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Macrozoobenthos Community Pattern And Diversity In Relation To Water Quality Status Of Stream Rambiara

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Abstract

Present study had been undertaken to work out the species composition and diversity of macrozoobenthos of Rambiara Stream in J&K and their relation to several physico-chemical parameters. The data collected on various physico-chemical parameters and benthic fauna showed slight site-specific fluctuations. The present study showed that the temperature, water velocity, turbidity, dissolved oxygen and nature and size of the bottom substrates do play a major role in determining the macro-invertebrate diversity of Rambiara Stream. The benthic fauna comprised of 17 genera belonging to 7 orders which mostly include *Ephemeroptera*, *Diptera*, *Coleoptera*, *Plecoptera*, *Malacostraca* and *Trichoptera*. Moreover, the macroinvertebrate fauna showed fairly good relation with the physico-chemical attributes.

Keywords: Diversity, Community structure, Macrozoobenhos, Physico-chemical parameters

Introduction

Species diversity and community pattern of macrozoobenthic invertebrates are important themes in aquatic ecology and are often used to evaluate environmental stress resulting from a variety of anthropogenic disturbances. These organisms have long been used as potential indicators of water quality in the rivers, streams, lakes, wetlands and other types of waterbodies. Most interestingly, freshwater macrozoobenthic species vary in sensitivity to organic pollution loads. In natural pristine conditions, high diversity and richness of species could be found (Armitage *et al.,* 1983).

Macrozoobenthos being diverse in nature, react strongly and often predictably to human influences in aquatic ecosystem. They act as a viable tool for biological monitoring of freshwater ecosystems as they have wide range of sensitivities to

change in both water quality and habitats (Hallewell, 1986; Abel, 1989). Macrozoobenthos form the basis of the trophic level and any negative effect caused by pollution in the community structure can in turn affect trophic relationships. Macrobenthic invertebrates convert low quality low energy detritus into high quality high energy food for larger consumers in complex food webs (Hynes, 1970; Jimoh *et al.*, 2011). Different species comprises distinct functional groups that provide ecological integrity. In some cases, these functional groups may be represented by only a few species, so that any loss of species diversity could be detrimental to continued ecosystem functioning. Thus, it is increasingly becoming important to protect macrozoobenthic communities owing to their immense importance in their natural habitats.

The present study conducted on "Rambiara stream" which is one of the principal left bank tributaries of the River Jhelum in Kashmir (northern India), is an attempt to assess the water quality of the stream with special reference to the diversity and community structure of macroinvertebrates.

Materials and Methods

Study Area: The present study was carried out on Rambiara stream of District Shopian, which is located in the south and south-west extremity of Kashmir valley within the coordinates of 33□ 20′ and 34□ 54′ North latitude and 73□ 35′ and 75□ 35′ East longitude. The Rambiara stream originates from the Bhagsar Lake at Rupri peak near Naba Pass and drains the high hills between Pir Panjal range and Rupri pass. Rambiara is a shallow stream with wide catchment area of 270Km^2. The catchment comprises of two sub catchments, six water-sheds and 41 micro-watersheds. It traverses about 68Km from its source before it meets Vaishav Stream at Naiyun and then moves across another 2Kms before it merges with river Jhelum at Sangam.

Rambiara begins as a small stream in the mountains and flows through rocks, woods, farms and urban areas; the substratum subsequently changes from cobles at the head waters to fine sand near its mouth at Sangam. On it way although the stream expresses virginity of ecological conditions in terms of physico-chemical parameters and biological characteristics, at the upstream sites due to least anthropogenic pressure yet it tolerates a great deal of pollutants from the catchments at the downstream locations. Agriculture runoff, domestic sewage etc are the main harmful pollutants that enters the stream in its downstream course till it confluences with the river Jhelum at Sangam. Generally speaking, in the former stage, the stream retains the virginity of ecological conditions and the later stage gesticulates towards the worsening ecological health of the stream.

STUDY SITES:

For facilitating the conduct of present investigation, three sampling stations/sites were raised, the details of which are produced below:

SAMPLING SITE I (S_1) HIRPORA:
Hirpora, located at about 20 Kms from Shopian town, in the mountainous Pir Panjal range, is surrounded by dense forests and agricultural orchards. Here stream Rambiara experiences heavy anthropogenic intervention. The rural population mainly depends on it for irrigation and other daily needs such as washing and bathing, irrigation and other domestic uses. Due to its fast and furious nature, so many breaches are formed which in turn makes it more pleasant, attractive and decorative.

SAMPLING SITE II (S_2) CHOWGAM:
This site located about 6kms south west of the main Shopian town is enveloped by dense forests on one side and famous historical Mughal road on the other. Here, the water mostly receives domestic sewage emanating from the residential quarters located in the nearby catchments. The level of water as well as flow is decreased to a much lesser level. Here the area is characterized by unsanitary and poor drainage system, due to which hardness of water increases.

SAMPLING SITE III (S_3) SHIRMAL:
This site located about 10kms from Shopian town is one of the polluted sites of stream Rambiara. Here the stream water receives the domestic waste from human settlement. The sediment texture observed is muddy and loamy type.

WATER ANALYSIS:
Water samples were collected on a monthly basis from each sampling site during the course of the present study (December, 2014 to May, 2015) for the determination of various physico-chemical parameters such temperature, pH, conductivity, total hardness, total chloride, calcium at district PHE LAB Shopian while following Golterman *et al.* (1978) and A.P.H.A. (1998)

MACROZOOBENTHOS SAMPLING
A D-net (Cuffney *et al.*, 1993) with 0.5 mm mesh is used for sampling macrozoobenthos. Using a D - frame net (500 micro meter mesh), macrozoobenthos were collected on monthly basis at productive spots in each station. To dislodge the macrozoobenthos, 2-feet by 2-feet of sampling area was thoroughly stirred up with feet for 3 minutes. All the dislodged organisms were carried by the water into the net. Then the net was removed from the stream with a forward scooping motion to prevent any of the organisms it contained to wash away; after which the contents of the net were poured into a white basin big tray with water. Any fish, amphibian or reptile caught was immediately returned to the stream. The macrozoobenthos were picked from white basin tray with the help of forceps and kept in separate sampling bottles.

Sorting of sample
Sorting was performed at the site immediately after sampling. Some or the entire sample was emptied into a white tray, which was having about 2 cm of clean water.

The sample was allowed to settle and any movement in the water was observed. Any taxa that were seen were carefully collected using a spoon or a plastic pipette. The collected taxa were transferred into a white ice-block tray for a closer observation with a magnifying glass. The ice-block tray also was filled with clean water in the compartments. Similar macroinvertebrates were placed into the same compartments. The sorting process took greater than 20 minutes as some taxa were quite hard to find.

Preservation

The organisms were kept separately in different bottles after fixing them with 90% ethanol. The preservation was done right at the time of collection. If the invertebrates were not treated with chemicals they were found to undergo excessive and irregular contraction. Macrozoobenthic classes/orders/taxa were then identified and counted.

Identification of Macroinvertebrates

Identification of the organisms was done with the help of standard works of Edmondson (1959) and Adoni (1985) and protocols adopted from the USEPA (1997).

Results

The results obtained during the present study have been deliberated in detail under following headings:

Physico-chemical Parameters:

Of all the abiotic parameters affecting the water quality, temperature is an important regulatory factor which influences mixing and stratification patterns. During the present study, all the parameters have been found to follow more or less similar trend (Tables 1). The air and water temperature recorded higher values in summer (16^0C for air and 15^0C for water) and lower values in winter (3^0C for air and 0^0C for water). Likewise pH, total alkalinity, total hardness, calcium, chloride and TDS recorded maxima in summer (9.2, 355mg/l, 280mg/l, 60mg/l, 47mg/l, 297.3mg/l) and minima in winter (7.1, 200mg/l, 190mg/l, 14mg/l, 15mg/l, 140.1mg/l). In contrast dissolved oxygen and turbidity values varied from a maxima of 18.5NTU and 180NTU in winter to a minima of 5.9mg/l and 130nts in summer. But conductivity recorded higher values in spring (230µS/cm) and lower values in winter (120 µS/cm).

Macrozoobenthos:

During the present study, a total of 17 taxa of benthic organisms (Table 2) were recorded from all the three sampling sites viz., Arthopoda (Insecta - 15, Crustacea - 1 and unidentified - 1). Thus, benthos comprised of 16 species of insects and 1 Crustacea of phylum Arthropoda. Perusal of table 3 reveals that the species rich class Insecta is in itself an assemblage of different forms belonging to 6 different orders (Ephemeroptera - 4, Diptera - 6, Trichoptera - 2, Plecoptera - 1, Coleoptera - 2 and Malacostraca -1). The five most common species found at all the sites during the period of present study included *Chironomous sp., Baetis rhodani, Baetiella sp., Tipula sp.,* and *Diamesinae sp.* and the 8 rare ones (*Tabanus sp., Simulium sp., Hydropsygche sp., Dytiscus sp., Perlidaesp,. Gamarus sp., Lamprima sp.* and

unidentified Pupa) found only at one site. Certain forms like *Athrix sp., Ecdgnorus sp., Epeorus sp. and Limniphillus sp.* were recorded only from two sites. Amongst the 17 taxa, the greatest number was noted for site 1 (12 taxa), followed by site III (9 taxa) and then site II (7 taxa). In general, the highest numbers of taxonomic forms were encountered from sites having relatively higher flow velocity as at site I. The pattern of dominance of various benthic forms in terms of their abundance and density at various sites was as follows:

Distributional pattern of macrozoobenthos at Site 1 (Hirpora):
Diamesianae sp. > Athrix sp. > Chironomous sp. > Tipula sp. > Baetis sp. >Baetiella sp. > Limniphilus sp. > Ecdgnorus sp. > Epeorus sp. > Pupa (unidentified) > Lamprima sp. > Tabanus sp. > Simulium sp.

Distributional pattern of macrozoobenthos at Site II (Chowgam):
Diamesianae sp. > Limniphilus sp. > Tipula sp. > Baetiella sp. > Baetis sp. > Dytiscus sp. > Chironomous sp.> Hydropsgche sp.

Distributional pattern of Macrozoobenthos at Site- III (Shirmal):
Diamesianae sp. > Tipula sp. > Ecdgnous sp. > Epeorus sp. > Baetiella sp. > Baetis sp. > Gammarus sp >.Chironomous sp. > Athrix sp. > Perlidae sp.

Table 1 : Monthly Variation of Various Physio-chemical Parameters of Stream Rambiara in Winter Season at various Sites

Parameters	Hirpora						Chowgam						Shirmal					
	Dec.	Jan.	Feb.	Mar.	Apr.	May	Dec.	Jan.	Feb.	Mar.	Apr.	May	Dec.	Jan.	Feb.	Mar.	Apr.	May
Air Temperature (⍰C)	8.0	3.0	7.0	5.0	11^0C	15.0	9.0	3.5.0	7.0	9.0	11.0	15.5	10.0	3.5	7.0	9.0	13.0	16.0
Water Temperature (⍰C)	6.0	0.0	4.0	8.0	12.0	14.0	9.0	11.0	4.0	12.0	12.5	14.5	6.0	0.0	5.5	9.0	10.0	15.0
pH	7.1	7.5	8.0	9.2	8.0	8.4	7.3	7.7	8.0	8.5	8.2	8.0	7.5	7.7	7.8	7.9	7.7	7.7
Electrical Conductivity (µS/cm)	120	135	180	200	170	177	135	147	180	215	120	180	150	160	190	230	175	180
Total Alkalinity (mg/l)	200	220	270	300	320	350	205	225	275	250	330	355	200	220	250	220	235	280
Total Hardness (mg/l)	190	205	220	200	220	280	200	230	210	225	220	235	210	230	240	213	230	260
Calcium (mg/l)	35	39	39	40	45	60	18	25	29	36	43	50	14	27	32	34	38	47
Chloride (mg/l)	35	38	15	20	25	40	37	41.1	18	25	29	45	30	25	19	23	35	47
Turbidity (NTU)	130	150	170	165	160	155	132	147	164	152	150	147	135	145	180	178	170	160
TDS (mg/l)	140.1	147.7	152.3	155.9	169.6	177.4	170.1	186.2	230.1	247.1	277.9	283.3	175.0	210.4	220.2	265.5	290.0	297.3

TABLE 2: DISTRIBUTIONAL PATTERN OF BENTHIC FAUNA IN RAMBIARA STREAM AT THREE STUDY STATIONS

Species/Taxa	Hirpora						Chowgam						Shirmal					
	Dec.	Jan.	Feb.	Mar.	Apr.	May	Dec.	Jan.	Feb.	Mar.	Apr.	May	Dec.	Jan.	Feb.	Mar.	Apr.	May
Baetiella sp.	3	2	2	0	3	4	2	2	0	4	3	3	0	0	2	3	4	3
Baetis sp.	3	3	4	0	3	4	0	2	0	3	3	4	0	0	2	3	3	2
Ecdyourus sp.	1	1	2	2	3	3	0	0	0	0	0	0	1	1	3	3	2	2
Epeorus sp.	0	0	2	3	2	4	0	0	0	0	0	0	1	1	2	2	3	3
Tipula sp.	5	6	8	0	0	0	1	2	2	3	6	5	2	2	4	6	5	6
Chironomus sp.	0	0	4	3	3	4	0	0	0	3	3	2	0	0	0	0	3	4
Athrix sp.	2	2	3	4	4	5	0	0	0	0	0	0	0	1	0	1	2	1
Diamesinae sp.	3	5	6	4	4	5	6	9	20	30	5	4	4	5	5	9	7	6
Limnephilus sp.	0	1	2	4	3	3	3	4	5	3	2	3	0	0	0	0	0	0
Lamprima sp.	0	0	2	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Hydropsyche sp.	0	0	0	0	0	0	0	0	1	2	1	1	0	0	0	0	0	0
Dytiscus sp.	0	0	0	0	0	0	0	2	0	3	2	1	0	0	0	0	0	0
Perlodidae sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	1	1
Gammarus sp.	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	2	1	1
Tabanus sp.	0	0	0	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0

TABLE 3: MACROBENTHIC INVERTEBRATE DIVERSITY OF RAMBIARA STREAM

Group /Orders	Hirpora						Chowgam						Shirmal						TOTAL
	Dec	Jan	Feb	Mar	Apr	May	Dec	Jan	Feb	Mar	Apr	May	Dec	Jan	Feb	Mar	Apr	May	
Ephemeroptera	7	6	10	5	11	13	2	4	0	7	6	7	2	2	9	11	12	10	124
Diptera	10	13	21	10	13	16	7	11	22	36	14	11	6	8	9	16	17	17	257
Trichoptera	0	1	2	4	3	3	3	4	6	5	3	4	0	0	0	0	0	0	38
Coleoptera	0	0	2	1	0	1	0	2	0	3	2	0	0	0	0	0	0	0	11
Plecoptera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	1	1	5
Malacostraca	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	2	1	1	7
Pupa (Unidentified)	0	0	0	0	3	4	0	0	0	0	0	0	0	0	0	0	0	0	7

DISCUSSIONS

Rivers and streams are characterized by variation in the physico-chemical variables along different stretches of the river. Any change either through natural or anthropogenic sources influences water quality as well as the biotic interactions. Sites of the upper course of the river was characterized by fast flowing waters which decreases as we move downwards and is related to the gradient as the river slope decreases in downward direction and the concentration of dissolved oxygen was always high which may be due to high altitude, low temperature, high turbulence, low human interference and also attributed to the substrate composition of boulders, pebbles or cobble's which increases the turbulence of the water. Although the conductivity helps in assessing the tropic status of water body, but at sites of upper stretch higher values of conductivity and alkalinity was mainly due to the catchment rocks which with interaction of water for some time renders substances into it. In addition, the channel width also play an important role in changing the physico-chemical features as it is directly related with low velocity, decrease in dissolved

oxygen, increased depth and diminished substrate size. This assertion is in agreement with our findings as we move along different stretches of stream Rambiara, the middle and lower course which showed a decrease in dissolved oxygen and low velocity while as the depth increases and the substrate composition changes from pebbles to muddy and sandy. It is thought that the majority inputs of nutrients into an ecosystem comes from the domestic sewage, detergents, residual fertilizer rich in agricultural runoff and industrial wasteswhich in concurrence with our results as we move along the gradient towards lower course anthropogenic activities increases thereby increasing the values. All along the river mostly in the middle and down the course of the stream, the untreated sewage pours into the stream and also the garbage is dumped near the stream banks which ultimately deteriorate the aquatic ecosystem. Macrozoobenthos abundance varied from site to site with minimum at upper course and maximum at middle course of the river, but reverse was recorded with regard to diversity which could be attributed to the fact that the anthropogenic alterations decreases species diversity and increases dominance of pollution tolerant taxa due to the abundant organic matter. High diversity in natural pristine rivers at high altitude was related to the low stress while the low diversity at lower course signifies the environmental stress due to human activities. About 75% of all animals on earth are insects, and about 3% of all species of insects live in freshwater. Ephemeroptera was the most abundant insect order in the upper stream. Chironomids were abundant in the middle and lower sections of the stream. This clearly indicates that the Ephemeroptera groups thrive better in clear waters having least anthropogenic disturbances, while the abundance of Chironomids is directly related to the quantity of organic matter in the water. The variability in the biotic data at different sites might be due to the substrate type, velocity, depth and altitude. The decreasing trend of biota from upper course to down course which is clearly related with the fact that the diversity of the zoo benthic community decreased with increase in the pollution, while at the same time the population density of the tolerant species increased with increased environmental stress. This is also supported by the lowered dissolved oxygen concentration in the stream with increase in distance from the head waters. Chironomids were used as indicators of pollution as they were reported in waters rich in organic matter which favors pollution tolerant species.The present study is in complete conformity with the findings of past work of researchers. During the present study the *Diamesinae* were found in good numbers almost at all sites. These organisms are generally found attached to the sides, in cracks and under surfaces of a variety of substances such as rocks and logs. They are less abundant in the waters of great depth because of the lack of vegetation or attachment surface. In the middle & down course of the river, they were recorded only in the peripheral areas, when the water level was low. It may be concluded that the diversity and abundance of zoo benthos in the Stream Rambiara are influenced not only by pollution level; however, bottom substratum also affects its distribution. At the sites of upper course, altitude, geology and the substratum of the river plays an important role in the distribution of macro zoo benthos, though the organic pollution, impairment and increase in encroachment acted strongly on the abundance of macrozoobenthos at sites of middle and lower stretches.

CONCLUSIONS

- In all the three selected sites, water temperature was always found to be less than air temperature and followed the trend of air temperature. A positive significant correlation between air and water temperature was observed.
- High values of pH were recorded in all the selected sites throughout the course of study, which might be related to enhanced photosynthesis carried out by phytoplankton and macrophytes, wherein CO_2 is removed, and hence pH is raised.
- High values of dissolved oxygen content in December and January could be related to increased oxygen retention capacity of water and reduction in respiratory consumption of oxygen due to reduced metabolic rate, while lower values during April and May might be due to death and decomposition of organic matter, increasing water temperature leading to decrease in oxygen retention capacity of water and increase in the respiratory consumption of oxygen due to increased metabolic rate.
- High values of hardness recorded throughout the study period in all the three selected sites might be due anthropogenic activities in and around this water body in addition of incoming sewage.
- High values of calcium recorded in all the three selected sites could be attributed to heavy input of sewage from surrounding area and weathering of calcareous materials.
- Higher values of chloride during may in all selected sites might be due to the higher rate of evaporation and organic pollution of animal origin, whereas lower values during Feb. and Mar. could be related to reduction in siltation or allochthonous import of chloride along with rain water from catchment area.
- Higher values of TSS during April and May in all selected sites might be due to eroded soil particles, surface runoff, high rate of evaporation and sedimentation.
- Benthic fauna of this stream comprised of Ephemeroptera, Diptera, Coleoptera, Malacostraca,Trichoptera and unidentified group.
- Class insect formed the first most abundant group of benthic fauna and was represented by *Baetiella, Baetisrhodani, Ecdyourus, Epeorus, Tipula, Tabanus, Chironomus, Simulium, Athrix, Diamesinae, Limnephilus and Lamprima*.
- Trichopterans showed low frequency across selected sites. This clearly indicated that they are sensitive to pollution. It can be further concluded that these insects can live in polluted water which can be related to the availability of food and oxygen in this stream in addition to other factors.
- Benthic forms are an important component of food chains and energy flow pathways. Benthic community constitutes an important part of animal production and is tightly integrated into the structure and functioning of these habitats (e.g. organic matter processing, nutrient retention, food resources for vertebrates, such as amphibians, fish).
- Benthic organisms are often good indicators; insects mostly sensitive to water pollution are the Ephemeropterans (may flies), Plecopterans (stone fly) and

Trichopterans (caddisfly). The sparse distribution, low numerical abundance and low species diversity in present study is therefore, indicate that this stream have been severely disturbed.

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