Impact of Floating Gardens on the Water Quality and Zooplankton Community in Dal Lake, Kashmir

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ABSTRACT

A study of the various physico-chemical parameters of lake revealed that the water near the floating gardens was more enriched with nutrients as was indicated by increased level of chloride, phosphorus, nitrogen and conductivity. In response to the variations in the ecological conditions the zooplankton community around these gardens also revealed differences in species composition and abundance from the open water areas of the lake.

Keywords: Dal lake, floating gardens, zooplankton, Kashmir

INTRODUCTION

The Dal lake, situated in the north west of Srinagar at an altitude of 1584 m, is a multibasined water body comprising five basins Hazratbal, Nishat, Gagribal, Nigeen and Brarinambal. The lake is under heavy anthropogenic pressure. Its water quality has deteriorated to a large extent due to the entry of untreated domestic sewage. Its area has also got reduced as a result of encroachment of its shallow zone for the construction of floating gardens. These floating gardens (locally called Radh), are made from decayed vegetation into the shape of long strips floating on the surface of water. The floating gardens are used by people for the cultivation of different vegetables and several fertilizers are used on them in order to get more production. A significant quantity of these fertilizers gets washed into the surrounding water, thereby changing the water quality. A year long study was conducted during 2002 to assess the impact of the floating gardens on the water quality and the zooplankton density of the lake.

MATERIAL AND METHODS

The data on various physico-chemical parameters and zooplankton were collected on monthly basis from four sampling sites. (Fig 1). Site I and site II were located in the open water area of Nigeen and Nishat basins respectively, while the sites III and IV were located adjacent to the floating gardens in the Nigeen and Gagribal basins respectively. In the open

water areas dominant macrophytes were *Ceratophyllum demersum, Myriophyllum spicatum, Potamogeton crispus and P. leucens,* while in floating garden areas *Salvinia natans, Lemna* sp., *Nelumbo nucifera and Nymphaea* sp. were conspicuous components. Water samples were analysed for physico-chemical characteristics as per the standard methods given by Mackereth (1973), CSIR (1974), APHA (1998). The zooplankton were preserved in 4 % formalin and identified with the help of Edmondson (1959), Smirnov (1974), Pennak (1978), Koste (1978) and Michael and Sharma (1988).

Fig. 1. Map of the Dal lake showing study sites

RESULTS AND DISCUSSION

Physico- Chemical Features of Water

The mean values of various physico-chemical parameters are presented in Table 1. The water temperature followed closely the air temperature showing only a slight spatial difference. Secchi transparency was quite low, particularly in the floating garden areas. The mean concentration of DO was lower in floating garden areas ranging from 2.0 mg/l in summer to 3.9 mg/l in spring, while the mean CO_2 concentration did not show any marked difference between the two areas. However, lower values in both-zones were recorded in summer season. The study sites did not show any marked difference in their pH values and the water seemed to be well buffered. As far as the total alkalinity is concerned it varied greatly between the sampling sites, lesser values were observed in open water areas. It was mainly due to bicarbonate ions and carbonates ions also made their presence from late spring to early autumn at site I and in late spring to mid summer at site II .In the floating gardens area carbonates were not recorded at any time. Conductivity and chloride values were high concentration throughout the year, particularly in the floating garden areas. The concentration of ammonical nitrogen in open water area ranged from 108µg/l in winter to 188µg/l in summer, while in floating garden area its content ranged from 319µg/l in winter to 552µg/l in summer. The concentration of nitrate ranged from 391µg/l in winter to 555µg/l in autumn in open water area and from 190µg/l in spring to 256µg/l in autumn in floating

garden area. The concentration of nitrite ranged from 37µg/l in summer to 67µg/l in spring in open water area and from 33µg/l in summer to 105µg/l in winter in floating garden areas. The concentration of the orthophosphorus in the lake ranged from 17µg/l in winter to 261µg/l in summer in open water area, while in floating garden area it fluctuated from 153µg/l in winter to 296µg/l in summer. The total phosphorus concentration ranged from 462µg/l in spring to 708µg/l in summer in the open water area and from 483µg/l in winter to 899µg/l in summer in floating garden area. Higher concentration of N and P as observed at all study sites are attributed to the use of fertilizers in and around the lake and addition of faecal matter and other effluents from the human habitation.

Table 1. Seasonal fluctuations in the physicochemical features of the Dal lake

Parameter		Site I	Site II	Site III	Site IV
Air temperature (°C)	Spring	20	19.3	19.4	19.3
	Summer	31	31	31.3	31.2
	Autumn	20.6	21.3	21	21.1
	Winter	10.3	11	10.6	10.6
Water temperature (°C)	Spring	18	17.8	18.5	18.6
	Summer	29.3	29	28.3	28.3
	Autumn	18.6	19	14	14
	Winter	9.2	9.4	9.2	9.2
Transparency (m)	Spring	1.5	1.6	0.5	0.4
	Summer	2.1	2.1	0.4	0.4
	Autumn	1.7	1.7	0.4	0.4
	Winter	1.5	1.6	0.6	0.5
DO (mg/l)	Spring	6.4	9.8	3.9	2.7
	Summer	5.4	4.8	2.9	2
	Autumn	5.3	4	3.2	2.1
	Winter	6.7	7.2	3	2.2
pH	Spring	8.7	8.5	8.2	8.4
	Summer	9.4	9	8.3	8.4
	Autumn	8.5	8.2	7.8	8.7
	Winter	8.2	8.2	7.9	7.9
Conductivity (µS/cm)	Spring	216	281	333	432
	Summer	292	367	582	726
	Autumn	243	404	674	821
	Winter	231	348	434	555
Chloride (mg/l)	Spring	15.3	15.6	45	75
	Summer	18	3	52	82
	Autumn	28	15.6	55.6	93
	Winter	17.5	17.3	23.3	35
Free CO2 (mg/l)	Spring	12.3	4.1	6.5	7.5
	Summer	A	1.2	2	2.8
	Autumn	12.5	6.5	8.7	10.4
	Winter	25.3	8.9	8.9	19.6
Carbonates (mg/l)	Spring	6.7	11.9	A	A
	Summer	21	13.5	A	A
	Autumn	6.4	A	A	A
	Winter	A	A	A	A

Contd

Table Continued

Parameter		Site I	Site II	Site III	Site IV
Bicarbonates (mg/l)	Spring	81	95.3	133	159
	Summer	54	61.3	72	98
	Autumn	70	88	107	151
	Winter	126	132	155	176
Ammonical-Nitrogen (µg/l)	Spring	163	145	461	417
	Summer	126	188	369	552
	Autumn	185	187	472	541
	Winter	183	108	583	319
Nitrite-nitrogen (µg/l)	Spring	67	55	70	50
	Summer	44	37	50	33
	Autumn	43	55	62	41
	Winter	59	63	92	105
Nitrate-nitrogen (µg/l)	Spring	525	445	243	190
	Summer	428	395	144	104
	Autumn	555	431	201	256
	Winter	484	391	255	239
Ortho-phosphorus (µg/l)	Spring	24	66	249	247
	Summer	27	261	298	202
	Autumn	20	179	278	284
	Winter	17	77	153	201
Total phosphorus (µg/l)	Spring	520	462	681	826
	Summer	708	501	676	899
	Autumn	650	600	612	754
	Winter	504	476	48	617

Biological Features

During the year round study a total of 65 species of zooplankters were recorded, out of which 32 species belonged to Rotifera, 28 to Cladocera and only 5 to Copepoda. Branco et al (2002) reported that the abundance of rotifers followed by Cladocera as an indication of the eutrophic nature of the water bodies. Gliwicz (1969, b), Forsyth and Mc Coll (1975), Sandhu *et al* (1984) also recorded higher percentage of Rotifers and Cladocera and a decrease of Calanoid Copepods in eutrophic lakes. In general rotifers showed their superiority over other groups in the lake, both in terms of number of taxa and population density. On the whole the sequence of dominance of various groups in the lake was Rotifers > Cladocera > Copepoda (Fig 2).

A comparison of the two zones reveals that the zooplankton population density recorded its peak values in floating gardens areas (Table 2) which seems to be related with the fact that majority of the pollution resistant species, viz, *Brachionus calyciflorus, K. cochlearis, K. quadrata, Lapedella patella, Monostyla quadridentata* and *Daphnia longispinna* had high population density in the floating garden areas. *Pleuroxus denticulatus , Camptocercus* sp , *Acropeus harpae , Alonella* sp. *Alona quadriangularis , A. rectangular* and *A. affinis* were restricted to open water areas only .Among Branchnoidae *Platiyas quadricornis, Keretella cochlearis, Brachionus quadridentata* were dominant forms in open water areas while areas *K. cochlearis, Brachionus calyciflorus, B. quadridentata, P. quadricornis* were main contributors in floating gardens areas. All of these are true representatives of eutrophic nature (Pandit, 1980: 99). Gannon (1981) has also reported that species in the genus *Brachionus* are particularly good indicators of eutrophy and according to Hutchinson (1969) *Brachionus* sp are almost entirely limited to alkaline waters. Kumar and Tripathi (2004) reported *B. calyciflorus, B. falcatus, B.rubens, B. plicatilis* and *Testudinella* sp. as the most abundant rotifers and consider them to indicate the eutrophicated nature of the waterbody.

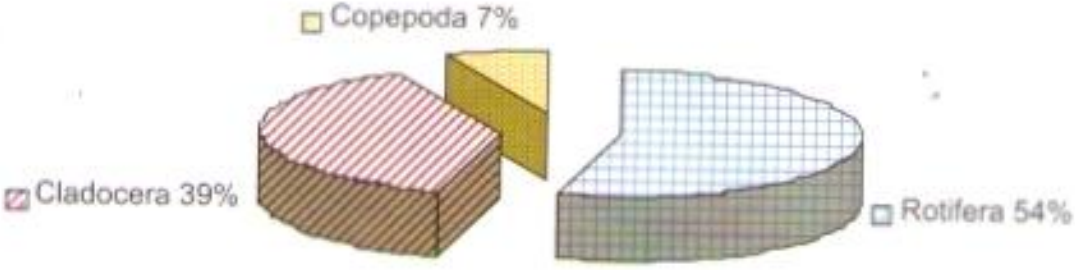

Fig 2. Overall % composition of three groups of zooplankton in Dal lake during study period

From the other families *Lapedella ovalis , Monostyla bulla , Filinia longiseta , F. terminalis, Philodina* sp.were main representatives in open water area ,while in the floating garden areas *Lapedella patella , Lecana luna , Trichocerca longiseta , Gastropus* sp., *Filinia longiseta* and , *Asplanchna priodonata* were main contributors. Over all population density of rotifers in open water areas fluctuated between 1 ind/l to 55 ind/l with *Platiyas quadricornis* contributing about 12.1% followed by *Lapedella ovalis* (11.7%) ,while in floating garden areas it fluctuated between 1 ind/L to 75 ind /l with *B. calyciflorus* contributing about 11.3%, followed by *Keratella cochlearis* (9.5%).

Table 2 (a). Population density of rotifer plankton (ind/l) in Dal lake

	OPEN WATER AREAS		FLOATING GARDEN AREAS	
	Site I	Site II	Site III	Site IV
Brachionidae				
Brachionus angularis	2	0	11	16
B. bidentata	7	19	7	3
B.calyciflorus	3	0	6	15
B.quadridentata	12	10	50	75
B.cochlearis	27	10	12	22
Keretella cochlearis	37	15	41	64
K.quadrata	0	10	37	43
K.tropica	2	8	1	7
P.quadridentata	6	9	15	9
P.patulus	0	16	22	12
P.quadricornis	38	54	10	22
Notholca sp.	0	0	2	0
Trichotridae				
Trichotria tetractis	6	0	3	0
Euchlanidae				
Euchlina dilatata	0	0	2	0
Colurellidae				
Lepedella ovalis	34	55	13	40
L.patella	0	14	10	39
Squattinella mutica	0	0	1	0
Courella obtusa	0	0	2	0
Synchaetidae				
Polyarthra vulgaris	23	15	13	9
Synchaeta sp.	0	0	1	0
Lecanidae				
Lecana luna	0	3	5	15
Monostyla bulla	21	18	14	35
M.lunaris	0	0	4	25
M.quadridentata	0	1	14	15
Trichocercidae				
Trichocerca longiseta	15	14	20	15
Trichocercs sp.	3	1	10	3
Gastropodidae				
Ascomorpha sp	5	13	4	7
Gastropus sp.	12	2	11	25
Filinidae				
Filinia longiseta	22	33	22	53
F.terminalis	30	24	21	30
Asplanchnidae				
Asplanchna priodonta	23	16	21	47
Philodinidae				
Philodina sp.	37	30	21	29

Table 2 (b). Population density of crustacean plankton (ind/l) in the Dal lake

	OPEN WATER AREAS		FLOATING GARDEN AREAS	
	Site I	Site II	Site III	Site IV
Chydoridae				
Chydorus sphericus	7	60	129	50
C.ovalis	8	21	3	0
Pleuroxus similis	0	16	16	5
P.denticulatus	3	0	0	0
P trigonellus	3	0	9	4
Pleuroxus sp.	6	10	22	0
Graptoleberis testudinaria	29	25	12	14
Camptocercus sp.	4	5	0	0
Acropeus harpae	12	10	0	0
Alonella sp.	6	7	0	0
Alona quadrangularis	6	6	0	0
A.rectangula	2	2	0	0
A.affinis	0	4	0	0
Bosminidae				
Bosmina longirostris	16	64	75	21
B.corgoni	5	25	13	2
Macrothricidae				
Macrothrix rosea	6	19	0	20
Macrothrix sp.	1	60	24	0
Illyocryptus sp	0	0	5	0
Sididae				
Diaphanosoma brachyurum	9	20	26	5
Sida crystallina	2	14	6	0
Daphnidae				
Daphnia pulex	34	21	14	12
D.longispinna	0	7	32	43
D.similis	17	16	17	2
Ceriodaphnia reticulata	6	24	9	6
C.quadriangula	2	20	4	4
Moina daphnia sp.	13	23	7	12
Simocephalus sp.	0	6	5	0
Moinidae				
Moina micrura	0	8	3	1
Cyclopidae				
Cyclops scutifer	12	12	17	10
C. vicinus	57	17	33	15
Eucyclops speratus	4	3	0	0
Macrocyclops albidus	9	10	11	12
Canthocamptidae				
Canthocamptus sp.	5	5	4	3

Among cladocerans Chydoridae was the best represented family in the lake with 13 taxa. The family was dominant in floating garden areas and the dominant forms among it were Chydorus *sphericus* and Graptoleberis *testudinaria*, while in the open water area, besides these two *Acroperus harpae* was also a dominant form. Daphnidae was dominated by Daphnia *longispina*, *D. pulex* in floating garden and *Moinadaphnia* sp, *Ceriodaphnia reticulata* and *D. pulex* in open water areas. *B. longirostris*, *Macrothrix rosea*, *Sida crystallina* were abundant in both areas. *Moina micrura*, was quite low at both sites throughout the year. Parveen and Yousuf (1999) reported *M. micrura* and *D.longispinna* to be mainly restricted to polluted waters of Brarinambal basin of Dal Lake. *Pleuroxus denticulatus*, *Camptocercus sp. Acroperus harpae*, *Alonella* sp, *Alona quadriangula*.*A. rectangular* and *A. affinis* were totally absent from the floating garden area, indicating that these species avoid the polluted water in the vicinity if floating islands. Population density of Cladocera in open water area fluctuated between 11 ind/l to 64 ind /l with highest contribution by *Bosmina longirostris* (11.5%), followed by *C. sphaericus* (9.7%) and *Graptoleberis testudinaria* (7.8%), while in the floating garden area it fluctuated between 1 ind/l to 129 ind /l with highest contribution by *C. sphaericus* (28.3 %), *B. longirostris* (15.1%) and *D. longispina* (11.8%).

Group Copepoda was represented by two families Canthocamptidae and Cyclopoidae. The former one was represented by only one species i.e. *Canthocamptus* sp. Although recorded in both zones, it recorded higher density in the floating garden areas. Cyclopoidae was dominated by *Cyclops vicinus* (55.2% in open water area and 45.7 % in floating garden areas) and *Cyclops scutifer* (17.9% in open water area and 25.7 % at floating garden area). Besides these two, *Macrocyclops albidus* (21.9%) was also recorded in a sufficient numbers in floating garden areas. Yousuf (1988) had also reported *C. vicinus* abundant in limnetic zone and *Canthocamptus* sp, *C. scutifer* and *M. albidus* more important in littoral zone. Overall population density of this group in open water areas fluctuated between 3 ind/l to 57 ind /l and in floating garden areas from 3 to 33 ind /l.

The analysis of the results obtained in the present study shows that alteration in abiotic factors exerts considerable influence on zooplankton abundance and diversity. To assess the importance of abiotic interactions an attempt was made to analyze the date statistically. Rotifers showed a negative correlation with DO and transparency ($r = -0.32$), with total alkalinity ($r = -0.44$), with nitrogen forms ($r = -0.24$ for nitrate , $r = -0.70$ with nitrite and $r = -0.74$ with ammonia), with chloride ($r = -0.84$) while Cladocera recoded negative relationship with CO_2 ($r = -0.36$), transparency ($r = -.57$), total alkalinity ($r = -0.48$), ammonia ($r = -0.39$) , chloride ($r = -0.29$) and conductivity ($r = -0.18$). Copepods showed negative correlation with the O_2 ($r = -0.22$), CO_2 ($r = -0.82$), transparency ($r = -0.50$), with forms of nitrogen ($r = -0.57, -0.08, -0.75$ for nitrite, nitrate and ammonia respectively) and total alkalinity ($r = -0.54$). Sorenson's similarity index (modified by Marczewski and Steinhaus) was applied to the data on zooplankton community. The highest similarity was observed between Site III and IV (0.87), thereby suggesting more qualitative similarity between the floating garden areas. The least similarity (0.71) was found between Site I open water area in Nigeen) and III (Floating garden area of Gagribal) which seems to be related to the differences in the abiotic features as well as the macrophytic community of the two areas. From the forgoing description it may be concluded that the contiguity of floating gardens have a significant impact on the water quality and consequently the zooplankton community in the Dal Lake.

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REFERENCES

A.P.H.A. 1998. *Standard Methods for the Examination of Water and Wastewater* Washington, D.C.

Branco C.W.C., Rocha, M.I.A. Pinto, G.F.S., Gomara, G. A. and Filippo, R De. 2002. Limnological features of Funil Reservior (R.J., Brazil) and indicator properties of rotifers and Cladocerana of the zooplankton community. *Lakes and Reservoirs: Res. and Management.* **7** (2): 87.

CSIR 1974. Analytical *Guide (Laboratory Techniques)* -CSIR, Pretoria, South Africa.

Edmondson, W.T. 1959. *Freshwater Biology*. John Wiley, N.Y. Smirnov, N.N. *Fauna of the USSR. Crustacean* Vol.I. No. 2 Chydoridae .Keter, S. Pub. House Jerusalem Ltd.

Forsyth, O.J. and R.H. S. Mc Coll 1975. Limnology of lake Nigahewa , North Island , New Zealand . *N.Z. J. Freshwat. Res.* **9**: 311 - 332.

Gannon, J.E. 1981(a) Zooplankton of the Northern American Great Lakes. *Verh. Internat. Verein. Limnol.* **21**: 1725-1733.

Gliwicz, Z.M. 1969 b. Studies on the feeding of pelagic zooplankton in lakes with varying trophy *Ekol. Pol. Ser.* A. **17**:663-707.

Koste , W 1978 *Rotatoria* Vol I and II Gebruder Borntraeger, Berlin.

Kumar, A. and Tripathi, S. 2004. Zooplanktonic diversity in relation to aquaculture in some ponds of DurgBhilai city , Chattisgarh State. *Nat. Env. And Pollution Tech.* **3** (2): 175-178.

Mackereth, F.J.K. 1973 Some *Methods of Water Analysis for Limnologists* Freshwater Biol.Assoc .Sci.Pub Michael, R.G. and Sharma, B.K. *Fauna of India and adjacent countries: Indian Cladocera (Crustacean: Branchiopoda: Cladocera)* Zool. Surv. India.

Pandit, A .K. 1980. *Biotic factor and food chain structure in some typical wetlands of Kashmir* Ph.D thesis, Kash. Univ., Srinagar -190006

Pandit, A.K. 1999. *Freshwater Ecosystems of the Himalaya.* Parthenon Publishing, New York , London.

Parveen, M. and Yousuf, A.R. 1999. Cladocera population in Dal lake, Kashmir. ***Abs*** 5th *National Seminar on Fish and their Env.* Univ. of Kashmir. pp. 34-35.

Pennak, R.W. 1988. *Freshwater Invertebrates of United States.* John Wiley and Sons, London.

Sandhu, J.S. Sehgal, H.S. and Toor, H.S. 1984. Rotifer species diversity in manured experimental fish tanks *Indian J. Ecol.* **11** (2):303-308.

Smirnov, N.N. 1974. *Fauna of the USSR Crustacean.* Vol .**I.** No. (2) Chydoridae. Keter, S. Pub. House Jerusalem Ltd.

Yousuf, A.R. 1988. Copepod plankton of Lake Manasbal, Kashmir *J. Indian Inst. Sci.*, **68** 307-313.