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Biomonitoring with macrozoobenthos as a special tool to predict the water quality of Dal Lake Srinagar

Sajad Hussain Dar, Farooq Ahmed Dar, Asrar Amin Khan, Abid Rashid, Abdul Rashid Teli and Muzamil Bashir

Abstract
Ten sampling stations where chosen within the lake for the study of Biomonitoring during different seasons of 2016 by using the Macrozoobenthos to predict water quality characteristics. Two sampling stations where chosen from Nageen basin near Houseboats, directly fed by sewage from houseboats with a deepest depth of 6 meters. Site third and fourth is situated in Nishat basin near LAWDA. This site is constantly disturbed during summer by manual deweeding process by local Hanjies. Site fifth and sixth where chosen from Gagribal basin with dense growth of macrophytes. In the same way two more sampling sites designated as site seventh and eighth where chosen from floating gardens of Kandmohalla. Another two sites designated as ninth and Tenth selected from Dal gate. Sampling stations are represented by capital letter "S" followed by numerical prefix. Benthic fauna was dominated by three major phylum's belonging to phylum Annelida, phylum Mollusca and phylum Arthropoda. On the whole total number of 27 taxa was observed during overall tenure of sampling period.

Keywords: Snail, bovine, porcine, physicochemical properties, mucin, mucoadhesives

Introduction
Biomonitoring is the systematic use of living organisms or their responses to determine the quality of the environment. Water pollution is essentially a biological problem. Chemical measurements are like taking snapshots of the ecosystem, whereas biological measurements are like making a videotape. The ultimate purpose of environmental assessment and regulation is the maintenance of biological integrity, so setting water-and sediment-quality objectives should involve biological criteria as well as chemical surrogates Rosenberg, (1998) [9]. Macrobenthos in marine sediment play an important role in ecosystem processes such as nutrient cycling, pollutant metabolism, dispersion and burial, and in secondary production Snelgrove, (1998). Structure of benthic community is now frequently used in pollution effect monitoring programmers. Limited benthic studies have been conducted in the tropics compared to higher latitudes and the theory relating to the community structure is based on the studies from temperate regions Alongi, (1990) [2]. It is important to establish baseline for tropical regions and improve our understanding of biodiversity in aquatic environment. Benthic macro-invertebrates are common inhabitants of Lakes and streams where they are important in moving energy through food webs Rosenberg and Resh (1993) [8]. Monitoring of environmental component is difficult using physico-chemical method for pollution controlling activities. To overcome the cumbersome problem, environmentalists all over the world are exploring the possibility of using biomonitoring techniques. The effect of all the pollutants through bio monitoring can be properly estimated Zwart, (1995) [13]. Monitoring is an important tool for water quality management. It can be defined as "the process of repeated measurement and observations for defined purposes of one or more indicators of the chemical, physical, or biological state of an environment. Bio-monitoring is the introduction of biological variables to assess the functional and structural aspects of aquatic ecosystems. Bio monitoring can be used as a cost-effective and alternative means of supplementing the physico-chemical techniques Parivash, (Central pollution Control Board 2012) [7].
Webster's dictionary defines monitoring as, to adjust and check for quality or fidelity, to watch to observe, especially for special purpose, to control, or to keep track of regulate. The following attributes are included in monitoring activity. 1. Survey: an intensive program to measure for definite duration and evaluate the quality of environment for specific purpose. 2. Surveillance: specific measurement observation and reporting for the purpose of operational and environmental quality management. 3. Monitoring: standardized measurement, continuous

observation and reporting of the environment in order to define status and trends. Thus, environmental monitoring must have a function and purpose of pollution control and risk management.

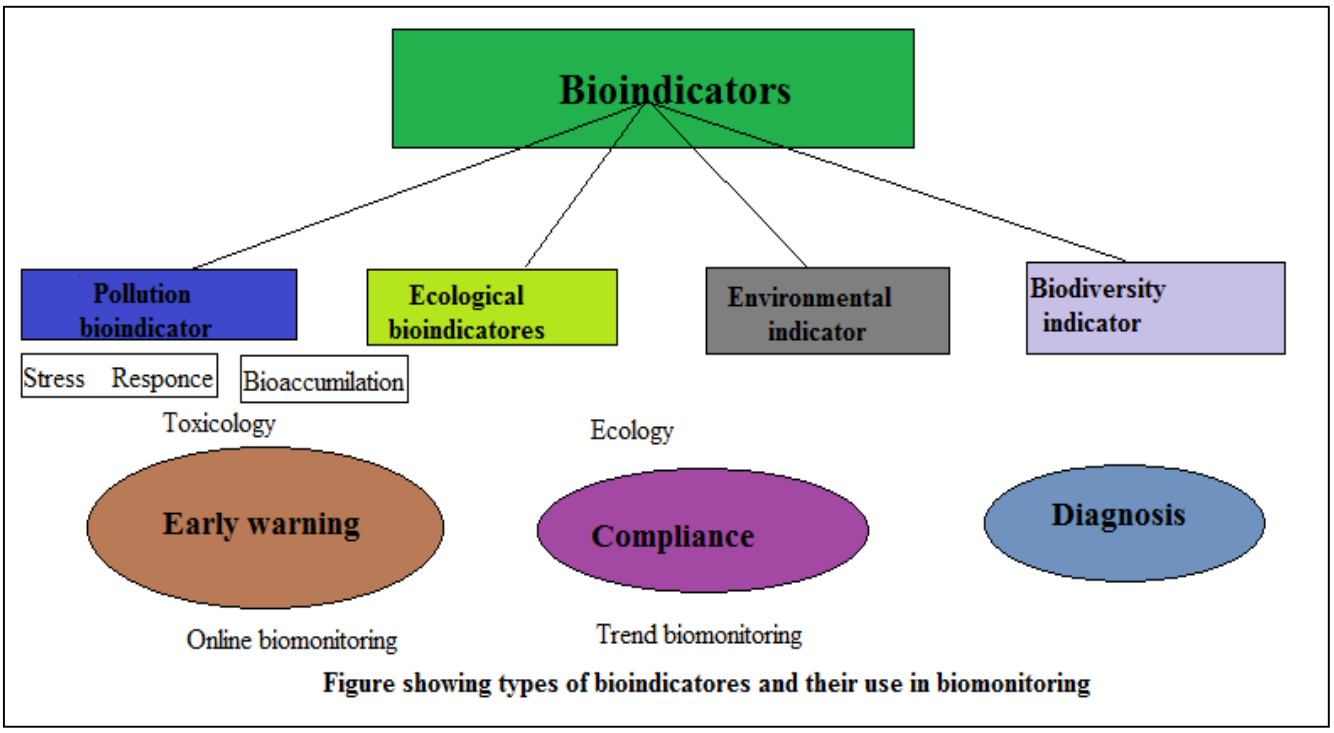

Figure showing types of bioindicatores and their use in biomonitoring

Biomonitoring system is required to signal, control or predict change or trends of changes in the quality of a particular water body so that curative or preventive measures can be taken to restore and maintain ecological balance in the water body. The present work is aimed to fill the gap of monitoring program and to provide a preliminary data to understand the important and major lentic ecosystem of Kashmir valley.

Study Area

The lake is classified under the sub-tropical lake category as 'warm monomictic' the perennial flow from Dachigam- telbal Nallah and Dara Nallah and number of small streams are the permanent feeding source to the Dal lake. No substantial spring source is worth mentioned, but during summer snow of the catchment area from higher reaches melts down and results in small streams which joins themselves and forms inflow into the lake. The maximum discharge of Telbal Nallah is estimated as 291.9 million cubic metres, accounting for 80% contribution and 20% from other sources. Dal lake is the second largest in the state, and also commercial centre of Hanjis for fishing and harvesting Hydrophytes and its products.

Dal Lake is located on the eastern part of Srinagar, on the right bank of river Jhelum and is the main reservoir of watersheds in the city. One of the significant features of a Dal lake is its diverse nature of watershed, spread over 331 km^2 with sub and secondary branching. The out washing of these watersheds bring contamination as they approach congested areas up to the mouth of the Dal Lake. Dal Lake is famous not only for its beauty, but also for its unique life style anywhere in the world. The inhabitant of Dal Lake called Hanjies had lived for centuries and is acclimatized with the harsh climatic conditions as well as complete infrastructure that help them to thrive well within it. The one and only life line of Srinagar city is unfortunately, under constant pressure as these Hanjies are also involved in land transformation and their focus on land expansion. The Multi-basined Lake is having five main stations with evident geographical and morphological features. These basins include Bod Dal, Lokut Dal, Nageen, Gagribal and Hazatatbal. The two main outlets are Dal Gate and Pokhribal Nallah and also supplied by two main watersheds called Dhara Danihama and Dachigam. Dal Lake is second largest lake covering an area of 316 square kilometers in zabarwan mountain valley with diverse watershed. The main problem of these watershed and aquatic ecosystems is enrichment of nutrients from residential and catchment areas as well as, runoff from agriculture fields. Catchment area of the lake stretches from North of Dal Lake to areas that border the lake on the north and covers an area of 337.44 km^2. In this way multi-linage water source is under constant threat and the deteriorating quality of drinking water results in amalgamation of different diseases, and the constant anthropogenic pressure with its tremendous deterioration results in shrinkage of lake surface area.

The present study was carried out from Dal Lake, Srinagar and ten sampling stations were chosen from the lake for the study of macrozoobenthos. The choice of sampling sites was opted keeping in view anthropogenic pressure, organic pollution load and least interference by human activities. Two sampling stations where chosen from Nageen basin (S1, S2) near Houseboats directly fed by sewage near LAWDA. Nishat basin designated as (S3, S4) is constantly disturbed during summer by manual deweeding process by local Hanjies. Site fifth and sixth where chosen from Gagribal basin (S5, S6) with dense growth of macrophytes. In the same way two more sampling sites designated as site seventh and eighth where chosen from floating gardens of Kandmohalla (S6, S7). Another two sites designated as ninth and Tenth were selected from Dal gate (S9, S10).

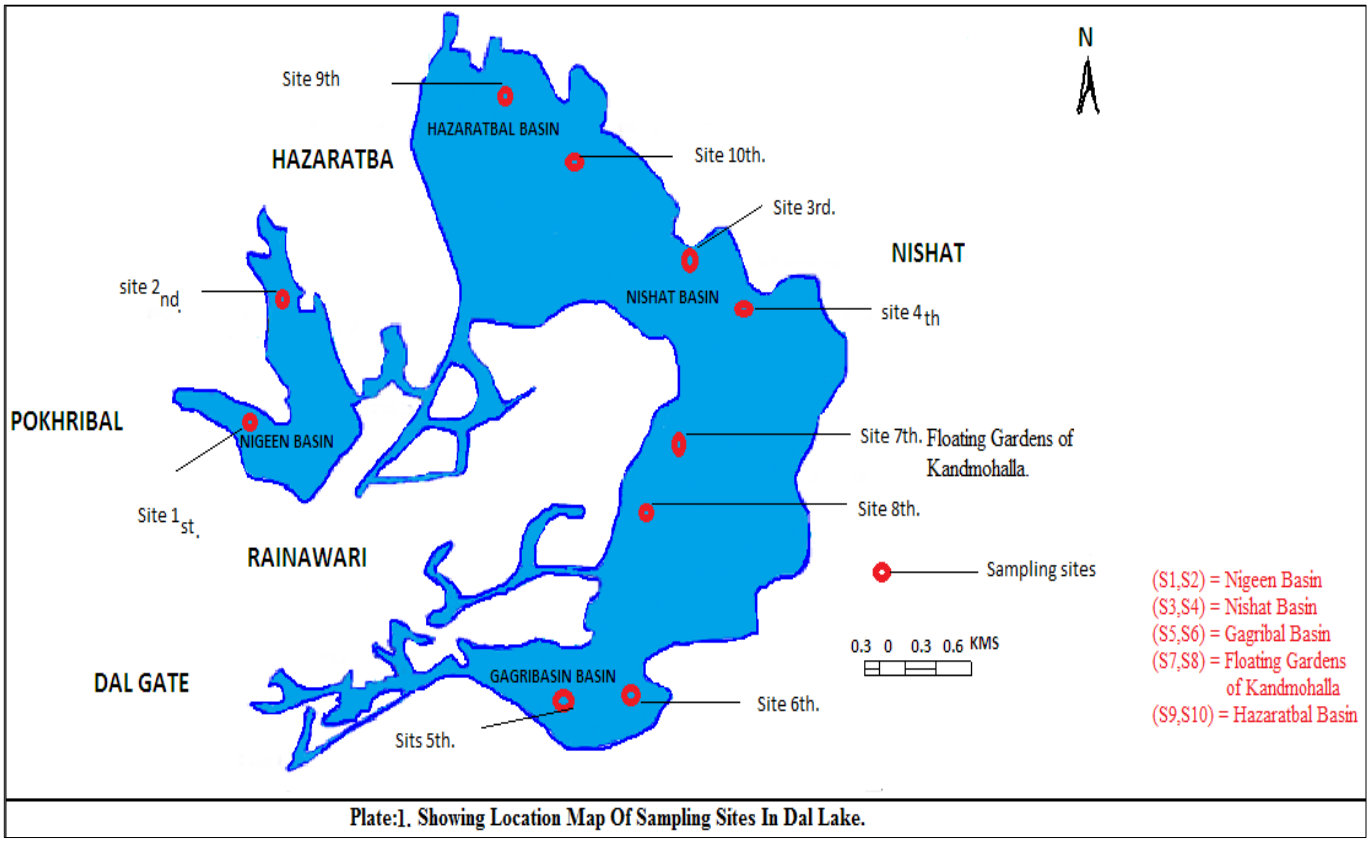

Plate 2: Map Showing Location of Different Sites in Dal Lake.

Method and Material

Biological analysis was done followed by following methodology

For biological analysis data was run in past and online help from revised biomonitoring working party score table. As the biological observation is measure or counted, it becomes evident that some objectives methods are necessary to help the biological presentation and verifying the research data. For biological analysis data was run in past and online help from revised biomonitoring working party score table.

Biological analysis was carried out by collecting samples from all the sites, sediments (between 8.30 am-5.30 pm) with the help of Petersons grab mud sampler and the collection was sieved with the help of 0.5mm sieve (Ankar and Elmgreen 1976). Samples were handpicked in sites involves boulders within the quaderant of 50×50 cm^2. Macrophytes demarked by quadrant were uprooted with the help of a hook and dropped in a white finished tray and poured into 70 percent ethanol for fixing. The substrate collected is washed and punched against the floor of tray. The water retained in tray was sieved through 0.5mm sieve. For shallow water kick net was used and bed agitated for standard three minutes, filtrate was sorted out with the help of forceps and brush, and then collected in plastic bottle, containing 70 percent alcohol as preservative Adoni (1985) [1], Helsonhoff (1988) [5] and subsequently shifted to laboratory for identification.

Macrofauna were identified under the Metzer light microscope and highly magnified hand lens with the help of standard keys and manuals, Chandra (1991) [4] and Mike *et al.* (2005) [6], Population of organisms were counted species wise i.e., number of individuals of a species per sample and were expressed as number /m^2. During one year study period, seasonal sampling was carried out, in which ten samples were collected from Dal Lake Lake. From each sample the number of individuals of different species and group percentage were calculated per meter square (Welch, 1948) [11] according to following formula:

Number of benthos per unit area was calculated as follows:

$$N = \frac{O}{AS \times 10^4}$$

Where N = Number of organisms per sample /m^2,
O = number of individuals actively encountered.
A = area of sampler (Ekmans Dredge in m^2).
S = number of samples taken at one sampling point.

Biological monitoring working party (1980)

The Biological Monitoring Working Party (BMWP) score system was introduced in 1980 to provide an index of river water quality for England and Wales based on aquatic macroinvertebrates.

Procedure:

The BMWP score equals the sum of the tolerance scores of all macroinvertebrate families in the sample. BMWP Score given to particular taxa reflects water quality.so it follows higher the score higher is the water quality. Alternatively, also the Average Score per Taxon (ASPT) score is calculated. The ASPT equals the average of the tolerance scores of all macroinvertebrate families found, and ranges from 0 to 10. The main difference between both indices is that ASPT does not depend on the family richness. Once BMWP and ASPT are calculated, results are subjected to Wright *et al.*, (1993) [12] matching table and inference is prepared to get the final results and assess the scenario of water quality.

Biostatical Calculation

The data obtained for biomonitoring variables were subjected to statistical analysis by using software programs, Microsoft Excel, Past and Graphed 8.

Results

Distribution of benthic fauna in Dal Lake

During different seasons of 2016 data obtained is represented in table number 96 and its analysis is shown in table number 97 Seasonal fluctuation of benthic fauna was obtained from 10 sampling sites which were dominated by three major phylum's belonging to phylum Annelida, phylum Mollusca and phylum Arthropoda. On the whole total number of 27 taxa was observed during overall tenure of sampling period. Phylum Annelida comprises five orders, contributes eight species and dominates other phyla in terms of density followed by phylum Arthropoda and least count was observed in phylum Mollusca. At the same time it maintains second status in terms of species composition overwhelmed by phylum Arthropoda and least count of species number was observed in phylum Mollusca, so the order of dominance in terms of species composition was beaten by phylum Arthropoda followed by phylum Annelida and least count of species was contributed by Phylum Mollusca. Phylum Mollusca comprises only two families and represents four species; on the other hand phylum Arthropoda comprised nine families and shows presence of fifteen species. During summer season maximum number of individuals was contributed by *Limnodrilus hofmeisteria* with an individual count of 310 individuals /m^2. On an average basis a value of 231 individuals /m^2 and a standard deviation of 70 with a total count of 2314 individual /m^2 from 10 sampling sites were observed in phylum Mollusca. Another species *Tubifix tubifix* from Phylum Annelida contributes 310 individual /m^2 with an average value of 195S.D± 79.1 with a total count of 1959 individuals /m^2 from 10 sampling stations. *Branchiura* species from phylum Arthropoda is the major contributor in terms of species density and shows an individual count 200/m^2 with an average value of 84.1S.D± 71 and contributes 841 Individuals /m^2. Chironomous maintains second position in phylum Arthropoda showing an individual count of 195 individuals /m^2 with an average value of 84.5S.D± 58.4 and a total count of 845 individuals /m^2. The least count was shown by *Erpopdella* species contributing 20 individuals /m^2 and showing a variance of 18 individuals /m^2 with standard deviation of 4.3.

Table 1: Showing total number of individuals from benthic fauna on seasonal basis during the year 2016.

Family	Species	Winter	Spring	Summer	Rainy S.	Autumn
Glassiphonidae	*Glossipnonia* sp.	0	3	25	32	15
	Helobdella sp.	0	5	25	34	16
	Eppopdella	58	0	25	11.6	119.3
Erpobdellidae	*Erpopdella octoculata*	11	27	26	39	39
Tubificidae	*Tubifix tubifix*	1008	1351	1959	2050	1776
Naididae	*Nais* sp.	219	290	411	429	380
	Limnodrilu hofmeisteria	1511	1745	2314	2433	2094
Aelosomatidae	*Aelosoma* sp.	150	212	263	306	270
Lymnaeidae	*Lymnaea columella*	121	178	195	226	232
	lymnaea stagnalis	24	44	81	108	65
	Lymnaea auricularia	178	232	238	262	184
Planorbidae	*Gyraulus* sp.	10	34	58	91	64
Chironomidae	*Chironomus* sp.	282	468	845	938	620
Chironomidae	*Ablabesmyia* sp.	10	29	24	30	26
Chironomidae	*Procladius* sp.	10	32	26	34	28
Chironomidae	*Pentenura* sp.	39	83	211	246	108
	Parapholex sp.	10	32	70	77	51
	Promenitus sp	14	50	71	137	86
Corixdae	*Sigara* sp.	33	77	68	87	68
Coenagrionidae	*Enallagma* sp	25	63	67	70	54
Psychodidae	*Psychoda* sp.	17	57	43	64	46
Ceratopogonidae	*Bezzia* sp.	10	45	42	48	38
Tabanidae	*Tabunus* sp	24	3	34	14	6
Gammaridae	*Gammarus* sp.	15	66	54	73	56
Dytiscidae	*Coptotomus* sp	9	61	45	69	52
Arguloda						
	Branchiura sp.	236	348	841	808	551

Table 2: Statistical analysis of benthic fauna found in different seasons of Dal Lake, Srinagar during the year 2016.

Species	Sum	Minimum	Maximum	Mean	Variance	Standard deviation
Glossipnonia sp.	75	0	32	15	189.5	13.7659
Helobdella sp.	80	0	34	16	195.5	13.98213
Eppopdella	213.9	0	119.3	42.78	2301.352	47.97241
Erpopdella octoculata	142	11	39	28.4	133.8	11.56719
Tubifix tubifix	8144	1008	2050	1628.8	192668.7	438.9404
Nais sp.	1729	219	429	345.8	7883.7	88.7902
Limnodrilus hofmeisteria	10097	1511	2433	2019.4	149296.3	386.3888
Aelosoma sp.	1201	150	306	240.2	3667.2	60.55741
Lymnaea columella	952	121	232	190.4	1997.3	44.69116
Lymnaea stagnalis	322	24	108	64.4	1056.3	32.50077
Lymnaea auricularia	1094	178	262	218.8	1321.2	36.34831
Gyraulus sp	257	10	91	51.4	946.8	30.77012
Chironomus sp.	3153	282	938	630.6	72133.8	268.5774
Ablabesmyia sp.	119	10	30	23.8	65.2	8.074652
Procladius sp.	130	10	34	26	90	9.486833
Pentenura sp.	687	39	246	137.4	7679.3	87.63162
Parapholex sp.	240	10	77	48	758.5	27.54088
Promenitus sp	358	14	137	71.6	2067.3	45.46757
Sigara sp.	333	33	87	66.6	414.3	20.35436
Enallagma sp	279	25	70	55.8	332.7	18.24007
Psychoda sp.	227	17	64	45.4	323.3	17.98055
Bezzia sp.	183	10	48	36.6	234.8	15.32319
Tabunus sp	81	3	34	16.2	165.2	12.85302
Gammarus sp.	264	15	73	52.8	505.7	22.48777
Coptotomus sp	236	9	69	47.2	538.2	23.19914
Branchiura sp.	2784	236	841	556.8	72603.7	269.4507

Table 3: Showing total number of benthic fauna and ASPT score during different seasons in the year 2016 at sampling site (S1).

Order	Family	Species	Total Connt.	Species. Count.	BMWP Score.	ASPT Score.
Rhynchobdellida	Glassiphonidae	*Glossipnonia* sp.	0			
		Helobdella sp.	0			
Arhynchobdellida	Erpobdellidae	*Erpopdella* sp.	0			
		Erpopdella octoculata	0			
Heplotaxida	Tubificidae	*Tubifix tubifix*	979	1		
	Naididae	*Nais* sp.	0			
Heplotaxida		*Limnodrilu hofmeisteria*	1390	1		
Aphanoneura	Aelosomatidae	*Aelosoma* sp.	0			
Gastropoda	Lymnaeidae	*Lymnaea columella*	0			
Gastropoda		*lymnaea stagnalis*	0			
Gastropoda		*Lymnaea auricularia*	0			
Gastropoda	Planorbidae	*Gyraulus* sp	0			
Dipteria	Chironomidae	*Chironomus* sp.	119	2	4.1	0.49
Dipteria	Chironomidae	*Ablabesmyia* sp.	0			
Dipteria	Chironomidae	*Procladius* sp.	0			
Dipteria	Chironomidae	*Pentenura* sp.	45			
		Parapholex sp.	0			
		Promenitus sp	0			
Hemiptera	Corixdae	*Sigara* sp.	0			
Zygoptera	Coenagrionidae	*Enallagma* sp	0			
Dipteria	Psychodidae	*Psychoda* sp.	0			
Dipteria	Ceratopogonidae	. *Bezzia* sp.	0			
Dipteria	Tabanidae	*Tabunus* sp	0			
Amphipoda	Gammaridae	*Gammarus* sp.	0			
Coleoptera	Dytiscidae	*Coptotomus* sp	0			
Arguloida	Arguloda	*Branchiura* sp.	0			
				4	4.1	0.11

Table 4: Showing total number of benthic fauna and ASPT score at sampling site (S2).

Order	Family	Species	Total Count	Species. Count	BMWP Score	ASPT Score
Rhynchobdellida	Glassiphonidae	*Glossipnonia* sp.	0			
		Helobdella sp.	0			
Arhynchobdellida	Erpobdellidae	*Erpopdella* sp.	0			
		Erpopdella octoculata	0			
Heplotaxida	Tubificidae	*Tubifix tubifix*	1115	1		
	Naididae	*Nais* sp.	825	1		
Heplotaxida		*Limnodrilu hofmeisteria*	1217	1		
Aphanoneura	Aelosomatidae	*Aelosoma* sp.	132	1		
Gastropoda	Lymnaeidae	*Lymnaea columella*	0			
Gastropoda		*lymnaea stagnalis*	0			
Gastropoda		*Lymnaea auricularia*	0			
Gastropoda	Planorbidae	*Gyraulus* sp	0			
Dipteria	Chironomidae	*Chironomus* sp.	547	2	4.1	0.48
Dipteria	Chironomidae	*Ablabesmyia* sp.	0			
Dipteria	Chironomidae	*Procladius* sp.	0			
Dipteria	Chironomidae	*Pentenura* sp.	215			
		Parapholex sp.	0			
		Promenitus sp	0			
Hemiptera	Corixdae	*Sigara* sp.	0			
Zygoptera	Coenagrionidae	*Enallagma* sp	0			
Dipteria	Psychodidae	*Psychoda* sp.	0			
Dipteria	Ceratopogonidae	. *Bezzia* sp.	0			
Dipteria	Tabanidae	*Tabunus* sp	0			
Amphipoda	Gammaridae	*Gammarus* sp.	0			
Coleoptera	Dytiscidae	*Coptotomus* sp	0			
Arguloida	Arguloda	*Branchiura* sp.	278	1		
				7	4.1	1.71

Table 5: Showing total number of benthic fauna and ASPT score during different seasons in the year 2016 at sampling site (S3).

Order	Family	Species	Total Count	Species Count	BMWP Score	ASPT Score
Rhynchobdellida	Glassiphonidae	*Glossipnonia* sp.	0			
		Helobdella sp.	0			
Arhynchobdellida	Erpobdellidae	*Erpopdella sp.*	34	1	2.8	0.36
		Erpopdella octoculata	689			
Heplotaxida	Tubificidae	*Tubifix tubifix*	0	1		
	Naididae	*Nais* sp.	258			
Heplotaxida		*Limnodrilu hofmeisteria*	53	1		
Aphanoneura	Aelosomatidae	*Aelosoma* sp.	54	1		
Gastropoda	Lymnaeidae	*Lymnaea columella*	0	1	3.2	0.31
Gastropoda		*lymnaea stagnalis*	0			
Gastropoda		*Lymnaea auricularia*	0			
Gastropoda	Planorbidae	*Gyraulus* sp	163			
Dipteria	Chironomidae	*Chironomus* sp.	0	1	4.1	0.24
Dipteria	Chironomidae	*Ablabesmyia* sp.	0			
Dipteria	Chironomidae	*Procladius* sp.	0			
Dipteria	Chironomidae	*Pentenura* sp.	0			
		Parapholex sp.	0			
		Promenitus sp	0			
Hemiptera	Corixdae	*Sigara sp.*	0			
Zygoptera	Coenagrionidae	*Enallagma* sp	0			
Dipteria	Psychodidae	*Psychoda* sp.	0			
Dipteria	Ceratopogonidae	. *Bezzia* sp.	0			
Dipteria	Tabanidae	*Tabunus* sp	0			
Amphipoda	Gammaridae	*Gammarus* sp.	0			
Coleoptera	Dytiscidae	*Coptotomus* sp	0			
Arguloida	Arguloda	*Branchiura* sp.	353	1		
			353	6	10.1	0.69

Table 6: Showing total number of benthic fauna and ASPT score during different seasons in the year 2016 at sampling site (S4).

Order	Family	Species	Total Count	Species Count	BMWP Score	ASPT Score
Rhynchobdellida	Glassiphonidae	*Glossipnonia sp.*	0			
		Helobdella sp.	0			
Arhynchobdellida	Erpobdellidae	*Erpopdella sp.*	108	1	2.8	0.35
		Erpopdella octoculata	1111			
Heplotaxida	Tubificidae	*Tubifix tubifix*	0	1		
	Naididae	*Nais sp.*	986			
Heplotaxida		*Limnodrilu hofmeisteria*	216	1		
Aphanoneura	Aelosomatidae	*Aelosoma sp.*	173	1		
Gastropoda	Lymnaeidae	*Lymnaea columella*	98	3	3.2	0.94
Gastropoda		*lymnaea stagnalis*	43			
Gastropoda		*Lymnaea auricularia*	0			
Gastropoda	Planorbidae	*Gyraulus sp*	461			
Dipteria	Chironomidae	*Chironomus sp.*	0	1	4.1	0.24
Dipteria	Chironomidae	*Ablabesmyia sp.*	0			
Dipteria	Chironomidae	*Procladius sp.*	0			
Dipteria	Chironomidae	*Pentenura sp.*	0			
		Parapholex sp.	0			
		Promenitus sp	0			
Hemiptera	Corixdae	*Sigara sp.*	0			
Zygoptera	Coenagrionidae	*Enallagma sp*	0			
Dipteria	Psychodidae	*Psychoda sp.*	0			
Dipteria	Ceratopogonidae	*. Bezzia sp.*	0			
Dipteria	Tabanidae	*Tabunus sp*	0			
Amphipoda	Gammaridae	*Gammarus sp.*	0			
Coleoptera	Dytiscidae	*Coptotomus sp*	447			
Arguloida	Arguloda	*Branchiura sp.*		1		
				8	10.1	0.89

Table 7: Showing total number of benthic fauna and ASPT score during different seasons in the year 2016 at sampling site (S5).

Order	Family	Species	Total Count	Species count	BMWP Score	ASPT Score
Rhynchobdellida	Glassiphonidae	*Glossipnonia sp.*	0			
		Helobdella sp.	0			
Arhynchobdellida	Erpobdellidae	*Erpopdella sp.*	0			
		Erpopdella octoculata	0			
Heplotaxida	Tubificidae	*Tubifix tubifix*	940	1		
	Naididae	*Nais sp.*	0			
Heplotaxida		*Limnodrilu hofmeisteria*	1316	1		
Aphanoneura	Aelosomatidae	*Aelosoma sp.*	0			
Gastropoda	Lymnaeidae	*Lymnaea columella*	0			
Gastropoda		*lymnaea stagnalis*	0			
Gastropoda		*Lymnaea auricularia*	0			
Gastropoda	Planorbidae	*Gyraulus sp*	86	1	2.6	0.38
Dipteria	Chironomidae	*Chironomus sp.*	532	5	4.1	1.22
Dipteria	Chironomidae	*Ablabesmyia sp.*	51			
Dipteria	Chironomidae	*Procladius sp.*	56			
Dipteria	Chironomidae	*Pentenura sp.*	0			
		Parapholex sp.	59			
		Promenitus sp	108			
Hemiptera	Corixdae	*Sigara sp.*	0			
Zygoptera	Coenagrionidae	*Enallagma sp*	0			
Dipteria	Psychodidae	*Psychoda sp.*	0			
Dipteria	Ceratopogonidae	*. Bezzia sp.*	0			
Dipteria	Tabanidae	*Tabunus sp*	0			
Amphipoda	Gammaridae	*Gammarus sp.*	0			
Coleoptera	Dytiscidae	*Coptotomus sp*	0			
Arguloida	Arguloda	*Branchiura sp.*	0			
				8	6.7	1.19

Table 8: Showing total number of benthic fauna and ASPT score during different seasons in the year 2016 at sampling site (S6).

Order	Family	Species	Total Count	Species Count.	BMWP Score.	ASPT Score.
Rhynchobdellida	Glassiphonidae	*Glossipnonia* sp.	0			
		Helobdella sp.	0			
Arhynchobdellida	Erpobdellidae	*Erpopdella* sp.	0			
		Erpopdella octoculata	0			
Heplotaxida	Tubificidae	*Tubifix tubifix*	82	1		
	Naididae	*Nais* sp.	0			
Heplotaxida		*Limnodrilu hofmeisteria*	1225	1		
Aphanoneura	Aelosomatidae	*Aelosoma* sp.	132	1		
Gastropoda	Lymnaeidae	*Lymnaea columella*	0	2	3.2	0.62
Gastropoda		*lymnaea stagnalis*	37			
Gastropoda		*Lymnaea auricularia*	0			
Gastropoda	Planorbidae	*Gyraulus* sp	67	1	2.6	0.38
Dipteria	Chironomidae	*Chironomus* sp.	79	5	4.1	1.22
Dipteria	Chironomidae	*Ablabesmyia* sp.	62			
Dipteria	Chironomidae	*Procladius* sp.	67			
Dipteria	Chironomidae	*Pentenura* sp.	0			
		Parapholex sp.	84			
		Promenitus sp	95			
Hemiptera	Corixdae	*Sigara* sp.	0			
Zygoptera	Coenagrionidae	*Enallagma* sp	0			
Dipteria	Psychodidae	*Psychoda* sp.	0			
Dipteria	Ceratopogonidae	. *Bezzia* sp.	0			
Dipteria	Tabanidae	*Tabunus* sp	0			
Amphipoda	Gammaridae	*Gammarus* sp.	0			
Coleoptera	Dytiscidae	*Coptotomus* sp	0			
Arguloida	Arguloda	*Branchiura* sp.	36			
				11	9.9	1.1

Table 9: Showing total number of benthic fauna and ASPT score during different seasons in the year 2016 at sampling site (S7).

Order	Family	Species	Total Count	Species Count.	BMWP Score.	ASPT Score.
Rhynchobdellida	Glassiphonidae	*Glossipnonia sp.*	0			
		Helobdella sp.	0			
Arhynchobdellida	Erpobdellidae	*Erpopdella sp.*	0			
		Erpopdella octoculata	0			
Heplotaxida	Tubificidae	*Tubifix tubifix*	1124	2		
	Naididae	*Nais sp.*	904			
Heplotaxida		*Limnodrilu hofmeisteria*	1168	1		
Aphanoneura	Aelosomatidae	*Aelosoma sp.*	0			
Gastropoda	Lymnaeidae	*Lymnaea columella*	0			
Gastropoda		*lymnaea stagnalis*	0			
Gastropoda		*Lymnaea auricularia*	0			
Gastropoda	Planorbidae	*Gyraulus sp*	56	1	2.6	0.38
Dipteria	Chironomidae	*Chironomus sp.*	141	4	4.1	0.97
Dipteria	Chironomidae	*Ablabesmyia sp.*	6			
Dipteria	Chironomidae	*Procladius sp.*	7			
Dipteria	Chironomidae	*Pentenura sp.*	218			
		Parapholex sp.	53			
		Promenitus sp	80			
Hemiptera	Corixdae	*Sigara sp.*	48	1	3.5	0.28
Zygoptera	Coenagrionidae	*Enallagma sp*	62	1		
Dipteria	Psychodidae	*Psychoda sp.*	54	1		
Dipteria	Ceratopogonidae	. *Bezzia sp.*	11	1		
Dipteria	Tabanidae	*Tabunus sp*	10	1		
Amphipoda	Gammaridae	*Gammarus sp.*	94	1	4.3	0.23
Coleoptera	Dytiscidae	*Coptotomus sp*	57	1	4.3	0.23
Arguloida	Arguloda	*Branchiura sp.*	279	1		
				16	18.8	0.85

Table 10: Showing total number of benthic fauna and ASPT score during different seasons in the year 2016 at sampling site (S8).

Order	Family	Species	Total Count	Species Count.	BMWP Score.	ASPT Score.
Rhynchobdellida	Glassiphonidae	*Glossipnonia sp.*	0			
		Helobdella sp.	0			
Arhynchobdellida	Erpobdellidae	*Erpopdella sp.*	0			
		Erpopdella octoculata	0			
Heplotaxida	Tubificidae	*Tubifix tubifix*	617	1		
	Naididae	*Nais sp.*	0			
Heplotaxida		*Limnodrilu hofmeisteria*	856	1		
Aphanoneura	Aelosomatidae	*Aelosoma sp.*	0			
Gastropoda	Lymnaeidae	*Lymnaea columella*	0			
Gastropoda		*lymnaea stagnalis*	0			
Gastropoda		*Lymnaea auricularia*	0			
Gastropoda	Planorbidae	*Gyraulus sp*	48	1	2.6	0.38
Dipteria	Chironomidae	*Chironomus sp.*	194	4	4.1	0.97
Dipteria	Chironomidae	*Ablabesmyia sp.*	0			
Dipteria	Chironomidae	*Procladius sp.*	0			
Dipteria	Chironomidae	*Pentenura sp.*	209			
		Parapholex sp.	44			
		Promenitus sp	75			
Hemiptera	Corixdae	*Sigara sp.*	56	1	3.5	0.28
Zygoptera	Coenagrionidae	*Enallagma sp*	73	1		
Dipteria	Psychodidae	*Psychoda sp.*	44	1		
Dipteria	Ceratopogonidae	*. Bezzia sp.*	45	1		
Dipteria	Tabanidae	*Tabunus sp*	40	1		
Amphipoda	Gammaridae	*Gammarus sp.*	91	1	4.3	0.23
Coleoptera	Dytiscidae	*Coptotomus sp*	104	1	4.3	0.23
Arguloida	Arguloda	*Branchiura sp.*	402	1		
				15	18.8	0.81

Table 11: Showing result of benthic fauna and ASPT score during different seasons at sampling site (S9).

Order	Family	Species	Total Count	Species count.	BMWP score.	ASPT Sscore.
Rhynchobdellida	Glassiphonidae	*Glossipnonia sp.*	30	2	3.3	0.6
		Helobdella sp.	26			
Arhynchobdellida	Erpobdellidae	*Erpopdella sp.*	23	1	2.8	0.36
		Erpopdella octoculata	0			
Heplotaxida	Tubificidae	*Tubifix tubifix*	758	1		
	Naididae	*Nais sp.*	0			
Heplotaxida		*Limnodrilu hofmeisteria*	496	1		
Aphanoneura	Aelosomatidae	*Aelosoma sp.*	0			
Gastropoda	Lymnaeidae	*Lymnaea columella*	91	2	3.2	0.62
Gastropoda		*lymnaea stagnalis*	0			
Gastropoda		*Lymnaea auricularia*	219			
Gastropoda	Planorbidae	*Gyraulus sp*	0			
Dipteria	Chironomidae	*Chironomus sp.*	113	1	4.1	0.24
Dipteria	Chironomidae	*Ablabesmyia sp.*	0			
Dipteria	Chironomidae	*Procladius sp.*	0			
Dipteria	Chironomidae	*Pentenura sp.*	0			
		Parapholex sp.	0			
		Promenitus sp	0			
Hemiptera	Corixdae	*Sigara sp.*	82	1	3.5	0.28
Zygoptera	Coenagrionidae	*Enallagma sp*	53	1		
Dipteria	Psychodidae	*Psychoda sp.*	75	1		
Dipteria	Ceratopogonidae	*. Bezzia sp.*	73	1		
Dipteria	Tabanidae	*Tabunus sp*	17	1		
Amphipoda	Gammaridae	*Gammarus sp.*	43	1	4.3	0.23
Coleoptera	Dytiscidae	*Coptotomus sp*	31	1	4.3	0.23
Arguloida	Arguloda	*Branchiura sp.*	260	1		
				16	25.5	0.62

Table 12: Showing total number of benthic fauna and ASPT score during different seasons in the year 2016 at sampling site (S10).

Order	Family	Species	Total Count	Species Count.	BMWP Score.	ASPT Score.
Rhynchobdellida	Glassiphonidae	*Glossipnonia sp.*	45	2	3.3	0.66
		Helobdella sp.	54			
Arhynchobdellida	Erpobdellidae	*Erpopdella sp.*	35	1	2.8	0.36
		Erpopdella octoculata	0			
Heplotaxida	Tubificidae	*Tubifix tubifix*	729	1		
	Naididae	*Nais sp.*	0			
Heplotaxida		*Limnodrilu hofmeisteria*	1072	1		
Aphanoneura	Aelosomatidae	*Aelosoma sp.*	668	1		
Gastropoda	Lymnaeidae	*Lymnaea columella*	634	3	3.2	0.94
Gastropoda		*lymnaea stagnalis*	187			
Gastropoda		*Lymnaea auricularia*	832			
Gastropoda	Planorbidae	*Gyraulus sp*	0		2.6	
Dipteria	Chironomidae	*Chironomus sp.*	804	1	4.1	0.24
Dipteria	Chironomidae	*Ablabesmyia sp.*	0			
Dipteria	Chironomidae	*Procladius sp.*	0			
Dipteria	Chironomidae	*Pentenura sp.*	0			
		Parapholex sp.	0			
		Promenitus sp	0			
Hemiptera	Corixdae	*Sigara sp.*	147	1	3.5	0.28
Zygoptera	Coenagrionidae	*Enallagma sp*	91	1		
Dipteria	Psychodidae	*Psychoda sp.*	54	1		
Dipteria	Ceratopogonidae	*. Bezzia sp.*	54	1		
Dipteria	Tabanidae	*Tabunus sp*	14	1		
Amphipoda	Gammaridae	*Gammarus sp.*	36	1	4.3	0.23
Coleoptera	Dytiscidae	*Coptotomus sp*	44	1	4.3	0.23
Arguloida	Arguloda	*Branchiura sp.*	824	1		
				18	28.1	0.64

Table 13: Showing comparison table of Wright *et al.*, (1993) [12] for the assessment of water quality.

Wright *et al.*, (1993) [12] table			
Site	**ASPT Value**	**Biological Class**	**Remark**
A	≥ 0.89	A	Very good
B	0.77-0.88	B	Good
C	0.66-0.76	C	Fair
D	< 0.66	D	Bad

Table 14: Showing result of biological assessment of Dal Lake Srinagar in accordance to Wright *et al.* (1993) [12] for the assessment and enumeration of water quality in 10 sampling sites.

SITES	Total number of species counted	BMWP Score.	ASPT Score.	Water quality	Remark
S1	4	4.1	0.97	A	Very good
S2	7	4.1	1.71	A	Very good
S3	7	10.1	0.69	C	Fair
S4	8	10.1	0.89	A	Very good
S5	8	6.7	1.19	A	Very good
S6	11	9.9	1.1	A	Very good
S7	16	18.8	0.85	B	Good
S8	15	18.8	0.81	B	Good
S9	16	25.5	0.62	D	Bad
S10	18	28.1	0.64	D	Bad

Conclusion

On the basis of biological Monitoring Working Party Score (BMWP) and Average Score per Taxon (ASPT) criteria, the Dal Lake sites including (S1, S2, S4, S5, and S6) are categorized under water quality (A) with very good remarks hence, are conducive and flourishing for aquatic life. Category "A" also applies for high amenity value and therefore, it can be used for drinking, washing and industrial processing. This category of water quality is also suitable for fish farming except few species which require certain desirable parameters of selected criteria.

On the other hand sampling sites S9 and S10 symbolical representation for Dal gate shows highest number of species but most of them belong to tolerant taxa and hence reflect low Average per Taxon Value (ASPT) and hence classified under "D" class sampling site. This site is under stress due to heavy inflow of sewage drains, tourists and local population and mushroom growth of hotels. It needs extensive recycling and treatment to make it ready for dirking, washing and industrial processing, although these sites are not fertile for fish farming which are mostly intolerant to pollution.

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