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WATER QUALITY ASSESSMENT OF LAR STREAM, KASHMIR USING MACROINVERTEBRATES AS VARIABLE TOLERANTS TO DIVERSE LEVELS OF POLLUTION

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ABSTRACT

The present study conducted on “Lar stream” which is one of the principal left bank tributaries of the River Jhelum in the Valley of Kashmir (northern India), was an attempt to assess the water quality of the Canal by using macro invertebrates present in the ecosystem. During the present study, a total of 26 species of macro-invertebrates were registered from Lar stream which belonged to the orders Diptera, Trichoptera, Hirudinae, Ephemeroptera, Plecoptera, Gastropoda, Coleoptera, Arachnida, Lepidoptera, Crustacea and Oligochaeta. Among all the eleven orders, Dipterans registered a highest of 7 species (27%) and was the most dominant order. Then trend was followed by Trichoptera which registered a total of 5 species (19%) and was the second most dominating group. Similarly, Ephemeroptera, Oligochaeta, Hirudinae, Plecoptera and Gastropoda which registered 2 species (8%) each were the next dominating orders. The least representing taxa were Coleoptera, Arachnida, Lepidoptera and Crustacea which registered only 1 species (4%) each during the entire study period. The present study concludes that the presence of some pollution indicator species such as *Tubifex tubifex*, *Limnodrilus* sp., (among Annelida) *Chironomous* sp. and *Tabanus* sp., etc. (among Arhropoda) *Lymnea* sp., (among Mollusca) points to the shifting status of the stream from non-polluted to polluted.

Keywords: Kashmir; Lar stream, Left bank tributaries, Macro invertebrates, water quality, River Jhelum

INTRODUCTION

Macro invertebrate species diversity and community composition are important themes in aquatics 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, wet lands and other types of water bodies. Most interestingly, freshwater macro invertebrate 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). However, high impacts due to human activities cause many changes to the assemblages and biodiversity of the stream and river fauna (Hellawell, 1986; Metcalf, 1989). Macrobenthic invertebrates are an important and integral part of an aquatic ecosystem as they form the basis of the trophic level and any negative effects caused by pollution in the community structure can in turn affect trophic relationships. According to Carlisle *et al.* (2007), macro invertebrate populations in streams and rivers can assist in the assessment of the overall health of the stream. Human induced hydrological changes, physical disturbances (habitat alterations, land use) and point and non-point sources of pollution (chemical contamination surface run off, intensive agriculture) are the examples of processes responsible for a broad scale deterioration of lot ecosystems (Chatzinikolaou *et al.*, 2006). Macrobenthic invertebrates can thus be incorporated in the important technique of biological assessment. Biological assessment and criteria can accordingly be used as the basis for management programmes, restoring and maintaining the chemical, physical and biological integrity of fresh water.

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Live organisms offer valuable information regarding their surrounding conditions and can be used to evaluate the physical, chemical and biological impact and their cumulative effects (Karr and Chu, 1999). The abundance of benthic fauna greatly depends on physical and chemical properties of the substratum. Benthic macro invertebrates can be used as a barometer of overall biodiversity in aquatic ecosystems (Chatzinikolaou *et al.*, 2006). The macrobenthic invertebrates can also be utilized in biological monitoring or biomonitoring systems. Biological monitoring or biomonitoring is the systemic use of living organisms or their responses to determine the quality of the aquatic environment (Barbour and Paul, 2010).Much of the traditional research on water quality focuses on physicochemical characteristics, but recent research has taken more of an interdisciplinary approach by including the relationships between water quality and biodiversity (Gower *et al.,* 1994).

The present study conducted on "Lar stream" which is one of the principal left bank tributaries of the River Jhelum in the Valley of Kashmir (northern India), was an attempt to assess the water quality of the stream and justify the correlation between macroinvertebrates found in such a stream and the water quality present during the period of study. The major objective of this study was to assess the water quality of Lar stream, Kashmir, India.

The primary objectives of this study were:

1. To analyze the density and distribution of aquatic macro invertebrate community in Lar stream.
2. To assess the water quality using the variable diversity, distribution and density of macro invertebrates at different sites of the Canal**.**

STUDY AREA

The present study was carried on the small sub tributary of river Jhelum and main distributary of famous Rambiara stream namely Lar stream, in Kashmir Himalaya. The Lar stream, which is under study for the assessment of water quality status through the application of aquatic macro invertebrates originates from the famous Rambiara stream, which in turn finds the the origin in Rupri Peak, the Bhagsar Lake, in the Pir panchal range near Naba Passes. It is one of the major distributaries of the Rambiara stream. The stream emerges as a tributary from the main stream, Rambiara near a famous village, Boherhalan/Tolihalan (District Shopian).The gushing waters of Lar flow through the foot-hills of Pir Panchal and the stream runs parallel to the giant Rambiara in its maximum coarse. It begins as a small stream in the mountains and flows through woods, farms and urban areas; the substrate changes from cobles at the head waters to fine sand near the mouth of the river Jhelum.

In the journey of its flow 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. Agricultural runoff, domestic sewage etc. are the main harmful pollutants that enter the stream in its downstream coarse till it confluences with the River Jhelum at Banderpora, situated in District Pulwama. The stream also joins Romshi Nallah at Gulbugh (Pulwama) which too ultimately confluences with River Jhelum at Lelhar (Pulwama). The Lar stream completes its first half of the journey in District Shopian and the rest in District Pulwama before it confluences with the river. 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.

Macrobenthic invertebrates are cosmopolitan in nature and owing to their strong reaction to human influences predictably reflect the perturbations in a range of aquatic habitats. The present study focused on evaluating the ecological health of Lar stream Kashmir, in terms of its water quality utilizing the macro invertebrate communities as potential indicators of water quality during the study period January, 2012 to May, 2012.The selection of sites was a keen attempt to extract a better yield of results so that actual status of the ecological health of the particular ecosystem could be presented and strategies to manage and conserve such an ecosystem can be devised accordingly. Keeping in mind, such an unavoidable and important fact two sites were chosen for the study: Site I represented the natural unpolluted site and the site II stood for the polluted site. A brief description of the sampling sites is as follows:

Site I (ZAWOORA VILLAGE)

The station falls in district Shopian, the Apple Town and is just 2 km away from the same. The site is located in the upper periphery of Zawoora village where it is surrounded by little agricultural catchment with least human interferences .The site I thus reflected the natural pristine state of the stream. Boulders and stones formed the bottom substrate of the station. The site I is supposed to possess rich biodiversity particularly in terms of aquatic invertebrate diversity and density which deserve our primary attention in the entire course of study.

Site II (WATHOO VILLAGE)

Wathoo village site has been intentionally selected for the present investigation, which represented a human interfered polluted site. At the station, the stream receives heavy loads of domestic sewage, waste water, and agricultural wastes in addition to the pollution loads which it receives in the course of its flow to the station. This site was accordingly supposed to exhibit poor water quality which in turn supports a poor aquatic biodiversity, especially of macrobenthic invertebrates. The bottom substrate is composed of clay, sand, stones, boulders pebbles and semidecomposed household wastes. Comparative study of the stream at the two mentioned sites, in terms of absence, presence or abundance of macro invertebrate assemblages found would better reflect the water quality of the stream.

MATERIALS AND METHODS

Sampling schedule and procedure for Macro invertebrate Collection in Lar stream

Sampling for macro invertebrate collection was carried out on monthly basis from January to May to assess the health of Lar stream, Kashmir, India. The sampling procedure and other processes required for the availability of macro invertebrate data ready to be analyzed were as follows:

Collection

For macroinvertebrate sampling in the stream, kick net and D-net samplers were used. The sediment and stones were disturbed immediately upstream of the net by stirring it up using our feet so that the animals are dislodged and are swept into the net, which was located just downstream of our feet. The focus in macro invertebrate sampling was to sample as many of these habitats as possible in order to collect the majority of the macro invertebrate taxa at a site. The net was carefully rinsed several times in the stream to let the excess sediment pass through. The contents of the net were transferred into a bucket half-filled with water that was waiting at the stream bank.

Sorting of sample

Sorting was performed at the site immediately after sampling. A position was selected to sort that was flat, and not in direct sunlight. The sample was gently mixed in the bucket to ensure that the contents are evenly distributed. 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, 1% Formaldehyde and 4% Formalin. 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. Insect larvae were preserved in 70% Alcohol, a little glyserine was added to it to prevent damage caused by evaporation. Macroinvertebrate classes/orders/taxa were then identified and counted.

Identification of macroinvertebrates

Identification was conducted concurrently with sorting or afterwards. An identification key was used to accurately identify what we have found. If we had some trouble in identifying a macroinvertebrate, we tried taking a photo or drawing a sketch with a description so that it can be identified later. The organisms were identified both visually as well as microscope and with the help of standard works of Edmondson (1959) and Adoni (1985) and a series of fauna of British India.

Counting

When we completed the sorting and identification, then we marked down what we found on a macro invertebrate Data Sheet. Each type of organism was counted only once. As the sampling was done in an area of one sq. meter of the canal, the number of organisms per square meter was the density of the particular organism. The collective contribution of a particular organism at a particular site was the overall density of the species at that particular site.

RESULTS

Overall species composition

During the present study, a total of 26 species of macro invertebrates were registered from Lar stream which belonged to the orders Diptera, Trichoptera, Hirudinae, Ephemeroptera, Plecoptera, Gastropoda, Coleoptera, Arachnida, Lepidoptera, Crustacea, and Oligocheata. Among all the eleven orders, Dipterans registered a highest of 7 species (27%) and was the most dominating order. Then trend was followed by Trichoptera which registered a total of 5 species (19%) and was the second most dominating group. Similarly, Ephemeroptera, Oligochaeta Hirudinae, Plecoptera and Gastropoda which registered 2 species (8%) each were the next dominating orders. The least representing taxa were Coleoptera, Arachnida, Lepidoptera and Crustacea which registered only 1 species (4%) each during the entire study period (Table and Fig.1& 2).

Overall population density of Macro invertebrates

Over all maximum population density of 975 ind./m^2 was registered by oligochaetes and a least density of 1 ind./m^2 was registered by Arachnida (Table -2). The trend of the overall density change as revealed by the study followed the pattern: , Hirudinae (114ind./m^2), Diptera(68 ind./m^2), Trichoptera (65ind./m^2) , Plecoptera (64ind./m^2), Lepidoptera (39 ind./m^2), Coleoptera (9ind./m^2 each), Crustacea (27ind./m^2), Gatropoda (24 ind./m^2), Ephemeroptera(6 ind./m^2) and Arachnida (1ind./m^2).

DISCUSSION

In the present study, a total of 26 species of macro invertebrates belonging to Insecta, Gastropoda, Crustacea, Hirrudinaea, and Oligochaeta representing three main phyla Arthropoda, Mollusca, Annelida, were recorded from two sites of Lar stream, Kashmir. Among all the eleven orders, Dipterans registered a highest of 7 species (27%) and was the most dominant order. Hutchinson (1993) concluded that Diptera are, by far, the most diverse order of insects in freshwaters. They are, in fact, the most diversified of any major taxon of freshwater organisms. The study revealed the presence of maximum number of *Chironomus* sp. which areinvariably the inhabitants of polluted waters with low oxygen content and high organic matter (Pandit and Kaul, 1981). Oligichaetes have also been used to assess organic pollution and trophic status inn water bodies (Millbrink, 1994). The organic matter present in the stream at the polluted

Table 1
Percentage of different classes/orders of macroinvertebrates throughout the study period (January-May, 2012).

Order	No.	% contribution
Diptera	7	26.92 = 27
Trichoptera	5	19.23 = 19
Oligochaeta	2	7.6 = 8
Hirudinae	2	7.6 = 8
Ephemeroptera	2	7.6 = 8
Plecoptera	2	7.6 = 8
Gastropoda	2	7.6 = 8
Coleoptera	1	3.8 = 4
Arachnida	1	3.8 = 4
Lepidoptera	1	3.8 = 4
Crustacea	1	3.8 = 4
Total	26	100

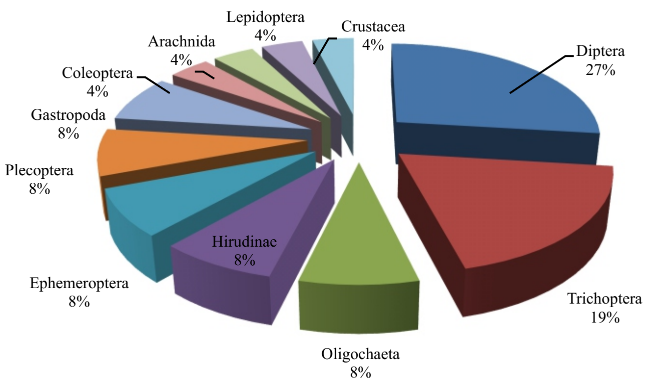

Fig. 1
Percentage contribution of taxa at all sites during study period (Jan-May2012).

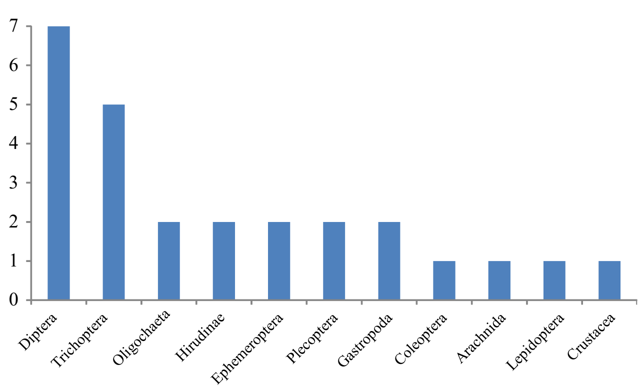

Fig. 2
Total number of taxa at all sites during study period (Jan-May2012).

Table 2
Overall population density of Macro invertebrates.

Order	Density (Individual per m^{-2})
Oligochaeta	975
Hirudinae	114
Diptera	68
Trichoptera	65
Plecoptera	64
Lepidoptera	39
Crustacea	27
Gastropoda	24
Coleoptera	9
Ephemeroptera	6
Arachnida	1

Table 3
Various taxa collected from the sampled study sites.

Annelida/Oligochaeta	*Limnodrillus hoffmestri* *Tubifex* sp.
Annelida/Hirudinae	*Pelicopdella* sp. *Erpobdella octoculata* *Total*
Arthropoda/Ephemeroptera	*Baetis* sp. *Caenis* sp.
Arthropoda/Plecoptera	*Perlodidae* *Unidentified* sp.
Athropoda/Trichoptera	*Hydropsychidae* *Lepidostoma* sp. *Glossosoma* sp. *Brachycentrus* sp. *Limnephillus* sp.
Arthropoda/Coleoptera	*Elmidae*
Arthropoda/Diptera	*Chironomus* sp. *Diamesinae* sp. *Tipula abdominals* *Tabanus* sp. *Atherix* sp. *Psychodus* sp. *Tipula abdominalis*
Arthopoda/Arachnida	*Hygrobatoidae*
Arthropoda/Lepidoptera	*Unidentified*
Mollusca/Gastropoda	*Lymnaea auricularia* *Lymnaea columella*
Arthropoda/Crustacea	*Gammarus pulex*

sites undergoes bacterial decomposition. The process requires a large amount of oxygen. As a result, the dissolved oxygen present in the water is rapidly used up. This limits the productive potential of the stream and also affects the distribution and abundance of macro invertebrate community. The presence of some pollution indicator species such as *Tubifex tubifex*, *Limnodrilus* sp., (among Annelida) *Chironomous* sp. and *Tabanus* sp., etc. (among Arhropoda) *Lymnea* sp., (among Mollusca) at site II directly points to the shifting status of the stream from non-polluted to polluted. Site I recorded maximum values of density and diversity due to least human interference. The low human population in its catchment resulted in maintaining the true ecological health of the stream at the site. This is also confirmed by the presence

Table 4
Contribution of different taxa at the two studied sites.

Phylum/Order/genus		S-I					S-II				
		Jan	Feb	Mar	Apr	May	Jan	Feb	Mar	Apr	May
Annelida/ Oligochaeta	*Limnodrillus hoffmestri*	0	0	0	0	0	170	220	70	250	245
	Tubifex sp.	0	0	0	0	4	0	0	0	3	13
Total		0	0	0	0	4	170	220	70	253	258
Annelida/ Hirudinae	*Pelicopdella* sp.	0	0	0	0	3	0	0	3	0	12
	Erpobdella octoculata	0	0	2	0	0	5	15	25	25	27
	Total	0	0	2	0	0	5	15	28	25	39
Arthropoda/	*Baetis* sp.	0	0	1		2	0	1	0	0	0
Ephemeroptera	*Caenis* sp.		2	0	0	3	0	0	0	0	2
Total		0	2	1	0	0	0	1	0	0	2
Arthropoda/	*Perlodidae*	1	0			1	0	0	3	0	0
Plecoptera	*Unidentified*	0	0	0	60	26	0	0	0	0	0
Total		1	0	0	60	0	0	0	3	0	0
Athropoda/ Trichoptera	*Hydropsychidae*	6	0	0	4	2	0	1	3	0	3
	Lepidostoma sp.	2	0	7	0	4	0	0	0	0	0
	Glossosoma sp.	0	3	0	0	0	0	0	0	0	0
	Brachycentrus sp.	0	1	0	4	6	0	0	0	3	3
	Limnephillus sp.	0	16	4	0	8	0	0	0	0	5
Total		8	20	11	8	0	0	1	3	3	11
Arthropoda/ Coleoptera	*Elmidae*	0	0	0	0	6	0	0	0	0	3
Total		0	0	0	0	6	0	0	0	0	3
Arthropoda/ Diptera	*Chironomus* sp.	0	0	0	3	6	50	2	3	3	4
	Diamesinae sp.	3	0	0	3	0	2	0	0	0	3
	Tipula abdominals	10	21	0	5	0	5	0	0	0	6
	Tabanus sp.	7	_	0	0	12	4	0	0	0	7
	Atherix sp.	0	2	0	0	2	2	0	0	0	0
	Psychodus sp.	0	0	6	0	3	0	0	0	0	6
	Tipulia abdominalis	0	0	20	0	0	0	1	9	0	4
Total		7	2	26	0	0	6	1	9	0	17
Arthopoda/ Arachnida	*Hygrobatoidae*	0	1	0	0	0	0	0	0	0	0
Total		0	1	0	0	0	0	0	0	0	0
Arthropoda/ Lepidoptera	*Unidentified*		0	0	35	0	0	0	0	0	4
Total		0	0	0	35	0	0	0	0	0	4
Mollusca/ Gastropoda	*Lymnaea auricularia*	0	0	0	0	0	1	2	1	5	6
	Lymnaea columella	0	0	0	0	0	1	1	0	2	5
Total		0	0	0	0	0	2	3	1	7	11
Arthropoda/ Crustacea	*Gammarus pulex*	0	0	0	0	0	0	0	15	0	12
Total		0	0	0	0	0	0	0	15	0	12

of Ephemeroptera, Trichoptera and Diptera at the site which are a characteristic feature of unpolluted waters. Similar findings were also reported by Bhat *et al.*, (2011), Sharma and Chowdhary (2011) and Pandit *et al.* (2007) while working on limnological survey of some fresh water bodies in Kupwara region of Kashmir Himalaya also showed that the streams were poor in nutrients compared to springs and varied markedly in their biotic setup in terms of periphytic algae and macro invertebrates. Studies carried out by Shazia and Yousf on Benthic macroinvertebrate community of Yousmarg streams reported that there was 'no apparent organic pollution' in Doodhganga stream as there is no source of pollution in its vicinity. However, in Khanshah manshah canal slight organic pollution is reported due inflow of organics from pasture and construction activity being carried out nearby. This variation in pollution status between the two streams resulted in considerable change in biotic set up as is the case in our study.

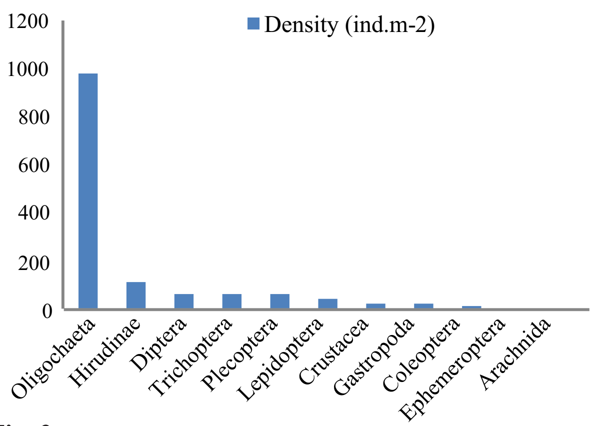

Fig. 3
Overall population density of Macro invertebrates.

CONCLUSION

Stream ecologists have long recognized that macro invertebrate species composition and abundance can be excellent monitors of ecosystem health. The abundance and diversity of these organisms are good indicators of local stream health because they have more limited movement and they respond quickly to pollutants such as nutrients and sediment and other environmental stressors. The river harbored 26 species, out of them insects were well dominant at whole study area because of their potency to tolerate the organic pollution. The present study concludes that the presence of some pollution indicator species such as *Tubifex tubifex*, *Limnodrilus* sp., (among Annelida) *Chironomous* sp. and *Tabanus* sp., etc. (among Arhropoda) *Lymnea* sp., (among Mollusca) directly points to the shifting status of the stream from non-polluted to polluted. The Lar Canal Kashmir, which was under the investigation has a vital ecological importance and is the backbone of agriculture and water supply schemes especially in two South Kashmir districts, Shopian and Pulwama.

The said water body is under a severe ecological stress. Appropriate steps are thus needed to control human interference by sound management policy and relative measures before it is too late. The significance and present pollution status of the particular ecosystem should be highlighted and consequences exposed so as to protect it from further degradation.

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