International Journal of Theoretical & Applied Sciences, 10(1): 117-125(2018)
Special Issue on Environmental Contaminants and Management

ISSN No. (Print): 0975-1718
ISSN No. (Online): 2249-3247

Macroinvertebrates of Dal Lake: An Effort to Assess the Diversity, Abundance, Population Density and Trophic Status

Aubid Bashir[1], Anuja Gupta[2] and Riyes Un Aziz[3]

[1]Hydrobiology Research Laboratory, Govt. SP College (The Constituent College, Cluster University Srinagar) J&K and Department of Zoology, Barkatullah University Bhopal (M.P.), India
[2]Department of Zoology, Govt. MVM Bhopal, (M.P.), India
[3]Department of Zoology, Devi Ahilya Vishwavidyalaya Indore (M.P.), India

(Corresponding author: Aubid Bashir)
(Received 12 November, 2017 accepted 15 December, 2017)
(Published by Research Trend, Website: www.researchtrend.net)

ABSTRACT: Macroinvertebrates play a significant role in aquatic ecosystems as they are immensely important for the ecological sustainability and these communities readily respond to change in physico-chemical properties of water [2]. The present study was conducted for a period of one year from July-2016 to Jun-2017 to assess the diversity, abundance, population density and trophic status of Dal Lake. Macroinvertebrates were presented by 31 species 6 classes, 13 orders and 22 families belonging to three major phyla viz; Annelida, Mollusca and Arthopoda. During the present work, the total population density of macro invertebrate fauna was found to be 8305 ind/m^2. Benthic macroinvertebrates were dominated by species characteristic to nutrient rich waters including *Tubifex tubifex* (472ind/m^2), *Limnodrillus hoffmeisteri* (446 ind/m^2), *Aeolosoma* (371 ind/m^2), *Nais* sps (272 ind/m^2), and *Chironomous* sps. (476 ind/m^2) which thrive in sediments rich in organic nutrients. The abundance of these specific pollution indicator species, especially *Limnodrillus* sp., *Tubifex tubifex, Chironomous* sp. and *Aeolosoma* is depictive of transition in the trophic status of the lake from mesotrophic to eutrophic. The analysis of population density (ind/m^2) of macro zoobenthos helped in the determination of dominance and trophic status of Dal Lake because of their sensitivity to pollution. Therefore, it forms an important criterion for determining the trophic status of lakes and hence it is concluded that Dal Lake is suffering from eutrophication. Therefore it is a grave concern to formulate effective conservation strategy to protect this jewel from becoming barren land in near future.

Keywords: Macroinvertebrates, Dal Lake, diversity, population density and Eutrophication.

I. INTRODUCTION

The fresh water bodies of the Kashmir Himalayas have been playing a great role in the socio-cultural and economic status of the valley since historic times. Besides being a source of attraction for tourists from all over the world, the valley lakes are great source of natural products like fish, fodder and a variety of economically important aquatic plants. However, the ecology of these lakes have changed considerably in the last few decades due to unplanned and unethical anthropogenic activities which have adversely effected these water bodies and thereby posing threat to aquatic biota in water bodies. To deal with these threats and associated problems (e.g chemical contamination, loss of diversity) it is necessary to implement adequate restoration measures. However, the primary step towards this ecological restoration process is to assess the status of these lakes, by analyzing the structure of its biological communities. In this regard macroinvertebrates have been considered as the most familiar targets for carrying out biological monitoring of water body because they represent the most diverse group of organisms that react to anthropogenic influence on aquatic ecosystem strongly and often predictably [5]. Macrozoobenthic fauna constitute an ecologically important community in aquatic ecosystems and are of immense ecological value. Reports have indicated that the composition and diversity of macro-zoobenthic community is closely linked to aquatic habitat conditions, with many species serving as biological indicators of pollution [2]. Study of the macro zoobenthos has received considerable attention due to their significance as biological indicators of environmental change in aquatic ecosystem and also as source of fish food organisms [32].

Macroinvertebrates are specified as the important areas for maintaining the biodiversity [11], [12]. The present study was undertaken to study the diversity, abundance and density of macro invertebrate fauna of the Dal lake in order to understand the status of the lake, so that necessary steps could be taken by management authorities towards the ecological restoration of the lake

II. MATERIALS AND METHODS

A. Study Area

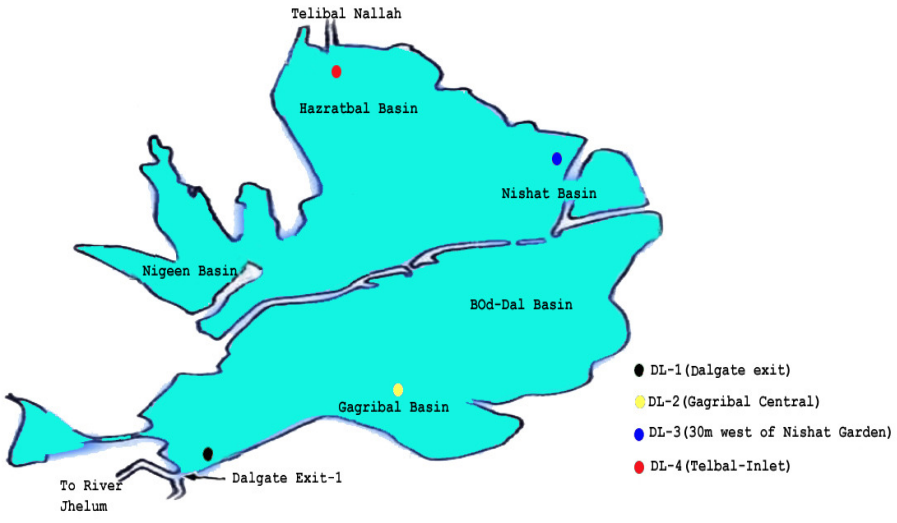
Dal lake is situated in the north east of Srinagar at an altitude of 1586m above sea level between geographical coordinates of 34° 6' -34° 10' N latitude and 74° 8' -74° 9' E longitude in the heart of the Kashmir valley on the north east of the state summer capital Srinagar at the foot of the Zabarwan hills. This Lake is a Himalayan urban lake of fluviatile origin surrounded by mountains on its three sides. This beautiful lake is bounded on the east by Mahadev mountain range, on the south by Kohi Suleiman and on the west by Hari Parbat Hill. The total catchment area of the Dal Lake is about 317 km^2 and can be divided into five sub-catchments. The major one is Dachigam-Telbal which alone is spread over 228 km^2, constituting about 72% of the total area. The catchment area of the Dal Lake is more than twenty times the area of the lake. The total water surface area of the lake is 11.45 Km^2 of which 4.1 Km^2 is under floating gardens. 1.151 Km^2 to 2.25 Km^2 are land marsh respectively, where as a total volume estimated is 9.05×10 m^3 and the ratio between the minimum and maximum depth (m) ranges between 2.3m – 6m indicating the gentle slope of the lake bed. It is believed that the Dal is fed up by a number of underground springs [25] but the main source is the perennial stream known as Telbal Nallah from north side which brings water from high altitude Marsar Lake. A small canal "Nallah Amir Khan" connects the Dal with Anchar Lake through Nigeen and acts as an additional outflow channel. The Lake is multi basined comprising of four basins viz., Hazratbal, Bod Dal, Gagribal and Nigeen [21].

Sampling Sites

Four sampling sites were selected from Dal lake on the basis of their spatio-temporal and geographical difference during study period and are discussed as follows:

SITE -1 (DL1): This site is located at the exit of Dal lake (Dal-lock-gate) near Ghat No.2. Sparsely distributed vegetation at the littorals of this site mainly comprises of *Myriophylum spicatum, Potamogeton pectinatus, P. luecens, Ceratophylum damersum, Hydrilla verticillata and Potamogeton crispus and Nympeae alba.* This site is shallower and is characterised by human habitation in the form of house boats and local population along the shore and within the basin and this site is designated as black spot on map.

SITE- 2 (DL2): This site is situated in between Nehru park and SKICC towards eastern side of lake locally known as Gagribal basin of Dal lake. Macrophytic vegetation at this site comprises of *Myriophyllum spicatum* is the most dominant form and covers extensive area of basin, other species associated with *Myriophyllum are Potamogeton leucens, P. filiformis, and P. nodosus. Nelumbo nucifera, Nymphoides peltata and Nymphaea alba, Trapa natans and Potamogeton natans* are common.



Map showing the sampling sites in Dal Lake.

This site also witnesses the sewage loading from nearby hotels into Dal Lake and is shown as yellow dot on map.

SITE-3(DL3): This sampling station is famous destination as far as tourism is concerned which is characterized by famous Nishat Garden made by Mughals. The sampling spot is located 30 meters towards west of Nishat Garden and in shown as blue dot on map. Commonly occurring macrophytic vegetation includes *Ceratophyllum demersum, Azolla pinnata, Salvinia natans and Hydrocharis dubia and lemna* sp. are quite common.

SITE-4(DL4): This site is located on northern side of the lake near Telbal area (designated in red dot on map) where telbalnallah along with heavy organic nutrient load enter into the part of Dal Lake locally known as Hazratbal basin. This site is charactarised by macrophytic vegetation viz., *Ceratophylum damersum, Myriophyllum spicatum* in the centre and *Utricularia flexuosa, Myriophyllum verticillatum* and *Typha angustifolia* towards sides.

Sample Collection, Preservation & Identification of Macroinvertebrates:

Collection of Samples was done on monthly basis for a total period of one year from July 2016 to June 2017. Surface invertebrates were collected by help of D-Frame net having 0.2mm mesh size and area of 15×15cm^2. The organisms were collected while disturbing the substratum by kicking or forcing ahead the net [24] and also by lowering the net in the macrophytic vegetation and lifted carefully with entire mass of macrophytes [36]. Certain organisms were also collected by hand picking method .For the collection of macro zoobenthos, the bottom sediments were collected with the help of Ekman's Dredge having an area of 15×15cm^2. At each site the sample was taken in triplicate and then pooled together. The samples were properly mixed with site water and passed through a series of different mesh size sieves. The individuals were sorted out manually using forceps and brushes and were preserved plastic bottles in 4% formalin and 70% alcohol depending upon the type of organisms to be preserved. The soft-bodied organisms were preserved in 70% alcohol while the shelled organisms like molluscs in 4% formalin [3]. For qualitative analysis preserved samples were identified to the lowest possible taxonomic level according to standard taxonomic works of [38], [28], [29] and [1]. However for quantitative analysis animals were counted individually species wise in whole sample and sub samples. The density of the benthic and surface macro invertebrate fauna was calculated/m^2 of bottom and surface area by using the formula:

$$N = O/A.S \times 10{,}000 \text{ (Welch, 1948)}$$

Where,

N = No. of Macrobenthic organisms/m^2.

O = No. of organisms counted.

A = Area of sampler (Ekman's dredge)/D-net in square meter for benthic macroinvertebrates and surface invertebrates

S = No. of samples taken at each site.

III. RESULTS

During the present study a total of 31 macro invertebrate species belong to three major phyla viz., Annelida, Arthropoda and Mollusca were recorded from four sites of Dal lake which differ in depth and vegetation. The total population density of macro invertebrate fauna of the lake was found to be 8305 ind/m^2. The greater density of macro invertebrate community was recorded mainly amongst Molluscs (3405 ind/m^2) with *Lymnaea stagnalis* being most dominant species (816 ind/m^2). The molluscs were followed in decreasing order by Arthropods (2651 ind/m^2) with *Chironomous* species being most dominant species (476 ind/m^2).The population density of Annelids was least among the three phyla (2249 ind/m^2) with *Tubifix tubifix* being most dominant (472 ind/m^2).Within these three major phyla a total of 31 species belong to 6 classes 13 0rders and 23 families. Annelids were represented by 9 species of which 8 species belong to class oligochaeta and 1 species belong to class polychaeta. Arthropods were represented by 15 species of which 14 species belong to class insecta and 1 species belong to class maxillopoda (malacostraca or crustacean). Molluscs were represented by 7 species of which 5 species belong to class gastropoda and 2 species belong to class bivalvia.

At site (DL-1): The total population density of macro invertebrate fauna at site 1 (DL1) was found to be 3487ind/m^2 with molluscs being most dominant (1975 ind/m^2) among the three phyla followed by Arthropods (759 ind/m^2) and Annelids (753 ind/m^2). A total of 24 species were recorded from this site throughout the survey 0f which *Helobdella*, *Glossophonia, Erpobdella octaculata, Hirudinaria* and *Limnodrillus hoffmeisteri* belong to phylum annelida with *Limnodrillus hoffmeisteri* being most dominant species (200 ind/m^2). *Chironomous, Bezzia, Simulium, Enallgama, Argia, Anax, Baetis, Corixapunctata, Sigara, Gerris, Coptotomus* and *Gammarus pulex* belong to phylum Arthropoda with *Argia* species being most dominant (158 ind/m^2). *Promenetus*, *Planorbis, Lymnaea auricularia,Lymnaea stagnalis,Lymnaea columella,Corbicula fluminea, Sphaerium* species among phylum Mollusca with *Promenetus* sp. being most dominant (420 ind/m^2). The total population density of macroinvertrebrate fauna at this site fluctuated from 75 ind/m^2 in the month of December to 713 ind/m^2 in the month of July with a mean population density of 282.4 ind/m^2.

Table 1: Variation in population density (ind/m^2) of macroinvertebrates during different months of the study period in Dal Lake.

Sites	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	Mean
DL1	713	505	400	178	266	75	298	330	135	104	237	148	282.4
DL2	699	254	75	75	15	50	225	283	105	30	135	75	168.4
DL3	849	357	120	60	90	164	75	245	209	280	266	180	241.2
DL4	345	266	278	188	76	44	32	98	189	276	256	343	199.2

Table 2: Average population density of macroinvertebrates (ind/m^2) at four Sites of Dal Lake.

S.No.	Macroinvertebrates	Site-DL1	Site- DL2	Site- DL3	Site- DL4	Total no. of ind/m^2
(I)	**Annelida**					
1	*Helobdella sp.*	75	0	0	0	75
2	*Glossophonia sp.*	104	30	22	23	179
3	*Erpobdella Octaculata*	25	30	0	20	75
4	*Hirudinaria sp.*	75	15	27	3	120
5	*Tubifix tubifix*	185	147	97	43	472
6	*Limnodrillus hoffmeisteri*	200	119	45	82	446
7	*Branchiura sowerbyii*	19	80	129	11	239
8	*Nais communis*	21	54	155	42	272
9	*Aeolosoma sp.*	49	100	193	29	371
	Total no. of ind/m^2 (Annelids)	**753**	**575**	**668**	**253**	**2249**
(II)	**Arthropoda**					
10	*Chironomous sp.*	15	154	291	16	476
11	*Pentaneura sp.*	15	22	48	20	105
12	*Tabanus sp.*	0	30	39	6	75
13	*Chaborus sp.*	0	129	115	11	255
14	*Bezzia sp.*	45	35	30	10	120
15	*Simulium sp.*	23	15	42	10	90
16	*Enallgama sp.*	80	139	65	20	304
17	*Argia sp.*	158	45	64	31	298
18	*Anax sp.*	30	0	0	0	30
19	*Baetis sp.*	60	15	0	0	75
20	*Corixa punctata*	45	15	15	0	75
21	*Sigara sp.*	30	30	0	0	60
22	*Gerris sp.*	75	45	75	0	195
23	*Coptotomus sp.*	105	60	15	0	180
24	*Gammarus pulex*	78	87	65	83	313
	Total no. of ind/m^2 (Arthropods)	**759**	**821**	**864**	**207**	**2651**
(III)	**Mollusca**					
25	*Promenetus sp.*	420	45	111	18	594
26	*Planorbis sp.*	370	60	119	0	549
27	*Lymnaea auricularia*	391	60	63	65	579
28	*Lymnaea stagnalis*	345	165	151	155	816
29	*Lymnaea columella*	180	45	89	29	343
30	*Corbicula fluminea*	164	45	75	0	284
31	*Sphaerium sp.*	105	60	75	0	240
	Total no of ind/m^2(Molluscs)	**1975**	**480**	**683**	**267**	**3405**
	Total no. of ind/m^2 at all four sites	**3487**	**1876**	**2215**	**727**	**8305**
	Total no. of ind/m^2 (Annelida+Arthropoda+Mollusca)	**2249**	**2651**	**3405**	**=**	**8305**

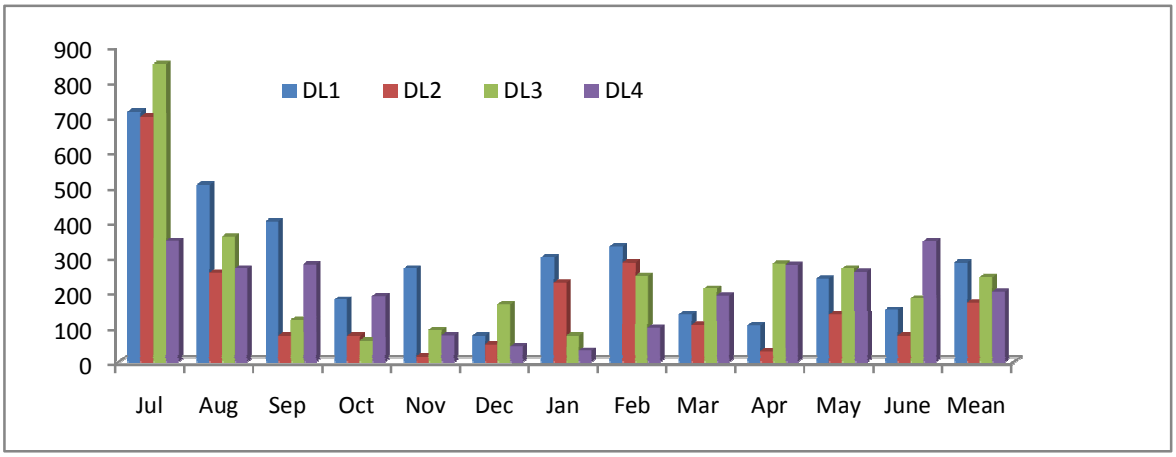


Fig. 1. Chart showing month wise population density at four sites of Dal lake.

Table 3: Species composition of macroinvertebrates at four different sites of Dal Lake.

S. No.	Macroinvertebrates	Site- DL1	Site- DL2	Site- DL3	Site-DL-4
	Annelida				
1	*Helobdella sp.*	+	-	-	-
2	*Glossophonia sp.*	+	+	+	+
3	*Erpobdellaoctaculata*	+	+	-	+
4	*Hirudinaria sp.*	+	+	+	+
5	*Tubifixtubifix*	-	+	+	+
6	*Limnodrillushoffmeisteri*	+	+	+	+
7	*Branchiurasowerbyii*	+	+	+	+
8	*Naiscommunis*	+	+	+	+
9	*Aeolosoma sp.*	+	+	+	+
	Arthropoda				
10	*Chironomous sp.*	+	+	+	+
11	*Pentaneurasp,*	-	+	+	+
12	*Tabanus sp.*	-	+	+	+
13	*Chaborus sp.*	-	+	+	+
14	*Bezzia sp.*	+	+	+	+
15	*Simulium sp.*	+	+	+	+
16	*Enallgama sp.*	+	+	+	+
17	*Argia sp.*	+	+	+	+
18	*Anax sp.*	+	-	-	-
19	*Baetis sp.*	+	+	-	-
20	*Corixa punctata*	+	+	+	-
21	*Sigara sp.*	+	+	-	-
22	*Gerris sp.*	+	+	+	-
23	*Coptotomus sp.*	+	+	+	-
24	*Gammarus pulex*	+	+	+	+
	Mollusca				
25	*Promenetus sp.*	+	+	+	+
26	*Planorbis sp.*	+	+	+	-
27	*Lymnaea auricularia*	+	+	+	+
28	*Lymnaea stagnalis*	+	+	+	+
29	*Lymnaea columella*	+	+	+	+
30	*Corbicula fluminea*	+	+	+	-
31	*Sphaerium sp.*	+	+	+	-

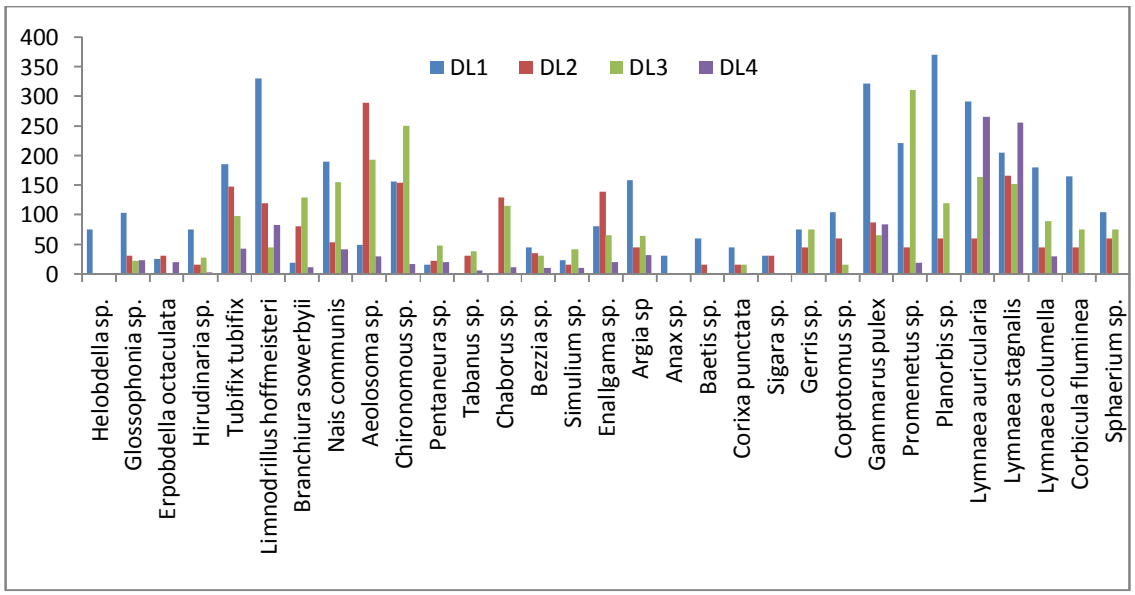


Fig. 2. Representation of Abundance and Dominance of invertebrate species.

At site (DL-2): The total population density of macroinvertebrate fauna at this site was found to be 1876 ind/m^2 with Arthropods being most dominant (821ind/m^2) among the three phyla followed by Annelids (575 ind/m^2) and Molluscs (480 ind/m^2).A total of 29 species were recorded from this site throughout the survey 0f which *Glossophonia, Erpobdell aoctaculata, Hirudinaria Tubifix tubifix, Limnodrillus hoffmeisteri Branchiura sowerbyii, Nais communis* and *Aeolosoma* species belong to phylum Annelida with *Tubifix tubifix being most dominant* species(147 ind/m^2). *Chironomous, Pentaneura. Tabanus, chaborus, Bezzia, Simulium, Enallgama, Argia, Baetis, Corixapunctata, Sigara, Gerris, Coptotomus* and *Gammaruspulex* belong to phylum Arthropoda with *Chironomous* species being most dominant (154 ind/m^2). *Promenetus*, *Planorbis, Lymnaea auricularia, Lymnaea stagnalis, Lymnaea columella, Corbicula fluminea, Sphaerium* species among phylum Mollusca with *Lymnaea stagnalis* being most dominant (165 ind/m^2). The The total population density of macroinvertrebrate fauna at this site fluctuated from 15 ind/m^2 in the month of November to 699 ind/m^2 in the month of July with a mean population density of 168 ind m^2.

At site (DL-3): The total population density of macroinvertebrate fauna at this site was found to be 2215ind/m^{2}with Arthopodsbeing the most dominant (864 ind/m^2) among the three phyla, followed by Molluscs (683 ind/m^2) and Annelids (668 ind/m^2).

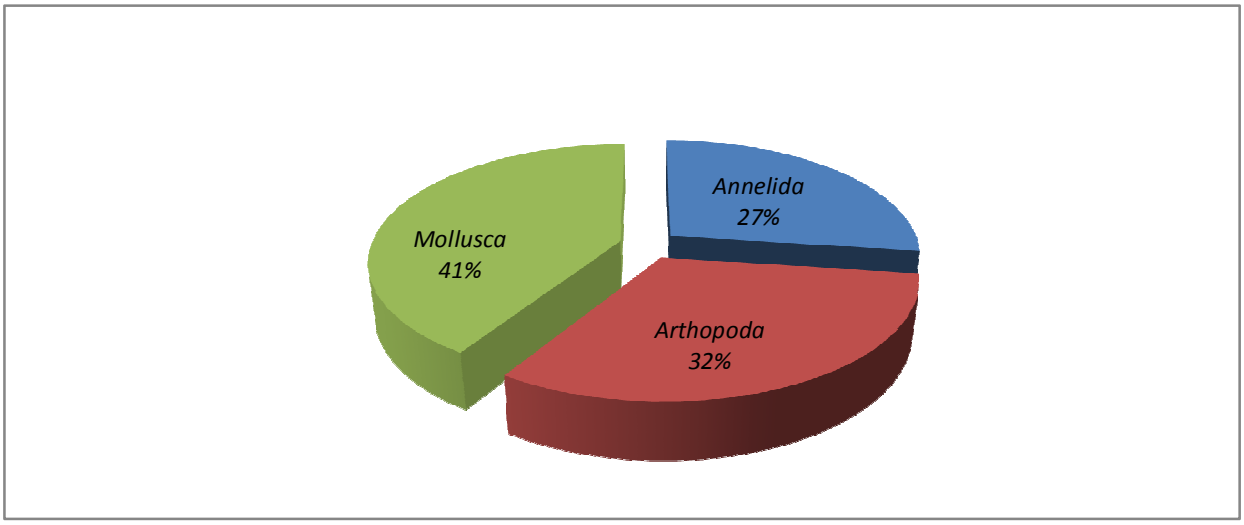


Fig. 3. Percentage contribution of Macroinvertebrates in Dal lake.

A total of 26 species were recorded from this site throughout the survey of which *Glossophonia, Hirudinaria, Tubifix tubifix, Limnodrillus hoffmeisteri, Branchiura sowerbyii, Nais communis* and *Aeolosoma* species belong to phylum Annelida with *Aeolosoma sp.* being most dominantspecies (193ind/m^2). *Chironomous, Pentaneura, Tabanus, Chaborus, Bezzia, Simulium, Enallgama, Argia, Corixa punctata, Gerris, Coptotomus* and *Gammarus pulex* belong to phylum Arthropoda with *Chironomous* species being most dominant (291 ind/m^2). *Promenetus*, *Planorbis, Lymnaea auricularia, Lymnaea stagnalis, Lymnaea columella, Corbicula fluminea, Sphaerium* species among phylum Mollusca with *Planorbis* being most dominant (119ind/ m^2) .The total population density of macroinvertrebrate fauna at this site fluctuated from 60 ind/m^2 in the month of October to 849 ind/m^2 in the month of July with a mean population density of 241.2 ind/ m^2.

At site (DL-4): The total population density of macroinvertebrate fauna at this site was found to be727 ind/m^2 with Molluscs being most dominant (267ind/m^2) among the three phyla followed by annelids (253 ind/m^2) and Arthropods (207ind/m^2). A total of 21 species were recorded from this site throughout the survey 0f which *Glossophonia, Hirudinaria, Tubifix tubifix, Limnodrillus hoffmeisteri, Branchiura sowerbyii, Nais communis* and *Aeolosoma* species belong to phylum Annelida with *Limnodrillus hoffmeisteri* being most dominant species (82 ind/m^2). *Chironomous, Pentaneura, Tabanus, Chaborus, Bezzia, Simulium, Enallgama, Argia, Corixa punctata, Gerris, Coptotomus* and *Gammarus pulex* belong to phylum Arthropoda with *Gammarus pulex* being most dominant (83ind/m^2).*Promenetus*, *Planorbis* ,*Lymnaea auricularia, Lymnaea stagnalis, Lymnaea columella,Corbicula fluminea, Sphaerium* species among phylum Mollusca with *Lymnaea stagnalis* being most dominant (155 ind/m^2).The total population density of macro invertebrate fauna at this site fluctuated from 32 ind/m^2in the month of January to 345 ind/m^2 in the month of July with a mean population density of 199.2 ind/m^2.

DISCUSSION

In the studied sites of the Dal lake the type of habitat was found to be the most influential factor affecting the taxanomic composition of macroinvertebrates. The macro invertebrate fauna collected from four sites of Dal lake differ with respect to habitat selection and impact of commercial settlements like Shikaras and hotelsin and around Dal lake. Among the sampling sites, the richness of macro invertebrates was found positively associated with abundance of macrophytes and sediments rich in organic nutrients. The abundance of phytophilous macroinvertebrates was found to be greatly determined by architecture of macrophytes. Macrophytes having large surface area were found to favour large number of macroinvertebrates. The similar type of relationship between macrophytes and macroinvertebrates was observed by [33] while studying macro invertebrate and macrophyte associations in Mansbal lake. Highest number of taxa were recorded from the sites having abundant macrophytic growth and organic matter rich bottom sediment. During present study, Arthropods were found to be most dominant group in terms number of taxa. During the study 15 species among arthropods were recorded from three different sites, when only 9 species among annelids and 7 species among molluscs were recorded. It was also observed that arthropods occupy almost all the four studied sites uniformly as compared to other two phyla which were found quite specific in terms of their habitat selection. At site first (DL1) located at the exit of Dal lake the bottom was found sandy with prevalence of gravely sediment and low availability of organic matter. The abundance of molluscs at this site as reported during the present study clearly indicates that macroinvertebrates prefer to inhabit the habitat with high sand content and luxuriant macrophytic growth. Similar type of results were found by [10] while carrying out an ecological study on macro zoobenthos of Nigeen lake. During the present study it was found that certain features of habitat at siteDL1 and DL4 like presence of sandy bottom, gravely sediment and low availability of organic matter interfere negatively with the numerical strength of oligochaetes. It was found that site 1 (DL1) reflected the lowest population density of Annelids (oligochaetes). Such results are in agreement with the findings reported by [14] and [13] in their studies. The heavy organic nutrient loading into Dal lake from nearby commercial enterprises like hotels at site 2 (DL2) and from telbal area via an inflow channel called telbal Nallah at site 3 (D3) was found to influence macro invertebrate spectrum to a greater extent.During the present study it was also found that the abundance of certain species more specifically *Limnodrillus hoffmeisteri* and *Tubifix tubifix* (oligochaetes) tend to increase in the habitat enriched with high organic nutrient loading which coincides with the findings of [14] and [34]. the abundance of both *Limnodrillus hoffmeisteri* and *Tubifix tubifix* clearly confirmed the fact that these species prefer organic matter rich habitat and clearly indicates that the entrance of organic matter in Dal lake is the main factor in the determination of distribution and abundance of species belong to tubificidae family. The high numerical density and range of tolerance of *Limnodrillus hoffmeisteri* and *Tubifix tubifix* at DL2 and DL3 and DL 4 clearly indicate the organic pollution in Dal lake. Such results correlate with findings of earlier studies carried out on different water bodies by [26], [23], [36], [6][27], [22], [9]and [16]. *Chironomids* have also been targeted as pollution indicators in biological monitoring of water body [7] are labelled as pollution tolerant species [9].

During the present study, the abundant presence of *chironomous* species present in Dal lake especially at DL3 and DL4 clearly Confirms the high organic load (organic pollution) in this water body. During the present study, macro invertebrate fauna in Dal lake was found to have increased both in terms of taxa and abundance as compared to previous studies carried out on Dal lake. As analyzed from the present study a sudden change has occurred in diversity, distribution, composition and density of macroinvertebrates fauna harbouring the lake. This change in macro invertebrate diversity patterns can be attributed to the fact that certain macro invertebrate species especially those belong to family tubificidae (oligochaeta) and chironomidae (Insecta) because of their tremendous ability to respond the change in physico-chemical changes with increasing organic matter replace other macroinvertebrates less tolerant for the conditions of particular habitat. [13] found almost similar type of fluctuations in diversity patterns of certain macroinvertebrates while carrying an ecological study on Habitat preference of aquatic oligochaeta (Annelida) in the Rokttna river. Present study reveals that a tremendous increase in densities of certain fundamental pollution indicator species like *limnodrillus hoffmeisteri, Tubifix tubifix* and *chironomous* followed by decrease or disappearance of other species in water body indicates that organic pollution level is increasing in water body at an alarming rate. The abundance of *limnodrillus hoffmeisteri, Tubifix tubifix* and *chironomous* at DL1, DL2 and DL4 clearly indicate that these two sites have high organic pollution level as compared to site-DL3 where these species thrive less. Such an alarming increase in organic pollution level in Dal lake can be attributed to heavy organic nutrient loading in Dal lake from catchment areas and the nutrient rich sediment brought into the lake by 2014 water deluge.

CONCLUSION

It is concluded from the present study that Dal lake is having the rich wealth of macro invertebrate fauna which reflects the health and vigour of lake. The environmental conditions of a particular habitat in an aquatic ecosystem like anthropogenic pressure, drainage systems and consequently high level of pollution has caused the changes in biological diversity, distribution and density of macroinvertebrates and consequently eutrophication of the lake. Dal lake is under great stress and is losing its aesthetic and ecological value as a result of organic pollution and is not only due to the large amount of untreated sewage flushed from nearby commercial enterprises in and around lake, but also due to the heavy organic nutrient rich slit loading into the lake via various sources especially from catchments areas (drains and nallahs). Hence an accurate ecological understanding of environmental factors that affect the biological diversity of lake especially their management must be taken into consideration so that proper conservation measures could be planned for Dal lake ecosystem.

ACKNOWLEDGEMENT

I express my gratitude to Dr. Mohammad Farooq Mir (Prof. & Head Hydrobiology Research Laboratory Govt. SP College, the *Cluster University* Srinagar Kashmir) and Dr. Anuja Gupta (Prof. Govt. MVM Bhopal M.P.) for providing necessary laboratory facilities and their constant whole hearted guidance, advice and encouragement throughout the Research programme. I also extend special thanks to scholars of Hydrobiology Research Laboratory for timely assistance and support.

REFERENCES

[1]. AD Adoni (1985). Work book of Limnology, *Pratibha publication Sagar*, M.P. India, 1-213.

[2]. AY Malik and M Ali (2012). Macrozoobenthos in the Bod-dal basin of Dal Lake, J&K, India. *Journal of Industrial Pollution Control,* **8**(2): 131-135.

[3]. DJ Borror., M Delongdwilight and CA Triplehorn (1976). An introduction to the study of Insects. 4th edition. *Library of Congress Cataloging in Publication*, USA.

[4]. D Bhattacharjee (2007). The proceeding of *Taaal*, The 12th world lake conference, 95-98.

[5]. DM Rosenburg, and VH Resh (1993). Introduction to freshwater biomonitoring and benthic macroinvertebrates. Chapman and Hall, York.1-194.

[6]. DR Oliver (1971). Life history of the Chironomidae. *Annual Reviews Entomology*, **16**: 211-230.

[7]. EC Bay., AA Ingham and LD Anderson (1966). Physical factors influencing chironomids infestation of water spreading basins. *Annual Entomological Society of America*, **59**: 714-717.

[8]. F Mukhtar and H Chisti (2013). Assessment of water quality by evaluating the pollution potential of Hazratbal basin of Dal lake, Kashmir, India. *Australian Journal of Basic and Applied Sciences,* **7**(14): 1-2.

[9]. G Milbrink (1980). Oligochaete communities in population biology; the Europian situation with rapid reference to lakes in Scandinavia. In: *Aquatic Oligochaete Biology,* (R.D Brink Hurst and D.G. Cook, eds.). Plenum press, N.Y. and London, 433-455.

[10]. H Qadri and AR Yousuf (2004). Ecology of macrozoobenthos in Nigeen Lake. *Journal of Research and Development,* **4**: 59-65.

[11]. JL Meyer., DL Strayer., JB Wallace., SL Eggert., Helfman and NE Leonard (2007). The contribution of head water streams to biodiversity in river networks. *Journal of American Water Research Association,* **43**: 86-103.

[12]. JS Richardson and RJ Danehy (2007). A synthesis of the ecology of head water streams and their riparian zones in temperate forests. *Forest Science.* **53**: 131-147.

[13]. J Schenkova and J Helesic (2006). Habitat preference of aquatic oligochaeta (Annelida) in the Rokttnariver, Czech republic-a small highland stream. *Hydrobiologia*, **564**(1): 117-126.

[14]. KJ Lin and SP Yo (2008). The effect of organic pollution on the abundance and distribution of aquatic oligochaetes in an urban water basin, Taiwan. *Hydrobiologia*, **596**(1): 213-223.

[15]. MA Ganie., M Parveen., MH Balkhi and MI Khan (2015). Structure and diversity of cladocerans communities in two lakes with varying nutrient compositions in the Jhelum River Basin, Kashmir. *International Journal of Fisheries and Aquatic Studies*, **3**(2): 456-462.

[16]. M Bazzanti (1983). Composition and diversity of the profundalmacrobenthic community in the polluted Nemi (Central Italy), 1979-80. *Oecol. Applic.* **4**(3): 211-220.

[17]. M Bashir., R Chouhan., MF Mir., M Ashraf., N Amin., SA Bashir and MY Gudoo (2017). To evaluate pollution studies in relation to the water quality status of Anchar Lake Srinagar Kashmir. *Journal of environmental science, computer science and engineering and technology,* **6**(1): 17-23.

[18]. MF Mir., A Bashir., MY Gudoo., S Tabassum., M Bashir., R Farooq and S Bundh (2017). Sediment Chemistry of Gagribal Basin of Dal Lake.*International Journal of Fauna and Biological Studies,* **4**(4): 126-130.

[19]. MF Mir and AR Yousuf (2005). Diversity patterns of macrobenthic fauna of Dal lake, Kashmir. *Oriental science*, **10**: 1-4.

[20]. MF Mir., N Amin., A Ramzan., NM Malik., MA Bhat and M Bashir (2016). Ecological study on macrozoobenthic community of Anchar lake. *International Journal of Advanced Biological Research.* **6**(2): 309-312.

[21]. MY Qadri and AR Yousuf (1980). Influence of physico-chemical factors on the seasonality of cladocera in lake Mansbal. *Geobiosciences,* **7**: 273-176.

[22]. OA Seather (1979). Chironomid communities as water quality indicators. *Holarctic Ecology*, **21**: 65-74.

[23]. PFM Verdonschot (1989). The role of oligochaetes in the management of waters. *Hydrobiologia*, **180**(1): 213-227.

[24]. PO Hoffsten and B Malmqvist (2000). The macroinvertebrate fauna and hydrogeology of springs in central Sweden. *Hydrobiologia*, **436**: 91-104.

[25]. Q Yaqoob and AK Pandit (2009) Distribution and Abundance of Macrozoobenthos in Dal Lake of Kashmir Himalaya. *Journal of Research & Development.* **9**: 22-29.

[26]. RI Aston (1973). Tubificids and water quality: are view. *Environmental pollution*, **5**(1): 1-10.

[27]. RO Brinkhurst and DG Cook (1974). Benthic macroinvertibrates in relation to water and sediment chemistry. *Freshwater Biology*, **4**(3): 183-191.

[28]. RW Pennak (1978). *Freshwater Invertebrates of United States*. John Wiley & Sons, New York.

[29]. RW Pennak (1978). *Freshwater invertebrates of United States*. John Wiley & Sons, New York.

[30]. SA Shah (2012). Tourism and lake sustainability. A case study of Dal lake. *International Journal of Environmental Sciences,* **1**(4): 230-234

[31]. S Kaushik., S Sharma and DN Saksena (1991). Ecological studies of certain polluted lentic waters of Gwailor region with reference to aquatic communities. *Current Trends in Limnology,* 185-200.

[32]. SS Lonkar and GT Kedar (2014). Macrozoobenthic diversity of three Urban lakes of Nagpur,central India. *International Journal of Advanced Research*, **2**(4): 1082-1090.

[33]. SU Bhat., GA Dar., AH Sofi., NA Dar and AK Pandit (2012). Macroinvertebrate community associations on three different macrophytic species in Mansbal Lake. *Research Journal of Environmental Sciences*, **6**(2): 62-76.

[34]. TD Slepukhina (1984). Comparison of different methods of water quality evaluation by means of oligochaetes. *Hydrobiologia,* **115**(1): 183-186.

[35]. UN Adholia., A Chakarwarty., V Srivastava and A Vyas. Community studies on macrozoobenthos with reference to limno-chemistry of Mansarovar reservoir, Bhopal. *J. Natcon*, **2**(2): 139–154, (1990).

[36]. V Kaul., AK Pandit and DN Fotedar (1980). Ecology of fresh water snails (Gastropod Molluscs) in Hygama typical wetland of Kashmir. *Tropical Ecology,* **21**(1): 32-46.

[37]. V Vyas and MA Bhat (2010). Macrozoobenthic diversity of tropical water body (upper lake) Bhopal.*The Ecoscan, An international quarterly journal of environmental sciences,* **4**(1): 69-72.

[38]. WT Edmondson (1959). *Freshwater Biology, John Wiley and Sons Inc.,* New York, London.