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BIOMONITORING OF KULLA BEEL, A FLOOD PLAIN WET-LAND, USING BENTHIC MACRO INVERTABRATES

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Kulia beel, a flood plain wetland, located in Nadia District of West Bengal is surrounded by hospital, industries and human settlements. In the present study the ecological assessment through biomonitoring was done by using benthic macro-invertebrates collected from five sites during pre-monsoon, monsoon and post-monsoon periods. Average Shannon-Weaver diversity index (H) was found to vary from 0.953 at S2 during pre-monsoon to 1.683 at S3 during post-monsoon. The evenness index (1) varied from a maximum average value of 0.998 at site S-4 to a minimum average value of 0.614 at site S-1 during pre-monsoon seasons. Both the indices indicate the water body to be moderately polluted.

INTRODUCTION

Kulia Beel is located between lat. 22°52' N-24°12' N and long. 88°07' E-88° 48' E in Nadia District of West Bengal, India. This beel, known to be the oldest in Nadia district, is formed by the shifting of the river Ganges and is surrounded by different types of industries, hospital and human settlements which directly or indirectly depend on the water for different uses. The rich faunal and floral diversity of beel supports livelihood for large number of population. The hydrography and productivity of beels in India have been studied earlier by Dey (1981), Saha *et al.* (1990), Rana *et al.* (1996) and Singha *et al.* (1997). Benthic macro-invertebrates are animals (organisms) inhabiting the sediment or other available bottom substrates of these beel ecosystems. Such communities respond to changing habits and water quality by alterations in the community structure. The environmental changes alter the macro-invertebrate community structure due to increased organic and inorganic nutrient loading, substrate alteration and toxic chemical pollution. Assessing the impact of pollution generally involves comparing macro-invertebrates community and their physical habitats at sites influenced by pollution with those from unaffected sites. The macro-invertebrates community of Kulia beel was analysed for biomonitoring its water quality as well as to suggest guideline for restoring the ecology and to conserve the water body in a sustainable manner of this valued ecosystem.

MATERIAL AND METHODS

The beel under the study is surrounded by a hospital (Gandhi Memorial Hospital, Govt. of W.B.) at one side, industries of gelatin, fertilizers, khadi, plywood etc. on the other. Besides, the human settlement is scattered along the entire periphery of the water body with residents using the water for washing, bathing and catching fishes. The water body is often contaminated through the discharges of domestic, industrial and hospital wastes. To get the detailed status of water quality, five sampling sites were selected integrating the entire stretch of the beel to one. The water samples and benthic macro-invertebrates were collected fortnightly from five sampling sites during pre-monsoon, monsoon and post-monsoon periods of 2001. The sensitive water parameters like dissolved oxygen (DO), free CO_2 and pH were analysed at the sampling site itself whereas samples for the estimation of ammonium nitrogen (NH_4-N), biological oxygen demand (BOD), chemical oxygen demand (COD) and dissolved organic matter (DOM) were brought to the laboratory for analysis. The standard analytical methods (APHA, 1998) were followed for the estimation of these parameters.

Macrobenthic organisms were collected fortnightly from five selected sites of the beel using Ekman's dredge (area 15.2 x I5.2 cm^2) for biomonitoring the water quality. The samples were sieved immediately through a 40 no sieve (256 mesh/cm^2) and the samples were preserved in 5% formalin. Numerical enumerations were made as per Jhingran *et al.* (1969). The diversity index of benthic fauna was assessed by the Shannon-Weaver index (1964) and calculated as:

$$H = - \sum_{i=1}^{S} Pi \, (\ln Pi)$$

where, Pi is the proportion of individuals belonging to species i and S is the number of species in the community.

The equitability or evenness index (J) (Pie lou, 1966) was calculated as the ratio of

$$\frac{\overline{H}}{\ln S}$$

where, $\overline{H}$ is the observed species diversity and S is the total number of species.

RESULTS AND DISCUSSION

For monitoring the water quality, analysis of biological material along with the chemical characteristics of water forms a more valid method (Cairns and Dickson, 1971). Therefore, along with the benthic macro-invertebrates the important water parameters were analysed and the results were illustrated in Table I. pH fluctuated in the range of

6.87 to 7.75 in the entire period of investigation and a lower average value was recorded during monsoon. Sugunan *et al.* (2000) observed the pH values in the beels of West Bengal ranging from 6.8 to 9.8. Free CO_2 reflected a wide seasonal variations and a higher value were recorded during monsoon and post-monsoon periods. This might be attributed to increase in organic matter brought by rain water. It was less during pre-monsoon, which might be due to enhanced photosynthetic rate and increasing dissolved oxygen level. Free CO_2 was generally high in polluted water bodies (Mishra and Saksena, 1991). Average dissolved oxygen values of 6.64, 6.65 and 6.63 mg/l during pre-monsoon, monsoon and post monsoon, respectively) were comparable in between the seasons. Seasonal fluctuations in the value of DOM ranged from 9.55 to 16.41 mg/l. Higher values were observed during pre-monsoon and monsoon periods which might be due to various industrial wastes along with oxidation of dead flora and fauna. BOD and COD are reliable parameters for judging the extent of pollution in water (Mishra and Saksena, 1991; Singh, 1999). Seasonal fluctuations in BOD ranged from 9.03 to 9.53 mg/l and COD from 27.50 to 34.01 mg/l showing higher value mostly during pre-monsoon. An average BOD of 3-8 mg/l was observed in a domestically polluted tropical water body (Varghese *et al.,* 1992) and the most significant sources of BOD and COD were the industrial effluents (Rao *et al.,* 1999). The fluctuations in NH_4-N content varied between 0.91 to 1.25 mg/l. The frequent oscillation in ammonia content was due to its unstable nature and its ability to convert to other nitrogenous compounds (Trivedi, 1988). Ammonia content of more than 1 mg/l was an indicator of pollution by organic matter (Elis *et al.,* 1946).

Table 1. Variations in physico-chemical characteristics of water during pre-monsoon, monsoon and post-monsoon periods

Parameters	Pre-monsoon	Monsoon	Post-monsoon
pH	7.18	7.06	7.25
	(7.07-7.37)	(6.87-7.22)	(7.05-7.75)
Free CO_2 (mg/l)	16.25	21.65	23.70
	1.25-28.75	1.25-30.75	1.0-34.5
Dissolved oxygen (mg/l)	6.44	6.65	6.63
	(5.20-9.60)	(5.70-7.42)	(3.77-8.82)
DOM (mg/l)	16.41	11.81	9.55
	(9.42-36.25)	(12.00-18.87)	(7.77-14.20)
BOD (mg/l)	9.53	9.18	9.03
	(8.80-10.35)	(7.97-10.62)	(8.10-1O.40)
COD (mg/l)	34.01	30.00	27.50
	(20.02-43.32)	(19.80-41.85)	(13.80-40.17)
NH_4-N (mg/l)	0.91	1.04	1.25
	(0.38-1.19)	(0.61-1.43)	(0.86-1.94)

Values are mean of five sampling sites with ranges in parentheses

Certain living organisms serve the purpose of monitoring the environmental pollution as they are tolerant to adverse environmental conditions and termed as bioindicators (Kumar and Bohra, 1999; Polivanayaa and Sergeyava, 1978; Saksena, 1987; Roy and Dattamunsi, 1993; Kumar 1994, 1998). The nature of substrate and available detritus control the composition and distribution of benthic fauna in an aquatic system. The average total number and average percentage composition of benthic macro-invertebrates (gastropods, oligochaetes and insects) from all the sampling sites have been presented in Table 2. Among the groups gastropods dominate over oligochaetes and insects in all the seasons. Total number of macro-invertebrates per square meter available was more in monsoon season than other seasons. During the present study, the highest average number of benthic fauna reported was 706 nos/m^2 during monsoon and a lowest average number of 655.7/m^2 during post-monsoon. This variation might be due to abundant availability of decaying organic matter during monsoon period (Singh *et al.*, 1998). This result is at par with the reports of Sugunan *et al.* (2000) who reported average density of 90-13,238 nos/m^2 in the beels of West Bengal, Sinha and Jha (1997) with a population range of 220-5414 nos/m^2 in oxbow lakes of Bihar, and Sugunan and Bhattacharya (2000) in the range of 0 to 1763 nos/m^2 in the beels of Assam. The percentage composition reflects that around 65% of the benthic fauna belonged to the gastropod group, whereas other two groups shared more or less equally to about 18% each. The species available were *Belamia* sp., *Pila* sp., *Gyralus* spp. and *Lymnaea* sp. from molluscans, oligochaetes and chironomids.

Table 2. Variations in major benthic macro-invertebrates of Kulia beel

Benthic macro-invertebrates (% in parenthesis)	Pre-monsoon	Monsoon	Post-monsoon
Total (nos/ml)	684.10±389.42	706.00±366.43	655.70±395.92
Gastropoda (no/ml)	465.30±382.69	473.30±346.76	406.40±369.47
	(68.01)	(67.03)	61.97)
Oligochaeta (no/ml)	108.70±57 .15	104.30±59.86	123.40±43.16
	(15.88)	(14.77)	(18.81)
Insecta (no/ml)	110.10±55.49	128.40±60.67	125.90±40.60
	(16.09)	(18.18)	(19.20)

Values are mean±SD of five sampling sites with percentages in parenthesis

The polluted water bodies have been classified into different categories depending on the density of benthic macro-invertebrates as follows (Singh and Sinha, 1993).

Nos of Oligochaetes/m²	Degree of pollution
< 100	Not polluted
100-999	Lightly polluted
1000-5000	Moderately polluted
5000 and above	Heavily polluted

The present study shows average oligochaetes of 104.30±59.86 nos/m² during monsoon to 123.40±43.16 nos/m² during post-monsoon indicating a lightly polluted status of the water body throughout the year. The concept of species diversity is based on the theory that aquatic communities living in a pollution-free habitat are characterized by occurrence of wide variety of species but only by a moderate number of individuals. A change in the biotic community structure resulted less species but greater abundance of selected tolerant ones, indicating onset of an environmental stress. Wilhm and Dorris (1968) gave the value of H>3 as clean water, 1-3 moderately polluted and <1 heavily polluted. Staub *et al.* (1970) suggested another scale of pollution in terms of species diversity which is given below:

Species diversity (H)	Pollution status
3.0-4.5	Slightly pollution
2.0-3.0	Light pollution
1.0-2.0	Moderate pollution
0.0-1.0	Heavily pollution

The average values of species diversity index and species evenness index for all the sites during all the seasons are illustrated in Table 3. Shannon index (H) calculated for macro-invertebrates varies from 0.953 at S2 during pre-monsoon to 1.683 at S3 during post-monsoon which is in agreement with Staub *et al.* (1970) and Wilhm and Dorris (1968) considering the whole water body as moderately polluted. The average equitability or evenness index (J) ranges from 0.614 at S1 during pre-monsoon to 0.998 at S4 during same season is similar to the reports of Kumariah *et al.* (1999), indicating the water body to be moderately polluted. The statistical analysis for total number of macro-invertebrates distribution was insignificant among sites but significant among seasons at 5% level.

Table 3. Species diversity index (H) and Evenness index (J) in benthic macro-invertebrates at five sampling sites

Season	S1		S2		S3		S4		S5	
	H	J	H	J	H	J	H	J	H	J
Pre-monsoon	0.98	0.614	0.953	0.760	1.354	0.963	1.360	0.989	1.574	0.978
Monsoon	1.242	0.692	1.556	0.981	1.417	0.923	1.032	0.939	1.493	0.879
Post-monsoon	1.609	0.898	1.313	0.877	1.683	0.940	1.406	0.940	1.335	0.962

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