Journal Home page : www.jeb.co.in ★ E-mail : editor@jeb.co.in

JEB
Journal of Environmental Biology

ISSN: 0254-8704
CODEN: JEBIDP

Studies on macrobenthic organisms in relation to water parameters at East Calcutta Wetlands

Arnab Basu, Shruti Sengupta, Sudipta Dutta, Atrayee Saha, Prantik Ghosh and Sheela Roy*

Department of Zoology, Vidyasagar College, Bidhannagar Campus, Kolkata -700 091, India

**Corresponding Author email : roysheela77@yahoo.co.in*

Publication Info

Paper received:
28 September 2011

Revised received:
24 May 2012

Re-revised received:
27 August 2012

Accepted:
20 October 2012

Abstract

East Calcutta Wetlands is an internationally important site for natural remediation of domestic sewage and organic waste and their successful recycling into habitat for pisciculture. Macrobenthic fauna is responsible for efficient utilization of sediments and their diversity indicates health of a wetland in accordance to its sediment quality. In the present study, several physico-chemical parameters such as DO (3.03-11.06 ppm), CO_2 (4.02-20.0 ppm), alkalinity (36.83-164.0 ppm), total hardness (100.0-270.00 ppm), TDS (450.0-620 ppm), chloride(142.0- 364.2 ppm), pH (7.3-8.5), water transparency (8.0-54.2 cm), organic contents like organic carbon (1.03-10.9mg g^{-1})were studied. Variation in macrobenthic fauna from the selected fields were also examined by calculating Simpson's dominance index, evenness index (Pielou index), Shannon's diversity index. 12 taxa of mollusk and 1 taxa of annelid were found in the study and *Bellamya* and *Thiara* were the most dominant species which indicated clean water of the pond. The correlation between macrobenthic diversity and physico-chemical parameters were also studied in selected ponds from East Calcutta Wetlands.

Key words

Macrobenthos, Physico-chemical parameters, Diversity Indices, Pisciculture

Introduction

A wetland is an area of land where soil is saturated with moisture either permanently or seasonally. Wetlands are considered the most biological diverse of all ecosystems (Buckton, 2007). Macrobenthic communities play a two-fold role in this aspect: firstly they act as connecting link in the food web and secondly they are used to purify the polluted water. The water, soil characteristics of the water bodies have a strong influence on the diversity of macrobenthos (Hellawell, 1983; Paul and Nandi, 2003)

The use of invertebrates as bio-indicators have been advocated by several researchers (Adakole and Annune, 2003; Edokpayi *et al.,* 2010). Macro-invertebrate organisms form an integral part of aquatic environment. They maintain various levels of interaction between the community and environment. The structure of the benthic macro-invertebrate community provides precise and local information on recent events(Marques *et al.,* 2003). The benthic macrofauna resides on or inside the deposit of bottom soil and feed on debris. They play a vital role in the circulation and recirculation of nutrients in aquatic ecosystem by accelerating the breakdown of decaying organic matter into simpler inorganic forms(Idowu and Ugwnmba, 2005). They also serve as food for a wide range of fishes.

Several studies deal with the relation of the aquatic macrobenthos diversity and water, sediment with physico-chemical status of the aquatic ecosystem.(Wang *et al.,* 2010, Jana and Manna 1995, Quasin *et al.,* 2009, Garg *et al.,* 2009, Edokpayi *et al.,* 2010). Literature reviewing on this aspect showed an inadequate information in the water bodies at East Calcutta wetlands. From this point of view, observations on the macrobenthic diversity in relation to water parameters in the unmanaged and managed ponds at East Calcutta wetlands have been presented in this paper.

Materials and Methods

The area of East Calcutta wetlands (ECW) is a complex of natural and artificial wetlands located at eastern side of Calcutta in West-Bengal. The area is of importance since the macrobenthos occupy the sediments of the water bodies and play an important role as bio-indicators of ecosystem. Three managed ponds (pisciculture is done scientifically) (pond 1, 2 , 3) were selected for the study located at ECW (latitude 22 ^{0}26' 59" N , longitude 88^{o}27' E , alt. 17 m a.s.) and one unmanaged pond (pisciculture is not done scientifically) (pond 4) located nearby at Panchasayar was also selected. The macrobenthic specimens were collected twice monthly (during November to April) using Ekman's dredge. The samples were collected from four corners (area: 1 sq m) of each pond (spot was 2 m away from the edge of the pond). The sediment samples of four stations were sieved through standard sieve (mesh size-0.5mm) by washing with water. The organisms were preserved in 10% formalin.

Macrobenthos organisms were identified upto genus level (Michael,1977; Barnes *et al.,* 1988). Shannon's diversity index (H), Simpson's index of dominance (C), Evenness index were calculated respectively as per methods of Shannon and Weiner (1964), Simpson (1949) and Pielou (1966).

Water samples were collected 30 cm below the surface water twice monthly for six months i.e. from November to April and water parameters like DO, CO_2 , alkalinity, total hardness, chloride, organic carbon were analyzed following the standard methods of APHA (2005). Water temperature was determined with the help of thermometer (range 0º – 60ºC) while pH of water was determined using pH meter (HANNA, model no. HI 98107).

Results and Discussion

Physical and chemical conditions : The average DO content was higher during November to December and lower in March-April (Table 1). The CO_2 content was also low in different culture ponds (pond 1, 2, 3) except in pond 4 where CO_2 content was higher (20 ppm) than other ponds. The water pH varied from 7.4-7.9 always being higher in November. Organic carbon was also higher in November and it decreased during the rest of the sampling period. Transparency was maximum in pond 2 (7.4cm) but in other ponds it was within the permissible limit for pisciculture . Alkalinity and chloride were within the range in all cultured ponds of wetlands.

Organic carbon (1.3-1.6 mg g^{-1}) and organic matter (1.53-3.8mg g^{-1}) of the soil were also within pisciculture permissible limit in all three cultured ponds, but it was higher in pond 4 (8.93 and 15.2 mg g^{-1}). The amount of organic matter increased with the water temperature. Organic carbon was higher in November and then it decreased.

Macrobenthic distribution and community composition : In all the 4 ponds, about 10 taxa of macrobenthic organisms were found. Diversity was higher in pond 3 and 4 (Table 2).Mollusks and annelids were found frequently in all four ponds. But annelids were very few in number. Chironomid larvae were found only in pond 1and pond 3. Among mollusks, *Bellamya* was the most dominant species in each pond. *Thiara* was the second more abundant species followed by *Lymnea*, *Bythinia* and *Lamellidens*. In pond 1, *Bellamya* dominated over the other species (40.8 %) whereas *Lymnea* and *Lamellidens* had lower contribution (1.7% and 1.7% respectively). In pond 2, *Bellamya* (61.62%) was more than total number of species(4.25%). In pond 3, *Bellamya* contributed maximum(66.3%) where as other species contributed only a meager amount (1.7%). In pond 4, almost all species were found to be abundant. But only *Amnicola* contributed minimum number of the total population (1.4 %). The maximum number of individuals were recorded during November in pond 1, November and December in pond 2, February in pond 3; while in pond 4 it was consistent throughout the year (Fig. 1).

Correlation between water and soil parameters with benthos: Table 1 shows the correlation value with macrobenthic organism. All the water and soil parameters showed a positive correlation with macrobenthic species, in pond 1, 2 and 3 but in pond 4 only DO and organic carbon were positively correlated , rest were negatively correlated.

Community structure : The values of Shannon's diversity index (H), evenness index (J), and index of dominance (C) are given in Table 2. The diversity index was more or less similar in three ponds except in pond 4 which was higher. Evenness index was highest in pond 2 followed by pond 4 , pond 1 and pond 3.

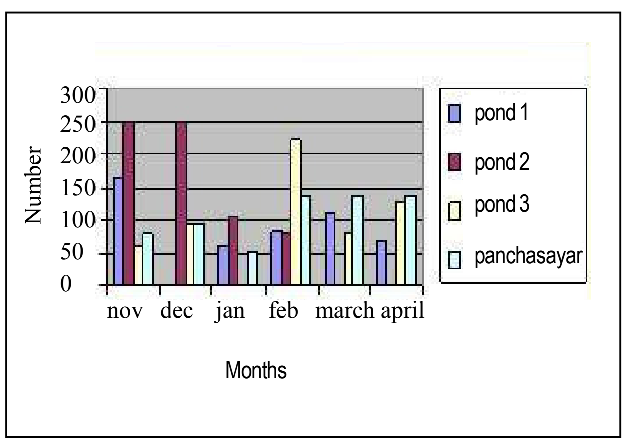

Fig. 1 : Shows month-wise variation of macrobenthos

Table 1 : Physico-chemical characteristics of water and its correlation (r) with macrobenthos organisms of four different ponds during November 2009 to April 2010

Parameters	Nov	Dec	Jan	Feb	Mar	Apr	Mean±S.E.	r
Pond 1								
DO (ppm)	4.2	-	5.1	4.54	11.06	9.65	6.9± 1.16	0.66[a]
Free CO_2 (ppm)	8.0	-	4.0	8.8	6.4	8.0	7.04±0.85	0.47[a]
pH	7.8	-	8.1	7.6	7.4	7.33	7.4±0.14	0.57[a]
TDS (ppm)	450.0	-	530.0	580.0	670.0	510.0	548±36.93	0.64[a]
Total hardness (ppm)	100.0	-	180.0	193.3	264.0	186.6	184.7±26.04	0.42[a]
Total alkalinity (ppm)	132.0	-	124.0	126.6	129.1	144.0	131.16±3.48	0.55[a]
Chloride (ppm)	200.1	-	142.0	202.35	216.5	284.0	208.9±22.68	0.64[a]
Organic carbon (mg g^{-1})	1.56	-	2.5	1.81	1.44	1.03	1.6±0.26	0.65[a]
Transparency (cm)	18.5	-	25.5	14.75	8.5	8.0	15.05±3.27	0.48[a]
Pond 2								
DO (ppm)	4.5	4.25	4.0	3.03	-	-	3.9±0.32	0.67[a]
Free CO_2 (ppm)	7.5	6.0	10.0	11.1	-	-	8.6±1.16	-0.47[a]
pH	8.0	8.1	7.5	7.4	-	-	7.7±0.17	-0.17[a]
TDS (ppm)	660.0	670.0	650.0	620.0	-	-	650±10.801	0.80[b]
Total hardness (ppm)	126.6	153.33	143.3	270.0	-	-	173.3±32.69	0.46[a]
Total alkalinity (ppm)	164.0	100.0	132.0	150.0	-	-	136.5±13.82	-0.38[a]
Chloride (ppm)	165.85	172.17	184.6	166.85	-	-	172.4±4.3	0.75[a]
Organic carbon (mg g^{-1})	1.23	2.1	1.44	2.26	-	-	1.7±0.25	0.35[a]
Transparency (cm)	9.5	7.4	16.9	23.0	-	-	14.2±3.57	0.25[a]
Pond 3								
DO (ppm)	4.5	7.56	-	6.24	5.67	5.3	5.8±0.51	0.44[a]
Free CO_2 (ppm)	10.0	6.4	-	6.6	4.0	10.0	7.4±1.15	0.75[a]
pH	8.3	8.5	-	7.5	7.0	7.62	7.78±0.27	0.72[a]
TDS (ppm)	520.0	460.0	-	250.0	520.0	560.0	462.0±55.35	0.22[a]
Total hardness (ppm)	100.0	163.33	-	190.0	193.33	230.0	175.3±21.62	0.74[a]
Total alkalinity (ppm)	173.2	152.0	-	136.6	106.6	152.0	144.08±11.03	0.73[a]
Chloride (ppm)	173.2	198.8	-	191.7	200.1	237.85	200.1±10.67	0.65[a]
Organic carbon (mg g^{-1})	0.90	1.07	-	1.35	1.67	1.40	1.3±0.13	0.483[a]
Transparency (cm)	24.5	18.2	-	12.5	11.0	10.0	15.24±2.7	0.23[a]
Pond 4 (Unmanaged pond)								
DO (ppm)	3.12	5.67	5.1	6.8	6.2	3.39	5.04±1.04	0.87[b]
Free CO_2 (ppm)	20.0	16.0	10.0	8.0	8.0	6.4	11.14±2.4	0.49[a]
pH	7.9	7.7	7.6	7.7	7.6	7.4	7.6±2.0	0.81[b]
TDS (ppm)	590.0	600.0	660.0	570.0	568.7	790.0	629.6±34.85	-0.27[a]
Total hardness (ppm)	93.33	146.6	166.66	260.0	240.0	243.3	191.6±27.081	0.74[a]
Total alkalinity (ppm)	148.0	120.0	136.0	100.0	144.0	98.0	124.3±36.83	0.71[a]
Chloride (ppm)	301.5	310.0	324.7	344.35	351.23	369.2	333.5±10.2	0.58[a]
Organic carbon (mg g^{-1})	5.68	5.87	6.12	6.32	7.2	8.9	6.7±0.49	0.64[a]
Transparency (cm)	52.8	54.2	51.6	49.1	48.2	47.9	50.63±1.06	-0.64[a]

a = $p < 0.05$; b = $p < 0.01$

Table 2 : Availability of taxa and diversity indices of different ponds during November to April

Sl. No.	Taxa	ni/N	Shannon (H)	Evenness (J)	Simpson (C)
Pond 1					
1.	*Bellamya*	0.428	1.141	0.724	0.306
2.	*Thiara*	0.321			
3.	*Bythinia*	0.036			
4.	*Amnicola*	0.054			
5.	*Lymnea*	0.019			
6.	*Lamellidens*	0.019			
7.	*Chironomid*Larva	0.125			
Pond 2					
1.	*Bellamya*	0.362			
2.	*Thiara*	0.162			
3.	*Bythinia*	0.075			
4.	*Amnicola*	0.025	1.8	0.865	0.202
5.	*Lymnea*	0.112			
6.	*Lamellidens*	0.05			
7.	Campeloma	0.087			
8.	Brotia	0.125			
Pond 3					
1.	*Bellamya*	0.573			
2.	*Thiara*	0.088			
3.	*Bythinia*	0.058			
4.	*Amnicola*	0.015			
5.	*Lymnea*	0.088	1.51	0.656	0.355
6.	*Lamellidens*	0.015			
7.	*Campeloma*	0.015			
8.	*Gyraulus*	0.073			
9.	*Goniobasis*	0.029			
10.	*Chironomid* Larva	0.044			
Pond 4					
1.	*Bellamya*	0.266			
2.	*Thiara*	0.226			
3.	*Bythinia*	0.04			
4.	*Amnicola*	0.013			
5.	*Lymnea*	0.066			
6.	*Lamellidens*	0.16	2.03	0.846	0.164
7.	*Pila*	0.04			
8.	*Vivipara*	0.053			
9.	*Goniobasis*	0.066			
10.	*Brotia*	0.026			
11.	*Planorbis*	0.04			

The abiotic factors of a pond ecosystem had significant role because of their functional role in the tropic dynamics. The water parameters were correlated with the production of benthic fauna (Sharma and Chowdhury, 2011; Carlisle *et al.,* 2007). The DO level of water could be used as an indicator to assess the water quality (Ghosh *et al.,* 2008). The chemical status of the soil seemed to influence the production of bottom fauna (Quasin *et al.,* 2009). The abundance of vegetation and aquatic plants of pond 2 and also in pond 4 supported the availability of more organic matter in these ponds.

The macrobenthic fauna was important for enhancing the aquatic resources and also play an important role in food chain and biological purification of water (Quasin *et al.,* 2009). Differences in macrobenthic diversity observed in pond 1 may probably be due to total drying up of pond during December for the purpose of culture. Pond 2 was dried in March and April. So, a gradual decrease of the population was observed from November to February. Pond 3 was drained out of water in January but it was not totally dry. Some amount of water retained at the pond bottom. So the maximum number of species was found in February. In pond 4, water was retained throughout the year. In all these ponds only mollusks were found. A very small amount of Chironomid larvae were present in pond 1 and 2. Drying up the bottom killed the bottom fauna especially the insect larvae, nymphs and oligochaetes which were not capable of moving down with the reducing level of water. The mollusks were able to overcome such conditions to some extent (Quasin *et al.,* 2009). Gastropoda and Pelecypoda were the most diverse dominant benthic fauna in four ponds (Mackie, 2004). In ponds 1, 2 and 3 *Bellamya* was the dominant species indicating unpolluted water (Quasin *et al.,* 2009).

The mollusks can be regarded as a bio-indicator species of fresh water. Availability of different species of mollusks only indicated the good cultural condition of these ponds (Choubisa, 1992; Sharma and Chowdhury, 2011). These three ponds were used as cultural ponds where local people cultured the several species of fishes. No signs of *Tubifex* species indicated that there was no pollution of water. All the water parameters were positively correlated with macrobenthic fauna found per square meter. Especially the DO and organic carbon were strongly correlated ($p < 0.05$) with macrobenthic fauna. These two parameters were most important in pisciculture. In contrast, in pond 4 even though DO and organic carbon were positively correlated with benthic fauna but all other water parameters exhibited negative correlation. So it was concluded that pond 4 was not scientifically prepared for pisciculture but the water quality was suitable for fish culture.

Acknowledgments

We are grateful to Mrs. Indrani Sarkar, Assistant Professor, Vidyasagar College and Sukanta Nayak, Lab attendant of P.G section of Zoology of Vidyasagar College for helping us during this project.

References

Adakole, J.A. and P.A. Annune: Benthic macroinvertebrates as indicators of environmental quality of an Urban stream, Zaria, Northern Nigeria. *J.Aquat. Sci.,* **18**, 85-92 (2003).

APHA: Standard methods for the examination of water and waste water. 21st Edn., APHA, AWWA, WPCF, Washington, D.C., USA (2005).

Barnes, R.S.K., P. Calow and P.J.W. Olive: The invertebrates: A new synthesis. Blackwell Scientific publications, Oxford, pp. 582 (1988).

Buckton, S.: Managing wetlands for sustainable livelihoods at Koshi Tappu. Danphe., **16**, 12-13 (2007).

Carlisle, D.M. , M.R. Meador, S.R. Moulton and P.M. Ruhi: Estimation and application of indicator values for common macro-invertebrates. *Ecol. Indicators,* **7**, 22-33 (2007).

Choubisa, S.L.: Mollusks as bio-indicators for the trophic stages lakes and lotic environments. *Bull. Pure. Appl. Sci.,* **11**, 35-40 (1992).

Edokpayi, C., A. Aveez, O. Olowoporoku and E. Uwadiae: The hydrochemistry and macrobenthic fauna characteristics of an urban draining creek. *Inter. J. Biodiver. Conser.,* **2**, 196-203 (2010).

Garg, R.K., R.J. Rao and D.N. Saksena. Correlation of molluscan diversity with physico-chemical characteristics of water of Ramsagar reservoir, India. *Int. J. Biodiver. Conserv.,* **1**, 202-207 (2009)

Ghosh, D., A. Deb, R. Sengupta, S. Mitra, S. Roy, M. Das, K. Sadhukhan, and S. Dutta: Radiological physio-chemical and biological analysis of water quality of river Ganga in relation to pollution. ESAIJ, **3**, 304-311 (2008).

Hellawell, M.: "Biological indicators of freshwater pollution and environmental management." Elsevier. Applied science, London and New York, (1983).

Idowu, E.O. and A.A.A. Ugwumba: Physical, chemical and benthic faunal characteristics of a southern Nigeria reservoir. *The Zoologist,* **3**, 15-25 (2005).

Jana, B.B and A.K. Manna: Seasonal changes of benthic invertebrates in two tropical fish pond. *J. Freshwater Biol.,* **7**, 129-136 (1995).

Mackie, G.I.: Applied aquatic ecosystem concepts. 2nd Edn., Kendall Hunt Publishing Co., Dubuque, IA, USA (2004).

Marques, M.J., E. Martinez-Conde and J.V. Rovira. Effects of zinc and lead mining in the benthic macroinvertebrate fauna of a fluvial ecosystem. *Wat. Air Soil Poll.,* **148**, 363-388 (2003).

Michael, Q.: Invertebrates of streams and rivers. A key to identification. Edward Arnold Publishers Ltd., London, p. 84 (1977).

Paul, S. and N.C. Nandi: Studies on intertidal macrobenthos of Hugli river in and around Calcutta in relation to water and soil conditions. Rec. Zool. Surv. India Occ. Paper No. 213, pp. 1-135 (2003).

Pielou, E.C.: The measurement of diversity in different types of biological collections. *J. Theor. Biol.,* **13**, 131-144 (1966).

Quasin, S., K. Ganguly, S. Roy and A. Nath: Diversity of macro-benthic fauna of two freshwater pisciculture ponds of west-Bengal. *Environ. Ecol.,* **27**, 1017-1021 (2009)

Shannon, F. and W. Weiner: The mathematical theory of communications Univ. Illinois Press, Urbana (1964).

Sharma, K.K. and S. Chowdhury: Macro-invertebrate assemblages as biological indicators of pollution in a Central Himalayan River, Tawi (J and K). *Int. J. Biodivers. Conserv.,* **3**, 167-174 (2011).

Simpson, E.H. Measurement of diversity. *Nature,* **16**, 688 (1949).

Wang, Chang-Fu, Xian-Qiu Ren, and Run-Lin Xu: Composition, abundance and diversity of the Peracarida on different vegetation types in the Qi'ao–Dan'gan Island Mangrove Nature Reserve on Qi'ao Island in the Pearl River Estuary, China. *Zool. Stud.,* **49**, 608-615 (2010).