Biospectra : ISSN: 0973-7057, Vol. 17(1), March, 2022, pp. 167-174
An International Biannual Refereed Journal of Life Sciences

35(AS).
Animal Science

ISSN : 0973-7057

Int. Database Index: 616 www.mjl.clarivate.com

Composition and abundance of benthic macro invertebrates in floodplain lakes (chaurs) of North Bihar, India

Dashendra Kumar[a], Jai Nandan Prasad Yadav[a] & Arun Kumar[b]*

[a]Department of Zoology, K.P. College, Murliganj, B. N. Mandal University, Madhepura, Bihar, India

[b]University Department of Zoology, B.N. Mandal University, Madhepura, Bihar, India

Received : 15th February, 2022 ; Revised : 16th March, 2022

Abstract- Floodplain wetlands in North Bihar, India are common features of river Gandak and Koshi river basins which have been used for a number of activities such as fisheries, agriculture and other human activities. Species composition and abundance of macro-invertebrates were studied in the floodplain lakes (chaurs). This study was conducted from July, 2019 to June, 2020. Samples were collected monthly at two floodplain lakes of Madhepura district of North Bihar. Macro-invertebrates of the lakes consist of 5 groups, viz., Oligocheata, Hirudinea, Insecta, Gastropoda and Pelecypoda. In total, 21 species of benthic macro-invertebrates were recorded, of these, 19 species were recorded at Ambhobasa chaur and 15 species at Doura chaur. The density of benthos was higher in poor-water condition at Doura chaur varied from 105 individuals/m^2 to 1922 individuals/m^2 with mean of 973.74±122.42 individuals/m^2, however lower in clean-water environment at Ambhobasa chaur ranged from 85 individuals/m^2 to 1443 individuals/m^2 with mean of 713.08±87.96 individuals/m^2. Species composition and abundance of the benthic fauna were almost same not differ much between the studied lakes, however minor differences could be due to heterogeneity of the habitat. Gastropoda was the most dominant group of zoo-benthos contributing of 42.65% and 43.18% followed by Oligochata 21.24% and 30.89%, Insecta 19.84% and 21.37%, Bivalvia 14.46% and 3.29% of total benthic fauna at Ambhobasa chaur and Doura chaur respectively. Benthic fauna abundance shows seasonal variation, higher in winter followed by summer and lower during monsoon. The results of this study will help to update information on benthic invertebrate resources of North Bihar.

Key words: Floodplain lakes, benthic macro-invertebrates, species composition, abundance

INTRODUCTION

Benthic invertebrates are those organisms that live in or on the bottom deposit of a body of water.[1] Benthic fauna are aquatic bottom-dwelling animals can be seen with the naked eye without using microscope, collectively referred to as macro-zoo benthos or benthic macro-invertebrates. Benthic invertebrates play a key role in ecological processes, such as food chain dynamics, nutrient cycling and recycling, productivity and decomposition.[2,3] Benthic invertebrates are important and integral part of aquatic food chain forms a vital link between primary producers, unavailable nutrient and energy in detritus and higher trophic levels in aquatic food web.[4,5] Most benthic fauna feed on debris that settles on bottom of a water body. Benthic fauna are of great significance in fisheries as they constitute main food source for many bottom feeder fishes. Benthic invertebrates are regarded as best biological indicator use

*Corresponding author :
Phone : 9006991000
E-mail : prf.arunkumar@gmail.com

for the assessment of water quality and overall aquatic ecosystem health.[6,7]

Wetlands associated with floodplain of major rivers (floodplain wetlands) are common feature of Indian landscape particularly along the Ganga and Brahmaputra river systems covering area of 0.2 million ha.[8] Not much attention has been given to study composition and abundance of benthic invertebrates existing in the floodplain wetlands of India. However, macro-invertebrates of the floodplain wetlands of this country have been studied by some workers.[3,9-12]

Many floodplain wetlands are available in North Bihar, mostly in Gandak and Koshi river basins either in form of floodplain lakes (tectonic-lakes) or ox-bow lakes (cutoff portion of river meander) or residual channels, locally called *chaurs*, *manus* and *dhars*, respectively. Floodplain wetlands cover an area of 40,000 ha,[13] where fish production is mainly depending on the natural food including benthos. Despite of their key role in aquatic ecosystems, the studies on benthic fauna inhabiting in the floodplain lakes is still meager. The main objective of the present study is to determine composition and abundance of benthic macro-invertebrate fauna in two floodplain lakes of the district Madhepura of North Bihar.

MATERIALS & METHODS

Study Area

The field work is carried out in the floodplain lakes of the district of Madhepura of North Bihar. Among the selected floodplain lakes, Ambhobasa *chaur* is located at 25°34'48" North latitudes and 86°52'28" East longitudes, however Doura *chaur* at 25°30'59" North latitudes and 86°56'32" East longitudes (Fig. 1). Studied lakes receive water during the monsoon season from flood and rainfall and contain abundant macrophytes belonging to several species.

Sampling

Sampling was initiated in July, 2019 and continued up to June, 2020. Sediment substrate samples were collected with the help of an Ekman's dredge of 15.5×15.5 cm^2. Monthly three replicate samples were taken from each floodplain lake.

Sample Preparation

Sediment samples collected were taken into a labeled polyethylene bag and transferred to a bucket and mixed with water. Then mixed water passed through a standard brass sieve No.40 (256 meshes per sq. cm.). All benthic fauna retained on sieve were transferred to specimen bottle and fixed with 10% buffered formalin for detailed examination in the laboratory.

Sample Analysis

In the laboratory, for identification, samples were taken into a white enamel tray for easy vision. The animals were then sorted out, enumerated to different taxonomic groups using brush and forceps and identified up to genus or species level using appropriate literature. [14-18] Hand lens and low power binocular microscope were used to identify benthic fauna. Benthic invertebrate was computed in terms of individual per meter square.[19]

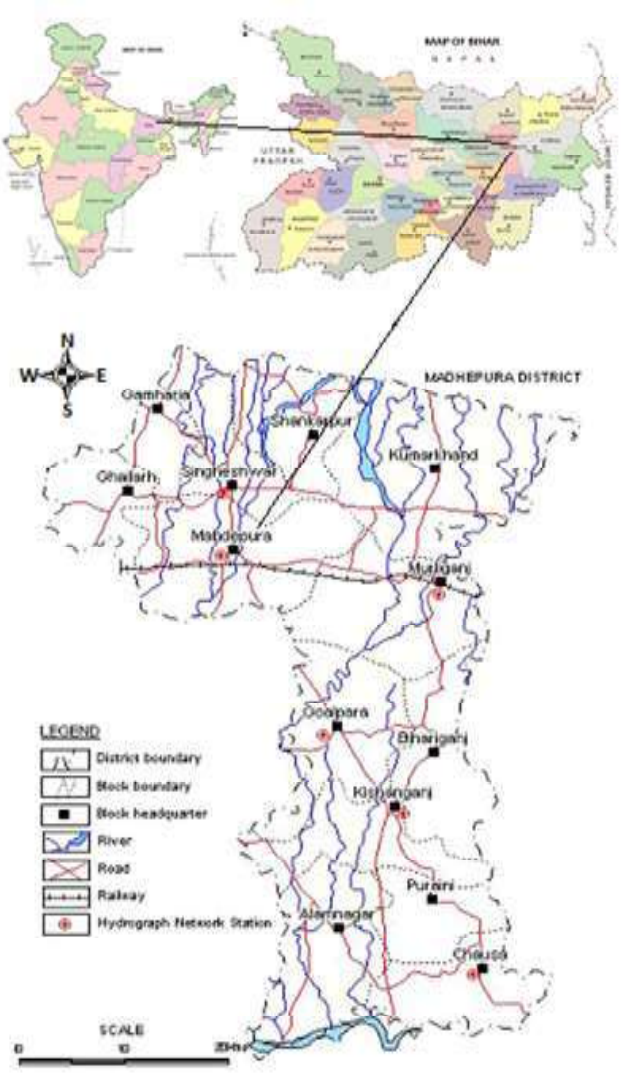

Figure 1- Location map of Madhepura district of North Bihar (India).

RESULTS & DISCUSSION

Composition and Abundance

Benthic invertebrates recorded in two floodplain lakes (*chaurs*) are presented in Table 1. Variation in the density of the total benthos is shown in Fig. 2. The studied lakes support a great diversity of benthic invertebrates. Altogether, 21 species of benthic macro-invertebrates were recorded from both lakes comprises of 5 major groups, such as Oligocheata, Hirudinea, Insecta, Gastropoda and Pelecypoda belonging to 3 major invertebrate phyla (Mollusca, Annelida and Arthropoda). In total, 19 species of benthos belonging to Oligocheta with 2 species, Hirudinea 2 species, Insecta 3 species, Pelecypoda 4 species and Gastropoda 8 species were

Table 1: List of benthic macro-invertebrates recorded in the studied wetlands.

Macro-invertebrates	Ambhobasa Badi *chaur*	Doura *chaur*
Phylum : Annelida		
Class : Oligochaeta		
Family: Naididae		
1. *Branchiodrilus semperi* (Bourne, 1890)	-	+
Family: Tubificidae		
2. *Limnodrillus hoffmeisteri* (Claparède, 1862)	+	+
3. *Branchiura sowerbyi* (Beddard, 1892)	+	+
Class : Hirudinea (Leeches)		
Family: Glossiphoniidae		
4. *Glassophonia* (Johnson, 1816)	+	+
Family: Hirudinidae		
5. *Helobdella* (Linnaeus, 1758)	+	-
Phylum : Arthropoda		
Class : Insecta		
Family: Chironomidae		
6. *Chironomus* sp.	+	+
Family: Lestidae		
7. Damselfly nymph	+	-
Family: Gomphidae		
8. Dragonfly nymph	+	+
Phylum : Mollusca		
Class : Bivalvia (Pelecypoda)		
Family: Unionidae		
9. *Lamellidens marginalis* (Lamarck, 1819)	+	+
10. *Parreysia* (*parreysia*) *favidens* (Benson, 1862)	+	-
Family: Corbiculidae		
11. *Corbicula bensoni* (Deshayes, 1854)	+	+
12. *Corbicula striatella* (Deshayes, 1854)	+	-
Class : Gastropoda		
Family: Viviparidae		
13. *Bellamya bengalensis f. typica* (Lamarck, 1822)	+	+
14. *Bellamya crassa* (Benson, 1836)	+	-
Family: Ampulariidae		
15. *Pila globossa* (Swainson, 1822)	+	+
Family: Bithyniidae		
16. *Bithynia* (*Digoniostoma*) *pulchella* (Benson, 1836)	+	+
Family: Thiaridae		
17. *Thiara* (*Melanoides*) *tuberculata* (Müller, 1774)	+	+
Family: Lymnaeidae		
18. *Lymnaea acuminata f. typica* (Lamarck, 1822)	+	+
Family Planorbidae		
19. *Gyraulus convexiusculus* (Hutton, 1849)	+	+
20. *Gyraulus euphraticus*	+	-
Family Bullinidae		
21. *Indoplanorbis exustus* (Deshayes, 1834)	-	+
Total Zoo-benthos	19	15

+ Present, - Absent

recorded at Ambhobasa *chaur*. Although,15 species belonging to Oligochata with 3 species, Hirudinea 1 species, Insecta 2 species, Pelecypoda 2 species and Gastropoda 7 species were collected at Doura *chaur* (Table 1).Number of species was the maximum in clean-water environment at Ambhobasa *chaur* than the poor-water condition at Doura *chaur*, but no significant differences were found in composition of benthic invertebrates. Previous workers have reported different diversity and density of benthos in different floodplain wetlands of India. Khan (2002)[20] reported 78 taxa of benthic fauna from ox-bow lakes, Beri Gopalpur *baor* and Sosadanga *baor* of North 24 Parganas district of West Bengal. Sugunan *et al*. (2000)[21] recorded benthic organisms from *beels* of West Bengal dominated by molluscs, insects and annelids. Sharma and Agrawal (2011)[22] reported 15 species of Gastropoda belonging to 2 orders and 6 families and 7 species of Pelecypoda belonging 2 orders and 2 families from flood plain wetlands of North Bihar. Sharma and Agrawal (2011)[22] reported 14 Gastropoda species belonging to 6 genera and 6 species of Pelecypoda belonging to 3 genera from Surha *Tal* of Ballia district of Uttar Pradesh. Patial *et al*. (2015)[23] recorded 18 species of benthos during pre-drought and 17 in post drought period in a floodplain wetland of Vaishali district of Bihar. Singh *et al*. (2019)[3] recorded 26 species of benthic macro-invertebrates belonging to 17 genera and 17 families from floodplain wetlands of Madhepura district of North Bihar. Singh and Sharma (2020)[24] recorded 29 species of benthic invertebrates from high altitude wetland, Dodi Tal of Garhwal Himalaya.

Density of benthic macro-invertebrate population ranged from 85 individuals/m^2 to 1443 individuals/m^2 with mean of 713.08±88 individuals/m^2 at Ambhobasa *chaur*, and varied from 105 individuals/m^2 and 1922 individuals/m^2 with mean of 972.74±122.42 individuals/m^2 at Doura *chaur* (Table 2). The highest density of benthos reflects eutrophic condition in the studied lakes agree with the findings of previous workers.[25] Density of benthos in both lakes were fairly same not differ much from each other, though minor difference observed could be due to heterogeneity of the environments, such as difference in water quality, sediment types and food quality and quantity.[26] Benthic macro-invertebrates showed seasonal

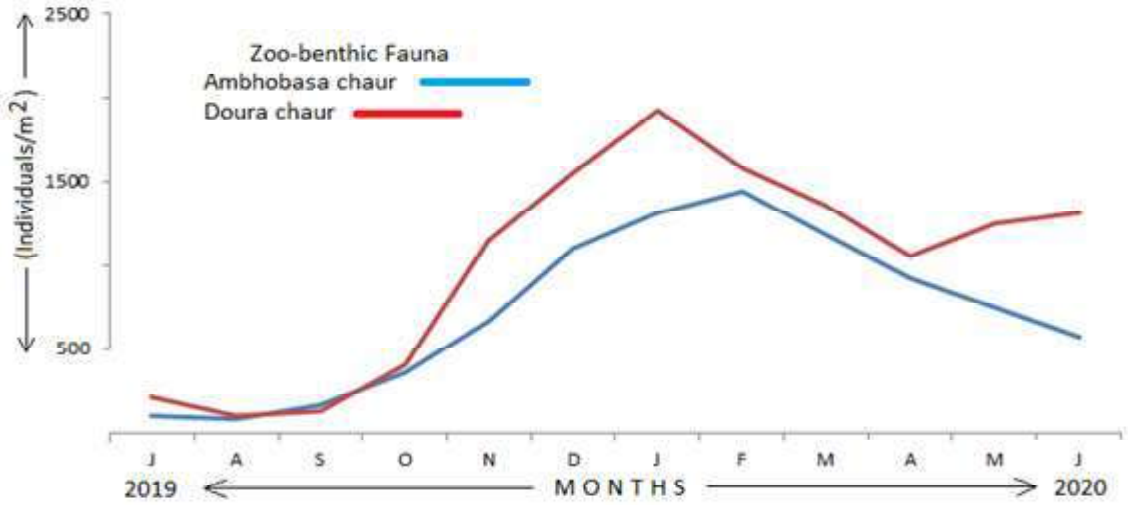

Figure 2- Richness in benthic fauna in Ambhobasa badi *chaur* and Doura *chaur*.

Table 2- Range and mean ± standard error (±SE) of benthic fauna (individual/m^2)

Macro-invertebrates	Ambhobasa badi *chaur*		Doura *chaur*	
	Min. - Max.	Mean ± SE	Min. - Max.	Mean ± SE
Oligochaeta	21 - 389	185.45 ± 22.74	21 - 691	328.73 ± 44.11
Hirudinea	21 - 43	24.23 ± 2.19	21 - 43	27.6 ± 3.36
Insecta	21 - 345	157.45 ± 21.98	21 - 455	226.77 ± 28.12
Pelecypoda	21 - 257	105.21 ± 13.27	21 - 108	45.18 ± 6.41
Gastropoda	42 - 710	310.25 ± 41.60	63 - 951	420.04 ± 54.33
Total Benthos	85 - 1443	713.08 ± 87.96	105 - 1922	972.74 ± 122.42

variation, the maximum density was observed in winter followed by summer and the minimum during monsoon season (Fig. 2). Similar trend was also observed by the earlier workers in the floodplain wetlands of this country.[3,9,20] Higher density was observed in winter could be due to decreased temperature, increased dissolved oxygen, medium to high water level and low predation pressure. The abundance and composition sharply declined during monsoon season could be attributed to dilution factors, incoming rain water and flood water dilutes summer population of benthos.

Different groups of benthic invertebrates showed different requirement to survive in the floodplain wetlands. Morphometery and size of the lake, discharge of domestic sewage, run-off from agriculture field and weedy environment brought significant alteration in water quality. The species composition and composition of benthic fauna depend on water quality of their habitat. Clean-water environment increase probabilities of survival of animals might be responsible for decreased density and increased diversity of benthos at Ambhobasa *chaur*, often dominated by pollution-sensitive benthos. However, poor-water condition might be accountable for increased density and decreased diversity at Doura *chaur*.

In terms of abundance and diversity, Oligochaeta was the second most dominant group of benthic fauna contributing 21.24% at Ambhobasa *chaur* and 30.89% at Doura *chaur* (fig. 3). The total density of Oligochaeta ranged from 21 individuals/m^2 to 389 individuals/m^2 at Ambhobasa *chaur* with mean density of 185.45±2.74 individuals/m^2, however varied from 21 individuals/m^2 to 691 individuals/m^2 at Doura *chaur* with mean of 328.73±44.11 individuals/m^2 (Table 2). The number of Oligochaeta was higher throughout the period of study, except monsoon when they were typically absent or less abundant. *Limnodrilus hoffmeisteri* is small, thin worm existing in all freshwater habitats worldwide.[27] In this study, *Limnodrillus hoffmeisteri* was most dominant oligochaete worm and along with *Branchiura sowerbyi* recorded in both studied lakes. *Branchiodrilus semperi* recorded only in Doura *chaur* (Table 1). Brinkhurst (1975)[4] reported occurrence of *Limnodrilus hoffmeisteri* with high abundance in the organically enriched aquatic environments often with *Tubifex tubifex*. Though, in this study, *Limnodrilus hoffmeisteri* were recorded with high abundance with *Branchiodrilus semperi* at Doura *chaur* where muddy-bed contain huge amount of organic matter frequently detritus. Prior to this study *Limnodrillus hoffmeisteri* has been also reported from freshwater bodies of this region.[3,28]

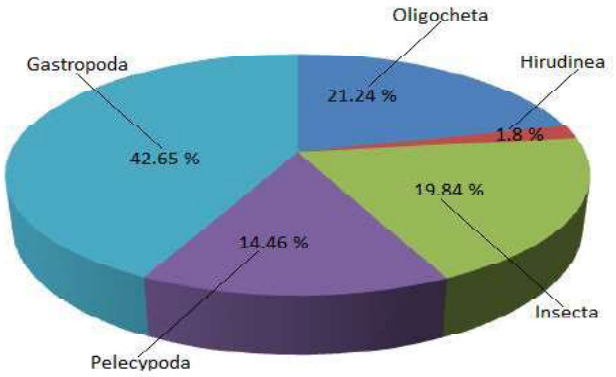

Figure 3- Relative composition of macro-invertebrates in Ambhobasa badi *chaur*.

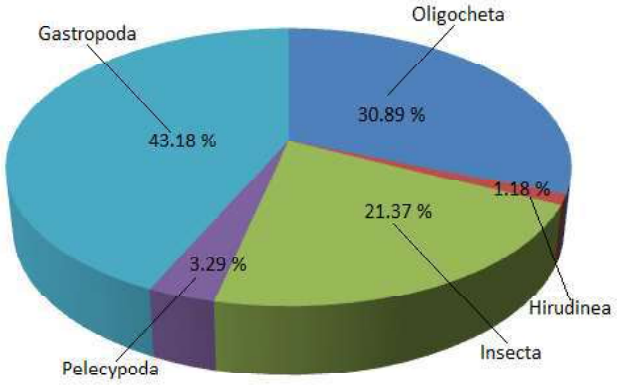

Figure 4- Relative composition of macro-invertebrates in Doura *chaur*.

In total, 2 species of Hirudinea (Leaches) were recorded from the studied lakes. Of these, *Glassophonia* was recorded in both lakes, though *Helobdella* only in Ambhobasa *chaur* (Table 1) contributing 1.8% and 1.18% of the total benthos (Fig. 3). Leaches were recorded with low abundance. Factors structuring leech community is not clearly known, however, their presence indicates organically-enriched environment.[29] The present study supports facultative nature of Hirudinea as recorded from both clean-water environments at Ambhobasa *chaur* and poor-water conditions at Doura *chaur*.

Insecta was the prominent group of benthic fauna. Benthic insects consist of one larva and two nymphs of flying insect. Density of benthic insects ranged from 21 individuals/m^2 to 345 individuals/m^2 with mean of 157.45±22 individuals/m^2 at Ambhobasa *chaur*, though,

varies from 21 individuals/m^2 to 455 individuals/m^2 with mean of 226.77±28 individuals/m^2 at Doura *chaur* (Table 2) contributing 19.84% and 21.37% of the total benthos (Fig. 3). *Chironomus* (dipteran larvae) was most dominant taxa. They were pollution-tolerant facultative organisms, thus found in both lakes.[30] Density of *Chironomus* larvae was generally high in poor-water condition at Goura *chaur* as they were well-adapted to oxygen-deficient environments[31] as their blood contains hemoglobin which traps oxygen[32]. Nymphs recorded from both lakes were juveniles of adult flying insects. Nymphs of damselfly and dragonfly were recorded in oxygen-rich water at Ambhobasa *chaur* as they need additional oxygen for their cellular metabolism.[33] Nymph of damselfly was absent in Doura *chaur* could be due to poor-water conditions. Nymphs are pollution-sensitive benthos restricted to clean-water environment,[34] their absences reflect water may be polluted. Benthic insects feed on bottom debris, planktons and other micro-organisms available in the floodplain lakes, though they themselves form leading food items of many fishes.

Pelecypoda (Bivalvia) found buried in the sediment on the lake-bed and majority is filter feeders. In total, 4 species of Pelecypoda was recorded from both the lakes (Table 1). Population density of Bivalvia ranged from 21 individuals/m^2 to 257 individuals/m^2 with mean density of 105.21±13.27 individuals/m^2 at Ambhobasa *chaur*, however varied from 21 individuals/m^2 to 108 individuals/m^2 with mean of 45.18±6.41 individuals/m^2 at Doura *chaur* (Table 2). Density of Pelecypoda was high at Ambhobasa *chaur* than at Doura *chaur*. All the 4 species of bivalves, like *Lammellidens marginalis, Parreysia* (*parreysia*) *favidens*, *Corbicula bensoni* and *Corbicula striatella* were recorded at Ambhobasa *chaur* (Table 1) contributing 14.46% of the total benthos, though only one species, *Corbicula* was recorded at Doura *chaur* constituting 3.29% (Fig. 3). Bivalvia population was maximum in summer and minimum during many months at Ambhobasa *chaur*, though the higher in winter and lowest during many months at Doura *chaur*. Ecological condition of floodplain lakes, such as the depth, altitude, temperature and physical stability of bottom substrate, all have varying degree of influence on species composition and abundance of bivalves. Occurrence of Bivalvia and their population structure allow easily receiving necessary information about water condition.[35] However, the present knowledge of this group of benthic fauna is very poor.

Gastropoda (snails) was the most dominant benthic fauna contributing major share to total molluscan fauna of both lakes. Gastropods showed a variety of shapes, in total, 9 species belonging to 7 genera and 7 families were recorded in this study. Out of these, 8 species were recorded at Ambhobasa *chaur* and 6 species at Doura *chaur* (Table 1), contributing 42.65% and 43.18% of the total benthic fauna (Fig. 3). Density of Gastropoda ranged from 42 individuals/m^2 to 710 individuals/m^2 at Ambhobasa *chaur* with mean of 310.25±41.60 individuals/m^2, however varied from 63 individuals/m^2 to 951 individuals/m^2 at Doura *chaur* with mean of 420.04±54.33 individuals/m^2 (Table 2). Maximum density of Gastropoda was recorded in winter and minimum during monsoon in both the lakes (Fig. 2). Among gastropods, *Thiara* (*Melanoides*) *tuberculata*, *Bellamya bengalensis f. typica* and *Pila globossa* were numerically most abundant at Ambhobasa *chaur* and rest was less abundant. Though, *Bellamya bengalensis f. typica* was most dominant Gastropoda followed by *Thiara* (*Melanoides*) *tuberculata* and *Bithynia* (*Digoniostoma*) *pulchella* at Doura *chaur*. Earlier workers reported Gastropoda as characteristics benthos of organically enriched environment.[36] Probably due to their facultative nature. In the present study, density of gastropods was higher in poor-water condition at Doura *chaur* than the clean-water environment at Ambhobasa *chaur* agree with the findings of earlier studies.[37,38]

CONCLUSION

Results of the present study showed that floodplain lakes of North Bihar support diverse groups of benthic fauna. Qualitative analysis of benthos reveals presence of 21 species belonging to 5 major groups, like Oligochaeta, Hirudinaria, Insecta, Pelecypoda and Gastropoda. Benthic fauna were relatively more divers at Ambhobasa *chaur* (19 species) than the Doura *chaur* (15 species). Higher density of benthos reveals eutrophic nature of the studied lakes. It was observed that species present at Ambhobasa *chaur* were absent at Doura *chaur* probably due to intolerant nature of the concerned benthic fauna. Food availability and environmental condition are most possible reason for declined number and disappearance of organisms. Benthic fauna constitutes the food of fish; if effective measures are not taken numerous species of benthos may become extinct in coming years. Information obtained during the present study can be used

for further analysis of benthic fauna in the floodplain lakes of this region.

ACKNOWLEDGEMENT

The authors are thankful to the Head, Department of Zoology, B.N. Mandal University, Madhepura, Bihar for providing all the facilities and support. The authors are especially indebted to Dr. A.K. Singh, Professor of Zoology, Patliputra University, Patna, Bihar for his comment and suggestion.

REFERENCES

1. **Odum. E. P. 1971.** Fundamentals of Ecology, 3rd W.B. Saunders Company. Philadelphia, pp. 574.
2. **Reice, S.R. and Wohlenberg, M. 1993.** Monitoring freshwater benthic macro invertebrates and benthic processes: measurement for assessment of ecosystem health. pp. 287-305 in D.M. Rosenberg and V.H.Resh, editors. Freshwater biomonitoring and benthic macro invertebrates. *Chapman & Hall, New York, USA*.
3. **Singh, A.K., Kumari, R. and Kumar, A. 2019.** Diversity and composition of macro-invertebrate in floodplain lakes of North Bihar, India. *Int. J. Fish. Aquat.Stud*., **7(5):** 106-112.
4. **Brickhurst, R.O. 1975.** "Oligochaeta," in Keys to the Water Quality Indicative Organisms of the South Eastern United States, F. K. Parrish, Ed., pp. 69-85, United States Environmental Protection Agency, Office of Research and Development, Environmental Monitoring and Support Laboratory, Cincinnati, Ohio, USA.
5. **Stoffels, R.J., Clarke, K.R. and Closs, G.P. 2005.** Spatial scale and benthic community organization in the littoral zones of large oligotrophic lakes: potential for cross-scale interations. *Freshwater Biology*, **50:** 1131-1145.
6. **Rosenberg, D.M. and Resh, V.H. 1993**. Fresh Water Biomonitoring and Benthic Macro-invertebrates. Chapman and Hall, Inc., New York,pp.820.
7. **Adeogun, A.O. and Fafioye, O.O. 2011.** Impact of effluents on water quality and benthic macro invertebrate fauna of Awba stream and reservoir. *J. Appl. SCI. Environ. Manag*., **15(1):** 105 -113.
8. **Vass, K.K., 2006.** Sustainable fisheries and environmental concerns of floodplain wetlands in India. *Intenal. J. Eco. Environ. Sci*., **32:** 49-62.
9. **Yadava, Y.S., Kolekar, V., Singh R.K. and Chaudhury, M. 1984.** Studies on the macro-benthic fauna of Dinghalibeel (Asam). *Prac, Nat. Acad. Sci. India.* **54(B):** 179-186.
10. **Choudhary, S., Kumar, U. and Kumar, Utpal 2013.** Seasonal changes in the standing crop of macro-invertebrates (Macro-zoobenthos) population in the wetlands (Chaurs) of North Bihar (Begusarai District). *Fishing Chimes*, **33(8):** 72-75.
11. **Malla, S. and Rout, S.K. 2015.** Assessment of the ecological status of Mathura Beel, a flood Plain wetland in Nadia, West Bengal, India by using benthic macro-invertebrates. *NeBIO*, **6(3):** 32-38.
12. **Sharma, G., Dey, A. and Sardana, M. 2011.** Molluscan Diversity. In: Faunal Diversity of Chaurs of North Bihar. *Zool. Surv. India, Wetland Ecosystem Series.* **14:** 21-47.
13. **Sugunan, V.V. and Bhattacharjya, B.K. 2000.** Ecology and fisheries of beels in Assam. Bulletin No.104, *Central Inland Fisheries Research Institute (CIFRI)*, pp. 65.
14. **Edmondson, W.T. 1959.** Freshwater Biology. John Wiley & Sons, New York, USA, pp. 525.
15. **Pennak, R.W. 1978.** Freshwater Invertebrates of the United States. 2nd Ed. John Wiley & Sons, New York, pp. 803.
16. **Tonapi, G.T., 1980.** Fresh Water Animals of India: An Ecological Approach. Oxford & IBH Publishing Co., New Delhi, pp. 341.
17. **Adoni, A.D., Joshi, D.G., Gosh, K., Chourasia, S.K., Vaishya, A.K., Yadav, M. and Verma, H.G., 1985.** Work book on limnology. Pratibha Publishers. C-10 Gour Nagar, Sagar, India**.** pp. 216.
18. **SubbaRao, N. V. 1989.** Handbook Freshwater Molluscs of India. Zoological Survey of India, Calcutta. Edited by the Director, ZSI, pp. 289.

19. **Jhingran, V.G., Natarajan, A.V., Banerjee, S.N. and David, A. 1969.** Methodology on reservoir fisheries investigation in India. *Bull. Cent. Inland Fish. Res. Inst., Barrackpore*, **12:**109 pp.

20. **Khan, R.A. 2002.** The ecology and faunal diversity of two floodplain Ox-bow lakes of South-Eastern West Bengal. *Records of the Zoological Survey of India, Occasional Paper No.* **195:** 1-57.

21. **Sugunan, V.V., Vinci, G.K., B.K. Bhattacharjya, B.K. and Hassan, M.A. 2000.** Ecology and fisheries of beels in West Bengal. Bull. No.103, Central Inland Capture Fisheries Research Institute (ICAR), Barrackpore, West Bengal, pp. 53.

22. **Sharma, R.K. and Agrawal, N. 2011.** Molluscan fauna of Surha Tal, District- Ballia (U. P.), India. *J. Appl. Nat. Sci.*, **3(2):** 295-297.

23. **Patial, P., Hassan, M.A. and A.P. Mishra, A.P. 2015.** Macrobenthic diversity during pre and post drought period of a floodplain wetland in Vaishali district of Bihar. *Int. J. Appl. Biol. Pharm*. **6(2):** 294-298.

24. **Singh, S. and Sharma, R.C. 2020.** Monitoring of benthic macro invertebrates as bio- indicator for assessing the health of the high altitude wetland Dodi Tal, Garhwal Himalaya, India. *Biodiversity Int. J.,* **4(4):** 164-173.

25. **Shyam Sunder and K.K. Vass, 1988.** Seasonal dynamics of benthos in some Kashmir lake. *Proc. Nat. Acad. Sci., India*, **5(11) B**: 193-203.

26. **Soldner, M., Stephen, I., Ramos, L., Angus, R., Wells, N.C., Grosso, A. and Crane, M., 2004.** Relationship between macroinvertebrate fauna and environmental variables in small streams of the Dominican Republic. *Water* Research, **38(4):** 863-874.

27. **Swayne, H., Day, M. and Wetzel, M.J. 2004.** *Limnodrilus hoffmeisteri* (Annelida: Oligochaeta: Tubificidae) in Pop's Cave, Wisconsin, USA. *J. Caves Karst Stud*., **66(1):** 28-31.

28. **Nesemann, H., Sharma, G. and Sinha, R.K. 2004.** Aquatic Annelida (Polychaeta, Oligochaeta, Hirudinea) of the Ganga River and adjacent water bodies in Patna (India, Bihar), with description of a new leech species (Family Salifidae). *Ann.Naturhist. Mus. Wien*., **105 B:** 139-187.

29. **Lenat, D.R. 1993.** A biotic index for the southeastern United States: derivation and list of tolerance values, with criteria for assigning water-quality ratings. *J. North Am. Benthol. Soc*., **12:** 279-290.

30. **Armitage, P., Cranston, P.S. and Pinder, L.C.V. 1995.** The Chironomidae: The biology and ecology of non-biting midges. Chapman and Hall, London, pp. 572.

31. **Clemente, J.M., Mazzeo, N., Gorga, J. and Maerhoff, M. 2005.** Succession and collapse of macrozoobenthos in a subtropical hypertrophic lake under restoration (lake Rodo, Uruguay). *Aquat.Ecol.,* **39:** 455-464.

32. **Mason, C.F. 2002.** Biology of Freshwater Pollution. 4th Edn., Prentice Hall London, pp. 400.

33. **Mophin-Kani, K. and Murugesan, A.G. 2014.** Assessment of river water quality using macro-invertebrate organisms as pollution indicators of Tamirabarani River basin, Tamil Nadu, India. *International Journal of Environmental Protection,* **4(1):** 1-14.

34. **Paine, G.H. and Gaufin, A.R. 1956.** Aquatic Diptera as indicators of pollution in a midwestern stream. *Ohio J. Sci.,* **56:** 291-304.

35. **Singh, A.K. 1995.** Effects of sewage on physic-chemical characteristics and macro-zoobenthic community of the river Ganga at Patna, India. *Proc. Nat. Acad. Sci., India*, **65 B (3):** 315-324.

36. **Satyamurti, T.S. 1960.** Land and Freshwater Mollusca. *Bull. Madras Govt. Museum*, pp. 177.

37. **Singh, A.K. 1997.** Abundance of macrozoobenthic organisms in relation to physico-chemical characteristics of river Ganga at Patna (Bihar), India. *J. Environ. Biol.,* **18(2):**103-110.

38. **Kumar, A. and Bohra, C. 1999.** Gastropoids as indicators of the pollution status of some wetlands in SantalPargana, Bihar, India. *Indian J. Envir. Ecol*., **2:** 83-87.

***