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Sediment chemistry and Macrozoobenthos of Gagribal Basin of Dal Lake

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Abstract
During the present investigation 9 species of Macrozoobenthos belonging to three phyla viz., Annelida, Arthopoda and Mollusca were recorded and the most dominant species found was *Limnodrilus hoffmeisteri* in terms of population density. The nature of sediment and the physico-chemical parameters of the sediment affected the population density of the Macrozoobenthos. Sandy clay was found most suitable for the bottom fauna.

Keywords: Macrozoobenthos, Sediment chemistry, Population density, bottom fauna

Introduction
The valley of Kashmir also referred to be “paradise on Earth” has been known for its scenic beauty. It is well known for its high altitude lakes like Alipather, Shesnag, Tarsar, Marsar, Kounsarnag, Nilnag, Naranag and low land lakes. The lakes have been experiencing significant ecological changes. the dal lake with the mountainous amphitheater in its back ground and a chain of Mughal gardens and summer places in its catchment is one among the most beautiful heritages and scenic spots of world.it has remained at the focal point of Kashmir’s tourist history, culture and tourism. The backdrop of zabarwan, Hariparbat, Shankar acharya, Placid water of Dal have bestowed unparalleled beauty and magnificence, which has attracted tourism from all over the world. The Dal Lake has been and is still the backbone of tourism industry in Kashmir. The ever increasing human interference has brought the lake to a point where concern is needed at regional and national level and attempts are needed to save whatever is left of the lake.
According to Kango *et al*. (1978) [7] about 35,500 ha. Catchment area of Dal Lake provides a huge slit washed in to the lake every year which is one of the greatest factor affecting the lake ecosystem. Large quantities of phosphorus and Nitrogen are added to the lake which has resulted into luxuriant growth of aquatic vegetation like *potomogeton sp. Ceratophyllum, Myriophyllum, Nelumbo sp., Nymphia, Lemna, Salvinia* and the newly evolved *Azolla* species. this inturn has effected all other components of the lake. The pollution Eutrophication level has affected to the bottom fauna of Dal lake. The present study deals with the study of some parameters of sediment chemistry, species composition and pollution density of zoobenthic fauna of Gagribal basin of Dal Lake.

Area of study
World famous Dal Lake is situated at an altitude of 1584m.a.s.l against the back drop of Zabarwan, Shankaracharya and Hariparbat is located in the heart of Srinagar city and is called as “city Lake”. The lake is situated on the Northeast of Srinagar at a mean latitude of 34^{o} 7’North and longitudes of 74^{o} 52’East. The lake is fed by Telibal nallah on its North, which brings water from high altitude Marsar Lake and also from agricultural fields. Towards the south western side an outflow channel called tsunti kol discharges the lake water into river Jhelum at Gawkadal. A small canal (Nallah Amir Khan) connects the nagin basin of Dal Lake with Khushalsar Lake and acts as an additional outflow channel. The lake is very shallow, the depth generally varying from 1.5- 2 meters, however at certain places viz., nagin, Sona lank it exceeds 3.5 meters. It also fluctuates seasonally as a result of changes in the amount of rainfall and stream flow.

Materials and Methods

The sediment samples were collected from the four sites of study area of Dal lake at two months interval from Jan. 2016 to Sep. 2016 after scooping out the samples from these sites they were put into buckets and brought to the lab. Air dried and pulverized. The pulverized samples were then passed through small pore sized sieves.

pH: the pH of soil samples was determined directly from 1:10 soil suspension with the help of Model 101 E pH meter, after shaking the suspension for half an hour.

Conductivity: conductivity of soil samples was determined with the help of model 490 conductivity meter directly from 1:10 soil suspension, after shaking it for half an hour and results were expressed in the units of μSCm^{-1}.

Chlorides: chlorides were determined by titration method by using silver nitrate as titrant and potassium chromate as indicator.

Alkalinity: alkalinity of soil samples were determined by titration method by using (0.02N) H_2SO_4 as a titrant.

Calcium and Magnesium: for the determination of total cations, leaching of the soil was done by ammonium acetate solution EDTA was used as a titrant.

Available Phosphorous: it was extracted from the soil with 0.002N H_2SO_4 (1 soil ×200 H_2SO_4) in accordance to and the concentration determined as per stannous chloride method (APHA, 1980) [1].

Sodium and Potassium: the concentration of Na and K present in the soil samples was determined by the standard flame photometric method.

Organic Matter: it was estimated in the sediments by modified walkeys and black (1934) rapid titration method detailed out in.

Results and Discussion

Macrozoobenthos: During the study a total of 9 species of benthic invertebrates belonging to three major phyla viz; Annelida, Arthopoda and the Mollusca were collected from Jan. 2016 to Sep. 2016 from different sites of Gagribal Basin of Dal Lake. The major contributor of Macrozoobenthos was phylum Annelida which contributed 5 species, of which four belong to Oligochaeta and one to Hirudinea. Arthopoda contributed two species which belong to class Insecta and Mollusca were represented by two species both of which belonged to Gastropoda. Detailed account of species recorded were

Phylum Annelida	
Class Oligochaeta	
Family	Tubificidae
Species	*Limnodrilus hoffmeister*
	Tubifex tubifex
	Branchiura sowerbyi
Family	Naidae
	Nais sp.
Class	Hirudinea
Family	Hirudinidae
Species	*Hirudo* sp.
Phylum	**Arthopoda**
Class	Insecta
	Chironomus sp.
Family	Chirnomidae
Order	Diptera
Family	Panypodinae
Species	*Pentaneura* sp.
Phylum	**Mollusca**
Class	Gastropoda
Family	Lymnaeidae
Species	*Lymnaea auricularis*
	Lymnaea stagnalis

In general Annelida was most dominant phylum of the benthic animals which were collected from the four sampling stations of Dal Lake, followed by arthopoda while as Mollusca was least in abundance.

The nature of sediment influences the species spectrum of the zoobenthos (Baker, 1918; Welch 1952) [3, 15]. Baker (1918) [3] recognized six general types of Lake Bottom which includes mud, sand, clay, sandy clay, gravel and boulders. In the present basin four different substrate type were recognized these include clay (site I), sandy clay (site II), Muck (site III) and gravel (site IV). A comparison of speceid composition and population density at different sites revealed that Muck substrate was least attractive to the benthic organisms. Sandy clay was inhibited by largest number of zoobenthos. However site I and site II showed absence of Mollusca.

Name and number (individuals/m^2) of Macrozoobenthos.

Macrozoobenthos	**I**	**II**	**III**	**IV**
Annelida				
• Oligochaetes				
Limnodrillus sp.	195	143	338	260
B. sowerbyi	26	65	26	26
Tubifex sp.	65	117	78	78
Nais sp.	143	169	130	286
• Hirudinea				
Hirudo sp.	-	13	-	-
Arthopoda				
• Insecta				
Chironomus sp.	91	455	52	-
Pentaneura sp.	13	-	-	-
Mollusca				
• Gastropoda				
L. auricularis	-	-	26	143
L. Stagnalis	-	-	13	52
Total no. of	6	6	7	6

Species a perusal of the species composition of benthos in a Gagribal basin reveals that only a limited number of taxa were present in this basin of lake which is generally characteristic of eutrophic/polluted waters. Limnodrillus hofmeister which is one of the dominant oligochaeta in the lake is a ubiquitous species predominant in sediments with abundant organic matter and pollution (Sang, 1987, Brinkhrust, 1965) [2, 10, 4]. Similarly *Tubifex tubifex* is typical of environments with high conductivity, low depth, low current velocity, clay sand or clay, mud sediments and variable amount of organic matter (Brinkhrust, 1965, Sang, 1987, whitley, 1968) [4 10]. During present study the species was rare only at site I which was characterized by clay sediment. Although clay or sandy clay has been shown to be suitable for this species it seems that some other ecological parameter most probably sewage contamination limits its population at this site.

Limnodrilus hoffmeisteri and *Tubifex tubifex* occurred in all substrates found in the Gagribal basin of dallake. All the other species had restricted distribution with respect to the type of substratum. *Limnodrilus hoffmeisteri* was the most dominant species and was found at all the four sites of study area.
The species showed a minimum mean density of 29 ind/m^2 at site II and maximum of 68 ind/m^2 at site IV.

Table 1: Variation in the physico-chemical parameters of sediments of Gagribal Basin of Dal Lake at site - I & II

S. No.	Parameters	Site-I						Site –II					
		Jan	**Mar**	**May**	**Jul**	**Sep**	**Mean**	**Jan**	**Mar**	**May**	**Jul**	**Sep**	**Mean**
1	pH	8.35	8.13	8.01	7.98	7.88	8.07	7.53	7.32	7.23	7.11	7.45	7.32
2	Conductivity (µScm^{-1})	211	346	26	313	302	287.8	549	643	585	547	518	568.4
3	Chloride (ppm)	387	603.5	298.2	568	521.3	475.6	394	788.1	431.32	788.1	681	617.1
4	Bicarbonates (ppm)	678	680	100.8	512	440	482.16	792	480	129.6	442.4	582.2	485.24
5	Calcium (ppm)	3748	3942	3870	3856	3932	3869.6	4939	5012	4756	4641	4806	4830.8
6	Magnesium (ppm)	386	475	398	380	384	404.6	454	592	569	498	502	523
7	Sodium (ppm)	170.15	204	113.4	116	158	153.3	189.6	168	157.95	161.95	164.2	168.3

Table 2: Variation in the physico-chemical parameters of sediments of Gagribal Basin of Dal Lake at site -III & IV

S No.	Parameters	Site-III						Site –IV					
		Jan	Mar	May	Jul	Sep	**Mean**	Jan	Mar	May	Jul	Sep	**Mean**
1	pH	8.09	8.03	8.01	7.76	7.99	7.97	8.03	7.93	7.86	7.66	7.89	7.87
2	Conductivity (µScm^{-1})	306	457	338	354	317	354.7	339	448	386	394	384	390.2
3	Chloride (ppm)	187	426	399.37	420	426	371.6	387	1349	420.67	683.37	702.32	708.46
4	Bicarbonates (ppm)	360	710.4	150	503.2	438	432.32	691	638.4	126.4	492.8	457.3	481.18
5	Calcium (ppm)	3996	4530	4300	4296	4705	4365.4	4246	4890	4235	4121	4610	4421
6	Magnesium (ppm)	394	431	414	394	398	406.2	469	546	420	359	379	434.6
7	Sodium (ppm)	182.4	155.4	127.5	129.5	131.3	145.2	222.3	167.2	201.45	196.35	184	194.2

Table 3: Population Density (ind/m^2) of Macrozoobenthos at Site- I & II

S No.	**Macrozoobenthos**	**Site-I**						**Site-II**					
		Jan	**Mar**	**May**	**July**	**Sep**	**Mean**	**Jan**	**Mar**	**May**	**Jul**	**Sep**	**Mean**
1.Annelida Class: Oligochaeta													
i)	*Limnodrillus* sp.	26	26	26	52	65	39	13	39	26	26	39	29
ii)	*B. Sowerbyi*	-	-	26	-	-	5	-	-	52	13	-	13
iii)	*Tubifex* sp.	-	13	26	26	-	13	-	26	39	39	13	23
iv)	*Nais* sp.	-	39	39	26	39	29	52	26	26	39	26	34
Class: Hirudinaea													
v)	*Hirudo* sp.	-	-	-	-	-	-	-	-	13	-	-	3
	Total annelida	26	78	117	104	104	86	65	26	26	39	26	34
2. Arthopoda Class : Insecta													
vi)	*Chironomus* sp.	13	13	26	13	26	18	91	91	104	91	78	91
vii)	*Pentaneura*	-	-	-	13	-	3	-	-	-	-	-	-
Total Arthopoda	13	13	26	26	26	21	91	91	104	91	78	91	Total Arthopoda
3. Mollusca Class: Gastropoda													
viii)	*L. auricularis*	-	-	-	-	-	-	-	-	-	-	-	-
ix)	*L. stagnalis*	-	-	-	-	-	-	-	-	-	-	-	-
	Total Mollusca	-	-	-	-	-	-	-	-	-	-	-	-
Total Zoobenthos	39	91	143	130	130	107	156	182	260	208	156	192	Total Zoobenthos

Table 4: Population Density (ind/m^2) of Macrozoobenthos at Site-III & IV

S No.	Macrozoobenthos	Site-III						Site-IV					
		Jan	**Mar**	**May**	**July**	**Sep**	**Mean**	**Jan**	**Mar**	**May**	**Jul**	**Sep**	**Mean**
1.Annelida Class: Oligochaeta													
i)	*Limnodrillus* sp.	65	65	65	78	65	68	13	52	39	104	52	52
ii)	*B. Sowerbyi*	-	-	13	-	13	5	-	-	26	-	-	5
iii)	*Tubifex* sp.	-	26	39	13	-	16	-	26	13	26	13	16
iv)	*Nais* sp.	26	-	39	39	26	26	52	65	78	39	52	57
i)	*Limnodrillus* sp.	65	65	65	78	65	68	13	52	39	104	52	52
Class: Hirudinaea													
v)	*Hirudo* sp.	-	-	-	-	-	-	-	-	13	-	-	3
	Total annelida	91	91	156	130	104	115	65	143	156	169	117	130
2. Arthopoda Class : Insecta													
vi)	*Chironomus* sp.	-	39	13	-	-	10	-	-	-	-	-	-
vii)	Pentane*ura*	-	-	-	-	-	-	-	-	-	-	-	-
	Total Arthopoda	-	39	13	-	-	10	-	-	-	-	-	-
3. Mollusca Class: Gastropoda													
viii)	*L. auricularis*	-	-	13	13	-	5	39	13	39	13	39	29
ix)	*L. stagnalis*	-	-	13	-	-	3	-	-	26	26	-	10
	Total Mollusca	-	-	26	13	-	8	39	13	65	39	39	39
	Total Zoobenthos	91	130	195	145	104	133	104	126	221	206	156	163

Physico -chemical Parameters of Sediment

The bottom sediments stratigraphy becomes an important key of gaining insight into past history of Lakes. The sediment chemistry is greatly influenced by major mineral matrix, soil texture, organic carbon and geophysical locations. The exchange of nutrients between sediments and overlying water is very likely to be dependent upon the chemical characteristics of both the water and the sediments (Golterman, 1975; William *et al*., 1976) [6, 17]. The sediments which participate in the matter turn over permit them to form and change many properties of lake environment. The most active sediment layer is the "upper one" remaining within the range of penetration of benthic organisms which take part in the process of matter exchange between the bottom and lake waters. The micro-organisms in the lake utilize different nutrients, incorporate them into their biomass and ultimately release them after the death and decay to the sediments as organic or inorganic materials. Thus, the sediments of lake serve as an important sink for nutrients and source for growth of organisms.

The present study on the sediments of Gagribal Basin of Dal Lake reveals a marked variations in its chemical features (Table-1). The pH throughout the basin was found to be alkaline ranging from a minimum 7.11 in july at site II to a maximum value of 8.35 in the January at site I. the decrease in pH during rainy season and early summer was attributed to microbial decomposition because of high water temperature, it conducted the liberation of H_2s which lower the hydrogen ion concentration and thus joining with uniform high organic material forming feS, freeing H^+ ion. Similar results for low pH were reported by Venu *et al.* (1993) [14]. Fall in pH was also attributed to the change in weather conditions.

Specific conductivity at all the four sites was found to fluctuate 211 µscm^{-1} at site I to 643 µscm^{-1} in March at site II at 25 ^{0}C. The low electric conductivity of sediments is attributed to presence of ionized salts in less quantities and high values of electric conductivity was generally associated with pollution. The higher value of specific conductivity at site II in the sediments indicates its less resistance to electric flow and there by high concentration of dissolved salts and higher trophic status of the system. The major cations like Sodium and Calcium and major anions like bicarbonates and chlorides are responsible for high conductivity of the month January and September. In the present study calcium was found to be a dominant cation followed by Magnesium. Thus the observations of Zutshi *et al*. (1982) [18] that calcium is the dominant cation in Kashmir lake sediments holds good for this basin of Dal lake. Higher values of Ca^{++} at site II were the density of Molluscs was very high support the observation of Tadajewski (1966) [11] who advocated that the dead planktonic organisms and snail shells are responsible for the presence of these cations in aquatic system. The higher values of Ca and Mg towards the winter is clear indication of decomposition of phytoplankton during that time while during summer the values decrease because of their uptake by macrophytes.

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