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RESEARCH ARTICLE

TO ELUCIDATE THE IMPACT OF WATER POLLUTION ON THE DIVERSITY OF ZOOPLANKTON IN THE GAGRIBAL BASIN OF DAL LAKE KASHMIR INDIA

Kousar Jan*[1], Rajendra Chouhan[2], Shiasta Masarat[3], M Farooq Mir[4] and Adil Hussain Shah[4]

[1,3,4]Hydrobiology Research Laboratory, S. P. College, Srinagar ,Jammu and Kashmir,India;
[2]Dept. Of Zoology MVM Bhopal, M.P, India

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**Corresponding Author:*
Kousar Jan

ABSTRACT

Background*:* To investigate the effects of water pollution on the diversity of zooplankton, a study was conducted in the Gagribal Basin of Dal Lake for a period of six months on a monthly basis from mid-March to mid-September (2021) in three different seasons. ***Methods:*** Water samples were collected for physico-chemical examination from the lake's surface in 1 L polyethylene bottles at inlet and outlet locations of Basin, and they underwent APHA analysis (1998). Using a Sedgwick-Rafter (S-R) counting cell, the zooplankton was quantitatively counted. ***Results****:* During the study period, there were 40 taxa of Rotifers, 26 taxa of Cladocerans, and 11 taxa of Copepods in the zooplankton population. At Inlet of Basin among the Copepoda *Eucyclops agilis*, *Cyclops albidus*, was found in all the three seasons but in decreasing order, *Alona rectangulata* was found in all the three seasons in an increasing order, *Bosmina longirostris* showing abundance in Grishum season. *Camptocercus sp* was found uniformly in all the three seasons. Among the Rotifers *Brachionus angularis, Asplanchna pridonta* was found in all the three seasons showing dominance in Grishum season, and also *Ascomorpha sp* was found in all the three seasons. While at outlet among the Crustaceans *Graptoleberis testudinaria , Eucyclops speratus* was found in all the three seasons in an increasing order while as *Bosmina coregoni* was found in decreasing order. Among the rotifers *Brachionus calciflorus* was found in all the three seasons in decreasing order. The overall alkalinity suggests that the water was relatively hard in both places. The high chloride content of the lake's water was a sign that organic contamination existed. Overall, the Gagribal Basin of Dal Lake has alkaline, somewhat hard, and nutrient-rich NO_3-N water. ***Conclusion****:* It was concluded that the zooplankton performs a crucial role, serves as bioindicators, and is an excellent instrument for assessing the level of water pollution.

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INTRODUCTION

Zooplanktons have considerable potential for assessing the ecological effects of pollution caused by humans and are ecologically suggestive in aquatic ecosystems. The term "plankton" refers to the tiny, typically immobile, freely floating creatures that inhabit watery settings (Powell *et al.* 1975). Because they are the productive basis of food webs and transform fundamental forms of energy into forms accessible by higher trophic levels, plankton drive energy cycling in aquatic ecosystems (Vilar *et al*. 2003). A wide variety of both single-celled and multicellular organisms make up zooplankton. They are abundantly concentrated towards the water's surface where they feed on phytoplankton (microscopic photosynthetic plants). Animals called zooplankton play a key role in the food chains of aquatic ecosystems. They contribute to the biological productivity of the freshwater ecosystem as well as being an essential component of the lentic community (Wetzel, 2001). Zooplankton communities frequently react swiftly to environmental changes as a result of their short life cycles (Sharma *et al.,* 2007).

Plankton, together with terrestrial primary producers, are the main forces behind the world's carbon cycles because of their crucial function in aquatic ecosystems and their consumption of carbon dioxide (Daly & Smith 1993; Vilar *et al.,* 2003). The availability of light and nutrients, temperature, salinity, pH, currents, turbulence, and predation intensity are all factors that affect plankton growth and dynamics. The four major groups of zooplankton are Rotifera, Cladocera, Ostracoda, and Copepoda. The physico-chemical and biological state of the aquatic environment is intimately related to the seasonal change in zooplankton species. Zooplankton are closely connected to their environment throughout their life cycles, and when a disturbance like eutrophication takes place, they exhibit quick population shifts. As a result, they may serve as indicators of water pollution (Jakhar 2013). Dal Lake in Kashmir Valley is an urban lake situated in the north-east of Srinagar, between 34°6° and 34°10°N latitude and 74°8° and 74°9°E longitude, at an elevation of 1586 m above sea level. It is a warm holomictic lake with a primary efflux regulated by two channels (Dal Gate and Nalla Amir) with a combined volume of 275.6 million cubic metres, and an elementary

influx from Telbal Nallah from Marsar Lake of 291.9 million cubic metres. It is also referred to as "Lake of Flowers" and is the second-largest lake in J&K. It has been excessively exploited for a variety of commercial reasons. To increase agricultural output, some of its areas have been transformed into floating gardens. At a number of locations, waste from houseboats and nearby hotels is carelessly dumped into the lake. The present study was carried out at the selected sites of Dal Lake at different periods of time to find out the changes in the water quality over the years and its impact on Zooplankton communities.

MATERIALS A ND METHODS

STUDY AREA (Sampling sites): The depth of water in Dal lake varies from 6 metres (20 ft) at its deepest in Nigeen lake to 2.5 metres (8.2 ft), the shallowest at Gagribal. The samples were conducted at Gagribal basin of Dal lake. The two sampling sites were selected at inlet and outlet of basin**.** This basin is also highly polluted due to large number of house boats and dumping of the sewage is dumped into the lake directly. The interior of the Gagribal Basin is being choked up by the floating market and floating gardens. The sampling was done for a period of six months on monthly basis from mid-march 2021 to mid September 2021 which in the local language as per the climate of Kashmir has been described as three seasons - Sonth i.e spring season (mid-march – mid may), Grishum i.e hot season (mid may-mid July) ,Vahrath i.e Rainy season (mid-July –mid-September) .

Zooplankton Analysis

Sampling methods: Zooplankton samples were taken from the surface water of the Gagribal basin of Dal Lake's entrance and outlet sites. Each sample was obtained by filtering 50 litres of water through plankton net with a mesh size of 60 to 65 m. They were then preserved in 4% formalin, along with 4-5 drops of glycerine (which helps the organisms stay flexible), and 5% sucrose (which retain eggs in their brood chambers). Zooplankton samples were concentrated in a lab setting to a volume of 100 mL. Subsamples of 0.5 mL were utilised to inspect the contents. Each month, 100 people in total were measured.

With the help of a Sedgwick-Rafter (S-R) counting cell that measures 50 mm long, 20 mm wide, and 1 mm deep, the zooplankton was quantitatively counted. The cover glasses were positioned diagonally across the SR cell before the sample was added, and samples were then transferred using a large diameter pipette to prevent the formation of air bubbles in the cell covers. Each zooplankton taxon was counted and examined using a Vision 2000 binocular microscope. The amount of zooplankton in the S-R cell was calculated using the following formula (Gosh, *et.al*, 2011).

$$No./ml = C \times 1000\ mm3$$

$$L \times D \times W \times S$$

Where, C = Number of Organisms Counted; L = length of each strip (S-R cell length) in mm; D = depth of a strip (whipped grid image width) in mm; S = number of strips counted. The number of cells per mm was multiplied by a correction factor to adjust the number of organisms per liter (APHA 1976). Identification of zooplanktons was carried out with the help of standard books and monographs, Nedhaam and Nedhaam (1962), Pennak (1988), Edomondson (1959), Michael & Sharma (1988) and Dhanpati(2000). To obtain the statistical accuracy and the results were expressed as individuals/litre.

Physicochemical Analysis: For the water analysis the water samples were collected on monthly basis for a period of six months with the help of 2.5 litre water sampler in polyethylene plastic bottles and analysed for various physico-chemical parameters followed by the methodology by APHA (1998) Welch (1948), Murphy and Riley (1962), Mackereth (1963), Golterman and Clymo (1969), Trivedy and Goel (1986).

RESULT AND DISCUSSION

Physico-chemical parameters*:* Table (1) and Table (2) provide summaries of several physico-chemical parameters measured at sites 1 (inlet) and 2 (outlet) of the Gagribal basin of Dal lake (2). In both Gagribal basin locations, the calcium and magnesium values progress as Ca>Mg.

Table 1. Physico-chemical analysis of various parameters at Site I of Gagribal Basin of Dal Lake

S.No	Parameter	SEASON			Mean	±S.D	variance	min	max
		Sonth (mid march – mid may)	Grishum (mid may – mid july)	Vaharath (mid july – mid sep)					
1.	Free co2(mg/l)	44	14.7	30.8	14.9	32.15	215.3	14.7	44
2.	DO(mg/l)	14	4.68	10	4.8	10.3	21.9	4.7	14
3.	BOD(mg/l)	192	232	92	86	181.8	5200	92	232
4.	Total alkalinity(mg/l)	18	60	100	29.7	68.13	1681.3	18	100
5.	Total hardness(mg/l)	140	126.8	122	64.8	129.8	86.9	122	140
6.	Calciumhardness(mg/l)	76.96	57.2	27.25	26.9	57.6	626.4	27.3	76.96
7.	Magnesium hardness(mg/l)	12.64	3.208	13.2	4.8	10.8	31.52	3.21	13.2
8.	Ammonium nitrate (mg/l)	4	8	14	4.3	9.6	25.3	4	14
9.	Chloride(mg/l)	15	5.75	24.5	16.9	16.9	87.9	5.8	24.5

Table 2. Physico-chemical analysis of various parameters at Site II of Gagribal Basin (Dal Lake)

S.No	Parameter	SEASON			Mean	±S.D	var	min	Max
		Sonth (mid march – mid may)	Grishum (mid may –mid july)	Vaharath (mid july –mid sep)					
1	Free co2(mg/l	13.2	8.8	30.8	8.8	20.0	135.52	8.8	30.8
2	DO(mg/l	8	1.32	12	3.6	8.4	29.1	1.32	12
3	BOD(mg/l	40	352	53	74.2	206.8	31152.3	40	352
4	Total alkalinity(mg/l	20	18.8	94	22.1	56.5	1855.4	18.8	94
5	Total hardness(mg/l	180	65.2	120	60.9	130.4	3297.01	65.2	180
6	Calcium hardness(mg/l	91.4	64.2	21.7	29.6	65.7	1234.03	21.7	91.4
7	Magnesium hardness (mg/l	11.7	23.03	16.04	8.5	17.6	32.7	11.7	23.03
8	Ammonium nitrate(µ/l)	14	4	12	5.0	10.9	28	4	14
9	chloride(mg/l	21	4.49	30	9.2	21.3	167.4	4.49	30

Table 3. Prevalence of Zooplanktons at Site I of Gagribal Basin (Dal Lake) in different seasons

Group	Organisms	Season			Total	Abundance
		Sonth*(Mid.Mar-mid may*	Grishum*(Mid may-mid july)*	Vahrath *(mid july-mid sep)*		
Rotifer	*Ascomorpha saltans*	0	0	24	24	24%
	Asplanchna pridonta	18	0	24	42	42%
	Annurea hypelaema	9	0	0	9	9%
	Brachionus alchentron	0	9	18	27	27%
	Brachionus angularis	0	0	9	9	9%
	Branchionus bidentata	0	0	18	18	18%
	Brachionus calyciflorus	18	9	9	36	36%
	Brachionus quadridentatus	0	0	18	18	18%
	Cephalodella sp	0	0	18	18	18%
	Colurella adriactica	0	0	9	9	9%
	Ephiphanes senta	0	9	0	9	9%
	Filinia terminalis	0	0	18	18	18%
	Gastropus sp	0	0	9	9	9%
	Keratella quadrata	0	6	24	24	24%
	Keratella valga	0	0	24	24	24%
	Lecane leotina	0	0	24	24	24%
	Lepadella patella	0	0	9	9	9%
	Monostyla bulla	0	0	9	9	9%
	Mytilina ventralis	0	0	18	18	18%
	Notholca sp	0	0	18	18	18%
	Philodina acuticornis	0	0	9	9	9%
	Pleuroxus denticulatus	0	0	9	9	9%
	Pompholyx sulcata	0	9	0	9	9%
	Synchaeta sp	0	0	18	18	18%
	Trichocerca longiseta	0	0	9	9	9%
Cladocera	*Acropes harpae*	6	0	9	15	15%
	Alona exigua	0	0	9	9	9%
	Alona elongata	9	0	0	9	9%
	Alona quadrangularis	9	0	0	9	9%
	Bosmina coregoni	18	18	9	45	45%
	Bosmina longirostris	24	0	0	24	24%
	Camptocercus sp	6	0	18	26	26%
	Ceriodaphnia dubia	18	0	0	18	18%
	Ceriodaphnia reticulata	9	0	18	27	27%
	Ceriodaphnia quadrangula	18	9	0	27	27%
	Diplostraca	9	0	0	9	9%
	Daphnia longispina	24	0	0	24	24%
	Daphna magna	0	0	9	9	9%
	Daphnia pulex	24	0	0	24	24%
	Diaphanosoma brachyurum	9	0	9	18	18%
	Graptoleberis testudinaria	9	9	18	36	36%
	Macrothrix sp	9	0	0	9	9%
	Moina macrocopa	24	0	0	24	24%
	Nauplius larva	0	9	9	18	18%
	Pleuroxus straminius	9	0	0	9	9%
	Pleuroxus trigonellus	0	18	0	18	18%
Copepoda	*Canthocamptus sp*	24	9	0	33	33%
	Harpacticoid sp	0	9	18	27	27%
	Cyclops agilis	0	0	18	18	18%
	Cyclops scutifer	0	0	9	9	9%
	Cyclops vicinus	9	0	9	18	18%
	Cypridopsis viduella	0	0	18	18	18%
	Eucyclops agilis	9	0	9	18	18%
	Eucyclops speratus	9	18	24	51	51%
	Eucyclops prinophorus	0	0	9	9	9%
	Macrocyclops albidus	9	0	0	9	9%

The overall alkalinity indicates that both locations water is moderately hard. The existence of organic pollution is indicated by the high chloride concentration in lake's water. Overall, the water in Dal Lake's Gagribal Basin is alkaline, somewhat hard, and NO_3-N nutrient-rich. The seasonal variability was present in both sites for practically all of the metrics investigated.

Zooplankton: During the study period zooplankton community identified includes 40 taxa of Rotifers, 26 taxa of Cladoceran and 11 taxa of Copepods.

The diversity and abundance of zooplanktons at site 1 and site 2 is shown in Table 3 and Table 4. At Site Ist which was the inlet of basin, out of 56 species of zooplankton identified 25 species belonged to Rotifers, 21 species belonged to Cladocerans and 10 species to Copepoda. In Sonth (Spring season) among the rotifers *Brachionus alchentron* was found in abundance and among the Crustaceans, *Cladocera* was found to be most dominant followed by *Copepoda*. In Grishum (Summer season) among the rotifers *Asplanchna pridonta, Brachionus angularis*, *Cephalodella sp, Mytilina ventralis* was found

Table 4. Prevalence of Zooplanktons at Site II of Gagribal Basin (Dal Lake) in different seasons

Group	Organisms	Season			Total	Abundance
		Sonth*(Mid.Mar-mid may*	Grishum*(Mid may-mid july)*	Vahrath *(mid july-mid sep)*		
Rotifer	*Ascomorpha saltans*	0	0	24	24	24%
	Asplanchna pridonta	18	0	24	42	42%
	Annurea hypelaema	9	0	0	9	9%
	Brachionus alchentron	0	9	18	27	27%
	Brachionus angularis	0	0	9	9	9%
	Branchionus bidentata	0	0	18	18	18%
	Brachionus calyciflorus	18	9	9	36	36%
	Brachionus quadridentatus	0	0	18	18	18%
	Cephalodella sp	0	0	18	18	18%
	Colurella adriactica	0	0	9	9	9%
	Ephiphanes senta	0	9	0	9	9%
	Filinia terminalis	0	0	18	18	18%
	Gastropus sp	0	0	9	9	9%
	Keratella quadrata	0	6	24	24	24%
	Keratella valga	0	0	24	24	24%
	Lecane leotina	0	0	24	24	24%
	Lepadella patella	0	0	9	9	9%
	Monostyla bulla	0	0	9	9	9%
	Mytilina ventralis	0	0	18	18	18%
	Notholca sp	0	0	18	18	18%
	Philodina acuticornis	0	0	9	9	9%
	Pleuroxus denticulatus	0	0	9	9	9%
	Pompholyx sulcata	0	9	0	9	9%
	Synchaeta sp	0	0	18	18	18%
	Trichocerca longiseta	0	0	9	9	9%
Cladocera	*Acropes harpae*	6	0	9	15	15%
	Alona exigua	0	0	9	9	9%
	Alona elongata	9	0	0	9	9%
	Alona quadrangularis	9	0	0	9	9%
	Bosmina coregoni	18	18	9	45	45%
	Bosmina longirostris	24	0	0	24	24%
	Camptocercus sp	6	0	18	26	26%
	Ceriodaphnia dubia	18	0	0	18	18%
	Ceriodaphnia reticulata	9	0	18	27	27%
	Ceriodaphnia quadrangula	18	9	0	27	27%
	Diplostraca	9	0	0	9	9%
	Daphnia longispina	24	0	0	24	24%
	Daphna magna	0	0	9	9	9%
	Daphnia pulex	24	0	0	24	24%
	Diaphanosoma brachyurum	9	0	9	18	18%
	Graptoleberis testudinaria	9	9	18	36	36%
	Macrothrix sp	9	0	0	9	9%
	Moina macrocopa	24	0	0	24	24%
	Nauplius larva	0	9	9	18	18%
	Pleuroxus straminius	9	0	0	9	9%
	Pleuroxus trigonellus	0	18	0	18	18%
Copepoda	*Canthocamptus sp*	24	9	0	33	33%
	Harpacticoid sp	0	9	18	27	27%
	Cyclops agilis	0	0	18	18	18%
	Cyclops scutifer	0	0	9	9	9%
	Cyclops vicinus	9	0	9	18	18%
	Cypridopsis viduella	0	0	18	18	18%
	Eucyclops agilis	9	0	9	18	18%
	Eucyclops speratus	9	18	24	51	51%
	Eucyclops prinophorus	0	0	9	9	9%

in abundance and among the Crustaceans Cladocera was found to be most dominant followed by Copepod. In Vaharath (Rainy season) among the rotifers *Brachionus alchentron, Colurella adriacta, Filinia terminalis* were found in abundance and among the crustaceans Cladocera was dominant followed by Copepoda. Overall at the inlet of basin, among the Copepoda *Eucyclops agilis* , *Cyclops albidus* , was found in all the three seasons but in decreasing order, *Alona rectangulata* was found in all the three seasons in an increasing order, *Bosmina longirostris* was found in all the three seasons but showing abundance in Grishum season. *Camptocercus sp* was found uniformly in all the three seasons.

Among the Rotifers *Brachionus angularis, Asplanchna pridonta* was found in all the three seasons showing dominance in Grishum season, and also *Ascomorpha sp* was found in all the three seasons. At site 2nd which is outlet of basin a total of 62 species were recorded among them 29 belonged to rotifera 25 species belonged to cladocera, 8 species belonged to copepod and ostracoda. In Sonth (Spring season) among the rotifers *Asplanchna pridonta* and *Brachionus calyciflorus* was found to be the most dominant and among the crustaceans Cladocera was dominant followed by Copepoda. In Grishum (hot season) among the crustaceans cladocera was most dominant followed by copepod.

In Vaharath (rainy season) among the rotifers *Ascomorpha saltans*, *Asplanchna pridonta*, *Brachinos alchentron*, *Brachionusbidentata*, *Brachionus quadridentatus*, *Cephalodella* sp, *Filinia terminalis, Keratalla valga, Lecaneleontina* sp, *Mytilina ventralis*, *Notholoca*, *Synchaeta oblonga*, was found in abundance and among the crustaceans Cladocera was found in abundance followed by copepoda and followed by ostracoda. Over all at site second among the Crustaceans *Graptoleberis testudinaria , Eucyclops speratus* was found in all the three seasons in an increasing order while as *Bosmina coregoni* was found in decreasing order. Among the rotifers *Brachionus calciflorus* was found in all the three seasons in decreasing order. The zooplankton plays an integral role and serves bioindicators and it is well suited tool for understanding water pollution status. Similar work has been conducted by Murugan *et. al*., 1998; Dadhick and Saxena, 1999; Sinha and islam, 2002.

CONCLUSION

Gagribal Basin of Dal Lake is a source of livelihood for thousands of people dwelling in the vicinity of the lake. The access of direct vents of untreated sewage, agrarian run-off from the floating gardens and solid waste within and outside into the Lake water and also anthropogenic activities has lead to nutrient enhancement and because of that the aquatic weeds have reached to hike and had resulted the eutrophication of this Basin of Dal lake. Use of machineries like mechanical de-weeders for the removal of nutrient rich sediments and aquatic plants from this basin has resulted into the loss of Zooplanktonic biodiversity, as is clearly depicted in the analysis. Presently, there is a sparse control on the source of pollution in and around the basin and also the lack of public participation has also resulted into deterioration of the Gagribal Basin of Dal Lake. Zooplanktons are highly sensitive to environmental variation, as a result change in their abundance, species diversity or community composition can provide important indication of environmental change or disturbance. The present study was undertaken to understand the water quality and zooplankton biodiversity so that measures can be taken to restore the immaculate splendour of the Gagribal Basin of Dal Lake.

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