Eco. Env. & Cons. 26 (3) : 2020; pp. (1170-1174)
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ISSN 0971–765X

Macroinvertebrate diversity of effluent affected Dhansiri and Kaliani Rivers of Assam, India

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(Received 27 November, 2019; accepted 8 February, 2020)

ABSTRACT

A survey of macroinvertebrate diversity was carried out for two years in the two rivers of Assam - Dhansiri and Kaliani of Golaghat district which were used as basin to discharge the effluent from the Numaligarh Refinery. The rivers sections were divided into two areas- control area and contaminated area for comparison. The two rivers experienced a change in the occurrence and abundance of the macroinvertebrate community. A total no. of 23 genera and 2 tribes (Chironomidae family) belonging to 25 families of macroinvertebrates have been recorded belonging to 10 orders, 4 classes and 3 phyla. The point of effluent discharge harbored only 8 families indicating an adverse effect from the refinery effluent.

Key words : *Diversity, Effluent, Freshwater ecosystem, Numaligarh refinery, Macroinvertebrate.*

Introduction

Biological indicators may reflect the intensity of anthropogenic stress and have been used as a tool in risk assessment and evaluation of human induced change in freshwater ecosystem (Toham and Tegugets, 1999). Biological assemblage especially macroinvertebrates have been widely used groups of organisms for evaluating the quality of flowing waters, because they are easier to sample than fish, are not as restricted in distribution as are aquatic vascular plants and are easier to identify and to quantify than algae or fungi. Because of their unusual respiratory, food-gathering and reproductive adaptations, characteristic assemblages or communities of macroinvertebrates become associated with particular water-quality conditions. As a part of sustainable regulatory measure, the aim of this study was to evaluate the macroinvertebrate diversity of effluent affected Dhansiri and Kaliani rivers of Assam.

Materials and Methods

The 3 MMTPA Numaligarh Refinery Limited (NRL) is located at Numaligarh in the district of Golaghat, Assam (Figure 1). To know the changes of macroinvertebrate diversity from March 2012- February 2014, one area located upstream of river Kaliani was considered as control area (S1, S2, S3, S4 and S5) where there was no contamination from refinery effluent; the S6 was the point of effluent discharge and the following S7 was located on Kaliani and the S8, S9 and S10 were located on Dhansiri.

Macroinvertebrate Sampling

Sampling of macroinvertebrates was carried out according to Barbour *et al.* (1999) and Mandaville (2002), preserved in 70% ethanol and transported to the laboratory for sorting, abundance counts and to ascertain the accuracy of field identification with the help of standard literature of Merrit and Cummins (1996).

Diversity Indices

The four diversity indices applied, were-

a. Shannon-Wiener Diversity Index ($) (Shannon and Weaver, 1963)

$H = -\Sigma_{s=1}^{S}(P_i)(log_2 P_i)$, where, "$P_i$" is the proportion of individuals in the "i^{th}" taxon of the community and "s" is the total number of taxa in the community.

b. Simpson's Diversity Index (D) (Simpson, 1949)

$D = 1- \Sigma_{s=1}^{S}(P_i)^2$, where, "$P_i$" is the proportion of individuals in the "i^{th}" taxon of the community and "s" is the total number of taxa in the community.

c. Marglef's Species Richness Index () or (M) (Marglef, 1958)

d = (S–1)ln N, where, = no. of species, and N = no. of individuals in the sample.

d. Sorensen's Similarity Index (S_S) (Sorensen, 1948)

Ss = 2A/(2A + B + C), where, A = no. of species sharing in two populations, B = no. of species which own only to first population, C = no. of species which own only to second population.

Results and Discussion

In the study, 23 genera and 2 tribes (Chironomidae family) belonging to 25 families of macroinvertebrates have been recorded belonging to 10 orders, 4 classes and 3 phyla. The Table 1 shows the taxonomic diversity of identified macroinvertebrates of rivers Dhansiri and Kaliani during March 2012-February 2014. The two rivers experienced a change in the occurrence and abundance of the macroinvertebrate community. Out of total 25 families recorded during the study, only 8 were recorded at the S6 of the contaminated area. The S6 harbored the taxa that were capable of surviving and thriving under low DO or highly turbid condition, that were Blood-red Chironomini (24%), *Tanytarsini* (11%), *Hirudinea* (3%), *Physella* (17%),

Table 1. Taxonomic diversity of identified macroinvertebrates of Rivers Dhansiri and Kaliani

Sl No.	Name of genus/species	Family	Order
1. 1999)	*Neocaridina*	Atyidae	Decapoda (crayfish) (Barbour *et al*.,
2.	Chironomini	Blood-red Chrionomidae (Chironomini) (non-biting or true midges), (Hauer & Lamberti, 1996)	Diptera (Two-winged or "true flies")
3.	Tanytarsini (Bode *et al*., 1996)	Other Chrionomidae (including pink) Bode *et al*., 1996	
4.	*Tipula* (Bode *et al*., 1996)	Tipulidae (crane flies) (Hauer & Lamberti, 1996)	
5.	*Baetis* (Bode *et al*., 1996)	Baetidae (Hauer & Lamberti, 1996)	Ephemeroptera (mayflies)
6.	*Caenis* (Barbour *et al*., 1999)	Caenidae (Hauer & Lamberti, 1996)	
7.	*Ephemera* (Bode *et al*., 1996)	Ephemeridae (Hauer & Lamberti, 1996)	
8.	*Heptagenia* (Bode *et al*., 1996)	Heptageniidae (Hauer & Lamberti,1996)	
9.	*Oligoneuriella* (Bode *et al*., 1996)	Oligoneuriidae (Hauer & Lamberti, 1996)	
10.	*Tortopus* (Bode *et al*., 1996)	Polymitarcyidae (Hauer & Lamberti, 1996)	
11.	*Hirudinea* (Barbour *et al*., 1999)	Glossiphoniidae (Bode *et al*., 2002)	Rhynchobdellida (leeches and bloodsuckers)
12.	*Sialis* (Bode *et al*., 1996; Barbour *et al*., 1999)	Sialidae (Hauer & Lamberti, 1996)	Megaloptera (dobsonflies, alderflies)
13.	*Lymnaea* (Bode *et al*., 1996)	Lymnaeidae	Basommatophora (pulmonates)
14.	*Physella* (Bode *et al*., 1996)	Physidae (Barbour *et al*., 1999)	
15.	*Sphaerium* (Bode *et al*., 1996)	Sphaeridae (Barbour *et al*., 1999)	Bivalvia(clams and mussels)
16.	*Aeshna* (Bode *et al*., 2002)	Aeshnidae (Hauer & Lamberti, 1996)	Odonata(dragonflies and damselflies)
17.	*Calopterix* (Bode *et al*., 1996)	Calopterygidae (Hauer & Lamberti, 1996)	
18.	*Ischnura* (Bode *et al*., 1996)	Coenagrionidae (Hauer & Lamberti, 1996)	
19.	*Neurocordulia* (Bode *et al*., 1996)	Corduliidae (Hauer & Lamberti, 1996)	
20.	*Ophiogomphus*(Bode *et al*., 1996)	Gomphidae (Hauer & Lamberti, 1996)	
21.	*Macromia* (Bode *et al*., 1996)	Macromiidae (Hauer & Lamberti, 1996)	
22.	*Branchiura* (Bode *et al*., 2002)	Tudificidae (Barbour *et al*., 1999)	Haplotaxida (aquatic worms)
23.	*Pristina* (Bode *et al*., 1996)	Naididae	
24.	*Hydropsyche* (Bode *et al*., 1996)	Hydropsychidae (Hauer & Lamberti, 1996)	Trichoptera (caddisflies)
25.	*Lepidostoma* (Bode *et al*., 1996)	Lepidostomatidae (Hauer & Lamberti, 1996)	

Sphaerium (13%), *Neurocordulia* (1%), *Branchiura* (20%) and *Pristina* (11%). The two dominant families of Blood-red Chrionomidae (24%) and Tudificidae (20%) recorded at S6 are considered indicators of pollution (Hynes, 1960; Mahadevan and Krishnaswamy, 1984). According to Pennak (1989) and Peckarsky *et al.* (1990), the aquatic worms (oligocheta) - Tudificidae and Naididae actively seek habitats with organic pollution and low dissolved oxygen levels. The families of Molluscs are generally sensitive to pollution and cannot tolerate very low dissolved oxygen levels (Verma *et al.*, 1978; Rao *et al.*, 1985). The third dominant family of the S6 - Physidae was lungs snail (pulmonate snail) that can tolerate water with little or no oxygen (Pennak, 1989), due to their adaptation to breathe atmospheric oxygen need not depend on the dissolved oxygen (Sampath *et al.*, 1981).

On the other hand, in the downstream of contaminated area (S7, S8, S9 and S10) of the S6, only 13 families were recorded and they were Atyidae (10%), Blood-red Chrionomidae (11%), other Chrionomidae (including pink) (14%), Caenidae (6%), Glossiphoniidae (1%), Lymnaeidae (8%), Physidae (9%), Sphaeridae (8%), Calopterygidae (7%), Coenagrionidae (4%), Corduliidae (7%), Tudificidae (8%), and Naididae (7%). The genera

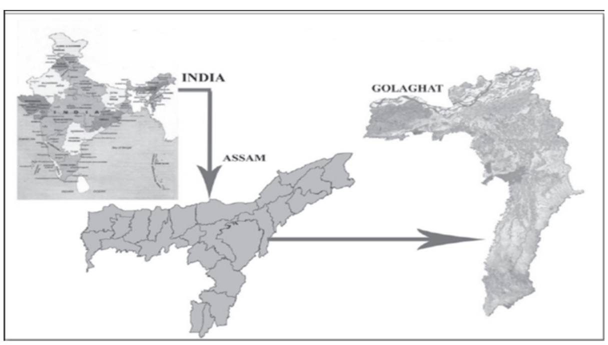

Fig. 1. Location map of Golaghat district of Assam

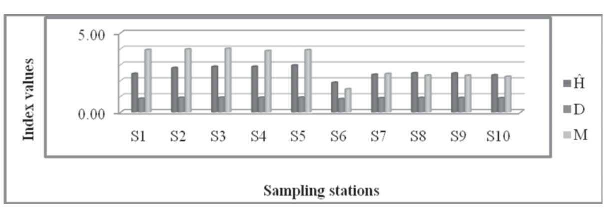

Fig. 2. Diversity indices of macroinvertebrate community of Rivers Dhansiri and Kaliani

Key: $´=Shannon-Wiener Diversity index, D=Simpson Diversity index and M=Margalef's Species Richness index

that were recorded only from the control area of Kaliani were *Tipula*, *Baetis*, *Ephemera*, *Heptagenia*, *Oligoneuriella, Tortopus*, *Sialis*, *Aeshna,* and *Macromia*; *Hydropsyche* and *Lepidostoma*. The most dominant family was Heptageniidae of order Ephemeroptera composed of 22% of the total families. In the order level, the Ephemeroptera or mayflies that were most abundant in the control area of Kaliani comprising of 48% of the total orders indicating cool, unpolluted ecosystem, as according to Peckarsky *et al.* (1990), they prefer clean water and an average oxygen supply. Barbour *et al.* (1999) reported that sampling station with a higher percentage of Ephemeroptera and Trichoptera, but low percentage of Chironomidae (% Chironomidae) is highly correlated with high quality water. Ephemeroptera are known to be particularly sensitive to metals and will disappear before other taxa (Fore, 2002). The presence of the genera *Sialis* of order Megaloptera or Dobsonfly larva, in the control area of Kaliani indicated well-oxygenated river condition (Peckarsky *et al.,* 1990).

The diversity indices of macroinvertebrates were calculated for the different sampling stations of the two rivers (Figure 2). H was ranged from 2.95 at S5 to minimum of 1.87 at S6, D value was recorded maximum with a 0.93 at S5 to minimum with a 0.83 at S6, M was recorded maximum with a 4.01 at S3 to minimum with a 1.45 at S6. According to Wilhm (1967), "H usually varies between three and four in clean-water stream areas and is usually less than one in polluted-streamareas." The higher value of H in the control area has indicated greater diversity of species, meaning larger food chain and more cases of inter-specific interactions and greater possibilities for negative feedback control which reduced oscillations and hence increases the stability of the community (Ludwig and Reynolds, 1988) than the contaminated area of S6 including the further downstream of the two rivers. The D value of the macroinvertebrate community was recorded highly diverse in control area with a maximum of 0.93 at S5 and least diverse at S6 with a 0.83 of contaminated area. The M value for macroinvertebrate community was lowest at S6 with a 1.45 of contaminated area and highest at S3 with a 4.01 of control area.

The macroinvertebrates have shown 100% (Table 2) similarity among all the sampling stations of control area and also the same was observed among all the sampling stations of contaminated area except the S6, which could imply that the supplies of environmental resources were more or less similar in types and quantities to support the macroinvertebrates of the 100% similar stations, whereas at S6 the organic pollution ultimately leading to the differences in composition of macroinvertebrate taxa resulting in dissimilarity with both the control area and within its downstream stations of contaminated area. The result might also suggest that among the sampling stations of control area and also among the sampling stations of downstream of S6 of contaminated area has not been either affected or somewhat equally affected by habitat disturbances.

Table 2. Sorensen's Similarity index (S_S) of macroinvertebrate community of Rivers Dhansiri and Kaliani

Comparison between stations		Biological community Macroinvertebrates
S1	S2	100
	S3	100
	S4	100
	S5	100
	S6	48
	S7	68
	S8	68
	S9	68
	S10	68
S2	S3	100
	S4	100
	S5	100
	S6	48
	S7	68
	S8	68
	S9	68
	S10	68
S3	S4	100
	S5	100
	S6	48
	S7	68
	S8	68
	S9	68
	S10	68
S4	S5	100
	S6	48
	S7	68
	S8	68
	S9	68
	S10	68
S5	S6	48
	S7	68
	S8	68
	S9	68
	S10	68
S6	S7	76
	S8	76
	S9	76
	S10	76
S7	S8	100
	S9	100
	S10	100
S8	S9	100
	S10	100
S9	S10	100

Conclusion

Thus the pollutant from the refinery effluent adversely affected the macroivertebrate community leading to the least taxonomic diversity at the point of effluent discharge (S6). To resist the further degradation of the aquatic environment of the macroiverterates along with other flora and fauna the refinery authority should implant a proper waste-water treatment plant in the refinery.

Acknowledgement

I want to thank my guides- Dr. Debojit Boruah and Professor S.P. Biswas of Dibrugarh University, Assam, for their constant support and advice. I also thank Dr. Rupok Neog for his technical support.

References

Barbour, M.T., Gerritsen, J., Snyder, B.D. and Stribling, J.B. 1999. *Rapid Bioassessment Protocols for Use in Streams and Rivers: Periphyton, Benthic Macroinvertebrates and Fish,* (2nd edition).U.S. Environmental Protection Agency, Washington, D.C., USA.

Fore, L.S. 2002. Biological assessment of mining disturbance on stream invertebrates in mineralized areas of Colorado.*Biological Response Signatures: Indicator Patterns Using Aquatic Communities,* ed. T.P. Simon. Boca Raton, Florida. CRC Press LLC.

Hynes, H.B.N. 1960. *The Biology of Polluted Waters.* Liverpool University Press, Liverpool.

Ludwig, J.A. and Reynolds, J.F. 1988. *Statistical Ecology.* John Wiley & Sons, New York.

Mahadevan, A. and Krishnaswamy, S. 1984. Chironomid larval population size: An index of pollution in river Vaigai. *Pollution Research,* 3: 35-38.

Mandaville, S.M. 2002. *Benthic Macroinvertebrates in Freshwaters-Taxa Tolerance Values, Metrics, and Protocols.* (Project H-1) Soil & Water Conservation Society of Metro Halifax.

Margalef, R. 1958. Temporal succession and spatial heterogeneity in phytoplankton. *Buzzati-Traverso, A.*

(ed.) Perspectives in Marine Biology.Berkeley, CA, University of California Press.

Merritt, R.W. and Cummins, K.W. 1996. *An Introduction to the Aquatic Insects of North America,* (3rd edition). Kendell/Hunt Publishing Company, Iowa.

Peckarsky, B.L., Fraissinet, P., Penton, M.A. and Conklin, D.J.Jr. 1990. *Freshwater Macroinvertebrates of Northeastern North America*.Cornell University Press, Ithaca, NY.

Pennak, R.W. 1989. *Fresh-water Invertebrates of the United States: Protozoa to Mollusca,* (3rdedition). John Wiley & Sons, New York, USA.

Rao, K.S., Das, N.K. and Pandya, S.S. 1985. Community structure of benthic macroinvertebrates and their utility as indicators of pollution in river Khan (Indore), India. *Proceedings of National Symposium on Pure & Applied Limnology* (edAdoni A.D.) Bull. Bot. Soc. Sagar, 32: 114-119.

Sampath, V., Sreenivasan, A. and Ananthanarayanan, B. 1981. Mollusca as indicators of organic enrichment and pollution in Cauvery River System. *(WI-K) Workshop on Biological Indicators and Indices of Environmental Pollution.* Central Board for the Prevention and Control of Water Pollution, Hyderabad, 149-162.

Shannon, C. and Weaver, W. 1963. *The Mathematical Theory of Communication.* University of Illinois Press. Chicago.

Simpson, E.H. 1949. Measurement of diversity. *Nature.* 163: 688.

Sorensen, T. 1948. A method of establishing of equal amplitude plant society based on similarity of the species content. *Royal Danish Academy of Sciences & Letters.* 5 : 1-34.

Toham, A.K.G. and Tegugets, G. 1999. First data on an index of Biotic Integrity (IBI) based on fish assemblages for the assessment of the impact of deforestation in a Tropical West African River System. *Hydrobiologia,* 397: 29-38.

Verma, S.R., Tyagi, A.K. and Dalela, R.C. 1978. Pollution studies of a few rivers of western U.P. with reference to biological studies. *Proceedings of the Indian Academy of Science.* 878 : 123-131.

Wilhm, J.L. 1967. Comparison of some diversity indices applied to populations of benthic macroinvertebrates in a stream receiving organic wastes. *Journal of the Water Pollution Control Federation.* 39 (10) : 1673-1683.