UTTAR PRADESH JOURNAL OF ZOOLOGY

42(19): 59-68, 2021
ISSN: 0256-971X (P)

A STUDY ON THE IMPACT OF BRICK EMBANKMENT ON AQUATIC ENTOMOFAUNA

PRITI RANJAN PAHARI[1], GOPAL CHANDRA JANA[1], SUDIPTA MANDAL[1], SUBHADEEP MAITI[1*] AND TANMAY BHATTACHARYA[2]

[1]PG Department of Zoology, Tamralipta Mahavidyalaya, Tamluk, 721636, West Bengal, India.
[2]Department of Zoology, Vidyasagar University, Midnapore, 721102, West Bengal, India.

AUTHORS' CONTRIBUTIONS

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

Editor(s):
(1) Dr. Luis Enrique Ibarra Morales, State University of Sonora, Mexico.
Reviewers:
(1) Muhammad Yusuf, Cokroaminoto University of Makassar, Indonesia.
(2) Belvi Vatria, The State Polytechnic of Pontianak, Indonesia.
(3) Amir Husni, Universitas Gadjah Mada, Indonesia.

Received: 05 July 2021
Accepted: 10 September 2021
Published: 15 September 2021

Original Research Article

ABSTRACT

Shrinkage of the littoral zone due to brick embankment around a pond caused an adverse effect on the floral & faunal composition. A brick embanked pond (BEP) had lower number of macrophytes and entomofauna as compared to a natural pond (NP). Index of similarity suggests that both the ponds were strongly dissimilar in their floral and entomofaunal composition. Hemiptera was the most predominating insect order (96.73%) in BEP while Odonata (41.14%) and Coleoptera (39.02%) were the common orders in NP. Lower diversity, equitability, signal, ASPT, BMWP indices/scores and higher dominance & FBI indices in BEP as compared to NP indicates that BEP provided a less equitable habitat with poor quality of water for the existence of lower diversity of entomofauna.

Keywords: Anthropogenic impact; aquatic insects; biodiversity indices; biomonitoring.

1. INTRODUCTION

Aquatic insects constitute an essential integral part of the lentic system. Through the analysis of their community structure the status and health of the ecosystem can be analyzed. These may serve as bioindicators and are useful tools in determining the habitat quality [1,2]. In last two decades ecological aspects of aquatic insects have been studied in India by Jana et al. [3], Das and Gupta [4], Hazarika and Goswami [5], Sharma and Agarwal [6], Barman and Baruah [7], Gupta and Narzary [8], Majumder et al. [9], Vasantkumar and Roopa [10], Barman and Gupta [11], Chowdhury and Gupta [12,13], Dalal and Gupta [14], Pahari et al. [15,16], Jana et al. [17] and Arumugam and Athikesavan [18]. In recent years construction of brick embankment surrounding water bodies has become a common practice for

**Corresponding author: Email: subhadeepmaiti1994@gmail.com;*

beautification and human use purposes. This results into a shrinkage of the littoral zone and makes the pond unsuitable for macrophyte growth. Since aquatic insects are susceptible to habitat alteration, their diversity is also likely to be adversely affected. In the present investigation insect fauna of two ponds, a normal pond without embankment (NP) and a pond with brick embankment (BEP) were compared with reference to their numerical abundance and relative abundance as well as using some biomonitoring indices. The objective of the investigation was to find if embankment of pond causes any significant adverse impact on the density and diversity of aquatic insect fauna.

2. MATERIALS AND METHODS

The present study was carried out in a natural pond [NP (22°18'02.7"N, 87°54'29.3"E)] with an area of 5,411.14 m² and a pond with brick embankment surrounding it [BEP (22°17'48.6"N, 87°55'31.9"E)] having an area of 4,288.35 m². Both the ponds are located in Tamluk municipality area in Purba Medinipur District, West Bengal within an aerial distance of 1880 mt (Fig. 1) and are used only for domestic purposes such as bathing, washing etc. Macrophytes of the ponds were identified following Bhunia and Mondal [19] and Das [20]. Insects were collected at monthly intervals between 8 to 11 am from July 2019 to June 2020 by hauling a hand net with a mesh size of 245 µm. Area of the circular net was 4208.0 cm^2. Samples were taken from four sites at four corners of the respective ponds. Specimens were identified, counted and released in ponds except for a few which were preserved in 4% formaldehyde and stored for further confirmation of identification.

Similarity or otherwise of flora and fauna was estimated by Sørensen index [21]. Dominance status of insect species was calculated on the basis of the relative abundance of each species following Engelmann [22]. Various community indices like species diversity [23], equitability [24] and dominance [25] were calculated using Past, Version 3.0. Common biomonitoring methods like Family level Biotic Index (FBI) of Hilsenhoff [26], Biological Monitoring Working Party (BMWP) and Average Score Per Taxa (ASPT) scores of Write et al. [27] and SIGNAL index [28] were also estimated.

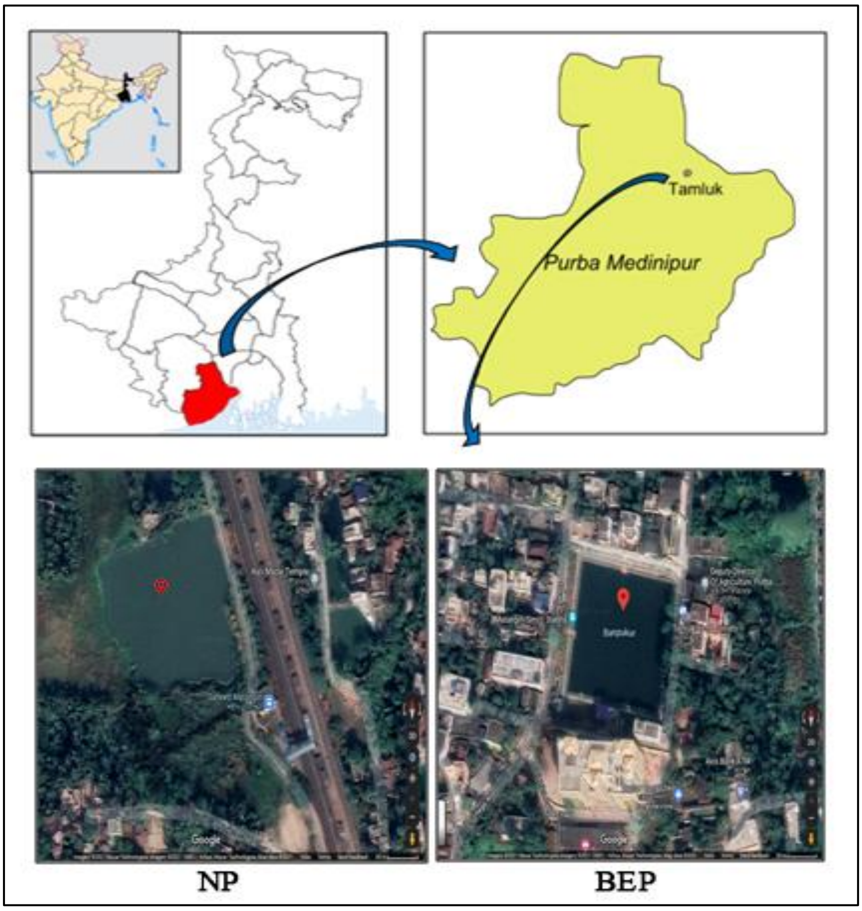

Fig. 1. Location and image of study sites, natural pond (NP) and brick embanked pond (BEP)

3. RESULT AND DISCUSSION

NP had a lush growth of vegetation with 16 species of macrophytes as compared to BEP which had only 3 species of which only 2 species were common to both the sites (Table 1). Index of similarity was only 0.22, as such both the ponds might be considered strongly dissimilar in floral composition. Macrophytes provide excellent diverse niche for aquatic insects [16,29]. Moreover, the land water ecotone, the littoral zone, being structurally complex also helped in the coexistence of large number of insect species by way of niche partitioning [30-32]. This is clearly reflected in the findings of the present study (Table 2) which shows that NP harboured 30 species under 23 genera, 13 families and 5 orders of insect as compared to 16 species under 10 genera, 9 families and 3 orders in BEP which had scant hydrophytes and an extremely impaired littoral zone. Of the 46 species recorded only 6 were found in both the ponds. Similarity index based on insect species (0.26) also made both the ponds strongly dissimilar. Of the three orders in BEP Hemiptera alone comprised 96.73% of the insects collected (Fig. 2). In NP Odonata and Coleoptera were the main orders constituting 41.14% and 39.02% of the total insects respectively. Preponderance of Hemiptera has also been earlier reported by Hazarika and Goswami [5], Choudhury and Gupta [12] in Assam, Takhelmayum and Gupta [33] in Manipur, Majumder et al. [9] in Tripura and Pahari et al. [16] in West Bengal. However, dominance of Odonata & Coleoptera as in NP has also been shown by Jana et al. [3] and Majumder et al. [9] in West Bengal and Tripura. Wilson [34] opined that severe reduction of macrophytes reduces density and diversity of odonates as it happened in BEP. Since littoral macrophytes are directly related to the abundance of odonates [35], these were the most predominating insects in NP in the present study. At family level it is seen that (Figure 3) Dytiscidae (30.32%) was the most predominating family followed by Libellulidae (24.07%) in NP whereas, Belostomatidae (0.79%) was the least common family. In BEP, on the contrary, Veliidae (45.33%) was the most predominating family followed by Notonectidae (22.32%) and Dytiscidae (0.35%) was the least abundant family. Seven families recorded in NP were absent in BEP and 3 families of BEP were absent in NP. Mostly hemipteran families like Corixidae, Gerridae, Veliidae, Mesoveliidae and Pleidae which do not require macrophytic vegetation and prefer limnetic zone for their existance [36,37] were mostly found in BEP. Similarly Nepidae, Belostomatidae, Dytiscidae and Hydrophilidae which need shallow littoral zone with macrophytes [3,38] were found only in NP. Turning to the species wise analysis (Table 3) it is seen that not only NP had more species as compared to BEP but their relative abundance also varied between the two ponds. In NP *Canthydrus luctuosus* (Coleoptera) and *Pantala flavescens* (Odonata) were the two most numerically abundant species. However, none of the 30 species was exclusively dominant and 14 species were subdominant in NP. Whereas in BEP *Microvelia diluta* (Hemiptera) was not only the most abundant species but was the eudominant species. Next in numerical abundance was another hemipteran species, *Anisops bouveri* which was dominant. Of the remaining 14 species 5 were subdominants (Table 4). Such findings clearly indicate that species abundance, relative abundance and dominance status changed in pond which was embanked in comparison to that which was not embanked and had a distinct littoral zone. Similar changes in number, relative abundance and dominance index due to human alteration of habitat have also been reported by earlier investigators [39,40].

Table 1. Macrophytes in NP and BEP

Sl. No.	Species	NP	BEP
1	*Nymphoides indica*	+	-
2	*Hydrilla verticulata*	+	+
3	*Eichornia carassipes*	+	-
4	*Marsilea minuta*	+	-
5	*Ceratophyllum demersum*	+	-
6	*Pistia stratiotes*	+	-
7	*Ipomoea aquatica*	+	-
8	*Enhydra fluctuans*	+	-
9	*Wolfia arrhiza*	-	+
10	*Alternanthera philoxeroydes*	+	-
11	*Salvinia molesta*	+	-
12	*Hygrophila auriculata*	+	-
13	*Lemna minor*	+	+
14	*Peltandra sagittifolia*	+	-
15	*Typha angustifolia*	+	-
16	*Limnophila indica*	+	-
17	*Schoenoplectus macronatus*	+	-
Total		**16**	**3**
Sørensen Similarity Index 0.22			

The afore mentioned contention may further be asserted through the findings involving various biomonitoring indices (Table 5). Diversity, equitability, SIGNAL, BMWP & ASPT indices/scores were higher and dominance and FBI indices were lower in NP than in BEP. Species diversity index tends to be low in simple, harsh, impaired and less stable ecosystem [3,41]. Similarly, higher dominance and lower equitability indices are indicative of increasing harshness and decreasing vegetational growth [3,20,41,42]. Shannon index exceeding 3, as in NP suggests that the water body is relatively unimpaired [43]. FBI scores also indicate that NP offers a fair and BEP offfers a poor quality of water habitat as suggested by Hilsenhoff [26]. Likewise higher ASPT and BMWP scores and SIGNAL index in NP as compared to those of BEP are indicative of good ecological potential and relatively better quality of water and that habitat was more compitable and stable in NP in comparison to BEP as per scales of Write et al. [27], Chessman [28] and Kazanci et al. [44].

Table 2. Aquatic insects in NP and BEP

Sl. No.	Species	NP	BEP
Order: Hemiptera			
Family: Nepidae			
1	*Laccotrephes griseus* (Gúerin-Méneville, 1844)	+	-
2	*Ranatra filiformis* Fabricius, 1790	+	-
3	*Ranatra sordidula* Dohra,1860	+	-
Family: Notonectidae			
4	*Anisops bouveri* Kirkaldy,1904	+	+
5	*Anisops barbatus* Brooks 1951	-	+
6	*Anisops breddini* Kirkaldy, 1901	-	+
Family: Corixidae			
7	*Corixa punctata* (Illiger, 1807)	+	-
8	*Micronecta scutellaris* (Stal, 1858)	+	+
9	*Micronecta haliploides* Horvath, 1904	-	+
Family: Belostomatidae			
10	*Diplonychus rusticus* (Fabricius, 1775)	+	-
Family: Gerridae			
11	*Neogerris parvula* (Mary, 1865)	-	+
12	*Limnogonus fossorum* (Fabricius, 1775)	-	+
13	*Limnogonus nitidus* (Mary, 1865)	-	+
Family: Veliidae			
14	*Microvelia diluta* Distant, 1906	-	+
15	*Microvelia leveillei* (Lethierry, 1877)	-	+
Family: Mesoveliidae			
16	*Mesovelia vittigera* Horvath, 1895	-	+
Family: Pleidae			
17	*Paraplea frontalis* (Fieber, 1844)	+	+
18	*Paraplea liturata* (Fieber,1844)	-	+
Order: Coleoptera			
Family: Dytiscidae			
19	*Hydrocoptus subvittulus* (Motschulsky, 1859)	+	-
20	*Laccophilus parvulus* Aube,1838	+	-
21	*Laccophilus anticatus* Sharp,1890	+	-
22	*Canthydrus luctuosus* (Aube, 1838)	+	+
23	*Canthydrus laetabilis* (Walker, 1858)	+	-
24	*Cybister tripunctatus* (Olivier, 1795)	+	-
25	*Hydrovatus bonovouloiri* Sharp,1882	+	-
Family: Hydrophilidae			
26	*Helochares anchoralis* Sharp, 1890	+	-
27	*Sternolophus rufipes* (Fabricius ,1792)	+	-
Order: Ephimeroptera			
Family: Baetidae			
28	*Cloeon bicolour* Kimmins, 1947	+	-
Order: Odonata			
Family: Ashenidae			
29	*Anaciaeschna jaspidae* (Burmeister, 1839)	+	-
Family: Gomphidae			

Sl. No.	Species	NP	BEP
30	*Ictinogomphus rapax* (Rambur, 1842)	+	-
Family: Libellulidae			
31	*Crocothemis servilla* (Drury, 1770)	+	-
32	*Brachythemis contaminate* (Fabricius, 1793)	+	-
33	*Orthetrum sabina* (Drury, 1770)	+	+
34	*Pantala flavescens* (Fabricius, 1798)	+	-
35	*Tholymis tillarga* (Fabricius, 1798)	+	-
36	*Diplacodes nebulosa* (Fabricius, 1793)	+	-
Family: Coenagrionidae			
37	*Ceriagrion coromandelianum* Fabricius, 1798	+	+
38	*Ischnura senegalensis* (Rambur, 1842)	+	-
39	*Agriocnemis pygmaea* (Rambur, 1842)	+	-
Order: Diptera			
Family: Chironomidae			
40	*Chironomus striatipennis* (Kieffer, 1910)	+	-
Total		**30**	**16**
Sørensen Similarity Index 0.26			

[Similarity Index <0.3 = strongly dissimilar, 0.3 - 0.4 = moderately dissimilar, 0.4 - 0.5 = slightly dissimilar, 0.5 - 0.6 = slightly similar, 0.6 - 0.7 = moderately similar and >0.7 = strongly similar]

Table 3. Relative abundance (RA) of aquatic insects in NP.

Sl. No.	Species	No. of Individual	Relative Abundance (%)	Dominance Status
Order: Hemiptera				
Family: Nepidae				
1	*Laccotrephes griseus*	7	0.31	SR
2	*Ranatra filiformis*	12	0.53	SR
3	*Ranatra sordidula*	6	0.26	SR
Family: Notonectidae				
4	*Anisops bouveri*	63	2.77	R
Family: Corixidae				
5	*Corixa punctata*	15	0.66	SR
6	*Micronecta scutellaris*	11	0.48	SR
Family: Belostomatidae				
7	*Diplonychus rusticus*	18	0.79	SR
Family: Pleidae				
8	*Paraplea frontalis*	89	3.92	SD
Order: Coleoptera				
Family: Dytiscidae				
9	*Hydrocoptus subvittulus*	108	4.75	SD
10	*Laccophilus parvulus*	79	3.48	SD
11	*Laccophilus anticatus*	53	2.33	R
12	*Canthydrus locustus*	167	7.35	SD
13	*Canthydrus laetabilis*	131	5.76	SD
14	*Sybister tripunctatus*	67	2.95	R
15	*Hydrovatus bonovouloiri*	84	3.70	SD
Family: Hydrophilidae				
16	*Helochares anchoralis*	102	4.49	SD
17	*Stenolophus rufipes*	96	4.22	SD
Order: Ephimeroptera				
Family: Baetidae				

Sl. No.	Species	No. of Individual	Relative Abundance (%)	Dominance Status
18	*Cloeon bicolour*	163	7.17	SD
Order: Odonata				
Family: Ashenidae				
19	*Anaciaeschna jaspidae*	126	5.54	SD
Family: Gomphidae				
20	*Ictinogomphus rapax*	119	5.24	SD
Family: Libellulidae				
21	*Crocothemis servilla*	137	6.03	SD
22	*Brachythemis contaminata*	66	2.90	R
23	*Orthetrum sabina*	57	2.51	R
24	*Pantala flavescens*	167	7.35	SD
25	*Tholymis tillarga*	72	3.17	R
26	*Diplacodes nebulosa*	48	2.11	R
Family: Coenagrionidae				
27	*Ceriagrion coromandelianum*	73	3.21	SD
28	*Ischnura senegalensis*	31	1.36	R
29	*Agriocnemis pygmaea*	39	1.72	R
Order: Diptera				
Family: Chironomidae				
30	*Chironomus striatipennis*	67	2.95	R
Total = 2273				

Table 4. Relative abundance (RA) of aquatic insects in BEP

Sl. No.	Species	No. of Individual	Relative Abundance (%)	Dominance Status
Order: Hemiptera				
Family: Notonectidae				
1	*Anisops bouveri*	171	19.98	D
2	*Anisops barbatus*	9	1.05	R
3	*Anisops breddini*	11	1.29	R
Family: Corixidae				
4	*Micronecta scutellaris*	39	4.56	SD
5	*Micronecta haliploides*	14	1.64	R
Family: Gerridae				
6	*Neogerris parvula*	67	7.83	SD
7	*Limnogonus fossorum*	27	3.15	R
8	*Limnogonus nitidus*	19	2.22	R
Family: Veliidae				
9	*Microvelia diluta*	346	40.42	ED
10	*Microvelia leveillei*	42	4.91	SD
Family: Mesovellidae				
11	*Mesovelia vittigera*	44	5.14	SD
Family: Pleidae				
12	*Paraplea frontalis*	32	3.74	SD
13	*Paraplea liturata*	*7*	0.82	SR
Order: Coleoptera				
Family: Dytiscidae				
14	*Canthydrus locustus*	3	0.35	SR
Order: Odonata				

Family: Libellulidae				
15	*Orthetrum sabina*	4	0.47	SR
Family: Coenagrionidae				
16	*Ceriagrion coromandelianum*	21	2.45	R
Total = 856				

RA <1= subrecedent (SR), 1-3.1= recedent (R), 3.2-10= subdominant (SD), 10.1-31.6= dominant (D), >31.7 = eudominant (ED) [22]

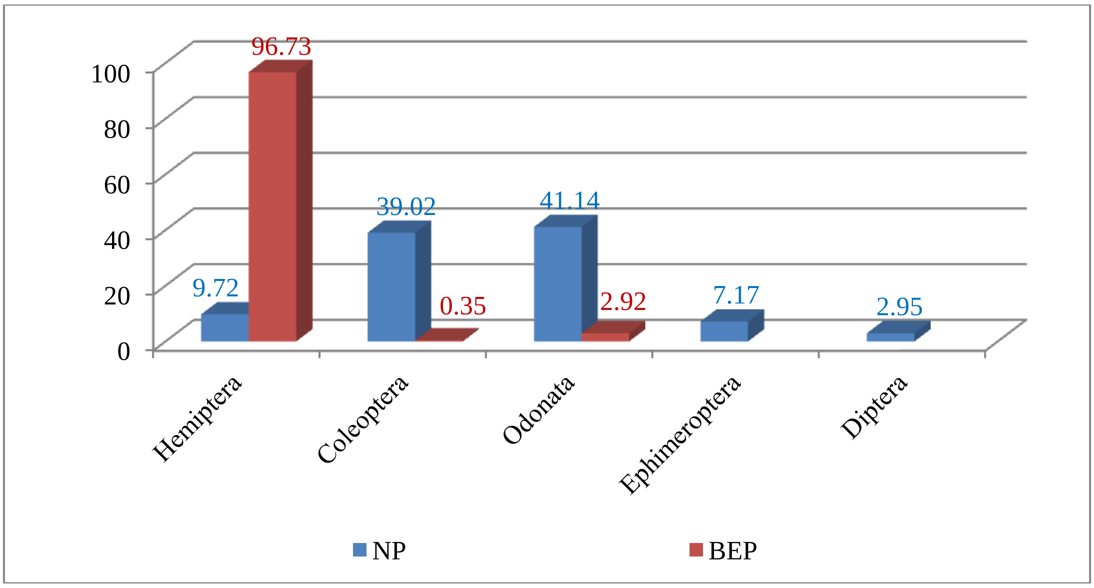

Fig. 2. Relative abundance (%) of insect orders in NP and BEP

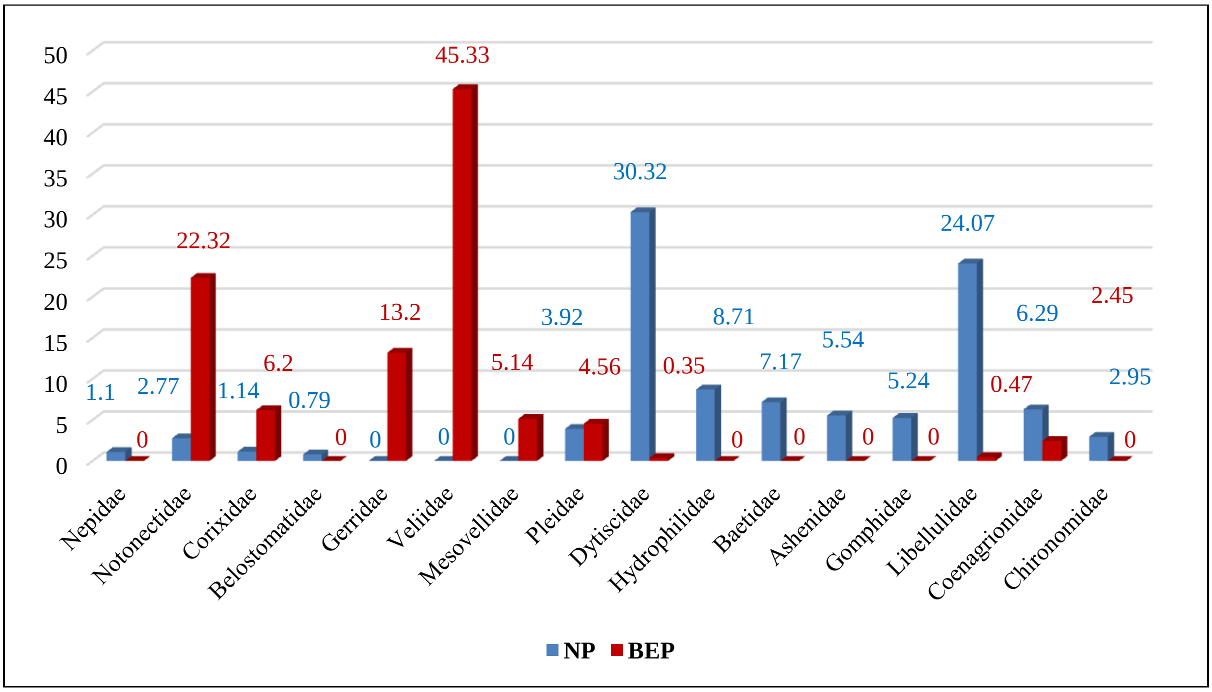

Fig. 3. Relative abundance (%) of insect families in NP and BEP

Table 5. Comparison of the biomonitoring indices/scores of NP and BEP

Indices/Scores		NP	BEP
Diversity index	Value	3.18	1.99
	Remark	Clean water	Moderate pollution
Dominance index	Value	0.05	0.22
	Remark	Very low	Low
Equitability index	Value	0.94	0.72
	Remark	High	Moderate
FBI index	Value	5.65	6.97
	Remark	Fair water quality	Poor water quality
BMWP score	Value	46	26
	Remark	Moderate water quality	Poor water quality
ASPT score	Value	5.68	3.53
	Remark	Good quality water	Poor quality water
SIGNAL index	Value	4.17	2.69
	Remark	Moderate pollution	Severe pollution

Diversity index: >3= Clean water; 1 -3= Moderate pollution; <1= Strong pollution [43].

FBI index: 0.00 - 3.75= Excellent water quality; 3.76 – 425= Very good water quality; 4.26 -5= Good water quality; 5.01 -5.75 = Fair water quality; 5.76 -6.50 = Fairly poor water quality; 6.51 -7.25= poor water quality, 7.26 -10 = Very poor water quality [26].

BMWP score: 0-10= very poor water quality; 11-40=Poor water quality; 41-70=Moderate water quality; 71-100=Good water quality; >100=Very good water quality [44].

ASPT score: >6.5= very good quality water, 5.6-6.4= Good quality water, 4.6-5.5 = Above average quality water, 3.6-4.5= Average quality water, 2.6-3.5= Poor quality water, <2.5 = Very poor quality water [27].

SIGNAL index: > 6= Clean water; 5-6= Mild pollution; 4-5=Moderate pollution; < 4=Severe pollution [28].

4. CONCLUSION

As such it may be concluded that embankment of pond resulted in a deterioration of the quality of that pond by way of the elimination of the littoral zone and macrophytes. This caused a detrimental effect on the density and diversity of the aquatic insect fauna which was reflected in various diversity and biomonitoring indices/scores. Such adverse impact on the insect diversity of pond can also negetively effect the fish farming and aquaculture.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Choudhury D, Gupta S. Rapid assessment of water quality of deepor beel (ramsar site), north east india using aquatic insects. International Journal of Ecology and Environmental Sciences. 2017;43 (1):35-46.
2. Marwein I, Gupta S. Aquatic Insects as Indicator of Water Quality : A Study on a Small Stream of Shillong, Meghalaya, North-east India. Indian Journal of Ecology. 2018;45(3):511-517.
3. Jana S, Pahari PR, Dutta T, Bhattacharya T. Diversity and community structure of aquatic insects in a pond in Midnapore town, West Bengal, India. Journal of Environmental Biology. 2009;30:283-287.
4. Das K, Gupta S. Aquatic hemiptera community of agricultural fields and rain pools in Cachar District, Assam, North East India. Assam University Journal of Science & Technology:Biol. Sci. 2010;5:123–128.
5. Hazarika R, Goswami M. Aquatic hemiptera of Gauhati University, Guwahati, Assam, India. Journal of Threatened Taxa. 2010;2:778-782. DOI:10.11609/JoTT.o2315.778-82.
6. Sharma R, Agrawal N. Faunal diversity of aquatic insects in Surha Tal of District -Ballia (U. P.), India. Journal of Applied and Natural Science. 2012;4(1):60–64.

7. Barman A, Baruah BK. Aquatic insects of Kapla Beel, a flood plain wetland of Barpeta District of Assam, India. The Clarion-International Multidisciplinary Journal. 2013;2:27–31.
8. Gupta S, Narzary R. Aquatic insect community of lake, Phulbari anua of Cachar, Assam. J. Environ. Biol. 2013;34:591–597.
9. Majumder J, Das RK, Majumder P, Ghosh D, Agarwala BK. Aquatic insect fauna and diversity in urban freshwater lakes of Tri. Middle-East Journal of Scientific Research. 2013;13:25–32. DOI:https://doi.org/10.5829/idosi.mejsr.2013.13.1.66123
10. Vasantkumar B, Roopa SV. Physico-chemical and aquatic insects diversity of pond ecosystem in Karwar, India. Int. J. of Life Sciences. 2014;2(2):148-154.
11. Barman B, Gupta S. Aquatic insects as bio-indicator of water quality- A study on Bakuamari stream, Chakras hila Wildlife Sanctuary, Assam, North East India. Journal of Entomology and Zoology Studies. 2015;3(3):178–186.
12. Choudhury D, Gupta S. Aquatic insect community of Deepor beel (Ramsar site), Assam, India. J Entomol. Zool. Stud. 2015;3(1):182-192.
13. Choudhury D, Gupta S. Impact of waste dump on surface water quality and aquatic insect diversity of Deepor Beel (Ramsar site), Assam, North-east India. Environ Monit Assess. 2017;189:540- 556.
14. Dalal A, Gupta S. A comparative study of the aquatic insect diversity of two ponds located in Cachar District, Assam, India. Turkish Journal of Zoology. 2016;40:392-401. DOI:10.3906/zoo-1505-18
15. Pahari PR, Pusti P, Dutta TK, Mandal B, Bhattacharya T. Diversity and community structure of aquatic insects in a fresh water lentic system of Purba Medinipur District, WB, India. Indian Journal of Biology. 2016;3:145–150. DOI:http:/ / dx.doi.org/ 10.21088/ ijb.2394.1391.3216.9
16. Pahari PR, Dey M, Mishra NP, Bhattacharya T. Aquatic Insects (Hemiptera) diversity in floating and emergent macrophytes in Garhbeta, West Bengal (India). Int. J. Env. Tech. Sci. 2018;6:228–232.
17. Jana PK, Mallick PH, Bhattacharya T. A study on the community structure of damselflies (Insecta:Odonata:Zygoptera) in Paschim Medinipur, West Bengal, India. Journal of Threatened Taxa. 2021;13:18809–18816. DOI:https://doi.org/10.11609/jott.6683.13.7.18809-18816.
18. Arumugam S, Athikesavan S. Diversity and distribution of aquatic insects in pond ecosystem in Cheyyar, Thiruvannamalai District of Tamil Nadu, India. Uttar Pradesh Journal of Zoology. 2021;42(9):10-15.
19. Bhunia D, Mondal AK. The exploration of aquatic wetland plants of Paschim Midnapur district of West Bengal. Ecol. Environ. 2009;27:64-70.
20. Das NR. Introduction to aquatic and semi aquatic plant of India. Kalyani Publishers, New Delhi, India. 2013;335p.
21. Sørensen T. A method of establishing groups of equal amplitudes in plant sociology based on similarity of species content and its application to analyses of the vegetation on danish commons. Kongelige Danske Videnskabernes Selskab, Biologiske Skrifter. 1948;5:1-34.
22. Engelmann HD. Untersuchungen zur Erfassung Predozoogener Komponenten im Definierten, Okosystem. Forschungsergebnisse Staatliche Museum Naturkunde, Gorlitz. Journal of Acta Hydrobiologica. 1973;23(4):349–361.
23. Shanon CE, Wiener W. The mathematical theory of communication. University Illinois Press, Urbana. 1963.
24. Pielou EC. Ecological diversity. Wiley Inter Science, London; 1975.
25. Simpson EH. Measurement of diversity. Nature. 1949;163(4148):688p.
26. Hilsenhoff WL. Rapid field asessment of organic pollution with a family-level biotic index. Journal of the North American Benthological Society. 1988;7(1):65-68.
27. Wright JF, Furse MT, Armitage PD. A technique for evaluating the biological quality of rivers in the UK. European water pollution control. 1993;15-25.
28. Chessman B. Rapid assessment of rivers using macroinvertebrates: A procedure based on habitat-specific sampling, family level identification and a biotic index. Australian Journal of Ecology. 1995;20:122-129.
29. Maitland PS. Biology of Fresh Waters, Tertiary Level Biology. Springer Netherlands. 1990; 276p. DOI:https://doi.org/10.1007/978-94-011-7852-5
30. Decamps H, Pinay G, Naiman RJ, Petts GE, McClain ME, Hillbricht-Ilkowska A, Hanley T A, Holmes R M, Quinn J, Gibert J, Tabacchi A M P, Schiemer F, Tabacchi E, Zalewski M. Riparian zones:where biogeochemistry meets biodiversity in management practice. Polish Journal of Ecology. 2004;52:3–18.

31. Thomaz SM, Dibble E, Evangelista LR, Higuti J, Bini LM. Influence of aquatic macrophyte habitat complexity on invertebrate abundance and richness in tropical lagoons. Freshwater Biol. 2008;53(2):358-367.
32. Jankowski JE, Ciecka AL, Meyer NY, Rabenold KN. Beta diversity along environmental gradients:implications of habitat specialization in tropical montane landscapes. J. Animal Ecol. 2009;78: 315-327.
33. Takhelmayum K, Gupta S. Distribution of aquatic insects in phumdis (floating island) of Loktak Lake, Manipur, northeastern India. J. Threat. Taxa. 2011;3:1856–1861. DOI:https://doi.org/10.11609/JoTT.o2526.1856-61.
34. Wilson KDP. Field guide to the Dragonflies of Hong Kong. Cosmos Book Ltd., Hong Kong. 2004.
35. Choi JY, Kim SK, Kim JC, Kwon SJ. Habitat Preferences and Trophic Position of *Brachydiplax chalybea* flavovittata Ris, 1911 (Insecta:Odonata) Larvae in Youngsan River Wetlands of South Korea. Insects. 2020;11:273. DOI :10.3390/insects11050273
36. Henrikson L, Oscarson HG. Waterbugs (Corixidae, Hemiptera-Heteroptera) in acidified lakes:Habitat selection and adaptations. Ecological Bulletins. 1985;37:232-238.
37. Rai DN, Sharma UP. Co-relation between macrophytic biomass and macroinvertebrate community structure in wetlands of North-Bihar. Int. J. Ecol. Environ. Sci. 1991;17:27‒36.
38. Khan RA, Ghosh LK. Faunal diversity of aquatic insects in freshwater wetlands of South Eastern West Bengal. Z.S.I. Kolkata. 2001;104p.
39. Azmi WA, Hussin NH, Amin NM. Monitoring of Water Quality Using Aquatic Insects as Biological Indicators in Three Streams of Terengganu. Journal of Sustainability Science and Management. 2018; 13(1):67-76.
40. Priawandiputra W, Zakaria FRN, Prawasti TS. Aquatic Insect Community as Indicator of Water Quality Assessment in Situ Gede System, Bogor, Indonesia. IOP Conf. Series:Earth and Environmental Science. 2018;197:012016. DOI :10.1088/1755-1315/197/1/012016.
41. Pahari PR, Mandal SS, Maiti S, Bhattacharya T. Diversity and community structure of Odonata (Insecta) in two land use types in Purba Medinipur District, West Bengal, India. Journal of Threatened Taxa. 2019;11, 13748–13755. DOI:https://doi.org/10.11609/jott.4139.11.6.13748-13755
42. Ghosh S, Bhattacharya T. A short-term survey on the post-winter avian diversity in Corbett National Park and associated areas, Uttarakhand, India. Journal of Threatened Taxa. 2018;10(1):11185–11191. DOI:https://doi.org/10.11609/jott.3220.10.1.11185-11191
43. Wilhm JR, Dorris CT. Biological parameters for water quality criteria. Bioscience. 1968;18(6):477–481.
44. Kazanci N, Ekingen P, Türkmen G, Basoren OE, Dügel M, Gültutan Y. Assessment of ecological quality of Aksu Stream (Giresun, Turkey) in Eastern Black Sea Region by using Water Framework Directive (WFD) methods based on benthic macroinvertebrates. Review of Hydrobiology. 2010;3(2):165-184.