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Contribution of substratum heterogeneity in the diversity and distribution of macrobenthic invertebrate fauna in Ban Ganga stream, Katra (J & K)

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ABSTRACT

The present paper deals with the study of substratum and macrobenthic invertebrate fauna inhabiting stream, Ban Ganga .The detailed study reveals that the diversity, abundance and distribution of macrobenthic organisms is affected by various sediment characteristics viz. texture, pH, conductivity, organic carbon and organic matter etc. The macrobenthic biodiversity of the stream is represented by three major phyla viz., Annelida, Arthropoda and Mollusca out of which Oligochaetes (Annelids) and Dipterans (Arthropoda) formed the major bulk of benthic forms at all the stations whereas Odonates (Arthropoda) and leeches (Arthropoda) contributed minima towards the total benthic population. Also, analysis of Pearson's coefficient of correlation showed the relationship between sediment characteristics (coarse sand, fine sand, pH, conductivity, organic matter and organic phosphorous) and different phyla.

Key Words: Abundance, Diversity, Macrobenthos and Substratum

INTRODUCTION

Substratum acts as an important site for organic matter decomposition (Ezekiel *et al.,* 2011) and serves as an important habitat for macrobenthic invertebrate fauna, whose metabolic activities contribute to the aquatic productivity. The different macrobenthic invertebrates that live in or near the substratum are important components of aquatic ecosystem as they serve as a link in the transfer of materials and energy from producers to top level consumers and also act as excellent indicators of stream health.

Different benthic organisms prefer different strata according to structural and functional adaptations. The various soil characteristics of water bodies have a strong influence on the diversity and abundance of benthic organisms. Moreover, a study of benthos-substratum relationship is very important in determining the community structure of benthos that occur in different strata and thus may help in planning the management of aquatic ecosystems.

Therefore, in order to study the dynamics of aquatic ecosystem, the present work has been designed to analyse the contribution of substratum in the distribution of macrobenthic invertebrates inhabiting Ban Ganga stream, Katra in Jammu region.

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MATERIAL AND METHODS

Study Area

Ban Ganga, a shallow water stream originates from Trikuta Hills of Himalayas. The small stretch of the stream flanking the path, leading to Mata Vaishno Devi shrine is the most celebrated one and is affected by pilgrimage activities. To analyse the biotic and abiotic components of stream Ban Ganga, five sampling stations were selected along the longitudinal profile.
Station-I: shows appearance of Ban Ganga at Charan Paduka

- Station II: dumping site of pony dung
- Station III: influenced by religious activities and also receives effluents from various dhabas and shops on its bank

- Station IV: receives huge amount of kitchen waste and warm water from Gulshan Langar
- Station V: it is quite far away and without any anthropogenic interference.

Sample collection

The bottom samples were collected from all the five stations by using Ekman's dredg**e.** The collected sample were washed through sieve no. 40 (256 meshes/ cm^2) and macrobenthic invertebrates thus segregated were transferred to vials and preserved in 5% formalin for subsequent identification (Ward and Whipple, 1959; Tonapi, 1980 and Adoni, 1985). The total number of macro-benthic invertebrates / m^2 was computed using the following formula:

$$\text{Individual / } m^2 = \frac{N}{a} \times 10000$$

Where N = Average number of microscopic organisms per sample

a = Area of sampler (cm^2)

Figure-1. Study site Ban Ganga at Charan Paduka

Sediment Analysis

Soil samples were collected monthly from the stream bed of the each selected station and stored in the polythene bags. These samples were initially sun dried and finally oven dried at 60 °C and then stored for further analysis of texture, pH, conductivity, organic carbon, organic matter and organic phosphorous using standard methodology: Texture; by textural triangle software (Gerakis and Baer, 1999), pH by digital pH meter (Bates, 1954), Electrical Conductivity by using conductivity meter (Godson *et al*., 2002), TOC and TOM by Walkley and Black Titration Method (Walkley and Black, 1934). Pearson's coefficient of correlation among physico-chemical parameters and macrobenthic invertebrate fauna was determined using Microsoft excel 2007.

RESULTS AND DISCUSSIONS

I. Sediment Characteristics

(i) Texture*:* The particle size distribution of the soil sediments of the stream bed of Ban Ganga has been given in Table I. The bottom sediments were comprised of sand (coarse and fine sand), silt and clay. Among these, sand was observed to be the dominating constituent of the stream bed and its maximum contents were observed at Station I and minimum at Station V. The silt and clay on the other hand showed their lower percentages throughout the study period at all the study stations and revealed an increasing trend longitudinally. Chutter (1969) also reported higher concentration of silt and sand in the river bed.

Predominance of coarse sand at St. I and St. II of stream, which are located at fairly good height, is understandable as the water here moves at great speed. Similar view points of different distribution of varied sized particles in the stream bed have also been reported by Dutta (1978).

(ii) Chemical Characteristics**:** The pH values of the sediments represented alkaline conditions with the mean values fluctuating between 7.63- 8.08. The alkaline conditions of the sediments can be attributed to the land drainage pollution arising due to the disposal of waste (Braide *et al*., 2004 and Sharma, 2013). EC on an average remained low throughout the study period, however, its mean values ranged between 0.09 (St-I) to 0.13 (St-IV). Conductivity of the sediments is strongly affected by the sediment particle size and texture. Braide et *al*., 2004 and Reddy *et al*., 2006 also reported that sands have low conductivity whereas silt and clay have more conductivity.

Further Table I shows the average values of organic content, which were found to be maximum at St- IV (5.25) and minimum at St-I (0.63). High organic content at Station-IV, which could be attributed to the fact this station receives heavy organic matter in the form of municipal wastes, sewage from nearby shops and hotels, human excreta and pony dung. Moreover, high clayey contents also contain more organic matter as also revealed by Odum (1971).

II. Macrobenthic Diversity

A total of 15 taxa of macrobenthic invertebrates were identified belonging to three phyla viz. Annelida (represented by four sps. of Oligochaetes and one sps. of Hirudinea), Arthropoda (represented by two sps. of coleopterans, one sps. of Trichopterans, five sps. of Ephemeropterans, five sps. of Dipterans and one sps. of Odonates) and Mollusca (represented by single sps.). Their overall abundance, distribution and percentage of each order have been shown in Table II and Fig.I. Out of the total macrobenthic fauna collected during the study period, Oligochaetes and Dipterans formed the major bulk of the benthic fauna at all the stations whereas Odonates and leeches contributed minima towards the benthic population of the stream. Jonasson (1979), Marshall and Winterbour (1979) and Sunder and Subla (1986) too found Oligochaeta to contribute

the major share of the total benthic fauna in their respective bodies.

III. Quantitative Analysis of Benthos

Macrobenthic organisms are sensitive indicators of environmental changes in streams because they express long term changes in water habitat quality. The presence of certain macrobenthic species at particular sites and absence at other sites can be related to various physico-chemical conditions of the substratum, which provided habitat to them. Quantitatively, macrobenthic fauna of the stream revealed marked variations at different stations with maximum abundance at Station –IV having sandy loamy type of substratum with high percentage of clay, silt and total organic matter.

Highest density of Oligochaetes at St-IV clearly depicts that it has organically rich substratum. Presence of detritus sediments, suitable soft habitat for burrowing activity could be the reasons behind their abundance as they feed on detritus particles and construct U- shaped burrows within soft sediments. Abundance of Oligochaetes due to greater load of organic detritus and soft sediment has well opined by Mukherje *et al* (1998). Quantitative abundance when further taken into consideration revealed the high number of *Tubifex tubifex* and *Limnodrilus* species at St-IV as compared to the other stations. Kazanci (1998), Swayne and Day (2004), Yildiz and Ergonul (2007) and Kucuk (2008) also reported the abundance of these species in organically polluted water. Thus, their high density and abundance at Station –IV clearly indicated it to be most polluted station, having high trophic status as compared to the other stations. From the Table..IV., showing correlation of Oligochaetes with physico-chemical characteristics of soil bed, it is evident that they observed a positive correlation with coarse sand, fine sand, pH, conductivity, organic carbon and available phosphorous.

Phylum Arthropoda was represented by orders Trichoptera, Coleoptera, Ephemeroptera, Odonata and Diptera. A close look at the Table III showed the numerical decline of Coleopterans and Trichopterans downstream from head to mouth. St- I (pollution free) recorded their maximum density, St-III being mildly polluted had their least abundance whereas St-IV (heavily polluted) showed their complete absence and St- V (revival zone), however recorded the reappearance of beetles. This can be attributed to the fact that high values of conductivity, pH and coarse sand at St- I and St-II favours their population Table IV).

The marked presence of macrobenthic invertebrates belonging to Ephemeroptera in upper reaches of the stream (St-I & St-II, clean water) may be due to the fact that they are sensitive to environmental stress. On the basis of these studies, these are regarded as clean water indicators. Also, their positive correlation was noticed with sand, pH, organic carbon, organic matter and available phosphorous. Quantitatively, the Odonates represented by single sps. (*Anax* sps.) were generally collected along the banks of the stream. Lenat (1983); G. Odelu et al (2014) and Thakial (1997) too reported their presence on the river banks. Persual of the Table III clearly revealed that odanates maintained their higher abundance at St-I and at St-V. They however, showed a decline in their population at the polluted sites of the stream viz., Stations II, III and IV. From the Table IV, it is evident that except for clay all other physico-chemical parameters of soil sediments were found to exhibit positive correlation with Odonates.

The abundance of Dipterans at Stations IV and V was mainly contributed by Pentaneura and Chironomous, which might be owing to the presence of thick layers of soft organically rich sediment (Edwards *et al*., 1971 and D.L. Bharamal et al, 2014). Greater density of the members belonging to Chironomidae family at Stations IV and V can be associated with the discharges of kitchen waste from Gulshan Langar, nearby hotels and dhabas etc., which contribute to the increase in organic matter, thereby making environment more conducive for the flourisment and survival of these species. Similar results were found by Silva *et al.,* 2009. A correlation of sediment characteristics and dipterans revealed clearly that except for silt and clay all other parameters like coarse sand, pH, conductivity, organic carbon and available phosphorous are positively related with them.

Molluscs contributed to a less but to a considerable extent all the stations. They were observed to maintain their maximum abundance at the highly polluted sites (St-IV) of Ban Ganga stream. Saksena and Kulkarni, 1982 reported that they could tolerate pollution up to some extent and can be treated as pollution indicators. Table IV showing correlation of physico-chemical quality of soil bed and molluscs very clearly revealed that they are positively related with coarse sand, pH and conductivity. Fine sand, silt, clay, organic matter, organic phosphorous were however negatively related with them.

CONCLUSION

Thus, the detailed study reveals the close relationship between macrobenthic fauna and sediment substratum. Also, macrobenthic fauna of the stream revealed well-marked seasonal variations in both its quality and quantity at different stations. Constant human interference is continuously deteriorating the water quality thereby affecting the sediment characteristics, diversity, distribution and abundance of macrobenthic fauna. Therefore, for restoring the water quality and to check the further deterioration, implementation of effective management strategies is the need of the hour.

CONFLICT OF INTERESTS

The authors declare that there is no conflict of interests regarding the publication of this paper.

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