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RESEARCH ARTICLE

DIVERSITY, DISTRIBUTION AND ABUNDANCE OF MACROINVERTEBRATES IN ANCHAR LAKE, SRINAGAR, KASHMIR, J & K, INDIA

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ABSTRACT

A comprehensive macroinvertebrate study was conducted on Anchar lake situated in Kashmir valley 12 kms to the northwest of the state summer capital Srinagar with main objective to trace out the rich wealth of macroinvertebrate fauna harboring the lake.Sampling was done on monthly basis for a period of one year from March 2016 to Feberuarary 2017.Benthic and suface invertebrates macroinvertebrates were collected by Ekman,s dredge and D-Frame net respectively. During the investigation a total of 31macroinvertebrate species were recorded which belong to 5 classes, 15 orders and 22 families of which 14 families belonging to Arthropoda, 4 to Annelids and 4 to Mollusca.During the survey the total population density of macroinvertebrate fauna was found to be 44516 ind/m2.Molluscs were found to be most prevalent (23145 ind/m2) with the most dominant one being Lymnaea stagnalis species (4976 ind/m2) followed by Arthropods (13958 ind/m2) and Annelids (7413 ind/m2) with most dominant ones being Chironomous species (5385 ind/m2) among Arthropoda and Lymnodrillus hoffmeisteri (3504 ind/m2) among Annelida. The population desity of macroinvertebrate fauna was found to be greatly influenced by certain factors like macrophytes, depth, and nature of bottom sediment.

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INTRODUCTION

Macroinvertebrates encompass the group of large sized invertebrates whose body size exceeds 500um at some stage of their life cycle or become visible to the naked eye (Bhattacharjee, 2007). Benthic macroinvertebrates have been considered as the most familiar targets for carrying out biological monitoring of waterbody because they represent the most diverse group of organisms that react to anthropogenic influence on aquatic ecosystem strongly and often predictably (Rosenberg and Resh,1993).Macroinvertebrates and water quality are interrelated to each other, as macroinvertebrates act as potential indicators of water quality (Sharma and Rawat, 2009). Macrozoobenthic fauna constitute an ecogically important community in aquatic ecosystems and are of immense ecological value.

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Reports have indicated that the composition and diversity of macrozoobenthic community is closely linked to aquatic habitat conditions, with many species serving as biological indicators of pollution (Malik and Ali, 2012). Data on macrobenthic community, their distribution and structure has been used in ecological monitoring programmes and is an important ecological tool to describe spatial and temporal changes (Vyas and Bhat, 2010) Study of the macrozoobenthos 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 (Lonkar and Kedar, 2014). They also play an active role in cycling of organic materials (Mir *et al.,* 2016). Macro invertebrates are specified as the important areas for maintaining the biodiversity (Mayer *et al.,* 2007, Richardson and Danehy, 2007). Every component of an aquatic ecosystem gets disturbed as a result of increasing eutrophication due undesirable anthropogenic activities. Studying any of these components can help us to evaluate and estimate the impact of pollution, thereby enabling us to formulate various management strategies to overcome this problem. Keeping this goal in mind and role of macroinvertebrates in achieving this goal, the present study was undertaken on Anchar Lake to

study the population dynamics of macroinvertebrate fauna harboring the lake.

MATERIALS AND METHODS

Study Area

The Anchar lake is situated 12 km to the North West of Srinagar city in Kashmir valley at an altitude of 1584m A.S.L within the geographical coordinates of 34°20′ - 34°26′ North latitude and 74°82′- 74°85′ East longitude. The lake is fluviatile in origin and is mono basined with its main catchment comprising Srinagar city and a number of bordering villages. The Anchar lake has shrinked to a large extent in the recent past. As per the report of Lawrence (1895), the area of the Anchar lake during 1893-1894 was 19.54 km^2 and since then there has been a considerable decrease in the surface area of the lake. The area of the lake was 6.5 km^2 in the year 2004.At present the area of Anchar lake is about 5.8 km^2. The lake is connected with Khushalsar Lake from is southern end which in turn is connected with the famous Dal Lake through small inflow channel known as Nalla Amir Khan. River Sind enters the lake on its northern side and forms a network of distributaries serving as a main source of water for Anchar lake. The lake is also fed by a number of springs present in the basin itself and along its periphery. Towards the south east of this water basin is situated the complex of SKIMS (Sheri Kashmir Institute of medical Science), discharging its toxic wastes into the lake. The lake also receives the agriculture runoff and domestic sewage from the surrounding crop fields and residential areas which enhance the nutrient levels of the lake. As a result of heavey anthropogenic pressure and negligence on behalf of local people and government authorities, the quality of the lake is detoriating continuously and is posing threat not only to the biodiversity of lake but also to people who directly or indirectly depend on the lake (Jeelani and Kaur, 2012 and Bhat *et al.,* 2013).

Description of Sites

SITE 1 (A1): This site is located on the northern side of lake where river sind enter into the lake via network of channels and brings lot of sediment along with it, thus the depth of the lake at this site is decreasing continuously. This site is charactarised by sparsely distributed macrophytes, silty and sandy bottom sediment

SITE 2 (A2): This site is situated in the centre of lake with jinab sahib shrine from its eastern side and sangam outlet from its western side.This site is charactarised by standing water colonized by thick strands of macrophytes and muddy bottom sediment.

SITE 3 (A3): This site lies at the exit of the lake on western side near the dam locally known as Kedar sahib dam.At this site water exits from the lake through sangam into river Jhelum. This site is charactarised by dense growth of macrophytes and muddy bottom sediment mixed with muck.

Collection, Preservation & Identification of Macro invertebrates

Sampling was done on monthly basis for a total period of one year from March 2016 to Feberuarary 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 (Hoffsten and Malmqvist, 2000) and also by lowering the net in the macrophytic vegetation and lifted carefully with entire mass of macrophytes (Kaul *et al.,* 1980). Certain organisims were also collected by hand picking method. For the collection of macrozoobenthos, 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 preserved in 4% formalin and 70% alcohol in plastic bottles 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 (Borror *et al.,* 1976).For qualitative analysis preserved samples were identified to the lowest possible taxonomic level according to standard taxonomic works of Edmondson (1959), Pennak (1978), Adoni (1985) and Tonapi (1980).However for quantitative analysis animals were counted individually species wise in whole sample and sub samples. The density of the benthic and surface macroinvertebrate fauna was calculated/m^2 of bottom and surface area by using the formula:

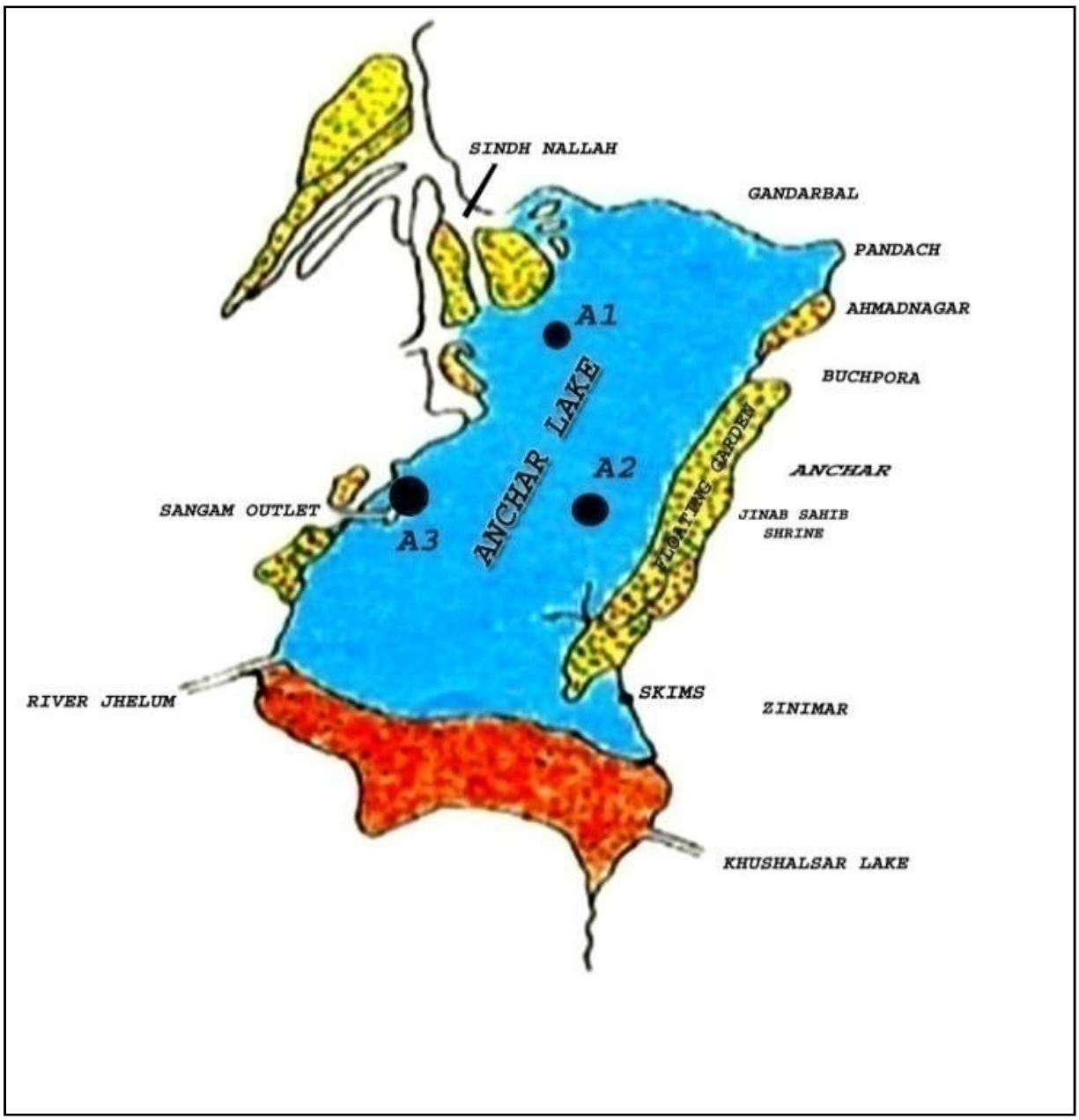
N= O/A.S x 10,000 (Welch, 1948)

Where,

N = no. of macrobenthic organisms/m^2.
O = no. of organisms counted.
A = area of sampler (Ekman's dredge) in square meter for benthic macroinvertebrates and area of D-net in square meter for surface invertebrates.
S = no. of samples taken at each site.

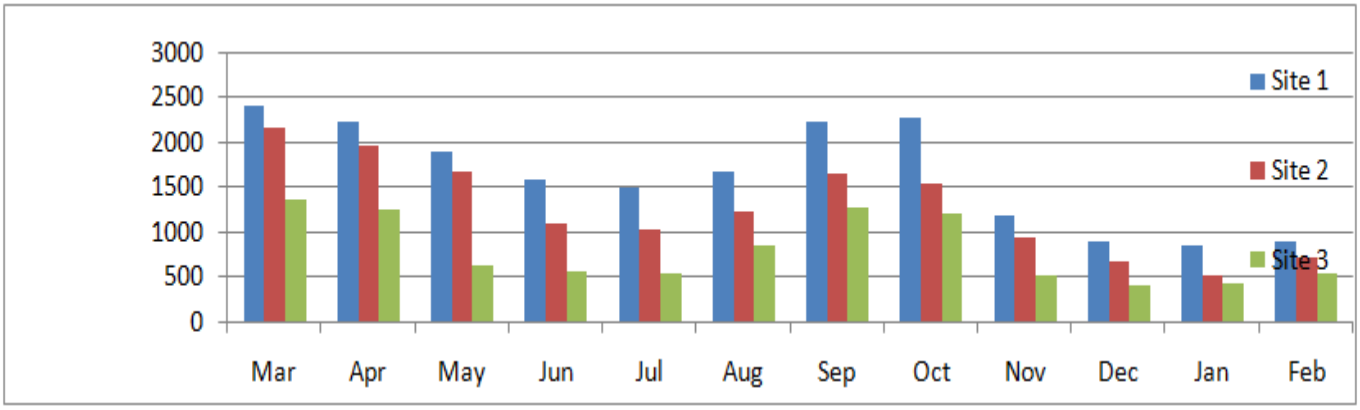
RESULTS

During the present study a total of 31 macroinvertebrate species belong to three major phyla viz Annelida, Arthropoda and Mollusca were recorded from three sites of Anchar lake.The total population density of macroinvertebrate fauna of the lake was found to be 44516 ind/m^2.The greater density of macroinvertebrate community was recorded mainly among molluscs (23145 ind/m^2) with *Lymnaea stagnalis* being most dominant species (4976 ind/m^2).The molluscs were followed in decreasing order by Arthropods (13958 ind/m^2) with *Chironomous* species being most dominant species (5385 ind/m^2).The population density of Annelids was least among the three phyla (7413 ind/m^2) with *Lymnodrillus hoffmeisteri* being most dominant (3504 ind/m^2).Within these three major phyla a total of 31 species belong to 5 classes,15 0rders and 22 families of which 14 families belonging to arthropoda, 4 to annelida and 4 to mollusca. Annelids were represented by 5 species all of which belong to class oligochaeta.Arthropods were represented by 17 species of which 16 species belong to class insecta and 1 species belong to class maxillopoda (malacostraca or crustacea).Mollusca were represented by 9 species of which 7 species belong to class gastropoda and 2 species belong to class bivalvia. The macroinvertebrate fauna revealed from the three sites varied with respect to the type of macrophytic vegetation and the impact of anthropogenic pressure. The site first (A1) is situated at the point,where River sind enter the lake.



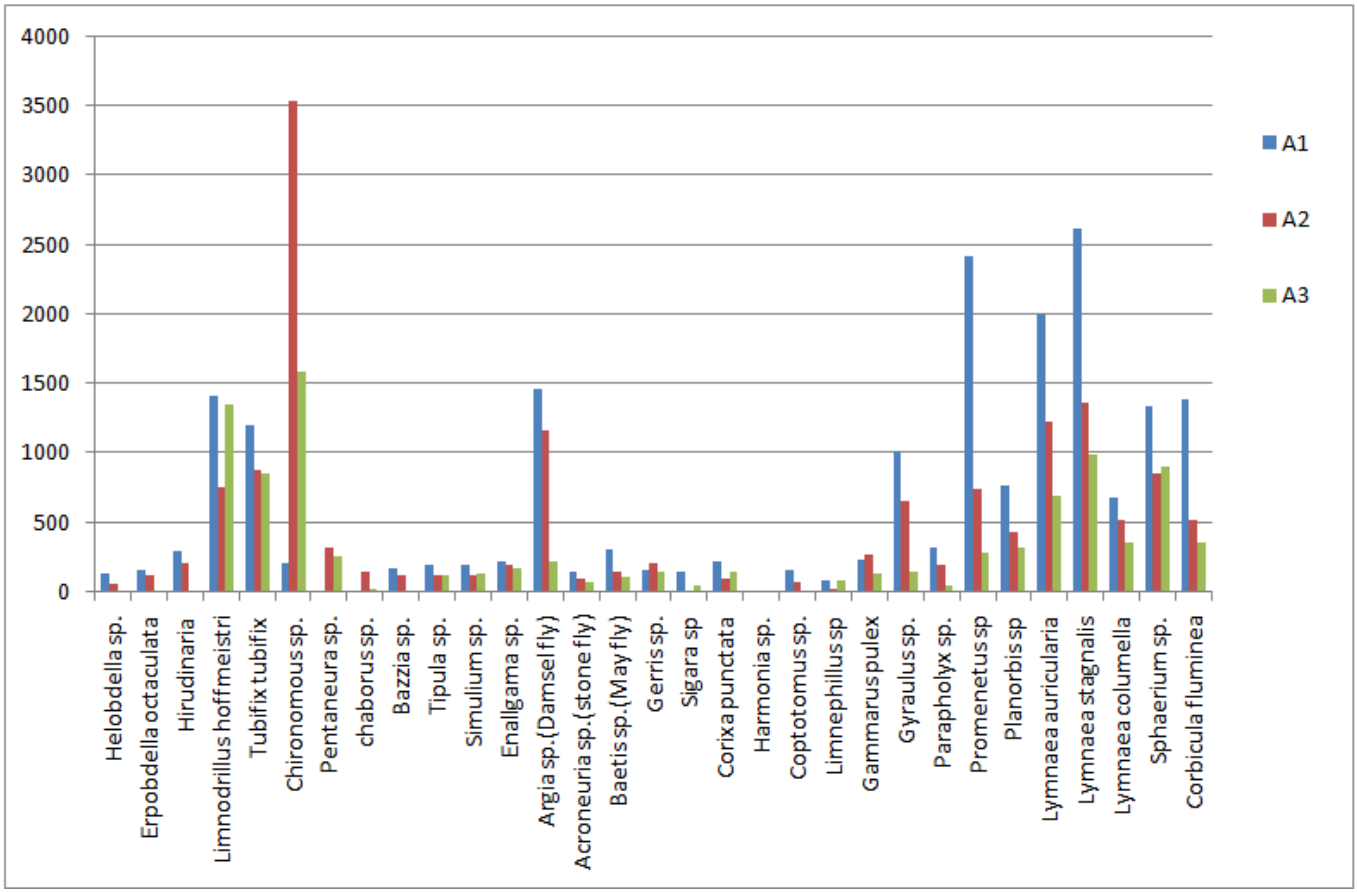
Variation in population density (ind/m^2) of macroinvertebrates during different months of the study period

Site	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mean
A1	2410	2235	1893	1600	1511	1673	2235	2294	1186	902	844	903	1641
A2	2172	1970	1684	1096	1037	1229	1660	1540	947	666	508	726	1270
A3	1364	1245	636	562	548	859	1276	1213	518	399	428	547	800



Speices composition of macroinvertebrates in Anchar lake at three different sites

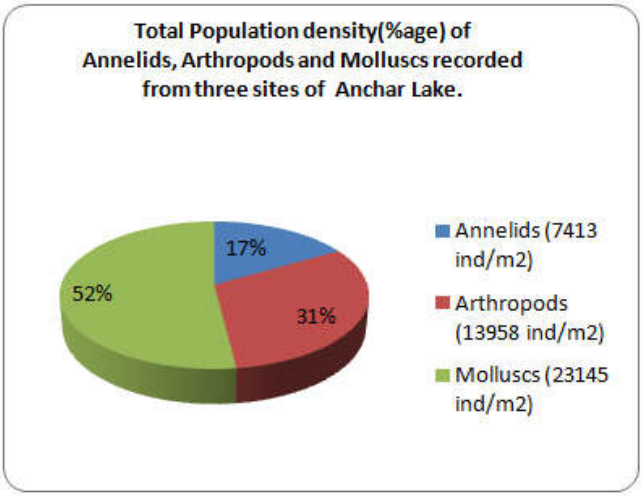
S. No	Species	Site1 (A1)	Site2 (A2)	Site3 (A3)
1	*Helobdella sp.*	+	+	-
2	*Erpobdella octaculata*	+	+	-
3	*Hirudinaria*	+	+	-
4	*Limnodrillus hoffmeistri*	+	+	+
5	*Tubifix ubifix*	+	+	+
6	*Chironomous sp.*	+	+	+
7	*Pentaneura sp.*	-	+	+
8	*chaborus sp.*	-	+	+
9	*Bazzia sp.*	+	+	-
10	*Tipula sp.*	+	+	+
11	*Simulium sp.*	+	+	+
12	*Enallgama sp.*	+	+	+
13	*Argia sp.(Damsel fly)*	+	+	+
14	*Acroneuria sp.(stonefly)*	+	+	+
15	*Baetis sp.(May fly)*	+	+	+
16	*Gerris sp.*	+	+	+
17	*Sigara sp.*	+	-	+
18	*Corixa punctata*	+	+	+
19	*Harmonia sp.*	-	+	-
20	*Coptotomus sp.*	+	+	+
21	*Limnephillus sp*	+	+	+
22	*Gammarus pulex*	+	+	+
23	*Gyraulus sp.*	+	+	+
24	*Parapholyx sp.*	+	+	+
25	*Promenetus sp.*	+	+	+
26	*Planorbissp*	+	+	+
27	*Lymnaea auricularia*	+	+	+
28	*Lymnaea stagnalis*	+	+	+
29	*Lymnaea columella*	+	+	+
30	*Sphaerium sp.*	+	+	+
31	*Corbiculafluminea*	+	+	+

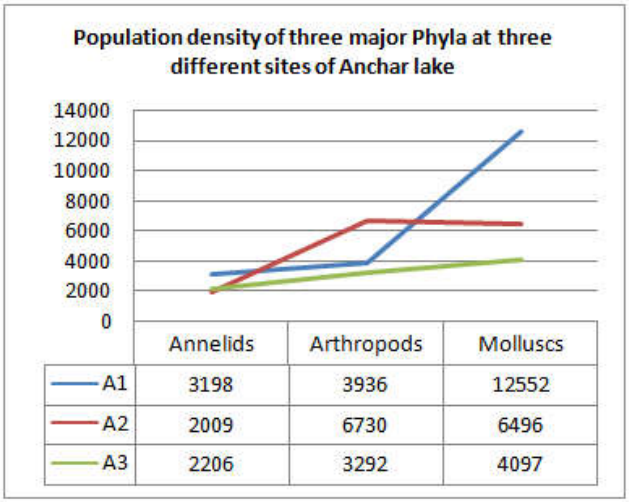


Due to sediment brought by River sind, this site is losing its depth and is getting shallowed continuously. Due to the shallow nature and rich macrophytic growth, this site provides the suitable habitat to certain macroinvertebrate species.The total population density of macroinvertebrates at this site of lake was found to be 19686 ind/m^2 with molluscs being most dominant group (12552 ind/m^2) followed by Arthropods (3936 ind/m^2) and Annelids (3198 ind/m^2). This site reflected the presence of a total of 28 species throughout the survey.Among Annelids, this site reflected the presence of a total 5 species, viz *Hellobdella, Erpobdella octaculata, Hirudinaria, Limnodrillus hoffmeisteri* and *Tubifix tubifix* with *Limnodrillus hoffmeisteri* being most dominant (1406 ind/m^2) followed by *Tubifix tubifix* (1199 ind/m^2).Among Arthropods,

Population density of macroinvertebrates (ind/m^2) in Anchar Lake at three different sites

Macroinvertebrates	Site 1	Site 2	Site 3	No.of ind/m^2
Annelida				
0ligochaeta				
Helobdella sp.	134	60	0	194
Erpobdella octaculata	163	119	0	282
Hirudinaria	296	207	0	503
Limnodrillus hoffmeistri	1406	750	1348	3504
Tubifix tubifix	1199	873	858	2930
Total no.0f ind/m^2(Annelida)	3198	2009	2206	7413
Arthropoda				
Insecta				
Chironomous sp.	207	3592	1586	5385
Pentaneura sp.	0	324	265	589
chaborus sp.	0	148	30	178
Bazzia sp.	177	119	0	296
Tipula sp.	192	118	119	429
Simulium sp.	194	120	134	448
Enallgama sp.	222	192	178	592
Argia sp.(Damsel fly)	1466	1169	221	2856
Acroneuria sp.(stone fly)	147	104	75	326
Baetis sp.(May fly)	309	148	105	562
Gerris sp.	163	207	148	518
Sigara sp.	149	0	45	194
Corixa punctata	223	104	149	476
Harmonia sp.	0	15	0	15
Coptotomus sp.	163	74	15	252
Limnephillus sp.	88	30	88	206
Maxillopoda				
Gammarus pulex	236	266	134	636
Total no.ofind/m^2(Arthropoda)	3936	6730	3292	13958
M0llusca				
Gastropoda				
Gyraulus sp.	1021	650	149	1820
Parapholyx sp.	324	192	44	560
Promenetus sp.	2415	738	281	3434
Planorbissp	768	428	325	1521
Lymnaea auricularia	2000	1230	694	3924
Lymnaea stagnalis	2618	1365	993	4976
Lymnaea columella	679	518	354	1551
Bivalvia/Pelcypoda				
Sphaerium sp.	1334	858	903	3095
Corbicula fluminea	1393	517	354	2264
Total no. of Ind./m^2 (m0llusca)	12552	6496	4097	23145
Total no. of ind/m^2 (Annelida+Arthropoda+Mollusca)	19686	15235	9595	44516
Total no. of Species	28	30	26	





this site reveals the presence of a total of 14 species viz *chironomous, Bezzia, Tipula, Simulium, Enallgama, Argia, Acroneuria Gerris, Baetis, Sigara, Corixa punctata, Coptotomus, Limnephillus and Gammarus pulex* with *Argia* species (damsel fly) being most dominant (1466 ind/m^2) followed by *Baetis* sp.(309 ind/m^2). Among Mollusca this site witnesses the presence of a total of 9 species viz *Gyraulus, Planorbis, Parapholyx, Promenetus, Lymnaea auricularia, Lymnaea stagnalis, Lymnaea columella, Sphaerium* and *Corbicula fluminea* with *Lymnaea stagnalis* species being most dominant (2618 ind/m^2) followed by *Promenetus* (2415 ind/m^2). The total population density of macroinvertrebrate fauna at this site fluctuated from 844 ind/m^2 in the month of januarary to 2410 ind/m^2 in the month of march with a mean

population density of 1641 ind/m^2. Site second (A2) receives most of the sewage from human settlement area locally known as Anchar and witnesses the luxurious growth of macrophytes and abundance of macroinvertebrates (15235 ind/m^2) with Arthropods being the most dominant group both in terms of taxa and abundance (6730 ind/m^2) followed by Molluscs (6496 ind/m^2) and Annelids (2009 ind/m^2) .This site reflected the presence of a total of 30 species throughout the survey.Among Annelids, this site reflects the presence of a total 5 species, viz *Hellobdella, Erpobdella octaculata, Hirudinaria, Limnidrillus hoffmeisteri* and *Tubifix tubifix* with *Tubifix tubifix* being most dominant (873 ind/m^2) followed by *Limnodrillus hoffmeisteri* (750 ind/m^2).*Chironomous, Pentaneura, Chaborus, Tipula, Simulium, Enallgama, Argia, Acroneuria, Baetis, Gerris, Corixa punctata, Coptotomus, Limnephillus, and Gammarus pulex* among Arthropoda with *Chironomous* species (insecta) being most dominant (3592 ind/m^2) followed by *Argia species* (1169 ind/m^2). *Gyraulus, Planorbis, Parapholyx, Promenetus, Lymnaea auricularia, Lymnaea stagnalis, Lymnaea columella, Sphaerium* and *Corbicula fluminea* among mollusca with *Lymnaea stagnalis* being most dominant group (1365 ind/m^2) followed by *Lymnaea auricularia* (1230 ind/m^2). The total population density of macroinvertrebrate fauna at this site fluctuated from 508 ind/m^2 in the month of January to 2172 ind/m^2 in the month of march with a mean population density of 1270 ind/m^2.Site third (A3) situated at the point where water from Anchar lake escapes through sangam area into River Jhelum revealed the macro invertebrate population density of 9595 ind/m^2 with molluscs being the most dominant group (4097 ind/m^2) followed by Arthropods (3292 ind/m^2) and Annelids (2206 ind/m^2).This site reflected the presence of a total of 26 species of macroinvertebrates of which *Limnodrillus hoffmeisteri* and *Tubifix tubifix* belong to Annelida with *Limnodrillus* being most dominant species (1348 ind/m^2) followed by *Tubifix tubifix* (858 ind/m^2), *Chironomous, Pentaneura, Chaborus, Tipula, Simulium, Enallgama, Argia, Acroneuria, Baetis, Gerris, Corixa punctata, Coptotomus, Limnephillus, and Gammarus pulex* among Arthropoda with *Chironomous* being most dominant species (1586 ind/m^2) followed by *Pentaneura* species (265 ind/m^2).*Gyraulus, Planorbis, Parapholyx, Promenetus, Lymnaea auricularia, Lymnaea stagnalis, Lymnaea columella, Sphaerium* and*Corbicula fluminea* among Mollusca with *Lymnaea stagnalis* being the most dominant group (993 ind/m^2) followed by *Sphaerium* species (903 ind/m^2).The total population density of macroinvertrebrate fauna at this site fluctuated from 399 ind/m^2 in the month of December to 1364 ind/m^2 in the month of march with a mean population density of 800 ind/ m^2.

DISCUSSION

During the present study certain physical charactaristics like depth, macrophytic growth and type of sediment of Anchar Lake at three studied sites were properly examined. Site 1 was found to have an average depth of about 2 feet, silty-sandy bottom and sparsely distributed macrophytic growth. Site 2 was found to have an average depth of about 3 feet, bottom enriched with heavey organic matter and dense macrophytic growth. Site 3 was found to have an average depth of about 2.5 feet, muddy bottom with muck and heavey macrophytic growth. Apart from chemical characteristics, these physical charactaristics were found have notable influence on diversity, distribution and density of macroinvertebrate fauna in lake ecosystem. Shallowness, macrophytes especially having large surface area and rich organic matter of habitat were found to have positive influence on diversity, distribution and abundance of certain macroinvertebrates of lake ecosystem. Simmilar observations were reported in findings of earlier studies of Bhat *et al* in 2012, Linn *et al* (2001) and Slepukhins (1984). During the present study it was found that all the three studied sites witnesses the rich diversity of macroinvertebrate fauna.The abundance of these macroinvertebrates can be regarded as direct indicators of water pollution in Anchar lake. During the present survey it was found that the macroinvertebrates belong to all the three phyla i.e annelida, arthropoda and mollusca inhabit almost all the three study sites, but their abundance varies with respect to nature of habitat reflected at three studied sites. During the present study the highest density of molluscs was found at site 1, which clearly confirms that macroinvertebrates belong to phylum mollusca prefer the habitat having sandy bottom and luxuriant macrophytic growth. Qadri and Yousuf in 2004 recorded similar type of results while studying ecology of macroinvertebrates in Dal Lake. Site 2 which witnesses the reception of heavey organic nutrient rich untreated sewage loading from residential area locally known as Anchar was found most detoriated site of the lake. During the present study it was found that certain species more specifically *Limnodrillus hoffmeisteri, Tubifix tubifix* (oligochaeta) and *chironomous* species (insecta) show highest density at this site, confirming the fact that these species prefer the type of bottom habitat rich in organic matter, thus indicating heavey organic pollution in lake especially at site 2.The results obtained are in agreement with the findings reported in earlier studies carried out by Wilham and Dorros (1968), Adholia *et al* (1990), Oliver(1971), Brinkhurst & Cook (1974), Saether (1979), Milbrink (1980), Bazzanti (1983), Bay *et al* (1966) and Kaushik *et al* (1991) while carrying out their ecological studies on different water bodies. Among the three studied sites, site 3 having muddy sediment mixed with muck was found to be least attractive for macroinvertebrates.However, certain species like *Limnodrillus hoffmeisteri, Tubifix tubifix* (oligochaeta) an *chironomous* species (Arthropoda) were found to flourish this site as well than rest of the macroinvertebrates. A comparison of the macroinvertebate species composition at different studied sites of ancahr lake reveals that the muck substratum represent the least favourable habitat for macroinvertebates to flourish well. The present study revealed that certain species viz *Limnodrillus hoffmeisteri, Tubifix tubifix* (oligochaeta) and *chironomous* species (Arthropoda) occupy and flourish well in any type of habitat in fresh water body, indicating the range of tolerance of these species to varied environmental conditions reflected at different habitats. Simmilar findings were obtained by Mir and Yousuf in 2005 while studying distribution pattern of macroinvertebrate fauna in Dal lake.

Conclusion

On the basis of present study it is concluded that Anchar lake harbours a rich diversity of macroinvertebrate fauna. The population density of macroinvertebrate fauna is greatly influenced by certain contolling factors like organic sewage flushed down into the lake from local residential areas,thick macrophytic growth due to heavy nutrient loading in the lake and continuous loss of depth of lake due the organic nutrient rich sediment brought by River sind into the lake. From the results and discussion, it is confirmed that Anchar lake is facing organic pollution. Hence proper management measures need to be taken by Government authorities and local inhabitants to prevent the lake from further detoriation.

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