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Macro-benthic diversity in relation to biotic indices in Song river at Dehradun, India

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Abstract

The composition and abundance of benthic animals are commonly used as bio-indicators to determine the impact of pollution on physico-chemical integrity of surface waters and changing pattern of biotic characteristics of lentic and lotic system. The benthos serves as a link between primary producers, decomposers and higher trophic level. Song river is a spring fed hill stream originated from different small rivulets of lesser Himalayan mountainous ranges at Garhwal region of Uttarakhand. The study was carried out from 2006-2008, the water samples were collected from three different sites in a stretch of about ten kilometres from Song river. All taxa were identified to species/genus level with the help of identification keys. The 5 faunal groups and 19 genera were observed at three different stations in the Song river. At all three sites, *Tubifex* was the dominant genera among Oligochaeta. Among polychaeta, *Namalycastic indica, Napthys polybranchia, Napthys oligobrunchia* species were reported at all above three different sites of Song river. Biotic indices indicated moderate pollution in the water quality of upstream and down stream water. The CCME (Canadian Council of Minister of Environment) water quality index (2001) showed marginal range of pollution in the river. The abundance of pollution tolerant organisms indicated the downstream site is receiving nutrient-rich urban runoff containing little or no toxins substances.

Keywords: *Benthic diversity, Biotic indices, Song river, Water quality index*

Introduction

The benthic flora and fauna of fresh water has been the subject of intensive ecological research because they play important role as indicators of water pollution (Mason, 1991). The benthos serves as a link between primary producers, decomposers and higher trophic level in aquatic ecosystem. The biological assessment of aquatic environments has been practiced since the1900s (Hynes 1960, 1994, Cairns and Pratt 1993). It has been evidenced by a number of recent books devoted entirely to the subject interest in distribution of benthos (Abel 1989; Plafkin *et al*., 1989; Loeb and Spacie, 1994). Many methods have assessed stream quality using invertebrates, ranging from assessing physiological and morphological changes of individuals to various measures of community structures (Rosenber and Resh 1993). Biotic indices based on macroinvertibrate community structure are widely used and alternatively biological monitoring offers a relatively affordable means of environmental measurement compared to chemical data for assessing degradation of aquatic habitats and loss of biological diversity induced by anthropogenic disturbances (Karr, 1991 and Hynes, 1994).

Benthic macro-invertebrates are being utilized as a tool to assess surface water quality. Understanding the response of aquatic communities to pollution is vitally important, as it forms the basis of a variety of biological methods for assessing water quality and biological productivity. Now a days, biotic indices are become the most common methods for river biological monitoring (Nerris and Georges, 1993; Norris and Norris, 1995). The present study was conducted to estimate the biotic status and water quality of Song river at Dehradun.

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Materials and Method

Geographically, Garhwal has almost central position in the long Himalayan sweep, it is the most important part of lesser Himalaya, which lies between latitudes 29˚ 26' to 31˚ 28' N and longitude 77˚ 49' to 80˚ 06' E in Indian subcontinent. Song river is a spring fed river originated with Sahastradhara streams flow downwards towards Doon valley basins and finally it assimilates into river Ganga at Raiwala. Song river is basically the tributary of Ganga. The present study was carried out from 2006-2008, the water samples were collected from three different sites *i.e.* Site-I Upstream point, Site-II Confluence point and Site-III-Downstream point in a riverine stretch of about ten kms .

The collections of macro-zoobenthic organisms were done at time between 8.00 to 10.30 A.M. on monthly basis. All benthic samples were collected with an Ekman's Dredge sampler and sieve having size US No. 60 cms and preserved in 4.0% formalin. In laboratory, the benthic animals were sorted out and identified to genus/species level with the help of identification keys (Edmondson, 1992). An average of three samples of macro-zoobenthic organisms were taken monthly from each sites and mean density value of the three replicates were converted to individual per meter square (ind./m^2) as following formula described by Jhingran *et al.* (1969). Three diversity indices were used, namely:

(1) Shannon-Wieners Index (1949) $(H) = - \sum \frac{ni}{N} \ln \frac{ni}{N}$

(2) Simpson's Index (1949) $C = 1- \sum \left(\frac{ni}{N}\right)^2$

(3) Margalef's Index (1958) $(D) = \frac{S-1}{\ln(N)}$

Where,

ni = number of individuals of a given family (i)

N = The total number of individuals of all families

S = total species number

ln = $\log_e$ (logarithm to the base)

The CCME Water Quality Index: The CCME-WQI produces a measure of the derivation of water quality from water quality guidelines described in (CCME- WQI, 2001).

Results and Discussion

Macrozoobenthos are important components of the bottom biocoenosis. Invertebrate macrobenthic organisms mainly consisted of sessile or sedentary animals and reflect characteristics of both sediments and water column of aquatic systems. Changes in land use in stream catchments often results in obvious changes in their invertebrate communities (Hall *et al.,* 2001 and Quinn, 2000). The removal of vegetation from the riparian strip along stream banks also affects stream communities, increasing water temperature and decreasing the input of organic matter (LeBlanc *et al.,* 1997 and Quinn, 2000).

The 5 faunal groups and 19 genera were observed at three different stations in the Song river (Table 1). Song river constituted by the different macro-zoobenthos groups mainly Oligochaeta, Polychaeta, Insecta, Pelecypoda and Gastropoda. Oligochaeta was reported as a dominant group among all other groups. In Oligochaeta, the *Tubifex* species was recorded maximum in number. Brinkhurst (1966) suggested that the *Tubifex* species and *Limnodrillus* species were more resistant of all kind of pollution in river. *Limnodrillus hoffmeisteri* and *Branchiora sowerbyii* were reported least in compare to *Tubifex* species. At all three sampling sites, *Tubifex* was the dominant genera among Oligochaeta. Among Polychaeta group the benthic species, *Namalycastic indica*, *Napthys polybranchia*, *Napthys oligobrunchia* were reported at all three different sites of Song river. The *Oligochaetes* are known to exhibit high percentage of the total benthic fauna in polluted water as reported by Howmiller and Beeton (1973) and Kaniewska-prus (1983). Tiwari *et al*., (1988) reported *Tubifex* species as pollution indicator species. Prater *et al.* (1980) stated that the *Branchiora sowerbyii* tolerates moderate organic pollution.Earlier work proves their presence from different stretches of the river Song (Singh *et al*., 1988, Ahmad and Singh, 1989 and Jhingran *et al*., 1986). Insects were poorly reported than Oligochaetes. Wiederholm (1980) suggested that in heavily polluted water, Oligochaetes are more abundant than Insecta. According to Paine and Gaufin (1956) some aquatic insect species were restricted in clear water conditions of riverine ecosystem.

Table 1: **The distribution of Macro-zoobenthic organisms (ind./m^2) at different sampling sites in Song river at Dehradun**

S.No.	Organisms	Site-I	Site-II	Site-III
1.	**OLIGOCHAETA**			
	Tubifex sp.	51-65	205-250	492-516
	Limnodrillus hoffmeisteri	6-7	28-40	89-97
	Branchiora sowerbyii	6-7	8-15	23-26
2.	**POLYCHAETA**			
	Namalycastis indica	79-94	40-46	45-52
	Napthys polybranchia	13-24	6-10	8-14
	Napthys oligobranchia	16-14	5-6	7-10
3.	**INSECTA**			
	Chironomous plumosus	99-125	66-71	9-16
	Strictochironomous sp.	22-31	11-13	10-14
	Culicoides	5-11	5-6	8-12
	Dragonfly *nymph*	12-17	5-6	7-10
4.	**PELECYPODA**			
	Parreysisa favidens	24-36	15-17	6-8
	Parreysia coerulea	32-37	18-23	7-9
	Corbicula striatella	11-17	6-7	2-4
	Noviculina ganetica	14-24	10-15	5-7
5.	**GASTROPODA**			
	Bellumya crassa	15-20	25-33	33-40
	Thiara scrabra	51-61	55-72	33-40
	Thiara granifera	27-30	32-37	61-73
	Thiara tuberculata	62-77	67-76	05-120
	Brotia costula	17-27	28-35	25-31

Maximum Pelecypodas were reported at Site-I followed by Site- II and III these were identified at different species like *Parreysisa favidens*, *P. coerulea*, *Corbicula striatella*, *Noviculina ganetica* which indicates good dissolved oxygen and physico-chemical characteristics associated with least organic pollution load in running water. Depletion in oxygen has shown major stresses in fresh water system by Pelecypodas (Ingram, 1957). Gastropods were found to be more tolerant of organic pollution in river water. These were found maximum at Site- III followed by Site- II and I. The presence of *Bellumya crassa*, *Thiara scrabra*, *Thiara granifera*, *Thiara tuberculata and Brotia costula* indicates that it has a broad tolerance range of organic enrichment. So present status of benthic organisms supports that Gastropods are facultative organism, therefore the Oligochaetes can serve as useful indicator of organic pollution prevailing riverine system of Song river. The response of macroinvertebrates to organic pollution has been well documented in different running water bodies (Hellawell, 1986; Mason, 1991 and Cao, 1996).

Sala *et al.* (1977) studied that polluted water has been showed low diversity indices due to occurrence of many pollution tolerant benthic organism flourished in absence of competition and presence of abundant food supply. The present result has implied that Song river was more affected by nutrients as organic matters added by distillery effluents at upstream of Site- II.

There were significant differences in the species composition and relatively abundance between all three sites of Song river. Diversity indices were calculated on the basis of occurrence of macroinvertebrate organisms as Shannon Weiner's Diversity Index (H), Simpson's Diversity Index (D) and Margalfes Index (MgI) (Table 2 and 3). At site I (upstream), the Shannon Weiner's index was recorded in the range of 0.629, 0.721, 0.914, 1.32 and 0.466 for Oligochaeta, Polychaeta, Insecta, Pelecypoda and Gastropoda respectively**.** For the same site, Simpson index was calculated as 0.331, 0.403, 0.482, 0.720 and 0.745 for Oligochaeta, Polychaeta, Insecta, Pelecypoda and Gastropoda respectively (Table 2). According to Shannon Weiner's diversity Index, the maximum diversity was found of Pelecypoda (1.32) and minimum diversity found in Gastropoda (0.466) and Simpson's Index showed maximum (0.745) diversity of Gastropods and minimum shown by Oligochaeta (0.331) at Site I. At Site II (Confluence point), the Shannon Weiner's index

Table 2: Macrobenthic Diversity Indices of Song river

		Site I Upstream		Site II Confluence point		Site III Downstream	
S. No.	**Groups**	**Shannon Weiner's Index (H)**	**Simpson's Index (C)**	**Shannon Weiner Index (H)**	**Simpson's Index (C)**	**Shannon Weiner's Index (H)**	**Simpson's Index (C)**
1.	Oligochaeta	0.629	0.331	0.300	0.135	0.577	0.316
2.	Polychaeta	0.721	0.403	0.723	0.400	0.798	0.447
3.	Insecta	0.914	0.482	0.486	0.425	1.473	0.743
4.	Pelecypoda	1.32	0.720	1.314	0.720	0.602	0.726
5.	Gastropoda	0.466	0.745	1.535	0.768	1.491	0.761

Table 3: Margalef's Index (D) at different sites of river Song

		Site I Upstream	Site II Confluence point	Site III Downstream
S.No.	**Groups**	**Margalef Index (D)**		
1.	Oligochaeta	2.784	2.723	2.586
2.	Polychaeta			
3.	Insecta			
4.	Pelecypoda			
5.	Gastropoda			

was ranged as 0.300, 0.723, 0.486, 1.314 and 1.535 for Oligochaeta, Polychaeta, Insecta, Pelecypoda and Gastropoda respectively. The Simpson index was calculated as 0.135 (Oligochaeta), 0.400 (Polychaeta), 0.425 (Insecta), 0.720 (Pelecypoda), 0.768 (Gastropods). At Site II (Confluence point of Song river), the Shannon Weiner's Index was calculated as maximum (1.535) shown by Gastropods and minimum (0.300) by Oligochaeta. The Simpson's index was recorded maximum (0.768) by Gastropods and minimum (0.135) by Oligochaeta. The decreasing trend of declining benthic species richness was also apparent at Site II, It may be correlated with the degrading water quality along with probably reflecting the pollution gradient.

At sampling Site III (Downstream of Song river), the Shannon Weiner's Diversity Index was calculated as 0.577 (Oligochaeta), 0.798 (Polychaeta), 1.473 (Insecta), 0.602 (Pelecypoda), 1.491 (Gastropods). The Simpson index recorded in the range of 0.316 (Oligochaeta), 0.447 (Polychaeta), 0.743 (Insecta), 0.726 (Polecypoda), 0.761 (Gastropoda) and Shannon Weiner's index showed maximum diversity (1.491) in Gastropoda and minimum diversity (0.577) reported in Oligochaeta at sampling Site III. The Simpson's Index was recorded maximum (0.761) by Gastropods and minimum (0.316) by Oligochaeta.

Margalef's Index (1958) was calculated for the simple ratio between total species and total number of individuals, which is used to compare one community with another. The Margalef's Index was calculated at Site I, II and III for Oligochaeta, Polychaeta, Insecta, Pelecypoda and Gastropoda were found as 2.784 (Upstream), 2.723 (Confluence point) and 2.586 (Downstream) respectively. At Site I, Margalef's index was reported maximum (2.784) and minimum reported at Site III (2.586). It showed that benthic community ratio was higher at Site I compared to Site II and III (Table 3). The present results revealed that Song river water quality is moderately polluted and macro invertibrates diversity also showed moderate variation in distributional pattern of different species occurred at different sampling sites in the river. Ravera (2001) analyzed the similar occurrence of benthic organisms in Ravell stream in North Italy. Kumar and Dobriyal (1993) reported the similar pattern of benthic diversity indices for the Garhwal Himalayan hill streams. It has been proved that higher benthic species diversity is always associated with minimum pollution load in hill stream like Song river.

Table 4: CCMI water quality index of Song river

Sites	WQI value in summer	Quality criteria	WQI value in rainy	Quality criteria	WQI value in winter	Quality criteria	Range
Site I Upstream	52.04	Marginal	42.56	Poor	54.95	Marginal	45-64
Site II Confluence point	23.52	Poor	20.96	Poor	23.56	Poor	0-44
Site III Downstream	48.53	Marginal	53.83	Marginal	49.9	Marginal	45-64

On the basis of CCMI water quality index, the water quality of Song river was categorised as marginal and poor (Table 4). At sampling Site I (Upstream), water quality was recorded almost in the marginal category during winter and summer season. The poor water quality was recorded in the rainy season, it may be due to sudden input of excessive domestic sewage drain and waste dumping into the river. At Site II, poor water quality was recorded during summer, winter and rainy season. It may be due to the discharge of doon distillery effluent. At Site III, the marginal water quality was recorded in all the three seasons that may be due to the self-purification process of water body depending upon the quantitative capacity of water and flowing velocity. Samantray *et al.* (2009) reported the national sanitation foundation water quality index in the Mahanadi and Atharabanki river. Therefore the present investigation revealed that the water quality of Song river is moderately polluted at Site II based on benthic species and their distributional pattern in aquatic ecosystem due to enormous change by polluted organic matter load. It is evident that higher benthic diversity is always associated with minimum pollution stress in running riverine system.

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