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Impact of water quality attributes and comparative study of icthyofaunal diversity of Asan lake and River Asan

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Abstract: The present study reported a total of 28 taxa with six families from Asan lake whereas only 18 taxa were reported from river Asan in Doon valley. The families identified were Cyprinidae, Chandadae, Belonidae, Cobitididae, Mastacembellidae, and Sisoridae. The impact of water quality parameters was quite evident on the fish diversity and density of Asan Lake and River Asan. Correlation between hydrological attributes showed good relationship in Asan lake and these parameters were found to be the most important variables in shaping fish assemblage. However, in River Asan the effect of physico-chemical factors were significant on fish diversity. The study showed that Asan lake supported considerable diversity of the fishes and is important for conservation. Its fish fauna is threatened being either vulnerable or endangered. The low fish diversity in river Asan indicated the disturbed habitat and ecological conditions of the river and the data generated from it would be useful for conservation planning and management and also for future assessment of this river.

Keywords: Asan lake, Conservation, Correlation, Hydrological, Icthyofaunal

INTRODUCTION

Rivers and other water bodies are facing number of environmental problems through out the world largely associated with anthropogenic activities in their catchment areas. The adverse effects of human activities have resulted in degradation of aquatic ecosystem which ultimately alter the structure and function of water biota. This is more critical in developing countries. Fish have been regarded as an effective biological indicator of environmental quality and anthropogenic stress in aquatic ecosystems not only because of its iconic value, but also because of sensitivity to subtle environmental changes and represents a wide range of tolerance at community level (Irigolen, *et al.* 2004). Fish is sensitive to changes in water chemistry due to different anthropogenic activities and its responses to environmental disturbances, including hydro morphological factors are different in time and space in comparison to simpler organisms, as they tend to be integrated over larger intervals. Fish has been identified as suitable for biological assessment due to its easy identification and economic value (Gaston, 2000). Water pollution makes water unsuitable for drinking, recreation, agriculture and industry that eventually also diminishes the aesthetic quality of water bodies. Even more seriously, when contaminated water destroys aquatic life and reduces its reproductive abilities, it eventually menaces human health. The present study was conducted to determine the impact of physico-chemical parameters on the fish fauna and its comparative study in river Asan and Asan lake in order to know the status of Icthyofauna in Asan lake and the river that fed this lake.

MATERIALS AND METHODS

Study area: The Asan Lake is a small man-made wetland of 4 sq km area, located 40 km west of Dehradun, in Doon valley on Dehradun-Paonta road. Geographically it is situated between latitude 30° 24'-30° 28' N and longitude 77° 40'-77° 44' E, near the confluence of the two perennial rivers, River Asan and Yamuna. River Asan is an important tributary of River Yamuna. It flows North West of Doon Valley and later joins the River Yamuna near Asan Lake in Dehradun district. The Asan River is a river fed by the streams of the western part of the Doon valley. The northern section of the river is known locally as the 'Tons nadi' originates from the southern slopes of Mussorie.

Collection and analysis of samples: The sampling was carried out on monthly basis from August 2011-July 2012. Water samples were collected early in the morning in sterilized sampling bottles and physico-chemical parameters like Temperature (^{0}C), Velocity (m/s), pH, Dissolved Oxygen (mg/l) Total Solids (mg/l), Total Alkalinity (mg/l), Total Hardness (mg/l), Calcium (mg/l), Magnesium (mg/l), Chloride (mg/l), BOD (mg/l), Phosphate (mg/l) and Nitrate (mg/l) were analysed in accordance with Trivedy and Goel (1986), Khanna and

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Bhutiani, (2004); and APHA (2005). Besides personal fish collection, fishes were also procured from local fishermen fishing at different sites using indigenous fishing method. Fish specimen were collected and preserved in 10% formaldehyde solution. The identification of fishes were done on the basis of various morphological characters by following the standard keys, literature and work of Day (1978), Talwar and Jhingran (1991), Jayaram (1999) and Badola (1979).

RESULTS AND DISCUSSION

Among habitat attributes, pH, temperature, velocity and total solids varyied considerably in both river Asan and Asan lake (Tables 1 and 2). Temperature is an important factor for the growth of biodiversity and influences the biological, biochemical, chemical characteristics of aquatic systems. In the present study temperature was found to be maximum of 20.0±2.0 ^{0}C in river Asan whereas it was found slightly minimum in Asan lake with an annual average of 19.25±2.17 ^{0}C. It varied as expected with seasonal climates and showed a great variation month wise. pH was recorded slightly alkaline in river Asan with an annual average of 7.4±0.14 while in Asan lake it was recorded with an average of 8.2±0.11. The pH was recorded maximum in the month of November in both the Asan Lake and River Asan. pH was positively correlated with temperature, velocity and total solids in both Asan lake and River Asan. Similar results were observed in River Yamuna by Khanna *et al*. (2012). Total solids were averaging from a maximum of 783.33± 327.06 mg/l in River Asan to the minimum of 533.3±238.68 mg/l in Asan lake. Total solids were recorded maximum in month of August and minimum in month of January in both the Asan lake and Asan river. Water velocity varied from slow 0.43±0.08 m/s in Asan Lake to swift 0.69±0.20 m/s with a fairly high in month of July in river Asan but it was almost low in all the months in Asan lake. Total alkalinity constitutes an important parameter in determining the quality of water. A variation in alkalinity values ranged from the maximum of 253.5±17.20 mg/l in river Asan and a minimum of 168.33±15.05 mg/l in Asan lake (Table 1 and 2). The overall alkalinity was recorded maximum in river Asan and fairly low in Asan lake. Alkalinity showed a positive correlation with pH and total solids in both the Asan lake and river Asan (Table 3 and 4). Total hardness was recorded highest in River Asan (161.16±11.94 mg/l) and this may be attributed to presence of high calcium and magnesium levels whereas lowest in Asan Lake with an annual average of 97.33±9.59 mg/l (Table 1 and 2). Presence of high calcium and magnesium indicates the hardness r of water of the river. Total hardness was positively correlated with all the parameters in river Asan and Asan lake but showed a negative relation with total solids in river Asan (r= -0.271, p < 0.01) (Table 4). DO data are valuable in determining the water quality criteria of water bodies. In the systems where the rates of respiration and organic decomposition are high, the DO values usually remain lower than those of the systems where the rate of photosynthesis is high. DO was negatively correlated with temperature and pH. Similar results were observed by Khanna *et al*. (2010) in river Tons in Dehradun. Temperature also plays an important role in determining DO in an aquatic body. A high pollution load may also decrease the DO values to a considerable level. The DO values were found maximum in Asan Lake with an average of 10.86±0.41 mg/l whereas it was reported with the lowest in all the months and seasons in River Asan with an average of 8.34±0.64 mg/l. BOD has been used as a measure of the amount of organic materials in an aquatic solution which support the growth of microorganisms (Ciaccio, 1971). BOD determines the strength or polluting power of sewage, effluents and other polluted waters and provides data on the pollution load in natural waters. Higher values of BOD indicate a higher consumption of oxygen and a higher pollution load. In the present study BOD concentration was found lower in Asan Lake (2.86±0.49 mg/l) and highest in River Asan with the maximum concentration of 4.15±0.88 mg/l. Chloride is one of the major inorganic anions in water and waste water. The chloride content showed fluctuations within 34.81±5.90 mg/l in Asan lake and 43.34±4.21 mg/l (Table 1 and 2) in River Asan. Significantly higher values were observed in river Asan in all the months than Asan lake. Nitrate represents the end product of oxidation of nitrogenous matters and its concentration may depend on the nitrification and denitrification activities of micro-organisms. The concentration of nitrate ranged from a minimum of 1.24±0.27 mg/l in Asan lake (Table1) with the highest in the month of June. The recorded values were significantly higher from November to July. Furthermore, the nitrate value was significantly higher in river Asan (1.45±0.13 mg/l) (Table 2). Overall the nitrate concentration was reported highest in river Asan than Asan lake. Phosphate determination is useful in measuring the water quality since it is an important plant nutrient and may play a role of a limiting factor among all other essential plant nutrients (Dugan, 1972). The phosphorous concentration was recorded highest in river Asan and lowest in Asan lake ranging from 0.66±0.10 mg/l to 1.44±0.39 mg/l. Phosphate and Nitrate was positively correlated with total alkalinity, total hardness but negatively correlated with pH and total solids in river Asan (Table 4).

It was quite evident from the results that hydrological attributes like water temperature, pH, total solid, velocity, dissolved oxygen do not favor the growth of fishes and decline the fish diversity of river Asan. Based on present study, the results and data collected on fishes during conducted on river Asan is presented in Table 6. The

Table 1. Monthly variation in physico-chemical parameters of Asan lake from August 2011-July 2012.

Month / Parameters	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	April	May	June	July	Avg.	±S.D
Temperature °C	21.0	20.0	19.0	18.0	17.0	15.0	17.0	19.0	21.0	22.0	22.0	20.0	19.25	2.17
Velocity m/s	0.57	0.53	0.49	0.38	0.35	0.33	0.36	0.34	0.36	0.43	0.55	0.48	0.43	0.08
TS mg/l	1000	800	500	400	300	200	300	400	500	600	600	800	533.33	238.68
pH	8.2	8.3	8.1	8.4	8.2	8.0	8.2	8.1	8.3	8.1	8.2	8.3	8.2	0.11
Total alkalinity mg/l	196.0	165.0	173.0	192.0	166.0	153.0	162.0	159.0	147.0	158.0	173.0	182.0	168.33	15.05
Total Hardness mg/l	92.0	95.0	110.0	105.0	94.0	85.0	92.0	84.0	93.0	105.0	98.0	115.0	97.33	9.59
Calcium mg/l	28.95	32.8	27.5	22.4	36.2	27.43	34.36	31.61	42.17	63.56	54.82	65.38	38.93	14.53
Magnesium mg/l	15.38	15.17	20.13	20.15	14.10	14.04	14.06	12.78	12.40	10.11	10.53	12.10	14.24	3.20
Chloride mg/l	34.25	32.44	28.68	35.21	29.87	27.55	31.47	34.21	37.38	35.77	48.29	42.65	34.81	5.90
D.O mg/l	10.67	10.72	10.92	11.25	11.43	11.56	10.74	10.33	11.23	10.67	10.36	10.47	10.86	0.41
B.O.D mg/l	2.87	2.68	2.64	2.36	2.41	2.25	2.64	2.57	3.29	3.38	3.57	3.71	2.86	0.49
Phosphates mg/l	0.922	0.734	0.582	0.563	0.572	0.563	0.628	0.657	0.735	0.752	0.648	0.629	0.66	0.10
Nitrates mg/l	0.75	0.83	0.92	1.21	1.33	1.25	1.32	1.29	1.38	1.44	1.63	1.57	1.243	0.277

Table 2. Monthly variation in physico-chemical parameters of River Asan from August 2011- July 2012.

Month / Parameter	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	April	May	June	July	Avg.	± S.D
Temperature °C	21.0	19.0	20.0	18.0	17.0	17.0	19.0	21.0	22.0	22.0	23.0	21.0	20.0	2.00
Velocity m/s	0.78	0.73	0.67	0.63	0.55	0.47	0.54	0.49	0.63	0.75	0.83	1.21	0.69	0.20
T.S mg/l	1400	1200	800	700	500	400	500	600	500	700	900	1200	783.33	327.06
pH	7.4	7.6	7.5	7.7	7.4	7.2	7.3	7.5	7.6	7.4	7.5	7.6	7.4	0.14
Total alkalinity mg/l	237.0	245.0	256.0	247.0	236.0	228.0	247.0	251.0	282.0	274.0	277.0	262.0	253.5	17.20
Total Hardness mg/l	143.0	145.0	152.0	155.0	159.0	154.0	163.0	167.0	172.0	168.0	182.0	174.0	161.16	11.94
Calcium mg/l	46.17	57.43	53.71	62.23	65.42	52.35	57.45	62.26	66.32	58.34	65.46	61.67	59.06	6.08
Magnesium mg/l	23.62	21.36	23.98	22.63	22.83	24.80	25.75	25.55	25.78	26.75	28.43	27.40	24.90	2.10
Chloride mg/l	48.61	46.54	42.17	39.46	37.92	35.47	42.15	43.62	45.63	48.52	42.66	47.35	43.34	4.21
D.O mg/l	8.42	8.33	8.27	8.21	9.32	9.45	8.72	8.53	8.23	7.45	7.31	7.85	8.34	0.64
B.O.D mg/l	3.24	3.27	3.66	3.71	3.28	3.17	4.34	4.55	4.66	5.42	5.65	4.86	4.15	0.88
Phosphates mg/l	0.84	0.72	0.93	1.56	1.62	1.38	1.57	1.73	1.64	1.88	1.72	1.79	1.44	0.39
Nitrates mg/l	1.32	1.38	1.31	1.36	1.43	1.35	1.54	1.57	1.35	1.54	1.76	1.57	1.45	0.13

Table 3. Correlation between physico-chemical parameters of Asan lake.

	Temp.	Velocity	T.S	pH	Total alkalinity	Total hardness	Calcium	Magnesium	Chloride	DO	BOD	Phosphates	Nitrates
Temp.	1												
Velocity	0.655	1											
T.S	0.733	0.859	1										
pH	0.258	0.190	0.337	1									
Total alkalinity	0.164	0.568	0.532	0.438	1								
Total hardness	0.347	0.398	0.348	0.369	0.449	1							
Calcium	0.589	0.244	0.326	0.042	-0.128	0.470	1						
Magnesium	-0.398	0.019	-0.107	0.223	0.470	0.210	-0.763	1					
Chloride	0.692	0.439	0.429	0.397	0.233	0.336	0.692	-0.521	1				
DO	-0.636	-0.545	-0.559	-0.023	-0.221	-0.183	-0.471	0.388	-0.592	1			
BOD	0.797	0.475	0.554	0.212	0.034	0.484	0.894	-0.636	0.835	-0.578	1		
Phosphates	0.658	0.534	0.767	0.081	0.183	-0.159	0.145	-0.277	0.181	-0.387	0.357	1	
Nitrates	0.094	-0.339	-0.343	0.014	-0.314	0.163	0.692	-0.647	0.597	-0.132	0.524	-0.398	1

Table 4. Correlation between physico-chemical parameters of River Asan.

	Temp.	Velocity	T.S.	pH	Total alkalinity	Total hardness	Calcium	Magnesium	Chloride	DO	BOD	Phosphates	Nitrates
Temp.	1												
Velocity	0.485	1											
T.S.	0.347	0.728	1										
pH	0.287	0.424	0.361	1									
Total alkalinity	0.832	0.403	0.006	0.440	1								
Total hardness	0.582	0.306	-0.271	0.141	0.750	1							
Calcium	0.173	0.048	-0.388	0.475	0.538	0.726	1						
Magnesium	0.685	0.389	-0.102	-0.139	0.660	0.874	0.301	1					
Chloride	0.733	0.605	0.674	0.343	0.501	0.094	-0.138	0.227	1				
DO	-0.830	-0.642	-0.438	-0.512	-0.815	-0.512	-0.240	-0.541	-0.659	1			
BOD	0.791	0.397	-0.057	0.183	0.861	0.897	0.518	0.878	0.403	-0.779	1		
Phosphates	0.246	0.076	-0.506	-0.0008	0.467	0.844	0.684	0.688	-0.106	-0.243	0.714	1	
Nitrates	0.506	0.322	-0.001	-0.013	0.469	0.797	0.490	0.759	0.145	-0.522	0.805	0.640	1

Table 5. Monthly variation in icthyofaunal diversity in Asan lake from August 2011- July 2012**.**

Month	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul
Ichthyo-Fauna												
Family Cyprinidae												
B. bendelisis (Hamilton-Buchanan)	-	+	+	+	++	+++	++	+	++	+	-	+
B. vagra (Hamilton-Buchanan)	+	+	++	++	+++	+++	++	+	+	+	+	+
C. catla (Hamilton)	-	+	+	++	++	++	++	+	+	-	+	-
C. mrigala (Hamilton–Buchanan)	-	+	+	+	++	+++	++	+	+	+	+	-
R. daniconius (Hamilton-Buchanan)	+	+	+	++	+++	+++	++	++	+	+	+	-
D. rerio(Hamilton-Buchanan)	+	-	+	++	++	++	++	+	+	+	-	+
D.devario(Hamilton-Buchanan)	-	+	+	++	++	+++	++	+	+	+	+	+
G. gotyla gotyla (Gray)	+	+	++	++	++	++	++	++	++	+	-	-
P. ticto(Hamilton-Buchanan)	+	++	++	++	++	+++	+++	++	+	+	+	-
P. sarana sarana(Hamilton-Buchanan)	-	+	+	++	++	++	++	+	+	+	+	+
L. gonius(Hamilton-Buchanan)	+	++	++	++	++	+++	++	+	+	-	+	+
L. boga(Hamilton-Buchanan)	+	+	+	+	++	++	++	+	+	+	+	+
L. calbusa (Hamilton-Buchanan)	+	+	+	++	++	+++	++	++	+	+	+	+
T. putitora(Hamilton-Buchanan)	-	+	++	++	+++	++	++	+	+	+	+	-
T. tor(Hamilton-Buchanan)	+	+	+	++	++	+++	++	+	+	+	+	+
Family Chandadae												
C. gauchua (Bloch and Schneider)	+	+	++	++	++	+++	++	+	+	+	+	-
C. puntatus (Bloch)	+	+	++	++	+++	++	++	+	+	+	+	+
Sub Family Schizothoracinae												
R. bola(Hamilton-Buchanan)	-	+	+	++	++	++	++	++	+	+	+	+
S. plagiostomus (Heckel)	+	+	++	++	++	+++	+++	++	+	+	+	+
S.progastus(Heckel)	-	+	++	++	++	++	++	+	+	+	+	-
Order Beloniformes												
Family Belonidae												
X. cancila(Hamilton-Buchanan)	-	+	++	++	++	+++	++	++	+	+	+	+
Family Cobitididae												
B. dario Hamilton-Buchanan)	-	+	+	++	+++	+++	++	+	+	+	+	+
N.savona Hamilton-Buchanan)	+	+	+	++	+++	+++	++	++	++	+	+	-
N. botia Hamilton-Buchanan)	-	++	++	++	++	++	++	++	+	+	+	+
C. latius latius Hamilton-Buchanan)	+	+	++	+	++	+++	++	+	+	+	-	-
Order Mastacembeliformes												
Family Mastacembellidae												
M. armatus (Lacepede)	-	-	+	++	++	+++	++	++	+	+	+	+
Order Siluriformes												
Family Sisoridae												
B. bagarius Hamilton-Buchanan)	+	+	+	++	++	+++	++	++	+	+	-	+
G. pectinoptrus (McClelland)	-	+	+	++	+++	+++	+++	+	+	+	+	-
Total number of taxa reported= 28												

Abundant: (+++); Present (++); Rare (+); Nil: (-)

fish fauna observed and collected belonged to 6 families which include Family Cyprinidae, Family Chandadae, Family Belonidae, Family Cobitididae, Family Mastacembellidae, and Family Sisoridae. A total of 18 taxa belonged to these 6 families which included *Barilius bendelisis* (Hamilton-Buchanan), *B. vagra* (Hamilton-Buchanan), *Danio rerio*(Hamilton-Buchanan), *D. devario* (Hamilton-Buchanan), *Garra gotyla gotyla* (Gray), *Puntius ticto* (Hamilton-Buchanan), *P. sarana sarana* (Hamilton-Buchanan), *Labeo boga* (Hamilton-Buchanan), *L. calbusa* (Hamilton-Buchanan), *L. rohita* (Hamilton-Buchanan), *Channa puntatus* (Bloch), *Schizothorax plagiostomus* (Heckel), *S. progastus* (Heckel), *Xenentodon cancila* (Hamilton-Buchanan), *Botia dario* (Hamilton-Buchanan), *Nemachelius savona* (Hamilton-Buchanan), *Mastacembelus armatus* (Lacepede), *Bagarius bagarius* (Hamilton-Buchanan)

In river Asan the hydrological factors favoured the growth of icthyofauna. The fish fauna observed and collected (Table 5) belonged to 6 families which included Family Cyprinidae, Family Chandadae, Family Belonidae, Family Cobitididae, Family Mastacembellidae, and Family Sisoridae. A total of 28 taxa were found belonging to these 6 families include *B. bendelisis* (Hamilton-Buchanan), *B. vagra* (Hamilton-Buchanan), *Catla catla* (Hamilton), *Cirrhinus mrigala* (Hamilton–Buchanan), *Rasbora daniconius* (Hamilton-Buchanan), *D. rerio*(Hamilton-Buchanan), *D. devario* (Hamilton-

Table 6. Monthly variation in icthyofaunal diversity in river Asan from August 2011- July 2012.

Month	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul
Icthyo-Fauna												
Family Cyprinidae												
B. bendelisis (Hamilton-Buchanan)	-	-	-	+	+	+	+	-	-	+	-	+
B. vagra (Hamilton-Buchanan)	-	-	-	+	+	+	+	-	+	-	-	-
D. rerio(Hamilton-Buchanan)	-	+	-	+	-	+	+	+	-	+	+	-
D. devario(Hamilton-Buchanan)	-	-	+	+	+	+	+	-	+	-	+	-
G. gotyla gotyla (Gray)	+	-	+	-	+	+	+	+	+	-	-	+
P. ticto(Hamilton-Buchanan)	-	+	-	+	+	+	-	+	-	-	-	-
P. sarana sarana(Hamilton-Buchanan)	-	+	+	+	+	+	+	-	+	-	-	+
L. boga(Hamilton-Buchanan)	-	+	+	-	+	+	+	-	-	-	+	-
L. calbusa (Hamilton-Buchanan)	-	-	+	+	-	+	+	+	-	-	-	-
L. rohita (Hamilton-Buchanan)	+	-	-	+	+	+	+	-	-	-	-	+
Family Chandadae												
C. gauchua (Bloch and Schneider)	-	-	-	-	+	+	+	+	-	+	-	+
C. puntatus (Bloch)	-	-	+	+	+	+	+	-	-	-	-	-
Sub Family Schizothoracinae												
S. progastus(Heckel)	-	+	-	+	+	+	+	-		-	-	-
Order Beloniformes												
Family Belonidae												
X.cancila(Hamilton-Buchanan)	-	-	+	-	+	+	+	-	+	+	-	-
Family Cobitididae												
B. dario Hamilton-Buchanan)	-	-	+	-	+	+	+	+	-	-	+	-
N. savona Hamilton-Buchanan)	-	+	-	+	-	+	-	+	-	-	-	+
Order Mastacembeliformes												
Family Mastacembellidae												
M. armatus (Lacepede)	-	-	+	-	+	+	+	+	-	-	-	-
Order Siluriformes												
Family Sisoridae												
B. bagarius Hamilton-Buchanan)	-	-	-	+	-	+	+	+	-	-	-	+
Total number of taxa reported= 18												

Abundant: (+++); Present (++); Rare (+); Nil: (-)

Buchanan), *G. gotyla gotyla* (Gray), *P. ticto* (Hamilton-Buchanan), *P. sarana sarana* (Hamilton-Buchanan), *L. gonius* (Hamilton-Buchanan), *L. boga* (Hamilton-Buchanan), *L. calbusa* (Hamilton-Buchanan), *Tor putitora* (Hamilton-Buchanan), *T. tor* (Hamilton-Buchanan), *C. gauchua* (Bloch and Schneider), *C. puntatus* (Bloch), *Raimas bola* (Hamilton-Buchanan), *S. plagiostomus* (Heckel), *S. progastus* (Heckel), *X. cancila* (Hamilton-Buchanan), *B. dario* (Hamilton-Buchanan), *N. savona* (Hamilton-Buchanan), *N. botia* (Hamilton-Buchanan), *Crossoocheilus latius latius* (Hamilton-Buchanan), *M. armatus* (Lacepede), *B. bagarius* (Hamilton-Buchanan) and *Glyptothorax pectinoptrus* (McClelland). The Family Cyprinidae was dominant among all the families.

The present study revealed that the physico-chemical habitat variables played key role in the distribution of fishes in Asan lake and river Asan and the habitat alteration and fragmentation brought about significantly to the endangerment of freshwater fish fauna. We observed that among habitat attributes, water velocity, dissolved oxygen and pH are key habitat features and positively correlated with the fish assemblages and found the most important variables in shaping fish distributions. The variations in the habitat attributes like temperature, pH, and total solids in Asan lake was attributed to differences in land use pattern, which was responsible for variation of species diversity and distribution. Similar pattern of habitat attribute has been observed by Shahnawaz *et al.* (2010). Recently, the significance of habitat was endorsed by Peres-Neto (2004) with evidence suggesting species occurrence are driven more by relationship with abiotic factor than species interaction. The diversity recorded in the river Asan was lesser than Asan lake. Similar results were reported from tributaries of River Ganga (Sarkar *et al.* 2010). Due to lack of previous information on fish diversity from this river, it is 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 after interlinking. Most importantly, our study indicates considerable share in supporting fish biodiversity in the region despite alterations like anthropogenic activities and habitat degradations. Fish communities in riverine system typically follow a pattern of increasing species richness, diversity and abundance (Welcomme, 1985). However,

the current pattern of species diversity of fishes contrasts sharply with the typical pattern. Species diversity was lowered in river Asan in this study compared with the Asan lake. The pattern found in river Yamuna suggests cumulative temporal and spatial effects of habitat loss or environmental degradation (Scrimgeour and Chambers, 2000). Although the Asan lake is used for multipurpose activities like tourism, boating, irrigation and multiple water use but supported more species as compared to river Asan which might be due to positive influence of river Yamuna connected with the lake in this region as well as due to existence of more open river, slow water and pool habitats along with macrophytes which might have importance in fish assemblage and aggregation (Growns *et al*. 2003). The reason of low species of fishes in river Asan might be due to effect of discharge from the industries, high sedimentation rate, pollution, domestic and commercial waste water discharge which brought the changes in physico-chemical factors that indirectly affects the fish fauna. According to Bunn and Arthington (2002) many types of river ecosystem have been lost and populations of many riverine species have become highly fragmented due to human intervention.

Conclusion

Variation in species diversity in Asan lake and river Asan indicated that altered habitat supported less biological communities while less disturbed sites were characterized by a diverse fish fauna . The study revealed that Asan lake was not polluted to that extent as compared to river Asan and thus pollution free habitat of Asan lake contributed to the maximum diversity of fishes than river Asan, Some other potential impacts of physico-chemical attributes were quite evident on the icthyofauna of river Asan. The water quality was also affected by pollutants which act on elements existing in water such as DO or produce substances such as phosphates, nitrates etc and therefore effects the fish fauna indirectly. It is important to take effective strategies for the conservation of fish fauna of river Asan in order to sustain biodiversity and the balance of this aquatic ecosystem.

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