.28	23.62 ±1.10	25.11 ±2.32	43.01 ±4.06	74.48 ±13.45	58.01 ±16.35	36.75 ±3.40	39.4 ±3.97	36.76 ±3.83
15	**Magnesium (mg/L)**	6.37 ±0.45	3.85 ±1.51	4.47 ±0.75	7.97 ±0.07	19.42 ±5.42	15.02 ±7.81	7.13 ±0.36	5.86 ±0.86	5.36 ±0.75

Representative specimens (n=1 to 10) of all fish species were fixed in 10% formaldehyde and transferred to the laboratory and stored in glass bottles. The fish markets and landing centers associated with the river system were also monitored to find out the presence of fish species which were subsequently identified with the help of standard literature [13, 14 and 15]. Data regarding threats faced by the fish fauna were obtained from both primary (direct observations and interactions with local stakeholders and fishermen) and secondary (Journal articles, reports, books and internet search tools), resources.

Statistical analysis: The relative abundance (RA) as percentage of catch of fish across different sites was worked out. R.A. of individual species was calculated by the formula;

Table-2: Diversity of fish species, family, threat status, total length and relative abundance.

S.No.	Fish family/*species**	Threat status**	Total length (cm)		Seasonal relative abundance (%)		
			Max.	Min.	Summer	Rains	Winter
	I- Cyprinidae						
1.	*Puntius chola*	**VU**	12.5	8.5	0.42	2.11	1.16
2.	*Puntius ticto*	**LRnt**	8.5	4.0	0.00	2.75	1.37
3.	*Puntius sophore*	**LRnt**	9.8	6.5	0.00	1.58	0.31
4.	*Puntius sarana*	**VU**	22.2	5.7	0.00	1.05	0.21
5.	*Catla catla*	**VU**	45.7	28.0	0.84	2.96	0.21
6.	*Cirrhius reba*	**LRnt**	22.0	15.2	0.00	0.42	0.00
7.	*Cirrhinus mrigala*	**LRnt**	45.2	19.0	0.00	0.21	.095
8.	*Labeo bata*	**LRnt**	36.2	12.8	0.84	1.27	0.42
9.	*Labeo calbasu*	**LRnt**	56.2	11.2	00.0	8.89	2.11
10	*Labeo rohita*	**LRnt**	48.6	30.5	0.00	5.93	1.58
11	*Ctenopharyngodon idellus*	**EN**	22.5	11.5	0.00	1.90	0.63
12.	*Cyprinus carpiovar*	**VU**	27.5	11.2	0.00	1.69	0.84
13.	*Hypothalmichthys molitrix*	**LRlc**	23.7	12.5	0.00	3.60	0.10
	II- Bagridae						
14.	*Mystus cavacius*	**LRnt**	24.5	11.0	0.00	0.63	0.00
15.	*Mystus vittatus*	**VU**	126.0	4.8	1.16	0.84	0.00
16.	*Rita rita*	**EN**	28.00	7.5	0.00	1.80	0.31
	III- Schilbeidae						
17.	*Ailia coila*	**VU**	12.4	8.6	0.00	2.22	0.95
18.	*Clupisoma garua*	**VU**	46.2	9.2	0.00	2.01	1.27
19.	*Eutropiichthys vacha*	**EN**	32.5	10.6	0.00	3.70	1.16
	IV- Siluridae						
20.	*Ompak bimaculatus*	**EN**	36.5	9.2	0.00	0.52	0.00
21.	*Wallago attu*	**LRnt**	75.6	22.6	0.95	13.34	3.38
	V-Notopteridae						
22.	*Notopterus notopterus*	**EN**	31.4	13.2	0.21	1.27	0.10
23.	*Chitala chitala*	**EN**	83.2	24.2	0.00	2.33	0.63
	VI-Chandadae						
24.	*Channa punctatus*	**LRnt**	26.5	16.4	24.10	3.38	0.74
25.	*Channa marulius*	**VU**	56.5	15.9	0.10	0.84	0.00
	VII- Clupeidae						
26.	*Gudusia chapra*	**VU**	13.8	5.4	0.00	0.21	0.00
27.	**VIII- Sisoridae**						
	Bagarius bagarius	**VU**	112.5	15.5	0.00	0.95	0.10
	IX- Clariidae						
28.	*Clarius batrachus*	**VU**	28.5	13.6	0.00	0.42	0.00
	X- Heteropneustidae						
29.	*Heteropneustes fossilis*	**VU**	28.6	15.5	0.00	1.16	0.31
	XI- Belonidae						
30.	*Xenentodon cancila*	**LRnt**	31.6	21.5	0.00	1.69	0.00
	XII- Mastacembelidae						
31.	*Mastacembelus armatus*	**LRnt**	32.6	20.5	0.00	2.11	0.63
	XIII- Ambissidae						
32.	*Chanda nama*	**Lrlc**	10.4	3.6	0.00	0.52	0.21
	***XIV*-Nandidae**						
33.	*Nandus nandus*	**LRnt**	18.2	15.1	0.00	0.63	0.00
	XV- Anabantidae						
34.	*Anabas testudineus*	**Lrlc**	16.5	9.8	0.00	0.42	0.00

EN endangered, **VU** vulnerable, **LRnt** lower risk near threatened, **Lrlc** low risk least concern

*Taxonomic status adapted from Talwar and Jhingran (1991)

**Threat status adapted from Lakra and Sarkar (2007)

RA= {Number of samples of any species / Total number of samples}× 100

The fish diversity index was calculated by the standard method of Shannon and Wiener (1963).

The Shannon Wiener index 'H' is calculated as;

$$H = \left\{ -\sum_{i=1}^{n} Pi\,(lnPi) \right\}$$

ln Pi is the natural log of that proportion value for each species.

n = total number of species.

H = Shannon Wiener index.

3) RESULTS AND DISCUSSION

Physico-chemical parameters: Among various physico-chemical parameter attributes, pH, turbidity, total dissolved solids and conductivity varied considerably from site to site, as well as with changing seasons. **(Table-1)**

The pH was higher than 7.0, at all sampling sites, slightly alkaline with slight seasonal variation. The temperature variations at three sites were due to seasonal changes ranging from 18.3^{0}C minimum (winter) at sampling site I & 31.60C maximum (summer) at site II.

Total dissolved solids and electrical conductivity, were moderate at sampling site I with seasonal variations. Water transparency varied seasonally among all sites from highly turbid at sampling site III (25.56 NTU in rainy season) to quite clear in summer and winter at sampling site I (3.21 NTU and 2.74 NTU).

Water conductivity varied along all the sites ranging from 166.39 µ S cm^{-1} to 1333.84 µS cm^{-1}, it was highest at sampling site II in winter i.e. 1333.84 µS cm^{-1} and lowest at sampling site III, 667.24 µS cm^{-1} in winter. The high electrical conductivity in winter at sampling sites II and III were due to enhanced effluents of sugar factories in nearby areas of District Pilibhit.

The total dissolved solids were high in monsoon season at sampling site I (169.04 mg/L), while at site II and site III these were appreciably higher in winter i.e. 826.90 and 399.69 (mg/L), respectively.

Dissolved Oxygen (DO) is the most important parameter which is used as an index of water quality, primary production and pollution. The DO level of 7.5mg/L is reported [17] to be favourable for aquatic organisms. In the present study, slight variation of dissolved oxygen was recorded at different sampling sites and it was minimum 6.56 mg/L in rainy season and maximum 7.86 mg/L in winter at site I. At sampling site II it was minimum (0.26 mg/L) in winter and maximum (2.03 mg/L) in rainy season. The lower values of DO at site II may be due to high level pollution at this site and due to high metabolic rate of organisms. At sampling site III, minimum DO level (2.45 mg/L) was in winter and maximum (4.85 mg/L) in rainy season.

Biochemical oxygen demand (BOD) has been used as a measure of the amount of organic materials in aquatic solution, which supports the growth of micro organisms. The BOD values in river Devaha ranged from 1.20 to 34.08 mg/L. Maximum values of BOD during winter at sampling site II (34.08 mg/L) and at site III (18.45 mg/L) were probably due to the presence of higher amount of organic matter carried in by the surface run off of heavy rains. During rainy season, BOD values were low which is because the temperature may retard the rate of reproduction of organisms.

Total hardness is a measure of the capacity of water to precipitate soap. It is the sum of the polyvalent cations present in water. The total hardness ranged from 74.94 to 265.03 mg/L.

Chemical oxygen demand (COD) is useful in pin pointing the toxic conditions and presence of bio-chemical resistant substances. In the present investigations COD was maximum during winter and minimum in rainy season which indicates lower microbiological activities and presence of oxidisable matter in the water.

In the present study, the chloride value ranged between 7.57 to 10.01 mg/L at sampling site I. It was considerably higher at sampling site II (142.89 mg/L) and at sampling site III (63.75 mg/L) in winters, which is probably due to increased pollution level in winter season. In winter sugar factories of nearby area and city directly load the discharge in to the river which is rich in inorganic and organic substances.

Nutrients like phosphate, nitrite, calcium and magnesium were at low level which indicates the oligotrophic status of the water body. Apart from agriculture, all other human activities are negligible considering pollution factor in the catchment area. Agriculture is the main activity with significant and excessive usage of fertilizers and pesticides. These pollutants ultimately reach in river water due to run off. Even though there is no possibility of a high level of pesticides in water, in the higher order organism like fishes it becomes significant due to bio magnifications.

The recorded 34 species belong to 7 orders, 15 families and 26 genera; cyprinidae was the most abundant family, contributing 43.0% of the fish fauna followed by siluridae (21.71%) and schilbeidae (11.33%), respectively. The clupeiformes was the most predominated order, contributing to 38.23% of fish species; silureformes was the second (32.35%) of the total 7 orders.

The Shannon-Weiner index for fish diversity in river Devaha, were ranging from 1.82 to 3.06**(Table-3).**

This index was used to evaluate the diversity of Camaleao Lake [18] and the reported values varied from 3.9 to 4.1.

Table-3: Seasonal diversity, Shannon-Weiner index.

Season	Diversity index
Summer	1.82
Monsoon	3.06
Winter	2.86

In central Amazonian Lake, variation in the Shannon-index varied from 2.2 to 3.2 [19].

In our findings the species diversity was at its peak in post monsoon (H= 3.06; in October), coinciding with favorable post monsoon conditions such as sufficient water and ample food resources. The diversity was low in summer.

CONSERVATION STATUS

The present study is the first of its kind for river Devaha on fish diversity and conservation priority. Our depicted presence of 34 species contributing 56.74% of total fish diversity according to the data published from Uttar Pradesh [20] and about 45.46% ichthyofauna from Madhya Pradesh [21]. Based on our study, status of fish fauna of river Devaha was

categorized in to three categories; Endangered (EN), Vulnerable (VU) and Low Risk (Table-2).

It was observed that out of recorded 34 species, 6 were endangered species, 12 were vulnerable while remaining were at low risk.

3) CONCLUSION

Variation in species diversity in different sampling sites indicated that altered habitat support less biological communities while less distributed sites were characterized by a diverse fish fauna. Open river habitats, the most preferred habitat for fishes inhabited in tropical rivers [22 and 23]. It was also evident in river Devaha. Discharge of effluent from the sugar factories and sewage from the inhabited places has resulted in low species richness at sampling sites II and III. Some other potential impacts of physico-chemical attributes were quite evident on the ichthyofauna of river Devaha. The water quality was also affected by pollutants which act on elements existing in water such as DO, phosphates, nitrates etc. and therefore affect the fish fauna indirectly. Due to lack of previous information on fish diversity from this river, it was not possible to quantify the rate of decline in fish diversity but the present study would be useful as baseline data for any future assessment.

Effective strategies can be taken up the conservation agencies for sustaining biodiversity. A more refined biotic assessment program is required for effective protection of fresh water fish resources. This study allows consideration of a long term conservation strategy for ichthyofauna in river Devaha.

Our study suggests that Devaha is a very important river for fresh water fish diversity in the Tarai region of Rohilkhand division of Uttar Pradesh.

This study may be beneficial for further environmental bioassessment.

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