LIMNOLOGY OF SOME LOTIC HABITATS OF URI, A SUBTROPICAL REGION OF KASHMIR HIMALAYA

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ABSTRACT

The River Jhelum and its tributaries in and around Uri were studied for limnological features from October 2002 to April 2003. Water of the tributaries varied significantly with respect to hardness, while the main river water was always typical hard water type. The pH value of the river water at different sites was always on the alkaline side and fluctuated from 7.80 to 8.50. The coliform bacteria were totally absent in the samples from the streams. All the tributaries of the river in the area, viz., Buniyar, Islamabad, Jabla and Uroosa Nallas, were free from pollution. A total of 41 species of phytoplankton were recorded from different sampling sites, of which 21 belonged to Bacillariophyceae, 13 to Chlorophyceae, 5 to Cyanophyceae and one each to Euglenophyceae, and Dinophyceae. Periphytic community was represented by 55 species in the river system of the area. Bacillariophyceae was the most dominant class in both the algal communities and its proposition in phytoplankton fluctuated between 61.55% and 92.4%, while among periphyton its contribution ranged from 55.16% to 83.73%. Diversity index of phytoplankton showed a marginal increase from autumn to winter, being followed by a decrease in spring.

***Keywords**:* Uri, Himalaya, lotic waters, water chemistry, algal community

INTRODUCTION

The River Jhelum is an important tributary of the Indus River, originating from Pir Panjal range of mountains. The river flows across the main valley of Kashmir in Northwest direction up to Banyari in Bandipur District where it joins the Wular lake. It then reemerges from the lake near Sopore in Baramulla District taking southwestern direction leaving the valley near Gantamulla. From here it assumes torrential nature and flows through the Uri town before crossing over to Pakistan Occupied Kashmir (Fig. 1). All along its course through the valley of Kashmir the river water is loaded with large quantities of sewage and agricultural run off received from the catchment. However, from Gantamulla onwards the organic load into the river from the immediate catchment decreases significantly. In the present study an attempt was made to find out the limnological features of the river Jhelum and its tributaries in the Uri region so as to have an insight into the level of pollution in the river. For this purpose a detailed limnological study of the Jhelum and its main tributaries in Uri – Buniyar Nalla, Salamabad Nalla, Nambla Nalla and Goalta Nalla – was conducted during October 2002 – April 2003.

MATERIAL AND METHODS

Six sites, selected for the present study, are delineated in Fig.1. These include:

Site 1 (S1): Buniyar Nalla at Salamabad,

Site 2 (S2): River Jhelum just below the Tail Race Tunnel of Uri I HE Project,

Site 3 (S3): Haji Pir (Nambla) Nalla near Nambla bridge,

Site 4 (S4): Salamabad (Jabla) Nalla near Sri Dhar bridge, Site 5 (S5): River Jhelum at Dachhi Bridge,

Site 6 (S6): Goalta (Urusa) Nallah near Urusa bridge.

Various physico-chemical parameters of water were determined as per the methods listed below:

Parameter	Method	Reference
Ambient Temperature	Celsius thermometer	Welch (1948)
Transparency	Secchi disc method	Welch (1948)
Chlorides	Titrimetry with $AgNO_3$	Mackereth *et al* (1978)
Carbon dioxide	Titrimetry with NaOH	Mackereth *et al* (1978)
Sp. conductivity	Digital conductivity meter	Welch (1948)
PH	Digital pH meter	APHA (1995)
Dissolved oxygen	Winkler method and Oxygen Probe	APHA (1995)
B. O. D.	5 - day BOD test	APHAl (1995)
C. O. D.	Open Reflux method	APHA (1995)
Alkalinity	Titrimetry with H_2SO_4	Mackereth *et al* (1978)
Hardness	Titrimetry with EDTA	Mackereth *et al* (1978)
NH_4- N	Phenate method	APHA (1995)
NO_3- N	Salicylate method	CSIR (1974)
Ortho- and total PO_4 - P	Stannous Chloride method	APHA (1995)

Plankton samples were collected by sieving a fixed quantity of water (generally 30 litres) through Nylobolt No. 140 T plankton net. The plankton samples thus collected were preserved in modified Lugol's solution (APHA, 1995). Periphytic community was collected in triplicate by scratching 1 cm^2 of the substratum (bottom stones). The scratched material was preserved in Lugol's solution. For quantitative analysis of phytoplankton and periphyton samples, preserved in Lugol's solution/formalin solution, were diluted to 100 ml with distilled water and mixed thoroughly. From this diluted sample, one ml was transferred to a Sedgwick rafter cell and counting of the individuals and/or cells was done under the compound microscope after proper identification with the help of standard taxonomical works of Edmondson (1959), Heurek (1896), Randhawa (1959) and Pal *et al*. (1962). The density of phytoplankton was calculated as number of individuals or cells/litre and that of periphyton as Individuals or cells /cm^2. The relative abundance of the different biotic communities was calculated using methods as described by Eaton *et al.* (1995).

The bacterial density in the water samples was assessed by the help of Fermentation Tube Test (Theroux *et al.,* 2001). The coliform density was computed in terms of the Most Probable Number (MPN), (APHA, 1995).

RESULTS AND DISCUSSION

(i) Physico-chemical features of water

The data collected on various limnological features of the River Jhelum and its tributaries in Uri are presented in Table 1. According to Reid (1961) fluctuations in different physico-chemical characteristics of lotic habitats are primarily determined by the water current, nature of the substrate and the biological processes, a statement holding true for the Jhelum and its tributaries as well. Because of the unidirectional water flow the water temperature

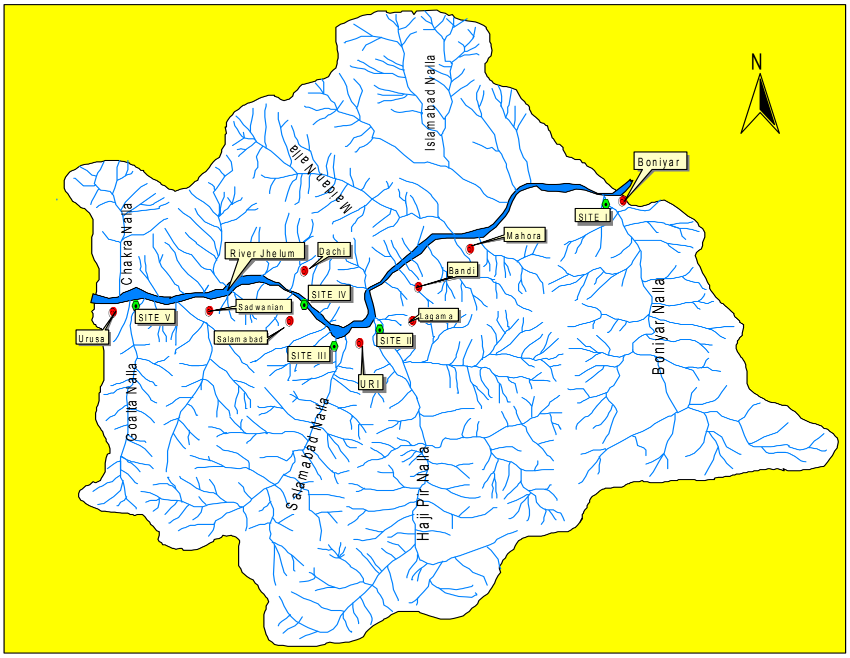


Fig. 1. Lay out map of Uri below Buniyar showing various aquatic sites

Table 1: Physico-chemical characteristics of water and bacterial counts of the River Jhelum and its tributaries

S. No	Parameter		SAMPLING SITES 1	2	3	4	5	6
1.	Water Temperature (^{o}C)	R	4 - 12*	7 - 18	6 - 16	6 - 14	7 - 13	6 - 12
		A	7**	12.5	10.2	10	10	9
2.	Transparency (cm)	R	25 - 40*	25 - 35	20 - 25	60 - 65	35 - 36	15 - 25
		A	29**	30	22	62	35	20
3.	Conductivity (µ S)	R	97 - 143*	165 - 243	108 - 360	243 - 274	152 - 265	146 - 220
		A	124**	204	278	258	208	188
4.	PH	R	8.23 - 8.50*	7.80 - 7.86	8.1 - 8.30	7.80 - 8.10	7.90 - 8.38	7.90 - 8.20
		A	8.35**	7.83	8.21	7.9	8.14	8.05
5.	Bicarbonates (mg/l)	R	54 - 80*	163 - 170	110 - 147	156 - 170	156 - 170	172 - 185
		A	69**	166	122	163	163	178
6.	Diss. Oxygen (mg/l)	R	8.5 - 12.6*	8.6 - 9.8	7.8 - 10.9	9.8 - 10.2	8.4 - 10.1	9.5 - 10.2
		A	10.5**	9.2	9.6	10	9.2	9.8
7.	Chloride (mg/l)	R	7 - 12.5*	12 - 14	10 - 14.5	12 -13	15 - 16	10 - 12
		A	9.2**	13	12.8	12.5	15.5	11
8.	Total hardness (mg/l)	R	60 - 97*	162 - 187	130 - 211	180 - 197	190 - 200	155 - 168
		A	79**	174	170	188	195	161
9.	Nitrate N (µ g/l)	R	120 - 150*	170 - 220	190 - 250	180 - 220	219 - 250	298 - 320
		A	139**	195	220	200	232	309
10.	Ammonium - N (µ g/l)	R	23 - 35*	32 - 38	27 - 80	27 - 32	26 - 36	29 - 36
		A	27**	35	46	29	31	32
11.	Orthophosphate P (µ g/l)	R	6 - 8*	14 - 20	8 - 24	12 - 16	9 - 10	10 - 11
		A	7**	17	12	14	9	10
12.	Total Phosphorus (µ g/l)	R	40 - 60*	87 - 90	68 - 85	80 - 92	76 - 82	76 – 82
		A	52**	88	79	86	79	79
13.	Coliform bacteria MPN	R	0	100 – 120	0	0	120 – 130	0
		A		110			125	

was not much influenced by the atmospheric temperature and the former was several degrees colder during the warmer season and warmer during the winter than the air. Due to variations in the immediate catchment as also the gradient the water in different streams showed significant variations in temperature, the Buniyar; flowing through forest almost throughout its course, contained coldest water among all the streams in the area.

The depth *vis-à-vis* the volume of water in the river was low in winter and high in spring. The depth had a direct bearing on the width of the river. During winter freezing of water at higher altitudes resulted in low volume and hence low flow, while during spring - summer melting of snow led to increased flow in the river. With the increase in flow and consequent tubulence the water became more turbid. Current velocity is directly associated with the volume of water (Hynes, 1979). On an average the current velocity at the study sites ranged from 76 to 124cm/sec. The highest velocity of 160cm /sec was recorded at site I in April when the spring thaw had greatly increased the volume of water in the streams, while the lowest of 32cm/sec at site 6 in January was due to the little volume of water in the streams.

The concentration of dissolved oxygen at all the study sites was high as the lotic waters tend to be always saturated with dissolved oxygen (Hynes, 1979) unless polluted. As the colder water retains more dissolved oxygen, the highest quantity of dissolved oxygen was recorded at all sites during winter and, thereafter, the concentration decreased towards Buniyar stream having the coldest water and recording the highest quantities of the gas. Its concentration was also influenced by the turbidity and nutrient load of the water. The values of dissolved oxygen in the main river indicated that the river did not contain much organic load and the impact of the pollutants received upstream up to the town of Baramulla had died down and the river had to a great extent recovered. This was substantiated by the data on the BOD and COD in the river and its tributaries, which were very low and fluctuated in a very narrow range of 3.5 - 4.3 mg/l and 3.5 - 5.0mg/l respectively. This holds especially true for the tributaries, which are torrential in nature and are not much disturbed by the human interference, except in their mouth region. The oxygen concentration as well as the BOD and COD in the tributaries clearly pointed towards their non-polluted state.

The pH value of the river water at all the sites was always on the alkaline side and fluctuated from 7.80 to 8.50. Hynes (1979) and Hutchinson (1957) have reported that most of the running waters show a complicated relationship between pH, CO_2, H_2CO_3, H^+, CO_3^{--}, HCO_3^-, Ca^{++} and Mg^{++}. The alkalinity of water in all the streams as well as the River Jhelum was mainly due to the soluble bicarbonates of Ca++ and Mg++, while the insoluble carbonates ($CaCO_3$) were not detected at any of the sites. The overall range of fluctuations of the total alkalinity was 69mg/l (site 1) - 166mg/l (site 2) with the highest values being generally obtained in spring months. These results suggest that with the approach of spring the snow melt and the rainwater from the catchment gets fully laden with soluble salts from the catchment, which lead to quick increase in the total alkalinity of the river water. The total alkalinity values clearly indicate that except for the Buniyar stream, whose water is medium hard, all other sampling sites show typical hard water type (Moyle, 1945). The total hardness was dominated by the cations of Ca++ and Mg++ and showed fluctuations, temporal as well as spatial, similar to that of total alkalinity. The highest concentration of total hardness (195mg/l) was recorded at site 5 (main river), while the lowest (79mg/l) at site 1. In the main river the total hardness increased downstream, mainly because of the entry of typical hard water from tributaries other than Buniyar Nalla. The fluctuations in the Ca++ and Mg++ concentration showed a trend similar to that of total hardness. The Ca++ content, on an average, ranged from 23mg/l at site 1 to 56mg/l at site 5. Similarly the Mg++ concentration ranged from 6mg/l to 26mg/l at sites 1 and 5 respectively.

The major sources of phosphorus and nitrogen in water are domestic sewage, agricultural effluents containing fertilizers and industrial wastes. The total phosphate phosphorus at the sampling sites ranged from 52 µg/l (site 1) to 88 µg/l (site 2). The orthophosphate phosphorus recorded a range of 7µg/l (site 1) - 17 µg/l (site 2) .The concentration of total and ortho-phosphate phosphorus increased from autumn through spring. The nitrate and ammonical nitrogen also depicted trends similar to that of phosphate phosphorus and ranged from 139 µg/l (site 1) - 232 µg/l (site 5) and 27 µg/l (site 1) - 46 µg/l (site 3) for the two ions respectively. Higher values of $NO_3 - N$ during summer may be due to rapid decomposition of organic matter (Singh; 1993 and Sharma and Kumar; 2002). Zafar (1964) also emphasized that when the dead organic matter decomposes in water, it forms complex proteins which get converted into nitrogenous organic matter and finally to nitrate by bacterial activity. The concentration of $NO_3 - N$ was low during autumn and winter but increased during spring due to entry of large volumes of snow melt and rain water which brought in appreciable quantities of nutrients from the catchments (Bhat and Yousuf, 2004).

(ii) Biological features

Coliform bacteria were totally absent in the samples from the four streams, i.e., Buniyar, Salamabad, Jabla and Uroosa streams. As per the MPN values water in these streams belongs to the Class I of Ananthanarayan and Panikar (1996). However, in the main river the MPN value (100 – 130) indicated that the water is not fit for drinking purposes and is polluted.

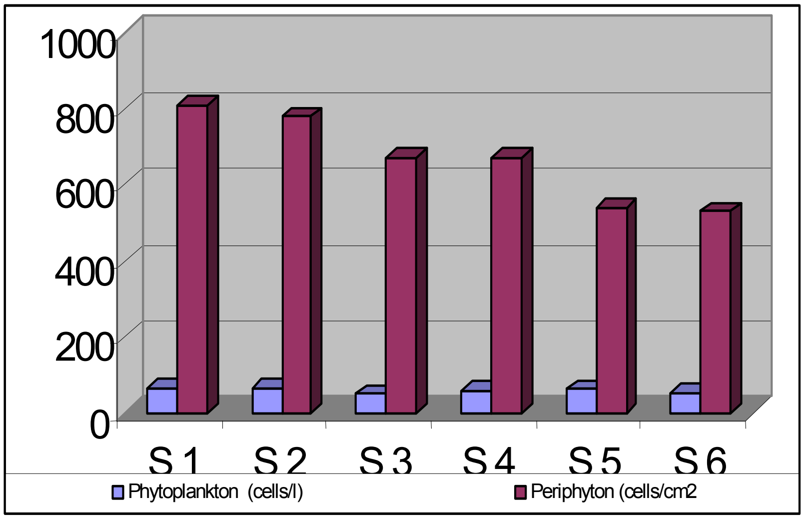
In all 41 species of phytoplankton were recorded at different sampling sites (Table 2), of which 21 belonged to Bacillariophyceae, 13 to Chlorophyceae, five to Cyanophyceae, one each to Euglenophyceae and Dinophyceae. *Navicula radiosa, Cymbella cistula, Synedra ulna, Diatoma elongatum,* and *Cyclotella striata* showed continuous distribution, whereas *Nitzschia diversa, Amphora ovalis, Fragilaria capucina, F. crotonensis, Synedra acus, Spirogyra varians, Botryococcus braunii, Pediastrum* sp., *Chlorella vulgaris, Volvox aureus* and *Merismopedia* sp. showed discontinuous distribution. *Navicula subtile, N. minor, Cymbella lanceolata, Asterionella* sp.*, Zygnema* sp.*, Botryococcus* sp.*, Scendesmus* sp.*, Coelastrum sphaericum*, *Ankistrodesmus* sp., *Tetraspora* sp., *Oedogonium* sp., *Dinobryon divergens* and *Oscillatoria* sp. showed site-specific distribution.

In comparison to phytoplankton, periphyton was represented by 55 species (Table 3). Eight of the species were observed throughout the study period, out of which *Navicula radiosa, Cymbella cistula* and *Synedra ulna* showed great tolerance to the fluctuations in the physicochemical nature of water. Species like *Achnanthes parvula, Navicula subtile, Navicula minor, Stauroneis* sp.*, Cymbella lanceolata, Fragilaria capucina, Tabellaria* sp.*, Melosira granulata and Cyclotella striata* indicated the unpolluted nature of water.

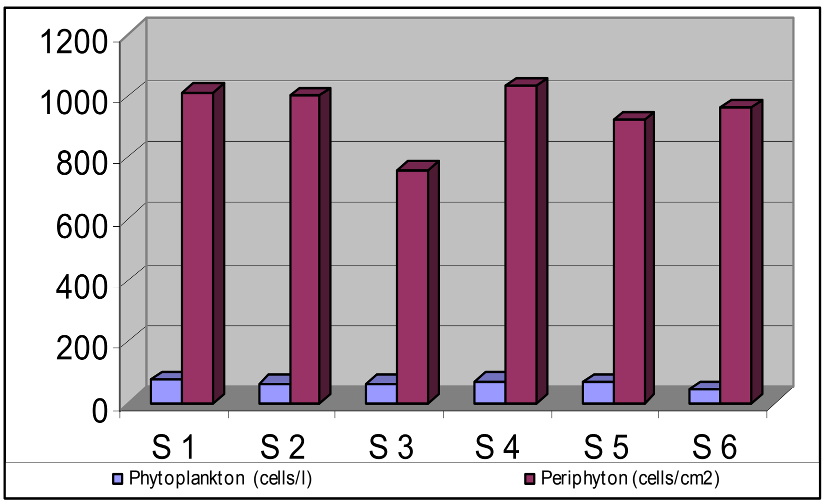
The population density of phytoplankton and periphyton is presented in Fig.2. In case of phytoplankton population density fluctuated from 44 cells/l (site 6) to 147 cells/l (site 4), with increasing trend during winter and spring. Periphyton also showed a similar trend but the density and range of fluctuations were much higher (530 cells/cm^2 at S6 – 1840 cells/cm^2 at S5). Low water temperature, low velocity,

Table 2: Distributional pattern of phytoplankton in River Jhelum and its tributaries during different sampling seasons

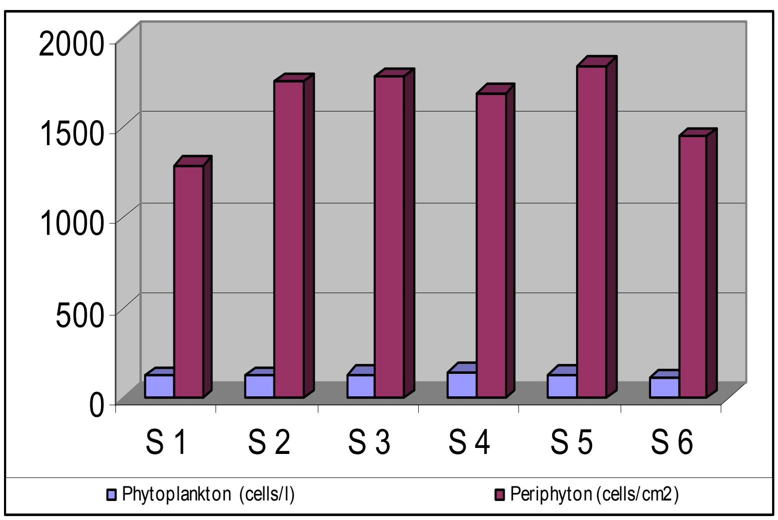
S. No.	Taxa	Autumn	Winter	Spring
	BACILLARIOPHYCEAE			
1	*Amphora ovalis*	++	+	+
2	*Tabellaria* sp.	+	+	-
3	*Asterionella* sp.	+	+	+
4	*Meriodon circulare*	+	+	++
5	*Diatoma elongatum*	++	+	++
6	*D. vulgare*	+	++	+
7	*Melosira granulata*	+	+	+
8	*Cyclotella striata*	++	++	+++
9	*Navicula radiosa*	++	++	+++
10	*N. subtile*	-	+	+
11	*N. minor*	+	+	+
12	*Stauroneis* sp.	+	+	-
13	*Nitzschia diversa*	++	+	+++
14	*Cymbella cistula*	+	+++	+++
15	*C. aequalis*	-	+	+
16	*C. lanceolata*	+	+	+
17	*Fragelaria capucina*	++	+++	+++
18	*F. crotonensis*	+	+	+
19	*Synedra ulna*	+	+++	+++
20	*S. famelica*	-	+	+
21	*S. acus*	+	+	+
	CYANOPHYCEAE			
22	*Oscillatoria agardhi*	+	+	+
23	*O. nigra*	-	+	+
24	*Lyngbia limnetica*	+	+	++
25	*Gomphoshaera* sp.	-	+	+
26	*Merismopedia tenuissem*	-	+	+
	CHLOROPHYCEAE			
27	*Spirigyra varians*	-	+	++
28	*Zygnema cylinderospermum*	+	+	+
29	*Botryococcus braunii*	+	+	+
30	*Pediastrum tetras*	+	+	+
31	*Scenedesmus acuminatus*	-	+	+
32	*S. denticulatus*	+	+	+
33	*Coelastrum sphaericum*	+	+	+
34	*Chlorella vulgaris*	+	+++	+++
35	*Ankistrodesmus* spp.	-	+	+
36	*Tetraspora cylindrical*	+	+	+
37	*Oedogonium* spp.	-	+	+
38	*Kirchneriella obesa*	-	+	+++
39	*Volvox aureus*	+	+	+
	EUGLENOPHYCEAE			
40	*Euglena acus*	-	+	+
	CHRYSOPHYCEAE			
41	*Dinobryon divergens*	-	+	+
	Total No. of taxa	**28**	**41**	**39**



AUTUMN



WINTER



SPRING

Fig. 2. Population density of phytoplankton and periphyton in the Jhelum and its tributaries

Table 3: Distributional pattern of periphyton in River Jhelum and its Tributaries during different sampling seasons

S. No.	Taxa	Autumn	Winter	Spring
	BACILLARIOPHYCEAE			
1.	*Navicula radiosa*	+	++	++
2.	*N. subtile*	-	+	+
3.	*N. minor*	+	-	+
4.	*Stauroneis* sp.	+	+	+
5.	*Nitzschia* sp.	+	+	+++
6.	*Nitzschia diversa*	+	+	+
7.	*Cymbella cistula*	++	+++	+++
8.	*C. aequalis*	-	-	+
9.	*C. lanceolata*	+	+	+
10.	*Amphora ovalis*	++	+	+
11.	*Fragelaria capucina*	+++	+++	+++
12.	*F. crotonensis*	+	+	+
13.	*Synedra ulna*	+++	+++	+++
14.	*S. acus*	+	+	+
15	*Epithemia turgida*	+	+	+
16.	*Tabellaria* sp.	-	-	+
17.	*Asterionella* sp.	+	+	++
18.	*Meriodon circulare*	-	+	++
19.	*Diatoma elongatum*	++	+	++
20.	*D. vulgare*	+	+	+++
21.	*Melosira granulata*	++	+	-
22.	*Cyclotella striata*	++	++	++
23.	*Actinella punctata*	+	+++	+++
24.	*Achnanthes parvula*	+	++	++
	CHLOROPHYCEAE			
25.	*Spirogyra varians*	-	+	+++
26.	*Zygnema cylinderderospermum*	-	+	+
27.	*Botryococcus braunii*	+	+	+
28.	*Pediastrum tetras*	+	-	+
29.	*P. duplex*	-	+	+
30.	*P. simplex*	-	+	+
31.	*P. boryanum*	+	-	+
32.	*Scenedesmus acuminatus*	-	+	+
33.	*S. denticulatus*	+	+	+
34.	*S. quadricauda*	+	+	+
35.	*Coelastrum sphaericum*	+	+	+
36.	*Chlorella vulgaris*	+	++	+++
37.	*Ankistrodesmus* sp.	-	+	+
38.	*Tetraspora cylindrica*	+	+	+
39.	*Kirchneriella obera*	-	+	++
40.	*K. microscopia*	-	-	-
41.	*K. malmeana*	-	+	+
42.	*Volvox aureus*	-	+	+
	EUGLENOPHYCEAE			
43.	*Euglena acus*	-	+	+
	XANTHOPHYCEAE			
44.	*Ophiocytium capitatum*	-	+	+
	CHRYSOPHYCEAE			
45.	*Dinobryon divergens*	-	+	+
	CYANOPHYCEAE			
46.	*Oscillatoria agardhii*	-	+	+
47.	*O. tenuis*	-	+	+

Table 3 Contd…….

48.	*O. proboscidea*	-	-	+
49.	*O. nigra*	-	+	+
50.	*Lyngbya limnetica*	+	+	+
51.	*Lyngbya* sp.	+	+	+
52.	*Gomphoshaera* sp.	-	+	+
53.	*Merismopedia tenuissima*	-	+	+
	PROTOZOA			
54.	*Centropyxis* sp.	-	+	+++
55.	*Arcella* sp.	-	+	++
	Total No. of taxa	**30**	**49**	**51**

high transparency, high dissolved oxygen and moderate concentration of nutrients are reported to be suitable for the growth of diatoms which formed more than 71% of total phytoplankton and periphyton (Vasisht and Sharma, 1975; Phillipose *et al.*, 1967; Kumar 1995; Nautiyal *et al.*, 1997). Similar phenomenon seems to prevail in the present case as with the onset of spring the population density of the periphytic diatoms increased considerably in response to suitable environmental variables. As is evident from the data the phytoplankton density did not show much change with the season. This is most probably because of the fact that true phytoplankton does not exist in running waters and the individuals collected by sieving the water are actually periphytic elements which get detached from the substrate due to fast flowing water.

Bacillariophyceae was the most dominant class in planktonic as well as periphytic communities. Its contribution in the population density of phytoplankton fluctuated between 61.55% and 92.4%, while among periphyton its contribution ranged from 55.16% to 83.73%. *Diatoma elongatum, Cymbella cistula and Cyclotella striata* formed the major part of the phytoplankton, while periphyton was dominated by *Navicula radiosa, Cymbella cistulla, Fragilaria capucina, Synedra ulna, Diatoma elongatum, Melosira granulata, Actinella punctata* and *Achnanthes parvula*. The contribution of planktonic Chlorophyceae fluctuated from 6.32%, to 30%, while in periphyton its contribution ranged from 12.97% to 28.31%. The dominant species like *Spirogyra varians*, *Chlorella vulgaris and Kirchneriella obesa* formed the major part in both communities. *Euglena acus* was the only euglenophyte represented in both the communities. Chrysophyceae was represented only by one taxon, *Dinobryon divergens* among the plankton. Cyanophyceae contributed 6.03% to 8.48% to the plankton and 2.72% to 8.30% to the periphyton.

Lowe and Gale (1980) reported diatoms to be the most important colonizers of river stones. The diatom composition at the sampling sites indicated that the ecological conditions were suitable for the growth of aquatic biota. Rao (1955) and Sarwar and Zutshi (1988) reported the coldwater to be more suitable for the growth of the diatoms. A healthy portion of a stream contains mostly diatoms and the contribution of green algae in such habitats is insignificant (Patrick, 1950 and Paramasivam and Sreenivasan, 1981). The dominance of Bacillariophyceae in both the phytoplankton and the periphyton community points to the fact that the Jhelum in the proposed Project area is not polluted and the river has significantly recovered from the anthropogenic pressures it experiences up to Baramulla. However, the presence of pollution-tolerant species like *Euglena acus* and *Synedra ulna* in the system indicates that all is not well with the system.

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