



ECOLOGICAL ASPECTS AND IMPACT OF POLLUTION ON PHYSICO-CHEMICAL CONDITIONS OF SONG RIVER IN DOON VALLEY OF UTTARAKHAND

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ABSTRACT

The present study was under taken for a period of one year, September 2013 to August 2014 to assess the species diversity and impact of pollution on physico-chemical conditions of Song river in Doon Valley. In the present study water samples were collected on monthly basis from three important sampling

sites, Lacchiwala (S1), Chhidarwala (S2) and Raiwala (S3). The samples were analysed for different physico-chemical attributes and various biological parameters including Phytoplankton, Zooplankton and Ichthyofauna diversity. In total phytoplankton include 23 taxa belong to three families, Chlorophyceae, Bacillariophyceae, and Myxophyceae were noticed out of which highest diversity was found in case of Bacillariophyceae. Similarity 21 taxa of zooplankton belongs to 4 different genera including protozoa, rotifer, copepod and ostracoda were noticed with highest diversity in case of protozoa. The results also revealed that Ichthyofauna was recorded with 25 different taxa belonging to 6 families. The physico-chemical conditions were favourable for the growth and survival of aquatic



organisms. The occurrence of phytoplankton population and fish diversity indicate a good water quality of Song River with positive effect of physico-chemical factors on the growth of these ecological indicators of aquatic ecosystem.

KEYWORDS: Ecological, Phytoplankton, Zooplankton, Ichthyofauna, Song River.

INTRODUCTION:

Millions of people all over the world particularly in developing countries are losing their lives

every year due to water born diseases. About 97% to earth's water supply is in the ocean which is unfit for human consumption and other uses because of its high salt content. The remaining 2% is locked in the polar ice caps, and 1% is available as freshwater in rivers, lakes, streams, reservoirs and groundwater, which is suitable for human consumption. Water can be obtained mainly from two sources namely surface and groundwater. Surface water is any water that travels or is stored on top of the ground. This would be the water in rivers, lakes, streams reservoirs and even the oceans. River water is the purest form of natural water, since it is obtained as a result of evaporation from the surface water. However in its downwards journey of industrial gases like CO₂, NO₂, SO₂ etc. and suspended solid particles both of organic and inorganic origin. Clean water is needed for drinking, cooking, bathing, washing for sanitary, disposal of domestic and human waste for agriculture, for industrial processes as in production of material such as steel, and other metals, textiles, beverages, rubber, plastics etc. Water is one of the most essential substances needed to sustain human life, animals and plants.

Water pollution is the alternation in physico-chemical and biological characteristics of water which may be cause harmful effects on man and aquatic biota, aquatic ecosystem harbors variety of plants and animals viz. phytoplankton.

Phytoplankton, Fishes, Aquatic insects and amphibians-plankton including phytoplankton and zooplankton forms the base of food chain in aquatic ecosystem and thus playing a vital role in fisheries. The spatial and temporal variation of plankton community is regulates by major environmental factors and contaminations of water bodies might lead to change in their trophic status and render than unsuitable for agriculture.

Zooplankton is an important constituent of pelagic ecosystem. Zooplankton feed on the phytoplankton, bacteria, microorganism and all freshwater fishes feed on zooplankton at some stage in their life history. Biological production is only aquatic body gives direct correlation with its physico-chemical status which can be used as trophic status and fisheries resources potential life in aquatic environment is eagerly governed by physico-chemical characteristics and their stability.

Study Area

Doon valley is one of the important valley of India. It is enclosed by the Shiwalik hills and the outer part of the Himalayan ranges. It occupies on area of about 1200 sq.km. between 77° 33' 10" and 77° 18' 30" Longitude and 29° 58' 40' and 31° 24' N Latitude (east). The physical features of the Doon Valley are the unique natural boundaries within which are enclosed viz. the Himalayan mountains in North, Shiwalik range in the South, and river Ganga and Yamuna on the east and west respectively. Uttarakhand as both the new and traditional name of the state that was formed from the hill districts of Uttar Pradesh (9 Nov. 2000). The river song originates from foot hills of Mussoorie range, which enters the valley at Mal Devta and receives all along its course a number of tributaries from Himalayan and Siwalik ranges.

Materials and Methods

The present study was conducted on Song river covering a stretch of approximately 44 km from upstream to downstream. Three sites were selected along the river which includes Lacchiwala (S1), Chhidarwala (S2) and Raiwala (S3). The study was carried out for a time period of one year from September 2013 to August 2014, on monthly basis. Water samples were collected every month early in the morning in sterilized sampling bottles and were analysed for physico-chemical parameters like Temperature (°C), Transparency (cm), Velocity (m/s), pH, Free CO₂ (mg/l) and dissolved Oxygen (mg/l) were performed on spot and other parameters like turbidity (JTU), Total solids (mg/l), Total dissolved solids (mg/l), Total alkalinity (mg/l), Total hardness (mg/l), Calcium (mg/l), Magnesium (mg/l), Chloride

(mg/l), Phosphate (mg/l), Nitrate (mg/l), Sodium (mg/l) and Potassium (mg/l) were analysed in laboratory by following the methodology of APHA (2005). The temperature, transparency, velocity was measured by using Celsius thermometer ($^{\circ}\text{C} - 1000\text{c}$). Secchi disc and flowmeter. Turbidity and pH were measured by using Jackson turbidity unit and digital pH meter. Total solids and total dissolved solids were measured by volumetric analysis. Alkalinity, Total hardness, Calcium, Magnesium, Chloride, Free CO_2 , Dissolved oxygen, were analysed by titration methods. Phosphate and Nitrate were analysed by using UV-VIS spectrophotometer and sodium and potassium by Flame photometer.

The collection of drift samples (zooplankton and phytoplankton) were made by hauling of water by plankton net (0.1 mm Mesh size) for one year (September 2013 to August 2014). Samples were brought to the Zoological laboratory where they were identified to the lowest possible level of taxonomic resolution with the help of books. The counting of plankton was made by sedgewick rafter under research microscope. Available literature of the fish fauna of Doon Valley was studied, Hora and Mishra (1938), Singh (1964), Grover (1971) and Grover et.al. (1994). Information on the habit and economic importance was collected from fisherman and local fish retailers. Further the names of the fishes were confirmed from the websites www.fishbase.org. However in the present check list, the present status of threatened, endangered etc., were determined for the physical verification of the prevailing threats caused by both natural and anthropogenic hazards.

Table 1

Physico-Chemical parameters of Song River at Lacchiwala (S1), Chhidarwala (S2) and Raiwala (S3) for the year September 2013 to August 2014.

S.No.	Sites	S1	S2	S3
1.	Temperature ($^{\circ}\text{C}$)	17.25	18.0	19.68
2.	Transparency (cm)	26.6	31.61	50.7
3.	Velocity (m/s)	1.28	1.31	1.00
4.	Turbidity (JTU)	300.0	301.0	240.0
5.	TD (mg/l)	232.0	321.15	35.41
6.	pH	8.20	8.32	8.00
7.	Total Alkalinity (mg/l)	150.15	147.72	161.25
8.	Total Hardness (mg/l)	81.00	72.62	71.00
9.	Calcium (mg/l)	34.60	31.61	35.71
10.	Magnesium (mg/l)	10.62	10.10	9.34
11.	Chloride (mg/l)	29.60	30.10	28.18
12.	Free CO_2 (mg/l)	1.10	1.16	1.61
13.	D.O. (mg/l)	10.31	10.62	10.19
14.	Phosphate (mg/l)	0.50	0.49	0.54
15.	Nitrate (mg/l)	0.39	0.29	0.31
16.	Sodium (mg/l)	0.26	0.21	0.25
17.	Potassium (mg/l)	0.35	0.37	0.31

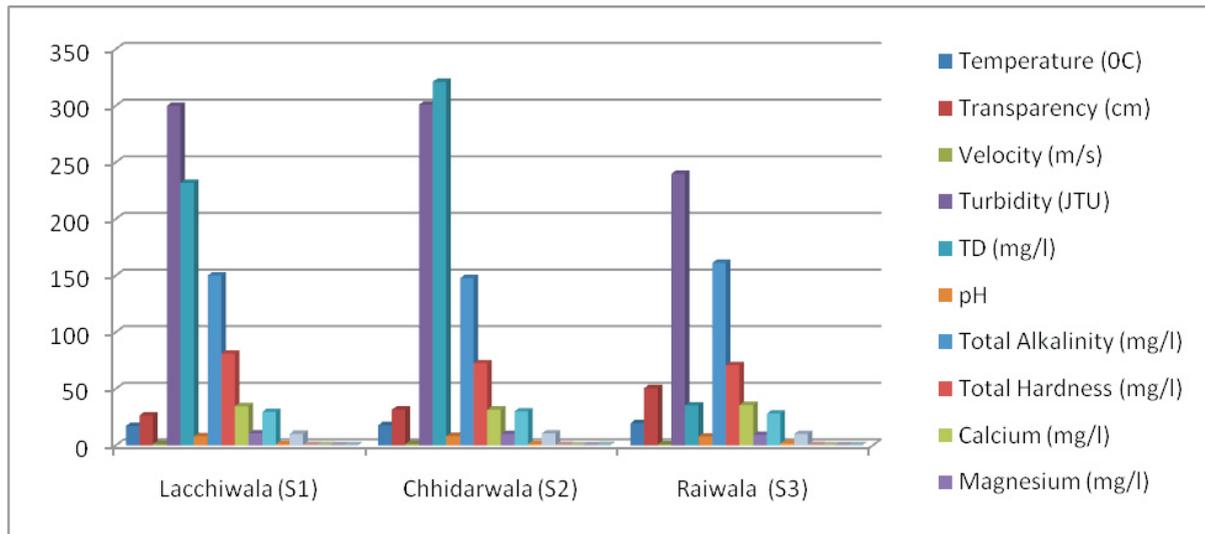


Fig. 1 : Showing Physico-Chemical parameters at S1, S2 & S3 of Song River.

Table 2

Biological diversity of phytoplankton at Lacchiwala (S1), Chhidarwala (S2) and Raiwala (S3) at Song river for the year September 2013 to August 2014.

Phytoplankton		SITES		
		S1	S2	S3
Family : Chlorophyceae	Volvox	20.2	24.08	24.0
	Syndemus	15.50	9.42	13.30
	Chara	15.0	12.0	15.06
	Chlorella	22.34	38.42	26.28
	Chlamydomonas	24.79	27.07	22.04
	Spirogyra	18.22	22.0	26.0
	Ulothrix	16.40	15.40	16.20
	Cladophora	17.75	16.00	14.24
	Oedogonium	12.60	9.60	12.34
	Microspora	15.63	14.20	13.20
	Total	178.43	178.77	170.32
Family: Bacillariophyceae	Fragilaria	110.2	138.20	147.29
	Synedra	40.55	45.70	37.21
	Navicula	162.42	130.42	151.81
	Diatoms	125.60	111.33	120.44
	Pinularia	24.08	11.43	20.66
	Cymbella	81.24	69.10	96.40
	Denticula	27.07	16.05	40.62
	Ceratoneis	14.33	24.40	15.25
	Tabellaria	60.15	90.35	71.30
Total	645.20	636.98	700.98	
Family: Myxophyceae	Anabaena	10.25	9.24	14.29
	Nostoc	10.10	8.81	12.63
	Oscillatoria	10.62	20.42	27.62
	Coccochloris	7.42	4.25	7.65
	Total	38.89	24.67	56.19

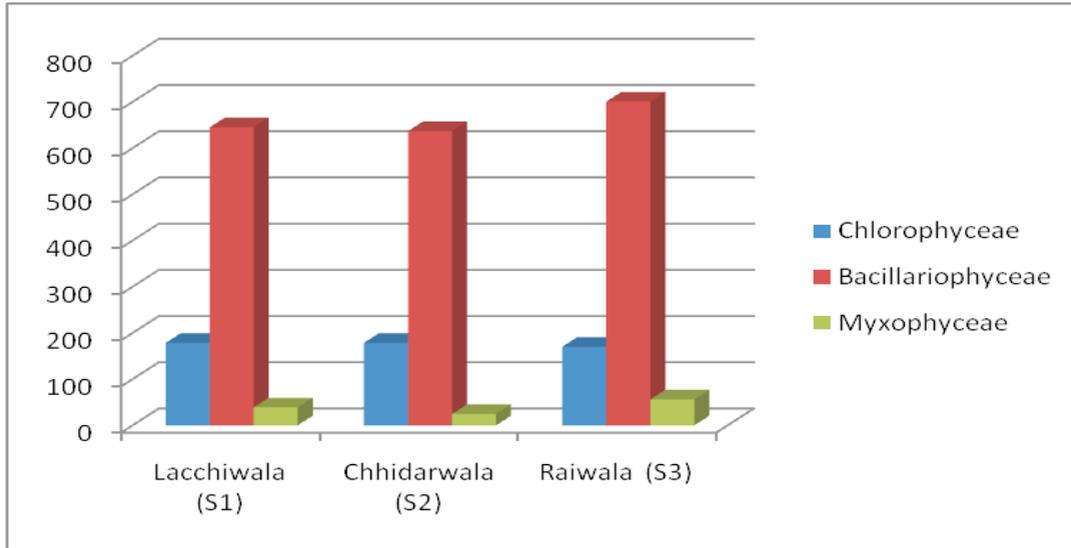


Fig. 2 : Showing average phytoplankton at S1, S2 & S3 of Song River.

Table 3

Biological diversity of zooplankton at Lacchiwala (S1), Chhidarwala (S2) and Raiwala (S3) at Song river for the year September 2013 to August 2014.

Zooplankton		SITES		
		S1	S2	S3
1. Protozoa	Arcella	11.15	8.91	16.28
	Actinophrys	12.13	9.32	14.30
	Actinosphaerium	11.62	14.33	20.41
	Campenella	15.16	9.24	8.34
	Difflugia	16.40	14.20	21.66
	Euglena	7.20	9.22	10.62
	Epistylis	10.81	5.61	13.82
	Paramecium	8.00	7.60	14.20
	Peridinium	11.0	9.20	12.62
	Total	104.47	87.63	132.25
2. Rotifera	Ascomorpha	14.06	17.07	22.81
	Asplanchna	30.4	22.09	26.44
	Brachinous	36.04	26.07	29.48
	Keratella	12.0	16.41	12.64
	Nolthoca	16.17	12.66	17.16
	Pomphalix	12.66	7.29	16.53
	Total	121.33	101.59	125.06
3. Copepoda	Cyclops	26.56	16.44	29.62
	Diaptomus	16.62	8.44	14.15
	Nuplius	10.61	14.33	22.81
	Helobdella	6.62	16.33	24.31
	Total	66.41	55.54	63.89
4. Ostracoda	Cypris	7.4	6.0	13.62
	Stenocypris	8.4	5.5	12.10
	Total	15.8	11.50	25.72

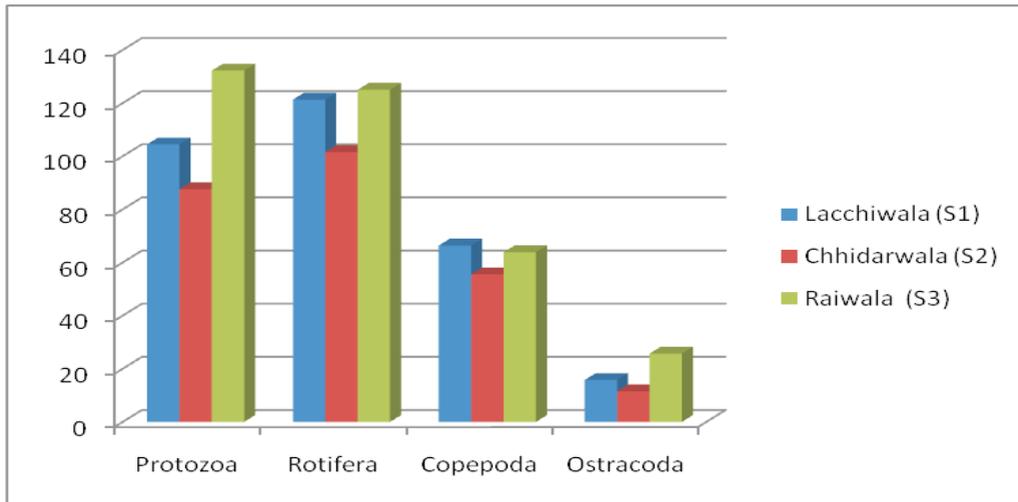


Fig. 3 : Showing average zooplankton at S1, S2 & S3 of Song River.

Table 4

Ecological status and diversity of Fish Fauna of Song river at Lacchiwala (S1), Chhidarwala (S2) and Raiwala (S3) for the year September 2013 to August 2014

Fish Fauna	Song River			Ecological Status
	S1	S2	S3	
A: Order Cypriniformes				
1. Family - Cyprinidae				
1. Barilius bola	+++	+++	+++	Intermediate
2. B. Vagra	+++	+++	+++	Intermediate
3. B. barna	+++	+++	+++	Intermediate
4. B. bendelisis	+++	+++	+++	Intermediate
5. Channa gauchua	-	+	+	Rare
6. Danio devario	-	+	+	Rare
7. Garra gotyla gotyla	+++	+++	+++	Intermediate
8. Puntius ticto	+++	+++	+++	Intermediate
9. P. sarna	+++	+++	+++	Intermediate
10. Labeo gonius	-	+	+	Rare
11. Labeo derio	+	++	++	Intermediate
12. Labeo dyochelius	+ -	+++	+++	Intermediate
13. Tor tor	-	++	++	Rare
14. Tor putitora	-	++	++	Rare
2. Family Schizothoracinae				
15. Schizothorax plagiostomus	-	-	++	Rare
16. S. progastus	-	+	++	Rare
B. Order - Beloniformes				
3. Family - Belonidae				
17. Xenentodon cancila	+++	+++	+++	Intermediate
4. Family - Cobitidae				
18. Botia dario	+	++	++	Rare
19. Nemachelius savona	+++	+++	+++	Intermediate
20. Nemachelius rupicola	+++	+++	+++	Intermediate
21. N. botia	+++	+++	+++	Intermediate
22. Crossocheilus latius latius	+	+++	+++	Intermediate
C - Order - Mastacembeliformes				
5. Family - Mastacembellidae				
23. Mastacembelus armatus	++	++	++	Intermediate
D. Order - Siluriformes				
6. Family - Sisorida				
24. Bagarius bagarius	+	+	+	Rare
25. Glyptothorax pectinopterus	+	++	++	Rare

Abundant	+++	Present	++
Common	+	Nil	-

Results and Discussion

Physico-Chemical parameters

The physico-chemical parameters values recorded from three sites of Song River is given in table 1. From the results the temperature noted at S1 was minimum (17.250C) and at S3 it was found maximum (19.680C). The highest values of transparency was observed at S3 (50.7 cm) and lowest at S1 (26.6 cm). The highest value of velocity was noted at S2 (1.31 m/s) while the lowest value of velocity found at S3 (1.0 m/s). Highest value of turbidity at S2 (301.0 JTU) and lowest at S3 (240.0 JTU). The pH recorded at S3 was minimum 8.00 and it was found maximum S2 (8.32). The total alkalinity was found to be highest at S3 (161.25 mg/l) and it was found minimum at S2 (147.72 mg/l). The concentration of dissolved oxygen was recorded to be maximum at S2 (10.62 mg/l). The total hardness was found to be highest at S1 (81.00 mg/l), and lowest at S3 (71.0 mg/l). The other parameters like Free CO₂, Calcium, Magnesium, Chloride, Phosphate, Nitrate, Sodium and Potassium showed on irregular trend and a little variation in their concentration from S1 to S3 during the study period.

Phytoplankton – The phytoplankton inhabiting the Song river at S1 to S3 comprises of 23 taxa out of which chlorophyceae constitutes 10 genera, Bacillariophyceae 9, genera, and myxophyceae 4 genera (Table 2). The diversity recorded at S2 was maximum for chlorophyceae (178.77) and minimum at S3 (170.32). The diversity recorded at S3 was maximum for Bacillariophyceae (700.98) and minimum at S2 (636.98). The diversity recorded at S3 maximum for myxophyceae (56.19) and minimum S2 (24.67). The qualitative study of phytoplankton in Song River of Doon Valley revealed that the family chlorophyceae was represented by *Volvox syndemus*, *Chara*, *chlorella*, *chlaymydomonas*, *spirogyra*, *ulothrix*, *cladophora*, *oedogoniumsm* and *mcirospora*. The family Bacillariophyceae was represented by *Fragilaria*, *Synedra*, *Navicula*, *Diatoms*, *Pinularia*, *Ceratoneis*, *Cymbella*, *Denticula* and *Tabellaria*. The family myxophyceae was represented by *Anabaena*, *Nostos*, *Oscillatoria* and *Cocchohloris*.

Zooplankton - The zooplankton inhabiting the Song river at S1, S2 and S3 include 21 taxa out of which protozoa consists of 9 genera, Rotifera 6 genera, Copepoda 4 genera and ostracoda 2 genera (Table 3). The diversity at S3 was found to be maximum for Protozoa (132.25) followed by Rotifera (125.06), Copepoda (63.89) and Ostracoda (25.72). The qualitative analysis of Zooplankton is Song river in Doon Valley revealed that the Protozoa were represented *Arcella*, *Actinophrys*, *Actinosphaerium*, *Compenella*, *Difflugia*, *Euglena*, *Epistylis*, *Paramecium* and *Peridinium*. The rotifera was represented by *Ascomorpha*, *Asplanchna Brachinous*, *Keratella*, *Nolthoca* and *Pompphalix*. The copepod was represented by *Cyclops*, *Diaptomus*, *Nuplinus* and *Helobdella*. The ostracoda was represented Cypris and Stenocypris.

Fish Fauna - A total of 25 taxa of fishes belonging to 6 families and 4 orders were recorded during the present study are in table 4. Cyprinidae family was found abundantly at three sites including *Barilius bola*, *B. vagra*, *B. barna*, *B. bendelisis*, *Channa gachua*, *Dario devario*, *Garra gotyla gotyla*, *Puntius ticto*, *P. sarna*, *Labeo gonius*, *L. derio*, *L. dyochelius*, *Tor tor* and *T. putitora*. Family schizothoracinae was present at S2 and S3, taxa including *Schizothroax plagiostomus* and *S. progastus* where as family Benonidae was recorded with only one taxa, *Xenentodon cancila*. The family cobitidae was recorded

with 5 taxa including *Botia dario*, *Nemachelis savona*, *N. rupicola*, *N. botia* and *Crossocheilus latius latius*. Family Mastacembellidae was found only one taxa *Mastacembelus armatus* and family sisoridae with two taxa *Bagarius bagarius* and *Glyptothorax pectinoptus*.

The physico-chemical variables are important factors of water in which all the biological communities live in association with each other. The most common physical assessment of water quality is measurement of temperature. During the present study the temperature recorded in Song river ranged from 17.25° C to 19.68° C respectively. However the values of temperature recorded at all the sites varies monthly as well as seasonally but overall the temperature was found to be slightly higher which had a strong effect on the chemical and biological parameters of water. The total alkalinity recorded alkaline nature of river water was revealed by the elevation of pH from 8.0 to 8.32. The increase in pH could be due to either increased concentration of carbonates or increased photosynthetic activity of producers (Trivedi and Goel, 1984). Total dissolved solids was recorded relatively in higher levels of during rainy season which may be attributed to the heavy rainfall resulting in soil erosion several fold concentration of elements and minimum in winter due to minimum velocity which favoured effective sedimentation and low level of water causing minimum silt. Hardness is an important parameters in decreasing the toxic effect of poisonous elements. The values of hardness ranged from 71.0 to 81.0 mg/l. Hardness values may be attributed to presence of high Calcium and Magnesium levels in aquatic ecosystem. (Gupta et.al. 2008).

In Song river dissolved oxygen concentration was almost high ranged from 10.19 to 10.62 mg/l which indicated the better conditions of water quality. The transparency was minimum in rainy season, while as turbidity was maximum during this period. The season for thus was heavy rainfall during rainy season which brings soil and other sediments resulting in less penetration of light, hence decreasing the photosynthesis of light, hence decreasing the photosynthetic activity of aquatic flora and resulting in low concentration of dissolved oxygen during rainy season. In Song river the concentration level of phosphate and Nitrate varied between 0.49 to 0.54 mg/l and 0.29 to 0.30 mg/l. The relatively low concentration of chloride in Song river may be due to dilution effect. The levels of sodium and potassium in Song river ranged from 0.21 to 0.26 mg/l and 0.31 to 0.37 mg/l.

The members of plankton community are important for their role in trophic dynamics and in energy transfer in the aquatic ecosystem. They provide the food for fishes in the freshwater and play a major role in fish production. Phytoplankton is the pioneer of an aquatic food chain. The productivity of an aquatic environment is directly correlated with the density of phytoplankton. The physico-chemical factors are directly related with their productions. The phytoplankton is the base of most of the lake food, food webs and fish production is linked to phytoplankton (Ryder 1974).

All the aquatic system and their biota affect directly or indirectly human beings. All forms of life, on the earth depend upon water for their mere existence. Among all the freshwater aquatic biota, zooplankton population is able to reflect the nature and potential of any aquatic systems. Zooplankton offer several advantages as indicators of environment quality in both lakes and rivers. As a group they have worldwide distribution species, composition and community structure which are sensitive to changes in environmental conditions, nutrients enrichment and different levels of pollution. The composition and occurrence of zooplankton recorded in various station during and period of the study is shown in table 3. The qualitatively the fauna of each sampling stations was dominated by protozoa, followed by rotifer, copepods and ostracods. Most of the zooplankton encountered in the study area appears to be normal inhabitat of natural lakes, ponds, streams and artificial impoundment in India. The protozoa constitute the large group of zooplankton recorded in all three sites. The high population abundance of rotifer may also be attributed to their parthogenetic reproduction pattern and short

development rates under favourable conditions in most freshwater system.

During the course of study fish fauna was more diverse in Song river as shown table 4. The river water is a natural medium for the growth of aquatic flora and the fluxing of the wastes by natural or anthropogenic factors cause a disturbance in its composition. Fish communities in riverine system typically follow a pattern of increasing species richness, diversity and abundance from upstream to downstream. In the present study it was revealed that dissolved oxygen and pH are key habitat features and positively correlated with the fish assemblages and are the most important variables in shaping fish distributions. The variations in the habitat attributes like pH, turbidity, total dissolved solids, across different stations was attributed to difference in land use pattern which was responsible for variation of species diversity and distribution. Our study depicted the presence of 25 taxa belonging to 6 families and 4 orders. Though the fish diversity was profoundly present in the Song river but there is great need of conservation strategies as far as the status of fish fauna is concerned. The present study suggested that Song river in Doon Valley Uttarakhand has to be preserved for its intended use, a sustainable and holistic management planning is necessary for conservation of this aquatic ecosystem. Habitat destruction, over exploitation and wanton destruction should be controlled and environment awareness with regard to aquatic ecosystem cant regard to aquatic ecosystem in Himalayas be propagated among the prospective and inhabitation of the areas for the general follow up.

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