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DIVERSITY AND ABUNDANCE OF BENTHIC INSECTS IN RELATION TO WATER POLLUTION IN A SEWAGE FED POND

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ABSTRACT

The aim of present work was to analyze the diversity and abundance of benthic macro insect assemblages and pollution level in a sewage fed pond. Samples were collected monthly over 1 year-cycles (February, 2009–January, 2010). This pond situated in Aligarh western region of U.P. is highly variable and sewage fed pond, has been used by fishermen. However, there is a concern about the impact of pollution on natural ecosystem, this study was conducted to evaluate insect occurrence and variation in terms of diversity and density in sewage fed water body so that one can know quality of water of other such ponds of this region. Benthic insect fauna was sampled with the help of Ekmann dredge. Five major groups (Diptera, Coleoptera, Hemiptera, Tricophtera and Ephemeroptera) and 19 species were identified. During summer season the density and abundance of insect fauna dropped inside sediment by around 49% indicating different responses during different months,. The value of Shannon diversity index ranged between 2.41-2.45. The fluctuation in the density as well as diversity indicated high pollution during winter season as compared to summer when pollution was low.

INTRODUCTION

Aquatic insects make up only 3-5% of all insect species but are taxonomically very diverse (Daly *et al*., 1998). These are insects in the order Ephemeroptera, Odonata, Plecoptera, Hemiptera, Orthoptera, and Hymenoptera that spend at least some stage of their lives under water. The Para insecta order collembola also has species that are closely associated with the water. Since aquatic insects are one of the most important components of the aquatic ecosystems, they have both ecological and economical value.

Diversity is an important structural attribute of a natural or organized community, which is related to other structural and functional properties such as productivity, niche structure, competition, stability, integration of the community. The sustaining of the so-called biological diversity is a priority of nature conservation in terrestrial, marine and freshwater environments (Brooks *et al.,* 2006). The diversity indices used in biological assessment studies are calculated for highly important indicator groups like Chironomidae (Cranston, 1995) and EPT (larval Ephemeroptera, Plecoptera and Trichoptera) or for a selected part of macrobenthic taxa (Barbour *et al.,* 1996), identified on the level of genus or family (Fleituch *et al.,* 2002), and much more rarely for all macrobenthos (Johnson and Hering, 2009). The idea that the groups richest in species should be excluded from the biomonitoring protocols to make the procedure easier has also been formulated (Rabeni and Wang, 2001). Some changes in biological diversity of aquatic organisms are based on data in which neither Insecta nor Oligochaeta are identified (Leppakoski *et al.,* 1999). Consequently, macroinvertebrate community structure has commonly been used as an indicator of the condition of an aquatic system (Armitage *et al.,* 1983).

According to Campbell (1939), Hynes (1960), Olive (1976) nymphs and larvae of stoneflies, mayflies and caddisflies are integral components of the benthic fauna of the most relatively undisturbed streams. The abundance of Ephemeroptera, Plecoptera, Tricophtera and Chironomidae indicates the balance of the community, since Ephemeroptera, Plecoptera, Tricophtera are considered to be more sensitive and Chironomidae less sensitive to environmental stress (Plafkin *et al.,* 1989). A community considered to be in good biotic condition will display an even distribution among these four groups, while communities with disproportionately high numbers of Chironomidae may indicate environmental stress (Plafkin *et al.,* 1989). Aquatic insects often make good indicators because they are present in some capacity in almost every type of habitat and many are habitat specialists. Aquatic beetles have their greatest abundance and diversity in the temperate regions (Spangler, 1982). These insects are not particular in their choice of water bodies and occur in wide variety of habitats (Galewwski, 1971; Zaitsev, 1953), although many species may prefer certain types of water bodies (Hosseinie, 1978).

The present study proposes to identify indicator species of pollution among benthic insects present in a sewage-fed waterbody.

MATERIALS AND METHODS

The sediment along with fauna was collected by Ekmann - dredge from the bottom of the water body for qualitative and quantitative analyses. After collecting the bottom sample slurry was prepared and it was sieved (No.) and then washed from the sediment. For this, transfer preserved macro benthic samples were washed once again on 500 μm sieve in running water. Organisms were preserved in 10 % buffered formalin. Insects were sorted and identified up to genus /species level under dissecting microscope. The population density was determined per square meter area and result was expressed as Ind/m^2. Identification was done with the help of keys given in Edmondson (1959), Needham and Needham (1962), Pennak (1978) and Tonapi (1980).

Statistical analysis

Multidimensional scaling (MDS) and level of similarity and the contribution of each species to the total similarity among samples were performed using PRIMER (Clarke and Warwick, 1994).

Benthic species diversity was calculated using the following formulae:

Shannon-Wiener's Index

H = (Σ pi ln pi); where

Pi = n/N

n = No. of individual species,

N = Total density of all organisms.

1.2.13 Menhinick's Index (Menhinick, 1964):

$Dmn = S/\sqrt{N}$;

Where; S = Total number of species

N = total density of all the species

Evenness was calculated using formula:

$E_1 = H^1/ \ln S$ (Pielou, 1975);

where H^1 = species diversity

Simpson index was calculated using formula:

1-D = Σn (n-1)/N (N-1)

Where n = the total number of organisms of a particular species

N = the total number of organisms of all species

RESULTS AND DISCUSSION

During the study period a total of 19 species of benthic insects belonging to 5 groups of benthic insects, with marked variation in population (Table 1). The most abundant group recorded was Diptera followed by Hemiptera, Coleoptera, Tricophtera and Ephemeroptera. The abundance of Diptera was noted in between 1262 to 188 m^2. The Diptera population was recorded highest during January, 2010 and lowest in June, 2009. Hemiptera was found maximum (579m^2) in December, 2009 and minimum (143m^2) in October, 2009. Coleoptera was highest (461/m^2) in January, 2010 and lowest (94/m^2) in May, 2009. Tricophtera showed highest abundance (15m^2) in January while lowest (4m^2) in April, 2009. Similarly Ephemeroptera were recorded maximum (7m^2) in November, 2009 and minimum (3m^2) in March, 2009 (Table 2). The Diptera formed one of the most dominating groups among all because this group can tolerate eutrophic condition of water body and also can survive at low concentration of dissolved oxygen. Other groups Coleoptera and Hemiptera can also survive in polluted water body but some species of this group can not tolerate polluted condition of water body. The higher abundance of these groups during winter season was due to low temperature because at low temperature the predation pressure is low and also the capacity of water to hold oxygen is high which make a suitable environment for growth and development of benthic insect community. The least contribution of Tricophtera and Ephemeroptera is because these groups are highly sensitive to the water condition and

Table 1: Species composition of benthic insects

Genera	Min.-Max.	Average value
Ephemeroptera	3-7	4.41
Baetis hiemalis nymph	1-4	2.166667
Caenis nymph	1-4	2.25
Trichoptera	4-15	8.58
Limnephilus larva	1-6	3.166667
Phryganaea larva	1-4	2.833333
Polycentropus larva	1-6	2.583333
Coleoptera	94-461	233.5
Hydrophilus	13-118	52.83333
Dystiscus	24-96	54.25
Berosus	18-95	51.33333
Haliplus	23-166	75.08333
Hemiptera	143-579	335.5
Notonecta insulata	54-218	117
Coroxid	13-126	85.5
Belostoma	5-58	14.91667
Hebrus sp.	5-115	34.08333
Sigara	3-51	13.58333
Hesperocorixa	21-149	70.41667
Diptera	188-1262	673.7
Chironomus larva	98-675	409.5
Chironomus pupa	3-79	25.91667
Helius larva	3-28	14.83333
Culex larva	33-145	68.58333
Pentanura	18-424	154.9167

Table 2: Fluctuations in density of different groups of benthic insects in different months

Months	Ephemer-optera	Tricophtera	Coleoptera	Hemiptera	Diptera
Feb'09	4	10	316	394	884
Mar	3	7	185	268	681
Apr	4	4	222	341	536
May	4	6	94	257	370
Jun	5	10	266	296	188
Jul	4	5	218	260	588
Aug	4	8	140	244	742
Sep	3	9	165	336	667
Oct	4	9	185	143	732
Nov	7	7	248	348	827
Dec	6	13	302	579	608
Jan'10	5	15	461	560	1262
Total	53	103	2802	4026	8085

Table 2: Shannon-Weiner diversity index ($\overline{H}$), Simpson index and Evenness index of different benthic insect groups

Groups	Simpson_1-D	Shannon_$\overline{H}$	Evenness_ $\overline{H}$/ lnS
Ephemeroptera	0.9114	2.455	0.9702
Tricophtera	0.9062	2.423	0.9402
Coleoptera	0.9036	2.41	0.9279
Hemiptera	0.9058	2.422	0.939
Diptera	0.9047	2.41	0.9276

Table 3: Fluctuation in the value of similarity index in different months

	Feb'09	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan'10
Feb'09												
Mar	90.91											
Apr	90.97	94.07										
May	81.04	89.46	89.07									
Jun	83.72	85.01	88.05	86.02								
Jul	90.03	96.71	96.82	90.44	87.21							
Aug	90.15	96.57	90.97	89.96	82.02	94.09						
Sep	91.96	97.26	94.98	88.43	84.80	94.43	95.40					
Oct	88.54	94.92	89.24	84.72	80.31	92.39	95.05	92.77				
Nov	96.19	93.78	93.84	83.84	85.14	92.89	92.73	94.29	90.84			
Dec	92.64	89.00	91.22	81.29	84.34	90.28	86.48	90.47	85.10	91.25		
Jan'10	91.05	82.11	82.17	72.56	75.50	81.25	81.37	83.14	79.80	87.67	90.03	

they can not survive in eutrophic water body as these groups can not tolerate low concentration of oxygen except few species of these groups which can survive at low concentration of oxygen but not less than 3.

The Variation in the Shannon-Weiner diversity index, Simpson index, Evenness index and similarity index was calculated to reveal the diversity of benthic insect. Shannon-Weiner index calculated higher (2.455) for Ephemeroptera and minimum (2.41) for Coleoptera. Simpson index were also calculated for the same water body and it showed the higher diversity (0.911) for Ephemeroptera and minimum (0.903) for Coleoptera. Evenness followed the trend of Diversity index. Maximum species richness (0.907) was shown by Ephemeroptera and minimum (0.927) by Coleoptera (Table 3). Highest value of similarity index was recorded between the months of March, 2009-October, 2009 whereas lowest value was recorded between the month of May, 2009- January, 2010 (Table 4; Fig. 1). If the Shannon – Weiner diversity index proposed as diversity index > 4 is clean water; between 3- 4 is mildly polluted water and < 2 is heavily polluted water (Shekhar *et al.*, 2008) therefore, the values of Shannon – Weiner diversity index showed that this pond is moderately polluted and the

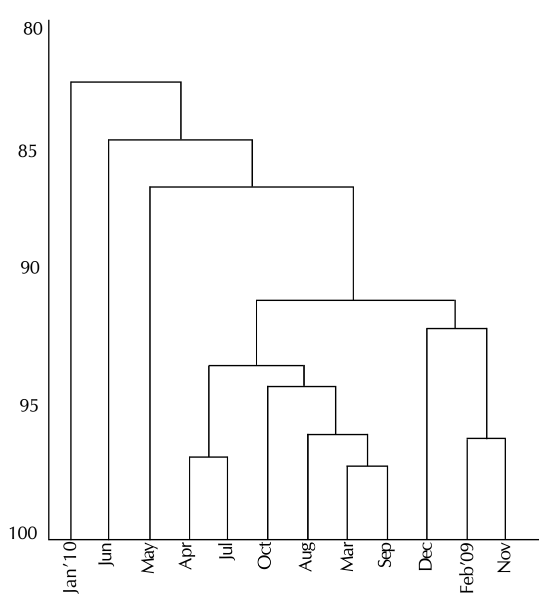

Figure 1: Cluster shows fluctuation trend in the value of similarity index in different months

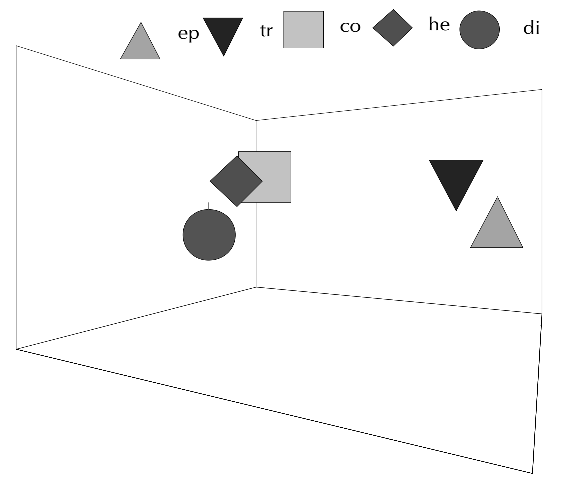

Figure 2: Multi Dimensional Scaling analysis (MDS) digram with 5 benthic insects group in 12 months. The benthic insect are ep = ephemeroptera; tr = Tricophtera; co = Coleoptera; he = Hemiptera and di = Diptera.

high population of benthic insect during winter season was due to highest contribution of *chironomus* sp., indicating high pollution in winter.

Although some taxa are primarily aquatic, most Hemiptera do not rely heavily on dissolved oxygen in the water, but instead obtain oxygen from the atmosphere. Due to their ability to utilize atmospheric oxygen, Hemiptera are often able to exist in water bodies with low levels of dissolved oxygen. Aeropneustic breathing methods allow the insect to continue to utilize surface air for respiration. Aquatic Coleoptera constitute an important part of the macro-zoobenthos of freshwater habitats. Small and temporary water bodies have more species than large and permanent ones (Larson, 1985). We used Multivariate method (MDS) and found clear difference between the density of different groups of benthic insects. However MDS showed clear difference between different groups. The Ephemeroptera and Tricophtera showed near about same trend whereas Diptera was different showed high abundance (Fig. 2).

Benthic aquatic insects are sensitive indicators of environmental changes because they express long term changes in water and habitat quality rather than instantaneous condition (Johson and Hering, 1993). Invertebrate communities are also good indicators of water quality conditions (Resh, 1995).

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REFERENCES

Armitage, P. D., Moss, D., Wright, J. F. and Furse, M. T. 1983. The performance of a new biological water quality score based on macroinvertebrates over a wide range of unpolluted running- water sites. *Water Res.* **17:** 333-347.

Barbour, M. T. J., Gerritsen, G. E., Griffith, R., Frydenborg, E., McCarron, J. S., White, M. L. and Bastian, A. 1996. Framework for Biological Criteria for Florida Streams Using Benthic Macroinvertebrates. *J. N. Am. Benthol. Soc.* **15:** 185-211.

Brooks, T. M., Mittermeier, R. A., Da Fonseca, G. A. B., Gerlach, J., Hoffmann, M., Lamoreux, J. F., Mittermeier., C. G., Pilgrim, J. D. and Rodrigues, A. S. L. 2006. Global Biodiversity Conservation Priorities. *Science.* **313** (5783): 58.

Campbell, M.S.A. 1939. Biological indicators of intensity of stream pollution. *Sewage works J.* **11:** 123-127.

Cranston, P. S. 1995. Introduction. The Chironomidae. The biology and ecology of non-biting midges. In: (Eds Armitage, P., P.S. Cranston and L.C.V. Pinder), Chapman and Hall, London: 1-7.

Daly, H. V., Doyen, J. T. and Purcell III, A. H., 1998. Introduction to insect biology and diversity .2nd Ed. New York: Oxford University Press, Inc.

Dudgeon, D. 1999. Tropical Asian streams: Zoobenthos, Ecology and conservation. Hong, Kong University Press, Hong Kong. p.828.

Edmondson, W. T. 1959. Ward and Whipple's Freshwater Biology, 2nd Ed. John Wiley and Sons Inc., New York, p.1248.

Fleituch, T., Soszka, H. Kudelska, D. and Kownacki, A. 2002. Macroinvertebrates as indicators of water quality in rivers: a scientific basis for Polish standard method. Arch. Hydrobiol. Suppl. 141/3-4: 225-239.

Galewwski, K., 1971. A study on the morphobiotic adaptations of European species of the Dytiscidae (Coleoptera). *Pol. Pismo Ent.* **41:** 488-702.

Hosseinie, S. H. 1978. Aquatic Coleoptera from South-western Iran (Haliplidae, Dytiscidae and Gyrinidae, with a note on Hydrophilidae). *The Coleopterists Bull.* **32(2):** 167-176.

Hynes, H. B. N. 1960. The biology of polluted waters. Liverpool University press, Liverpool, UK. p.202.

Johnson, R.K. and Hering, D. 2009. Response of river inhabiting organism groups to gradients in nutrient enrichment and habitat physiography. *J. Appl. Ecol.* **46:** 175-186.

Larson, D. J. 1985. Structure in temperate predaceous diving beetle communities (Coleoptera: Dytiscidae). *Holarct. Ecol.* **8:** 18-32.

Leppäkoski, E., Helminen, H., Hänninen, J. and Tallqvist, M. 1999. Aquatic biodiversity under anthropogenic stress: an insight from the Archipelago Sea (SW Finland). *Biodiv. Conserv.* **8:** 55-70.

Menhinick, E.F. 1964. A comparison of some species individuals diversity indices in samples of field insects. *Ecology.* **45**:859-861.

Needham, J. G. and Needham, P. R. 1962. A Guide to the Study of the Freshwater Biology. Holden-Dey Inc., Francisco, p.108.

Olive, J. H. 1976. Chemical-Physical and biological assessment of water quality in the Cuyahoga River (1973-1974). *Ohio J. Sci.* **76**: 5-15.

Pennak, R. W. 1978. Freshwater invertebrates of United States, 2nd Ed. Johan Wiley and Sons Inc., New York. p. 803.

Plafkin, J. L., Barbour, M. T., Porter, K. D., Gross, S. K. and Hughes, R. M. 1989. Rapid Bioassessment Protocols for use in Streams and Rivers: Benthic Macroinvertebrates and Fish. U.S. Environmental Protection Agency. EPA 440/4-89/001. 8 chapters, Appendices A-D.

Rabeni, C. F. and Wang, N. 2001. Bioassessment of streams using macroinvertebrates: Are the chironomidae necessary? *Environ. Monit. Assess.* **71:** 177-185.

Resh, V. H. 1995. Freshwater benthic macro-invertebrates and rapid assessment procedures for water quality monitoring in developing and newly industrialized countries. In: Davis WS, Simon TP (eds) Biological assessment and criteria. Lewis, Chelsea. pp. 167-177.

Shannon, C. E. and Weaver, V. 1949. A mathematical theory of Communication. Uni. Press, Tllinois. Urban 101 – 107.

Shekhar, S. T. R., Kiran, B. B. Puttaiah, E. T., Shivraj, Y. and Mahadevan, K. M. 2008. Phytoplankton as index of water quality with reference to industrial pollution. *Journ. Environ. Biol.* **29(2):** 233-236.

Spangler, P. J. 1982. Coleoptera. In: Aquatic biota of tropical South America. San Diego State University, San Diego, California. pp.328-397.

Tonapi, G. T. 1980. Fresh water animals of India. Oxford and IBH Publishing Co., New Delhi. p.341.

Zaitsev, F.A. 1953. Nasekamye zhestkokrylye. Plavuntsovyei vertyachki. *Fauna SSSR.* **58:** 1-376.