Ecology of Periphytic Community of Seven Springs of Kashmir

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ABSTRACT

Ecology of periphyton of seven springs of Kashmir valley has been discussed. All the springs had alkaline, moderate to typical hard water, with low dissolved oxygen and high free CO_2 content. A total of 50 algal taxa, representing six classes were recorded, with Bacilleriophyceae dominating qualitatively and quantitatively in most of these springs. The maximum density of algal population was present in Verinag, while it was minimum in Sherbagh. The microscopic animal community was represented by only three species of class Rhizopoda.

Keywords: Periphyton, springs, Kashmir Valley

INTRODUCTION

The valley of Kashmir is known throughout the world for its springs. Verinag, Kokernag, Achhabal, Mattan, Tullamulla, Cheshmashahi and many other springs have not only been associated with the religious practices of the region but have also played a significant role in the socio - economics of the valley. The Verinag spring is the source of the river Jhelum that is the lone drainage system of Kashmir. The Kokernag and Achhabal springs are famous throughout the world for trout hatcheries and Mughal gardens. Sherbagh and Mattan springs, lying in the premises of Andernag and Martand temples, also harbour fish populations.

Although a voluminous literature is available on the limnology of aquatic habitats of the valley (Zutshi and Vass, 1971; Zutshi et al, 1972; Kaul, 1977; Vass et al, 1977; Qadri et al, 1981; Yousuf and Qadri, 1981; Wanganeo et al, 1984; Yousuf et al, 1983; Yousuf and Shah, 1988; Pandit, 1996; 2002; Pandit & Pandit, 1996; Pandit et al, 2001), not much is known about the limnological features of springs of the region, except for a few reports (Qadri and Yousuf, 1979; Yousuf et al, 1983; Qadri and Yousuf, 1988). It was, therefore, thought worthwhile to investigate the various ecological aspects of some of these water bodies. In the present paper data collected during September, 2001 on the ecology of the periphytic community of seven important springs of the valley are presented.

STUDY SITES

The Verinag spring, lying about 26 km south-east of Anantnag town is a deep pool type water body, bound on all sides by an octagonal stone wall. The spring and the stream ensuing from it are inhabited by exotic trout (*Salmo* sp.) and indigenous snow trout (*Schizothorax* spp.) and other fish species. The Kokernag, a rheocrene spring located about 27 km south-east of Anantnag town, flows through a network of streams and sustains Asia's biggest trout farm.

The Achhabal spring, located about 8-km to the southeast of Anantnag, also sustains a trout farm. The Sherbagh spring famous for Andernag temple is located in the middle of Anantnag town and harbours a number of indigenous fish species. The spring is under great pressure due to human interference. Mattan spring is 6 km to the north- east of Anantnag and is famous for Martand temple. This spring also harbours a significant population of indigenous fish. All these spring form tributaries of the river Jhelum on its right bank. (Fig. 1).

The Nadihal spring is located on eastern bank of Wular Lake, about 5 km away from Bandipora, while the Rather Mohalla - Kaloosa spring is located on its north-eastern bank, about 1 km away from Bandipora. Both these springs drain into the Wular Lake, which lies in the deltaic region of the Jhelum.

Fig. 1. Map of Kashmir valley showing the locations of seven springs with reference to the River Jhelum.

Springs:

a. Verinag b. Kokernag c. Achhabal d. Sherbagh e. Mattan f. Nadihal g. Rather Mohalla

Tributaries of the Jhelum:

1. Sundran 2. Brengi 3. Arapat 4. Liddèr 5.Sindh 6. Erin 7. Madhumati 8. Pohru 9. Sukhnag 10. Romshu 11. Ranbiara 12. Vishav

MATERIAL AND METHODS

The water samples were collected from the springs by dipping one litre polyethylene bottle just below the surface of water. Temperature, pH, conductivity, depth and transparency were recorded on the spot. For the estimation of dissolved oxygen, separate samples collected in separate glass bottles, were fixed at the sampling sites in accordance with Winkler's method. Free CO_2, hardness, bicarbonate alkalinity and chloride were determined by titremetric methods (Mackereth, 1963).

Phosphate (stannous chloride method), nitrate (salicylate method), nitrite (buffer colour reagent method) and ammonia (phenate method) were analyzed with the help of Systronics 106 spectrophotometer in accordance with Eaton *et al* (1995), CSIR (1974) and EPA (1976). Sodium and potassium were determined with the help of G.S.I.O. flame photometer.

Periphytic community was collected in triplicate by scratching one cm^2 of the substratum (bottom stones). The scratched material was preserved in 4% formalin. Counting of the organisms was done in counting chamber after their identification with the help of standard taxonomical works, (Edmondson, 1959; Heurek, 1896; Randhawa, 1959; Pal *et al*, 1962).

RESULTS AND DISCUSSION

The physico-chemical characteristics of water have a great bearing on the distribution and abundance of periphytic organisms and therefore any change or alteration in a single parameter is bound to be directly or indirectly reflected in a series of changes in the biological set up. The physico- chemical features of the springs are given in Table 1.

The springs under study showed significant variations in their depth. The Rather Mohalla spring was the shallowest (34 cm), whereas the Verinag spring was the deepest. The latter has been reported to be about 16m in the centre and 1 ½ to 4 ½ m deep near the boundary wall (Peer, 1982). However, irrespective of the depth, the water in all the spring was clear and sunlight reached the bottom.

The air temperature at the sampling sites during the period of field collections fluctuated between 24 °C (Verinag) and 28 °C (Kokernag). Water temperature was appreciably lower than the air temperature and fluctuated between 7° C (Achhabal) and 18°C (Nadihal and Rather Mohalla). The greatest difference (18°C) between air and water temperature was recorded in Kokernag and the least (7°c) in Rather Mohalla. Significant difference between air and water temperature is related to the continuos oozing out of water from underneath.

Table 1. Physico-chemical characteristics of seven springs of Kashmir

Parameters	Verinag	Kokernag	Achhabal	Sherbagh	Mattan	Nadihal	Rather Mohalla
Air Tem. (°C)	24	28	25	25	25	26	25
Water Tem. (°C)	11	10	9	15	11	18	18
Depth (cm)	1600	28	102	52	35	56	34
Transparency (cm)	1600	28	102	52	35	56	34
pH	7.68	8.02	7.63	7.69	7.80	7.98	7.24
Diss. O_2(mg/l)	8.8	12	8.4	8	8.2	4.4	5.2
Diss. O_2(% sat.)	93	128	88	94	88	54	65
Free CO_2 (mg/l)	44	22	46	40	36	23	28
Conductivity (μS)	429	228	312	443	354	161	94
Alkalinity (mg/l)	138	114	122	180	142	102	92
Chloride (mg/l)	28	11	13	36	14	12	11
Calcium (mg/l)	52	34	40	54	43	12	11
Magnesium (mg/l)	5	5.5	8	8	7	8	2
Sodium (mg/l)	1	1	2	5	3	2	2
Pottasium (mg/l)	0.5	0.5	1.5	3	1	0.5	1
Nitrate-N (μg/l)	582	350	297	463	390	283	290
Ammonia (μg/l)	150	16	145	40	30	50	20
Nitrite-N (μg/l)	10	13	2	5	Tr	5	Tr
T.P.P. (μg/l)	32	19	35	40	20	22	45
O.P.P. (μg/l)	8	Tr	2.5	12	8	2	10

The water issuing from springs has been reported to be low in dissolved oxygen, often to the point of being anaerobic (Reid, 1961; Hynes, 1979). In the present springs the D.O. fluctuated from a minimum of 4.4 mg/l (54% sat.) in Nadihal to a maximum of 12 mg/l (128% sat.) in Kokernag. Thus, except for Kokernag, all other springs had water unsaturated with respect to D.O. However, the water was not altogether anoxic. Presence of relatively high oxygen values than proposed by Reid (1961) and Hynes (1979), seems to be a function of good periphytic algal population liberating oxygen during photosynthesis. In Kokernag, a rheocrene spring, the oxygen level increase quickly leads to supersaturated O_2 values.

Underground water has been reported to contain large amounts of CO_2. Because of its exposure to organic matter and bacterial respiration in the soil (Hynes, 1979), as well as its passage, percolation through limestone. Yousuf et al (1983) recorded the CO_2 values for Achhabal and Andernag (Sherbagh), 42 mg/l and 36 mg/l

respectively. Carbon dioxide seemed to be an important component of the buffer system in all the seven springs and fluctuated from 22 mg/ l to 46 mg/l.

Springs rich in CO_2 were comparatively less alkaline and a decrease in its concentration resulted in an increase in alkalinity. Consequently pH in these spring fluctuated from 7.63 to 8.02. Because of the low biological activity in the spring basins and continuous oozing out of water from underneath, the free CO_2 is not completely exhausted and as such the conversion of bicarbonates into carbonates is not significant. Therefore, the pH of the water generally did not exceed 8.0. This is substantiated by the data of Afroz et al (1986) who reported the pH in the 24 springs of Imamganj (U.P.) in the range of 7.3 – 8.0. Hazarike et al (1985) have also reported the pH of hot springs of Nambar forest between 7.5 & 7. 6.

Total alkalinity of these springs (92-180 mg $CaCO_3$/l) was due to bicarbonates of calcium and magnesium. The minimum and maximum values of Ca^{++} were found in Rather Mohalla (11 mg/ l) and Sherbagh (50 mg/l). Magnesium was much lower than Ca^{++} and fluctuated in the range of 2 mg/l (Rather Mohalla) and 8 mg/l (Achhabal, Sherbagh and Nadihal). The concentration of Ca^{++} and Mg^{++} was higher as compared to other cations and the usual progression of these was, $Ca^{++} > Mg^{++} > Na^{+} > K^{+}$. On the basis of the data on total alkalinity and Ca and Mg concentration, all these springs are hard water type, which is attributable to the ground water source. The concentration of Na^{+} and K^{+} was maximum in Sherbagh and minimum in Kokernag, Verinag and Nadihal.

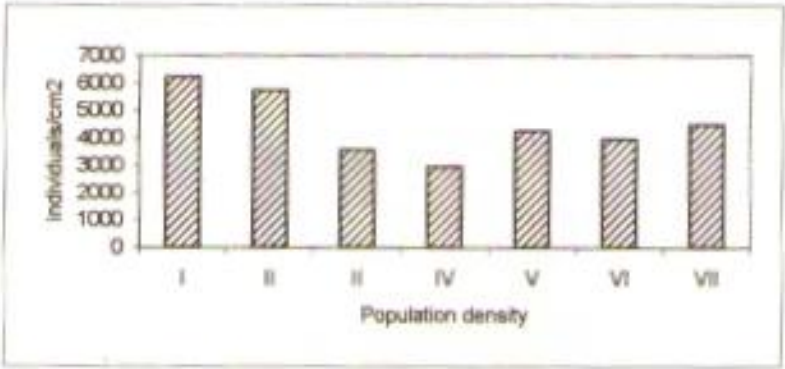
The chloride in these springs ranged between 11 mg/l (Kokernag) and 36 mg/l (Sherbagh). Yousuf (1979) has reported the concentration of Cl^{-} of freshwaters of Kashmir to be below 20 mg/l. In five of the present springs chloride concentration fell well within this range. However, in Sherbagh and Verinag spring it was much higher (28 mg/l in Verinag and 36 mg/l in Sherbagh). This high concentration seems to be directly related to the human interference as both the springs are regularly visited, particularly the latter being greatly used for bathing and washing purposes.

Ground waters have been reported to contain concentrations of NO_3 –N up to 3 mg/l and that of NH_3 up to 190 µg/l (Wetzel, 1983). NO_3-N concentration in these springs ranged between 283 µg/l and 582 µg/l with minimum in Nadihal and maximum in Verinag and that of NO_2 – N between traces (Mattan and Rather Mohalla) and 13 µg (Kokernag). The concentration of NH_3- N, however, fluctuated between 16 µg (Kokernag) and 150 µg (Verinag). TPP ranged from 19µg/l in Kokernag to 45 µg/l in Rather Mohalla. The OPP was maximum in Sherbagh (12

µg/l) and minimum (traces) in Kokernag. The low concentrations of Na and K in these springs may be due to scarcity of these nutrients in the rocks through which the spring water passes underneath the soil before oozing out. However, these considerable variations were seen in both the nutrients from one spring to the other. This may be attributed to the level of human interference in various springs. This is further substantiated by the fact that the Sherbagh and Verinag have high concentration of nutrients as compared to others as these are under high biotic stress. These inferences are well supported by the values of conductivity, which is a good and rapid measure of total dissolved salts in a water body. Thus, Sherbagh Spring showed higher values of conductivity (443 µS), while the Nadihal the least (161µS).

Periphytic algal community of the springs was represented by a total of 50 taxa, of which 33 belonged to Bacillariophyceae, nine to Chlorophyceae, five to Cyanophyceae, two to Chrysophyceae and one to Englenophyceae. Periphytic animalcules includedonly three protozoans,all belonging to Rhizopoda(Fig.2&3)Among the sites studied, the highest periphytic diversity was recorded in Verinag spring. The number of taxa among Bacillariophyceae fluctuated from a minimum of seven in Sherbagh spring to a maximum of 26 in Verinag and Kokernag. Qualitatively Bacillariophyceae dominated in all the springs with the highest contribution (90.82%) in Kokernag. But in Sherbagh spring the contribution of Bacillariophyceae was only 12.2%. The sequence of dominance of various taxa was *Navicula* > *Diatoma* > *Amphora* > *Cymbella* > *Fragillaria* > *Meriodon* > *Gomphonema* > *Achnanthes* > *Synedra* > *Cyclotella* > *Eunotia* > *Stauroneis* > *Surirella* > *Coconeis*. The Dominance of diatoms, which are good colonizers of bottom stones (Hynes, 1979) seems to be favoured by low temperature, high light penetration and slightly alkaline hard water (Vasisht and Sharma, 1975; Venkataswarlu et al, 1969). The dominance of Cyanophyceae in Sherbagh spring seems to be related to the anthropogenic pressure as is evident from the values of chloride concentration in this water body.

Cyanophyceae was represented by five taxa. Whereas all the taxa were present in Sherbagh and Verinag springs, only two taxa were recorded in Achhabal, Nadihal and Rather Mohalla. In Mattan spring it was represented by four taxa. This group was, however, totally absent in Kokernag, which seems to be related rheocrene nature of spring. In the other five springs its population was very low and, on the whole, it ranked third in order of population density. The sequence of dominance of the major taxa of Cyanophyceae was: *Oscillatoria* > *Anabaena* > *Synechococcus* > *Synechocytis* > *Microcystis*.



I= Verinag II= Kokernag III=Achhabal IV= Sherbagh
V= Mattan VI = Nadihal VII = Rather Mohalla

Fig. 2. Population density of seven springs of Kashmir.

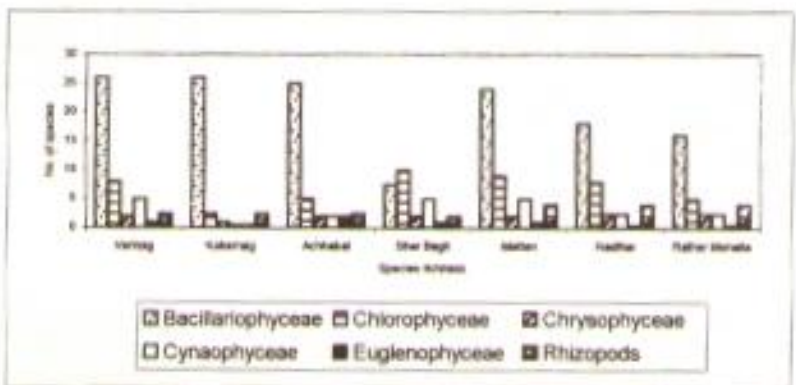


Fig. 3. Species richness in seven springs of Kashmir.

In *Sherbagh*, the *Microcystis*, *Synechocystis* and *Synechococcus* were the major taxa of the total population, while *Oscillatoria* and *Anabaena* the least. In Verinag although all the five taxa were present, they contributed only 0.35% of total population (Table 2). In Mattan spring four taxa recorded contributed only 7.47% of the total population. Achhabal, Nadihal and Rather Mohalla recorded only two taxa each. *Microcystis* and *Oscillatoria*, typically known to be eutrophic, were abundant in the springs having great human stress and sewage i.e., Sherbagh, Verinag and Mattan.

Chlorophyceae was present in all the springs but contributed only small part of the total periphytic community. The highest percentage contribution was recorded in Achhabal (15.02%) and lowest in Sherbagh (7.46%). With respect to number of taxa, it ranked second, while as per density it ranked third. The dominant genera were

Table 2. Percentage composition of different classes of periphyton in springs of Kashmir

Algal class	Verinag	Kokernag	Achhabal	Sherbagh	Mattan	Nadihal	Rather Mohalla
Bacillarriophyceae	83.15	90.82	71.15	12.20	76.00	86.31	87.64
Cyanophyceae	0.35	0.00	9.01	78.31	7.47	1.19	0.82
Chlorophyceae	14.03	8.03	15.02	7.46	13.35	9.52	10.25
Chrysophyceae	2.10	1.14	4.81	0.00	1.66	2.98	1.28
Euglenophyceae	0.35	0.00	0.00	2.03	1.07	0.00	0.00

in the order: *Desmidium Closterium Oedogonium Cosmarium Ulothrix Cladophora Rhizoclonium Mougetia Zygnema*. The group seemed to be thriving better in waters having pH between 7.5 and 8.0.

.Chrysophyceae, with a mean density of 1.98%, was present in low numbers. Its highest contribution (4.81%) was recorded in Achhabal. The group was totally absent in Sherbagh. *Dinobryon* and *Ceratium* represented the group in the present springs. Euglenophyceae, a characteristic feature of habitats having organic pollution (Kumar et al, 1974; Pandit, 1999), was recorded only in Verinag, Sherbagh and Mattan springs. Its population was, however, very low and was represented only by *Euglena acus.*

Periphytic animalcules in the present springs were represented by only three taxa - *Arcella, Difflugia* and *Centropyxis* (all belonging to class Rhizopoda, Protozoa). All the three are well adapted to the bottom substratum. These rhizopods dominated in Sherbagh spring.

In conclusion, the periphytic communities are well established in all the springs studied. All the seven springs have been serving as feeding grounds for indigenous fishes, particularly *Schizothoracine*, most of which are illiophagic omnivores (Yousuf, 1996). However, human interference in the neighbourhood as well as within the basins of all the springs (e.g., Sherbagh, Verinag and Mattan) is leading to a change both in the specific composition and the dominance pattern of periphytic community in these springs. Blue green algae, which is not a preferred food item of *schizothoracines*, has became a dominant item in Sherbagh because of the entry of wastes. If this trend continues in this and other springs of the valley, the fish population is bound to decline. Necessary steps, to stop the entry of affluents into the springs, need to be taken to conserve these freshwater resources of the region.

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