

Effect of Waste Sewage Pollution on Benthic Diversity of Fresh Water Ecosystem

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Abstract – Effect of sewage pollution on the benthic diversity of fresh water ecosystem of western region of U.P., India was carried out between February, 2009 – January, 2010, by investigating the biological environment of the habitats. The faunal species were obtained by sieving the sediment with 0.5mm mesh sieve and physical sorting. A total of ten major taxonomic groupings were recorded. These groupings and their percentage contribution to the total macro-benthic organisms collection are Rotifers (30%), Diptera (17.2%), Cladocera (12.25%), Coleoptera (8.9%), Ostracoda (8.5%), Hemiptera (8.37%), Oligochaetes (6.8%), Copepoda (6.7%), Trichoptera (0.27%) and Ephemeroptera (0.23%). Benthic diversity varied from a minimum of 3.11 in June, 2009 to a maximum of 3.23 in February, 2009 therefore this ecosystem can be considered as moderately polluted. Rotifers and Diptera were dominant in this ecosystem may be attributed to their level of pollution tolerance because some species of these groups can tolerate high eutrophic condition of water and easily survive in polluted water. The Mollusc and Plecoptera was totally absent throughout the study period. This suggests that the study area is polluted and Mollusc and Plecoptera can't tolerate hypoxia and eutrophic condition of aquatic ecosystem. The CO₂ was found to absent throughout the study period.

Keywords – Aquatic Ecosystem, Benthic Community, Diversity, Sewage Pollution.

I. INTRODUCTION

The present study on this fresh water ecosystem focused effect of high level sewage pollution resulting from human and natural activities on benthic diversity. This ecosystem in view of the economic importance and inherent scientific interests in respect of wild life, fisheries, flood control and water quality in order to ensure the sustainable use of the natural resources. Benthic macro fauna are those organisms that live on or inside the deposit at the bottom of a water body (Idowu and Ugwumba, 2005). Benthic communities are widely used in the monitoring of effects of pollution as the organisms are mostly sessile and integrate effects of pollutants over time. Most benthic communities comprise a large number of species and because of the varying sensitivities of species it should be possible to identify subtle effects of pollutants reflected in changes in community structure. Until fairly recently, the accepted methods for identifying pollution-induced changes have been relatively crude, using changes in total number of species, diversity indices and frequency of occurrence of opportunistic species, but in a recent review of such stress indices Gray (1989) suggests that they indicate end-points rather than first effects of pollution-induced change.

Benthic communities are especially useful in detecting and evaluating the impacts of low dissolved oxygen events and aquatic contamination because exposure to anoxia/hypoxia is greatest in near bottom waters and hydrophobic anthropogenic contaminants typically accumulate in sediments. Benthic organisms with limited mobility cannot avoid adverse conditions and better reflect local environmental conditions compared to most pelagic fauna (Gray, 1979). The diversity of physiological tolerances, life history strategies, feeding modes, and trophic interactions can make sedimentary benthic communities effective estimators of environmental condition. Several papers concern the use of benthic indices to assess the ecological quality, status of marine and estuarine environments (Borja *et al.*, 2008; Teixeira *et al.*, 2008; Weisberg *et al.*, 2008). They form the link between the unavailable nutrients in detritus and useful protein materials in fish and other organisms. Most benthic organisms feed on detritus that settle on the bottom of the water and in turn serve as food for a wide range of fishes (Idowu and Ugwumba, 2005). They accelerate the breakdown of decaying organic matter into simpler organic forms such as phosphates and nitrates (Galleg *et al.*, 1978). All forms of aquatic plants, which are the first link of several food chains existing in aquatic environments, can utilize the nutrients.

A highly diverse group, benthic macroinvertebrates are excellent candidates for studies of changes in biodiversity. Aquatic insects often make good indicators because they are present in some capacity in almost every type of habitat and many are habitat specialists (Lewis and Gripenberg, 2008). 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 and 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).

II. MATERIAL AND METHODS

Aquatic ecosystem directly or indirectly has an enormous ecological, commercial and socio-economic importance. They are rich in the components of biodiversity like, flora and fauna of local, national and regional significance. Aligarh and its adjoining areas are richly well off with hundreds of derelict ponds which are used as drainage basin and support an extensive and regular fisheries of various kind. This is a perennial fresh water sewage fed Pond is almost rectangular in shape. It is

shallow pond. Its source of water replenishment is mainly sewage effluent from Medical College through drains, the overhead tank and surface run-off from surrounding areas. Many washermen use this pond for washing clothes, thus adding certain chemicals and colour to its water almost every day that brings certain physico-chemical and biological changes in its flora and fauna regularly. The water of the pond is turbid due to luxuriant growth of microscopic algae, colour stains and washing chemicals used by washermen. Bottom of the pond contains mostly loose mud, sand, stones, part of dead plants, dead plankton and decayed litter deposited by trees situated on its bank.

A. Sediment analysis and Water analysis

Sampling of sediment and water was performed from February, 2009 to January, 2010. At each sampling site sediment sample was collected using Ekman-dredges and water sample in bottle after collection labeled and bring to laboratory. The collected sediment was washed and sieved on a mesh screen of 0.5 mm preserved and identify under microscope. The Benthic macro-invertebrates were identified using identification keys Edmondson (1959), Pennak (1978) and Tonapi (1980) and density determined per meter square area (ind/m^2). The conductivity and pH were measured using a digital conductivity meter, Dissolved oxygen, (TS), (TDS), (TS-TDS=TSS), Hardness, Calcium, Magnesium and Nitrate-nitrogen ($\text{NO}_3\text{-N}$), Phosphate- phosphorus ($\text{PO}_4\text{-P}$), Alkalinity and Free carbon dioxide (CO_2), composition of sand, silt and clay and Organic matter and organic carbon were analyzed according to the method given by Triedy and Goel (1984), Barnes (1959), Michael (1984).

B. Statistical analyses

Patterns of spatial and seasonal variation of Benthic macro-invertebrates population with environmental variables were described using Correspondence Canonical Analysis (CCA) with the help of Past by Hammer and Harper (2001) and diversity indices, MDS and dendrogram were calculated and plotted with the help of Primer v5 (version 5.2.4).

III. RESULT AND DISCUSSION

The percentage compositions of each of the major benthic fauna are presented in Table 1. A total of ten major taxonomic groupings were recorded. These groupings and their percentage contribution to the total macro-benthic collection are Rotifers (30%), Diptera (17.2%), Cladocera (12.25%), Coleoptera (8.9%), Ostracoda (8.5 %), Hemiptera (8.37%), Oligochaetes (6.8%), Copepoda (6.7%), Trichoptera (0.27 %) and Ephemeroptera (0.23%) (Table-I) were recorded in the study area. The Shannon Wiener index is based on both the number of species present and relative abundance of each species. Monthly benthos species diversity is given in Table II. The index values for benthic diversity varied from a minimum of 3.11 in June, 2009 to a maximum of 3.23 in February, 2009 and Menhinicks index of diversity for benthos varied from a minimum of 0.553 in December, 2009 to a maximum of 0.786 in July, 2009 (Table II). 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). Since, the Shannon-Weiner diversity index in the present study ranged between 3.11– 3.23 in the selected water ecosystem; they can be considered as moderately polluted. Moreover, diversity and evenness followed the same trend in selected study area. High diversity was always associated with high evenness (Ismail and Dorgham, 2003). Sorenson's index values (% species similarity) for Similarity index between different months of the recorded benthic groups is depicted in dendrogram and MDS (Fig. I). The highest similarity was recorded in April, 2009 – August, 2009 and lowest similarity was in July, 2009 – December, 2009 (Fig. I). Overall high Similarity index values suggest that most of the species in this ecosystem were common during the course of study. This has resulted in overlapping of faunal grouping and predictability of community composition.

Canonical correspondence analysis (CCA) of benthic community and water and sediment quality variables were drawn up in the form of one matrix and were analysed by canonical correspondence analysis (CCA) using PAST program, version (2.10) by Hammer and Harper (2001). CCA diagram was performed to determine relationships between 20 environmental variables and 10 groups of benthos. It is a non-linear technique used to relate variations in the environmental factors. Benthic data were log transformed to approach the assumed condition of normality and homoscedasticity of the data to standardize the data sets. The constrained ordination axis corresponds to the direction of the greatest variability of the data set that can be explained by the variables. In graph, environmental factors are indicated by the length of arrow, length of line represents the degree of relationship between benthic groups and environmental factors, the angle between arrow shaft and ordination axis indicates the degree of correlation between environmental factors. In addition the analysis make vertical lines connecting a particular group with the line of environmental factors, closer the connecting point on the line of environmental factors to arrow shows stronger positive correlation. Distribution pattern of groups in benthic community are represented by points, points of group and environmental factors indicates the distribution of groups and characteristics of benthic community variance along the gradient direction of each environmental factor.

The eigen value, value of p and Cumulative percentage variance of groups-environment relation of axes 1-4 are given the (Fig-II). Trichoptera and Hemiptera showed positive correlation with Dissolved oxygen whereas Diptera showed high positive correlation with Clay composition and Alkalinity. Copepoda showed high positive correlation with Clay, Sand, Chloride, pH and Mg. Other groups like Rotifera, Oligochaeta and Ephemeroptera showed high negative correlation with Water temperature, Nitrate, Hardness, TDS, % Organic matter, TS and Conductivity and Cladocera, Coleoptera and Ostracoda showed high positive correlation with Transparency, TSS, depth and Composition of Silt. CCA analysis indicates that, in this aquatic ecosystem important

factors affecting benthos distribution are Water temperature, Dissolved oxygen, Nitrate, Phosphate, Alkalinity, Calcium, Magnesium, Transparency, Chloride, Depth, Total dissolved solids, Total suspended solids, Total solids, % Organic matter, Composition of Silt and Clay. However, pH, Hardness, Conductivity and composition of Sand have a lesser influences on the distribution of the benthic species. The differences in species composition and abundance may be attributed to the ecological differences of the different habitat locations and period of investigation water quality, immediate substrate for occupation and food availability may also affect the abundance and distribution of the macroinvertebrates communities. The numerical numbers of the individual species recorded in this study were high. This suggests that they can survive eutrophic condition of water.

IV. CONCLUSION

- The absence of Mollusk and Plecoptera throughout the study area showed eutrophic condition and they can't survive in polluted water because Mollusk can't feed by their filter feeding mechanism which is blocked in polluted and high turbid water. Plecoptera can't survive at low oxygen concentration (hypoxia).
- The Shannon-Weiner diversity index in the present study ranged between 3.11– 3.23 in the selected water ecosystem; they can be considered as moderately polluted.
- The numerical numbers of the individual species recorded in this study were high this may be attributed to their level of pollution tolerance.
- The CO₂ was found to absent throughout the study period might be attributed due to its utilization in photosynthesis process as well as conversion in to carbonate and bicarbonate. This suggests that this aquatic ecosystem is polluted presently.

Table I: Monthly abundance (No/m²) and percent contribution of Benthic community

Month	CLADOCERA	COPEPODA	ROTIFERA	OSTRACODA	OLIGOCHAETA	DIPTERA	HEMIPTERA	COLEOPTERA	TRICHOPTERA	EPHEMEROPTERA
Feb'09	458	190	1049	366	157	499	329	393	9	11
Mar	488	293	904	303	186	598	203	361	7	8
Apr	389	200	975	269	200	367	260	222	4	2
May	329	174	802	257	230	704	272	241	7	4
Jun	290	168	1020	142	215	653	269	200	8	5
Jul	278	166	723	178	166	399	141	86	7	5
Aug	361	188	883	277	221	218	196	240	9	4
Sep	396	154	1021	176	257	439	162	285	5	11
Oct	327	247	1080	344	280	612	150	438	11	8
Nov	454	222	1101	392	251	508	173	261	10	11
Dec	632	219	1006	314	288	879	552	372	15	8
Jan'10	336	403	1282	271	195	777	532	345	13	12
Total	4738	2624	11846	3289	2646	6653	3239	3444	105	89
%	12.25	6.7	30.6	8.5	6.8	17.2	8.37	8.9	0.27	0.23

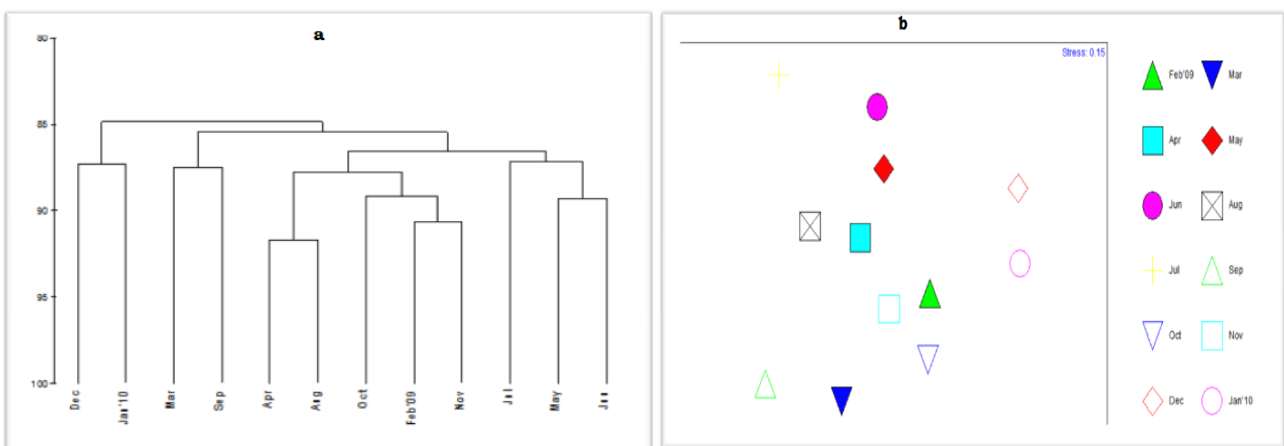
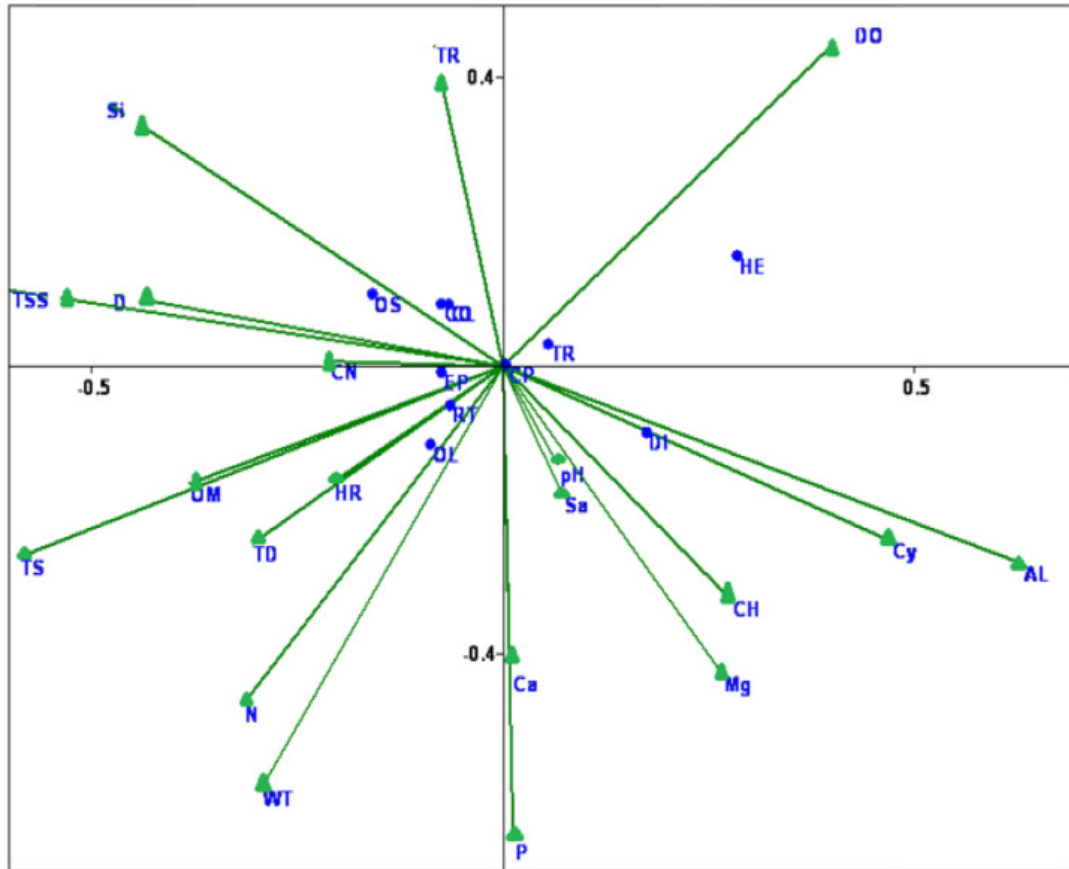


Fig.I. Dendrogram and MDS showing similarity of Benthic community between different months



Axis	Eigenval	p	%
1	0.01699	0.3069	40.35
2	0.007541	0.1584	17.91
3	0.006264	0.08911	14.88
4	0.005375	0.3861	12.77

Fig.II: Canonical correspondence analysis (CCA) diagram of 20 environmental parameters (Water temperature-WR, pH-pH, Dissolved-oxygen- DO, Nitrate-N, Phosphate-P, Alkalinity-AL, Hardness-HR, Calcium-Ca, Magnesium-Mg, Transparency-TR, Chloride-CH, Conductivity-CN, Depth-D, Total dissolved solids-TD, Total suspended solids-TSS, Total solids-TS, % organic matter-OM, composition of Sand-Sa, Silt-Si, Clay-Cy) and 10 benthic groups (Cladocera-CL, Copepoda-CP, Ostracoda-OS, Rotifera-RT, Oligochaeta-OL, Diptera-DI, Coleoptera-CO, Hemiptera-HE, Trichoptera-TR and Ephemeroptera-EP)

Table II: Monthly variation in Species Diversity and Species Evenness of benthos

Months	Species Diversity	Menhinick Index
Feb, 09	3.236	0.6089
Mar	3.205	0.6221
Apr	3.216	0.6751
May	3.169	0.6626
Jun	3.115	0.6668
Jul	3.205	0.7865
Aug	3.224	0.718
Sep	3.217	0.68
Oct	3.178	0.6171
Nov	3.192	0.6254
Dec	3.203	0.5537
Jan, 10	3.141	0.5554

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