International Journal in Physical and Applied Sciences
Volume 07 Issue 06, June 2020 ISSN: 2394-5710 Impact Factor: 4.657
Journal Homepage: http://ijmr.net.in, Email: irjmss@gmail.com
Double-Blind Peer Reviewed Refereed Open Access International Journal

EFFECT OF PHYSICO - CHEMICAL FACTORS ON THE BENTHIC MACROINVERTEBRATE DIVERSITY OF HAROHAR RIVER, BIHAR

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Abstract

The diversity of benthic invertebrate really depends on habitat conditions. Thus the diversity in benthic community varies with different habitat conditions. This investigation on the structure of the benthic invertebrate diversity was conducted on river harohar of Bihar state to assess the cumulative effects of water quality on the aquatic biota. The study period extended from February 2003 to January 2005. A total of 23 macrobenthic species belonging to three phyla, five classes and nine orders were identified. Fifteen species of benthic invertebrates belonging to Mollusca, three species under Annelida and five species under Arthropoda were found. The highest abundance density (3633.33 indiv.m-2) and species richness (18 species) were recorded in up-stream where marginal habitats covered by macrophytes were significantly higher than at other sites. Both the organic carbon (4.41±1.11) and organic matter (7.48±1.56) of soil at this site were the maximum thus influencing the richness of benthic macroinvertebrate diversity. Hydrological variables, viz, dissolved oxygen, pH, alkalinity; hardness, salinity, nutrients, calcium, and magnesium were studied to determine their influences on the benthic community in the upper, middle- and down-streams of the river, respectively. Shannon's diversity index (0.95–2.07; 0.00–0.72; 0.00–0.64), dominance index (0.57–0.86; 0.00–0.44; 0.00–0.44), evenness index (0.72–0.95; 0.61–1.00; 0.00–1.00), Margalef index (0.72–2.23; 0.00–1.32; 0.00-0.28) of the upper, middle- and down-streams were calculated. Benthic macroinvertebrate density was correlated with hydrological variables which indicated that the abiotic factors had either direct or inverse influence on the richness and abundance; however, the abiotic factors did not correlate identically in all three sites.

Key Words: Diversity, Benthic Macroinvertebrate, Abiotic factors, Harohar River, Sediment.

Introduction: Harohar river sub-basin is situated between Lat 24°10'N and 25°30'N and long 84°40'E and 86° 8'E with an elevation of 38 meters (125 feet). The basin is distinctly divided in two zones. The upper zone in the south covered with forest where as the lower zone falls in the gangetic planes. The basin is mainly drained by the river Harohar and Sakri. The lower portion of the basin is saucer shaped and forms a group of Tals commonly known as Mokama Group of Tals. Benthic macroinvertebrates are sedentary or sessile aquatic fauna that exist in the bottom substrates of their habitats (Idowu & Ugwumba 2005) at least for a part of their life cycle. The benthic fauna perform a key role in nutrient cycling and are also used as food for other aquatic animals. Further they play a critical role as a link in the aquatic food chain affecting bio-geochemical processes in the sediment (Wetzel 2001; Heck et al. 2003). Benthic invertebrates

are difficult to sample especially in deep subsurface sediments. Thus, the species richness and functional importance of freshwater benthic invertebrates usually goes unnoticed until unpredicted changes occur in the ecosystems. These organisms are used as bio-indicators as they frequently respond to pollution stress (Ikomi et al. 2005). The community structure of benthic macroinvertebrates is influenced by the physico-chemical parameters of the water body (Kagalou et al. 2006; Celik et al. 2010). Examination of parameters like richness, diversity, abundance, evenness and community composition are essential to determine the natural or anthropogenic changes with time (Srivastava 2007). In riverine ecosystem macrobenthic invertebrates show an uneven distribution.

River Harohar is facing various environmental constraints due to siltation, discharge of organic debris from human settlements, production of macrophytic biomass, lack of sanitation and over-fishing (Das et al. 2012). Thus, it is ever more important to preserve the biodiversity of aquatic flora and fauna in this river to lower the risk of sudden unwanted consequences. A number of studies on macrobenthic community structure and hydrochemistry of various water-bodies are well documented (Sharma & Dhanze 2012; Mishra & Nautiyal 2013).

To the best of our knowledge, information on macrobenthic fauna of River Harohar is unavailable so far. This encouraged us to undertake the present study on the river to ascertain:

(i) the structure and composition of the benthic macroinvertebrate species,
(ii) the environmental factors (natural as well as anthropogenic) responsible for the community patterns,
(iii) (iii) the present ecological status of the river and
(iv) (iv) determine the quality of water by using benthic fauna to establish the pollution level of the river to create a base line data.

Materials and Methods: The Harohar River is considered as life line of Lakhisarai (Bihar), which fulfills the needs of villages situated at both sides of the river. Harohar river sub-basin is situated between Lat $24^{o}10'$N and $25^{o}30'$N and long $84^{o}40'$E and $86^{o}\ 8'$E with an elevation of 38 meters (125 feet). Water samples were collected from different sampling points in each site in 1 L clean plastic containers between 06:00–08:00 hr during study period twice a month and transported to the laboratory for chemical analyses. Water temperature was recorded using mercury glass thermometer (0–60^{0}C). Electrical conductivity, total dissolved solids (TDS) and pH were measured by ELICO Ion analyzer (Model: PE 138, India). All other water quality variables such as dissolved oxygen (DO), free carbon dioxide, total alkalinity, total hardness, calcium, magnesium, phosphate, nitrate, salinity and transparency, organic matter and organic carbon were monitored following standard protocol, American Public Health Association (APHA, 2005).

Benthic invertebrates were collected twice a month with a specialized box sampler having a dimension of 15 x 15 cm which can penetrate a maximum depth of 15cm (Paul & Nandi 2003). The samples were sieved with No. 40 mesh (pore size: 0.420mm) (Tagliapietra & Sigovini 2010). Considering the depth of the down-stream, desired samples were collected with the help of local fishermen. Collected organisms were preserved in 4% formalin. Benthic macroinvertebrate were then identified for the phylum Annelida (Barnes et al. 1988 and Rao, 1989) for the phylum Mollusca whereas Arthropoda by the Zoological Survey of India, Kolkata, India. Benthic macroinvertebrates were quantitatively analysed by individual counting of each taxon and expressed in individuals/m2. Taxonomic indices was subjected to univariate analyses for studying the benthic community structure using Margalef's richness index, Margalef (1968) for species richness (counts the number of different species in a community), Pielou's Evenness index (Pielou 1966) for species evenness (quantifies the relative abundance of species present in a community), Shannon-Weiner index (Shannon & Weiner 1964) for species diversity and Simpson's Dominance Index (Simpson 1949) for dominancy (quantifies the dominancy sharing species in a community). The data were computed using Paleontological Statistical software (PAST version 3.15). Pearson correlation (r) was applied to analyse the relationship between the benthic macroinvertebrates density and hydrological variables. The graphs were plotted with MS Excel Software.

Result and Discussion: In the harohar, 23 benthic macroinvertebrate species were found from all the samples collected from upper-, middle- and down-streams. Of these, up-stream was the richest with species (18) followed by middle-stream (5) and down-stream (2). The maximum density (individual m-2) was found in the following sequence, i.e., up- > middle- > down-streams. Benthic macroinvertebrate community was available throughout the year up-stream with peaks in the months of June and September (Table 1). Down- and middle-streams showed similar trends where the diversity gradually increased from October and reached the maximum in May. In down-stream, during monsoons (June–September) it was not possible to find and collect any benthic macroinvertebrate samples due to the dangerous rise in water levels and the highly turbulent character of the water. Perhaps, due to the same reason a low concentration of benthic macroinvertebrate was found mid-stream during the monsoons.

Table 1: Benthic macroinvertebrate community available throughout the year

Benthic invertebrates		**Up-stream**	**Middle-stream**	**Down-stream**
Phylum: I Mollusca Class: I Gastropoda Order: I Mesogastropoda	**1.*Brotia costula* Rafinesque, 1833**	+	-	-
	2. *Bithynia cerameopoma* Benson, 1830	+	-	-
	3. *Bellamya bengalensis* Lamarck, 1822	+	-	-
	4. *Bellamya dissimilis* Muller, 1774	+	-	-
	5. *Bellamya crassa* Benson, 1836	+	-	-
	6. *Segmentina calatha* Benson, 1850	+	-	-
	7. *Melanoides tuberculata* Muller, 1774	+	-	-
	8. *Gabbia orcula* Frauenfeld, 1862	+	-	-
Order: II Basommatophora	**9. *Pseudosuccinea luteola* (Lamarck, 1799)**	+	-	-
	10. *Pseudosuccinea acuminate* (Lamarck, 1799)	+	-	-
	11. *Gyraulus convexiusculus* Hutton, 1849	+	-	-
	12. *Indoplanorbis exustus* Deshayes, 1834	+	-	-
Order: III Megagastropoda	**13. *Pila globosa* Swainson, 1822**	+	+	-
Class: II Bivalvia Order:I Eulamellibranchiata Family: Unionidae	**14. *Lamallidens marginalis* Lamarck, 1819**	+	-	-
Order: II Mytiloida Family: I Mytilidae	**15. *Modiolus striatules* Hanley, 1843**	+	+	-
Phylum: II Annelida Class:I Oligochaeta Order :I Ophisthophora	**16. *Pheretima postuma* Kinberg, 1867**	+	-	-

Order: II , Haplotaxida **Class: II Polychaeta** **Order: I Phyllodocida**	**17. *Glyphidrilus tuberosus* Stephenson, 1916**	+	-	-
	18. *Neanthes* sp. Frey & Leuckart, 1847	-	+	-
Phylum: III , Arthropoda **Subphylum: I Crustacea** **Order: I Decapoda** **Family:I Portunidae**	**19. *Scylla tranquebarica* Fabricius, 1798**	-	-	+
	20. *Scylla serrata* Forsskål, 1775	-	+	-
Family: II Gecarcinucidae	**21. *Sartoriana spinigera* Wood-Mason, 1871**	+	-	-
Family:II Grapsidae	**22. *Metapograpsus latifrons* White, 1847**	-	+	-
Family: III Ocypodidae	**23. *Ocypode macrocera* H. Milne Edwars, 1837**	-	-	+

The results are presented separately for all three different study sites as follows:

(A) At upper reaches of harohar: In the upper-stream, 13 species of Mollusca belonging to class Gastropoda (3 orders) and class Bivalvia (1 order) dominated the community followed by Annelida (2 orders) and Arthropoda (1 order). The population of benthic invertebrates was dominated mainly by three taxa of Mollusca: namely, *Bellamya bengalensis*, *Bellamya dissimilis* Muller, and *Gyraulus convexiusculus* Hutton). The abundance of *B. bengalensis* increased to maximum density (322.22) in the pre-monsoon period then its population declined. In comparison, the *B. dissimilis* after attaining its population peak in pre-monsoons (255.54) drastically declined in the post-monsoon period (33.33). *B. crassa* was completely absent in pre-monsoon periods. On the other hand, species like *Segmentina* in monsoon and pre-monsoon periods and *Melanoides* in the monsoons were completely absent. *Brotia* and *Bythinia* were found in all seasons. During the investigation, one Bivalvia taxa (*Lamellidens marginalis*) was found exclusively in the pre-monsoons. The benthic macroinvertebrate community was dominated by molluscans (82.35%) followed by annelids (11.76%), and arthropods (5.88%). The data on analysis revealed that benthic macroinvertebrate abundance was the highest in post-monsoons followed by pre-monsoon and monsoon periods. Maximum species diversity (1.79) and Simpson's dominance index (0.79) were recorded in the monsoon period and minimum species diversity (1.58) and dominance index (0.75) in the pre-monsoons. Species richness, i.e.,

Margalef's index was found to be the maximum during monsoons and minimum in the pre-monsoon period. Pielou's evenness index was found to vary from 0.81 to 0.87. Water temperature, transparency, free CO_2, salinity, organic carbon, TDS and nutrients were positively correlated with the benthic macroinvertebrate abundance. Dissolved oxygen and total alkalinity, two important parameters were negatively correlated with benthic macroinvertebrate density. These water parameters were additionally correlated individually with density of Gastropoda, Bivalvia, Annelida and Arthropoda in up-stream only.

(B) At middle reaches of harohar : The benthic macroinvertebrate community was dominated by Mollusca (88.43%) followed by Arthropoda (9.26%) and Annelida (2.31%)). Arthropoda *Metapograpsus latifrons* was found maximum (166.66) in post-monsoon whereas *Scylla serrata* was found only during the monsoons. Only one Annelida, i.e., *Neanthes* was found maximum during pre-monsoons and declined at the onset of the monsoon. *Pila globosa*, the Gastropoda were identified during monsoon and post-monsoon periods. One bivalvian species, *Modiolus* was recorded in maximum density (1965.33) during pre-monsoons. Diversity index and dominance index recorded were the maximum in the monsoons and minimum in the pre-monsoons. Evenness index and richness index was found to be maximum in the post-monsoon period. In the middle-stream, all the water and soil parameters except DO, free CO2 and phosphate were positively correlated with benthic macroinvertebrate density. The species richness of benthic macroinvertebrate were found to be the highest in up-stream probably due to suitable habitat conditions, organically enriched soft bottom, slow water current, shallow depth bottom substrate (muddy and clayey) and the presence of macrophytes in marginal water (Kumar et al. 2013).

(C) At Down reaches of harohar : Meager existence of benthic macroinvertebrate diversity in down-stream might be related to the depth of water, soaring water current, increased siltation, anthropogenic disturbances and unstable substratum. Absence of macrobenthos during monsoons was probably due to high turbulence and depth of water in the down-stream. Moreover, increased anthropogenic activities (organic debris from adjoining localities, ferry boats across the river, immersion of idols, domestic daily activities, river bank occupation by factories like brick kilns etc.) at this station caused substratum instability of macrobenthic community (Leprieur et al. 2008).

Conclusion: Any aquatic system with an average salinity of less than 0.5 parts per thousand is defined as a freshwater ecosystem. Freshwater ecosystems, which include lakes, ponds, rivers, streams, springs, and wetlands, are vital for all living things. They are essential for the long-term sustainability of aquatic life and systems, for the well-being of local communities, and for the conservation of biological diversity (Whitten et al., 2002). They provide different direct and indirect services, such as provisioning, regulating, supporting and cultural services. There is a growing recognition of the services provided by freshwater ecosystems – such as supplying

water for drinking, irrigation and industrial purposes; they also play a role in flood control, transportation, purification of toxins, sustaining the habitats of plants and animals, food supply, and even recreation (Baron et al., 2003). Though these freshwater systems occupy only 0.8% of the earth's surface and make up only 0.01% of the world's water, they support almost 6% of all the described species (Dudgeon et al., 2005).The results pointed out that benthic macroinvertebrate diversity was very poor in middle-and down- streams but had a moderate population in up-stream. Structure of macrobenthic population was mainly driven by seasonal variations, depth of water, water current, habitat type, riverbed characteristics and influence of anthropogenic interferences. The macrophyte vegetated marginal habitats supported greater species richness and abundance (up-stream) than non-vegetated habitats (middle- and down-streams). The Mollusca could be regarded as a bio-indicator species thus indicated a good water condition of the river. It was evident from the investigations that the seasonal changes in the hydrological parameters influenced the community structure of the benthic invertebrates in river harohar.

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