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Biomonitoring as a Strategy for Ecosystem Health – A Case Study at the Upper Reaches of Vamanapuram River, Kerala

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Abstract: ***The present study was carried out using aquatic insects as bio monitors in the upper reaches of Vamanapuram river Kerala, The investigation was for a period of one year, from February 2014 to January 2015. The study adopted large river bioassessement protocol to assess the impact of anthropogenic pressure on aquatic insect population. Insect population showed significant spatial and temporal variations in reference site and test site. Twenty insect families under seven orders were recorded from the reference site and 13 insect families under five orders were observed at test site. Cluster analysis, Two way ANOVA and PCA was conducted by using the software, PAST 3.4. for Windows 7.Family biotic index of reference site ranged from 4.43 to 4.7 whereas in test site it was in the range of 5.94 to 6.63, indicating poor water quality in the latter. The significant increase of the tolerant taxa in the test site implies considerable ecological degradation in the study period.***

Keywords: Biomonitoring, pollution, EPT taxa, aquatic insects

1. Introduction

Nowadays Environmental health is one of the most acute global problems. Aquatic biodiversity have been adversely hampered by anthropogenic pressure as it has received less attention during last few decades. Freshwater systems harbour diverse types of heterotrophic communities specially the zooplankton, macro-invertebrates and fishes. Moreover, biological indicators have the advantage of monitoring water quality over a period of time, providing more exact measures of anthropogenic effects on aquatic ecosystems, where physical and chemical data provide momentary evidence (Camargo *et al.,* 2004). Biomonitoring is one of the most widely accepted strategies to assess the health of aquatic ecosystems. It has been extensively used to measure the environmental impact of pollutant discharges using biological variables to survey the environment properly (Gerhardt, 2000; Sharma and Sharma, 2010). Among the biological quality elements that have been used for the water quality assessment, aquatic insects are the most often recommended. In India, a lot of biomonitoring studies have been conducted by using aquatic insects to assess the quality of lotic and lentic ecosystems (Sharma and Rai, 1991; Sivaramakrishnan *et al.* 1995, 1996, 2000; Thirumalai, 1999; Subramanian and Sivaramakrishnan, 2005; Balachandran and Ramachandra, 2010; Sharma and Sharma, 2010, Nandakumar,2013; Abhijna and Bijukumar 2015).

2. Materials and Methods

Vamanapuram river is an 88 km long river originates in Chemnjimotta hills (alt. 1860m) on the southern side of Western Ghats, flows westwards and finally drains into the Lakshadweep sea through Muthalappozhi. The river basin with a catchment area of 787 sq. km. is located mainly in Thiruvananthapuram district and a small part falls in Kollam district of Kerala state. Biomonitoring of entomofauna was conducted at the upper reaches of vamanapuram river , Palode region (8°43'14.4"N 77°01'46.1"E) as test site and Kallar segment (8°42'34.2"N 77°08'04.0"E) as reference site. Palode is a village located in the Thiruvananthapuram district, which forms a small helmet in the foot hills of Western Ghats. During the study period the reference site, Kallar segment was featured by small and moderate perennial rocky stream with shore-line trees of evergreen forest. Water was cool and clear, flowing over cobbles and boulders with good current velocity. The Palode region was considerable depth (4-5 metres) at mid-stream region. Eroded river banks and accumulation of domestic and market wastes makes this region visibly contaminated.

The present investigation adopted Large River Bioassessement Protocol for sampling aquatic insects (Flotemersch et al., 2006). Monthly sampling was done for a period of one year, from February 2014 to January 2015. The study sites were categorized into reference site and test site. River origin was taken as reference site, where anthropogenic activity is minimum and was near natural condition during the period of study.

At each site, a total of six transects were set. Transect A was located at downstream end of the segment with remaining five transects at 100 m, 200 m, 300 m, 400 m and 500 m. At each transect, aquatic insects were collected from a 10 m sample zone by taking 5 m on each side of transect. Bank-oriented sampling was chiefly done except shallow areas. The duration of sampling was set as 2 hours which consistently maintained for each site. Various habitats such as Run, Riffle, Pool, Riparian, Benthic zones and Point Bars at different orders were used for sampling approximate proportion to their representation of surface area of the total insect habitat in the reach. Sampling began at the downstream end and proceeded upstream. Sampling gears used are Peterson Grab, Kicknet and D-frame dip net. The collected insects were preserved in 95% ethanol. All insects and larvae were identified up to family level using a suitable key (Morse *et al.,* Yule and Young, 2004). The benthic metric calculated were structure metrics, composition

metrics, tolerance metrics, feeding metrics, habit metrics and Hilsenhoff's Family Biotic Index (Hilsenhoff, 1982). Cluster analysis, Two way ANOVA and PCA was conducted by using the software, PAST 3.4. for Windows 7.

Cluster analysis was used to alienate information on the similarities and dissimilarities between sampling sites. The classification is based on the similarity of object attributes. The clusters are characterized by high similarity within the cluster and high dissimilarity between clusters. To check the validity of obtained data and significance of the results, two way ANOVA and correlation coefficient were computed.

3. Results and Discussion

Premonsoon collection of insects in the reference site showed 20 families at reference site and 13 families at test site. The number of EPTtaxa showed 7 taxa at reference site and two taxa at test site. Percentage composition of EPT was 42% at reference site and 15% at test site. In reference site 23% of insects belong to Ephemeroptera whereas in test site it was only 15%. The number of intolerant taxa was 7 at reference site and only two in test site. Percentage of tolerant organism in reference site and test site was 62% and 30% respectively. Percentage of dominant taxa was the same in reference site and test site (15%). 38% of collected insects were filters in test site and that was only 15% at reference site. Percentage of grazers and scrappers in the test site (28%) outnumbered the test site (20%). Percentage of clinger taxa was 28% at reference site and 13% at test site. Family biotic index in the test site and reference site were 5.94 and 4.47 respectively. The results of theEPT taxa variations of the present study showed close similarity with Kochalumood segment of Achencovil river.(Nandakumar 2003)

In monsoon out of 20 insect families collected from reference site 7 represented EPT taxa whereas in test site it was 12 and 2 respectively. The percentage of EPT in the reference site (40) outnumbered test site (13%). In reference site Plecoptera and Trichoptera were represented by three families but they were completely absent in the test site. Percentage of EPT also showed remarkable difference, that is 21% at reference site and 13% at test site. The number of intolerant taxa was 7 at reference site and only 2 in the test site. 26% of the insects collected from the reference site belong to tolerant organisms but in test site it was significantly higher (69%). Percentage of dominant taxa was 21% at test site whereas 17% at reference site. Contribution of filters was 11% and 52% for reference site and test site respectively. Percentage of grazers and scrapers showed a hike of 26% at the test site and 23% at the test site. Number of clinger taxa reduced to 1 at test site when compared to 6 taxa at the reference area. Percentage of clinger taxa was 27% and 13% respectively in reference site and test site. Family biotic index had striking difference between sites with values of 4.43 and 6.01 at reference site and test site respectively. Akkulam Lake was due to deterioration of water quality due to anthropogenic activities like disposal of sewage, solid wastes, agricultural wastes and industrial pollution.

Postmonsoon collected of insects from Palode segment revealed the presence of 17 taxa in the reference site and 8 taxa at test site. Number of EPT taxa was 6 at reference site and their complete absence was noticed in test site. Percentage of tolerant organisms showed a hike of 78% at test site and 30% at the reference site. Percentage of dominant taxa in the reference site and test site were 25% and 23% respectively. Filters were Chironomidae, Culicidae and Simuliidae under the order Diptera that contributed 41% at test site and 11% reference site. Clinger taxa and Grazers and scrappers were completely absent in the test site. Family biotic index showed a striking pattern of difference with values 6.63 at test site and 4.70 at test site. Nandakumar (2013) also reported the complete absence of EPT taxa in Kochalumood segment during the entire study period. Absence of EPT taxa in the test site indicates that the pollutants tremendously increasing in post monsoon especially due to the stagnant nature of water.

On computation of between-site test for comparative analysis of pollution for reference and test site of Palode segment during premonsoon, 13 metrics matched with predicted values of increased perturbation at test site. One metric mismatched and one metric equalised at both sites. In monsoon, out of 15 metrics calculated 14 matched with the predicted values of contamination and only one showed mismatch. In postmonsoon, all the metrics except one confirmed the contamination at test site. Only one metric mismatched the predicted values of contamination.

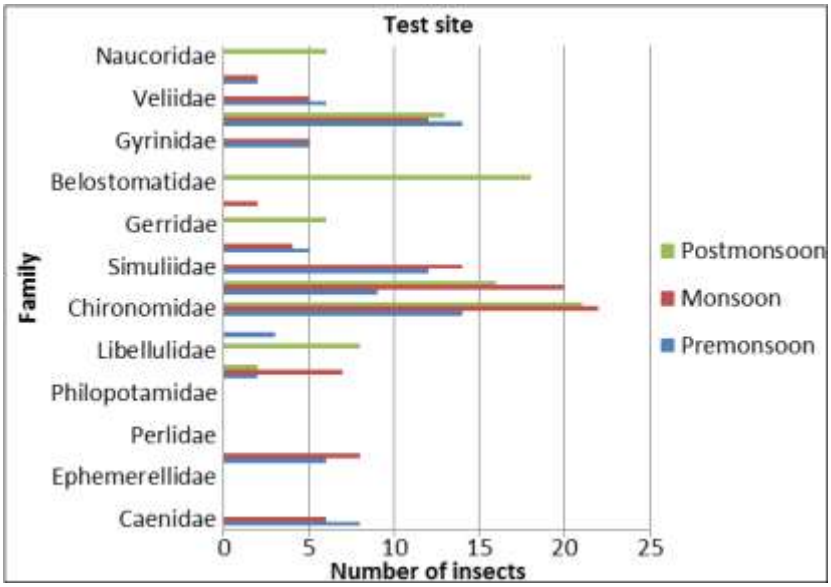

Figure 1: Number of samples obtained for different taxa in the test site during premonsoon, monsoon and postmonsoon.

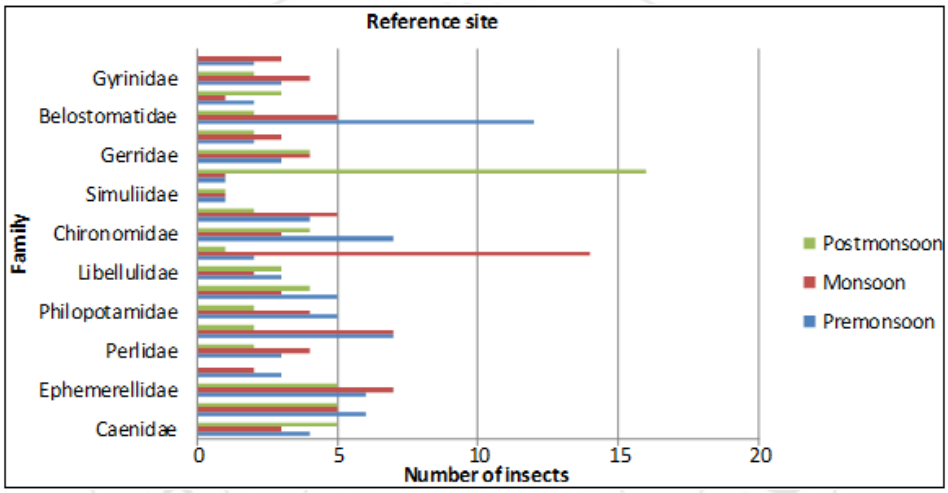

Figure 2: Number of samples obtained for different taxa in the reference site during premonsoon, monsoon and postmonsoon.

During the present study, the variation in occurrence of aquatic insects between test site and reference site can be explained by temporal changes that occur in on the water level and flux affecting some abiotic parameters such as temperature, dissolved oxygen and nutrient availability (Lalparmawii, 2013). EPT taxa richness is the single most reliable metric used for assessing the degree of habitat degradation due to anthropogenic interference. The percentage of EPT taxa in the reference site stood above 30 in all the three season whereas in the test site it was below 16. The comparatively higher proportion of intolerant taxa in the reference site implies excellent water quality in the reference site. Absence of intolerant taxa in the test site indicates that contaminants continuously flow in the river and become accumulated due to stagnant nature of water especially during postmonsoon. The insect species in the orders Odonata, Coleoptera and Diptera appear to show a certain relation to the condition of their location. The distribution of species in such orders can be correlated to physic-chemical characteristics of the habitats (Lalparmawii, 2013). The decline of water quality and biological conditions in the test site is related to the presence of point source pollution discharges, as suggested by Harding *et al.* (1999). This lower water quality and the decline in ecosystem health is revealed by 1) low level of insect diversity and consequent dominance of tolerant taxa (Diptera) as demonstrated by Marques et al. (1999) for the Piracicaba river. The seasonal variations in the aquatic insect assemblages has been significant in many studies which is in line with the present investigation (Grubaugh *et al.*, 1996., Batzer *et al.*, 2004; Bonada *et al.*, 2007; Bereczki *et al.*, 2012 and Nadakumar,2013.

Results of two way ANOVA revealed no significant temporal variations in the distribution of aquatic insects in the reference site ($F=0.26$, $P=0.078>0.05$) and test site ($F=2.97$, $P=0.067>0.05$)

The Bray-Curtis similarity analysis confirmed that, there is four distinct clusters- cluster 1 includes premonsoon and monsoon of test site, cluster 2 includes test site post monsoon, cluster three comprises reference site post monsoon, cluster four includes premonsoon and monsoon of reference site. Cluster 1 showed 93% similarity with cluster 2 and 72% similarity with cluster 3.Cluster 3 shows 92% similarity with cluster 4.

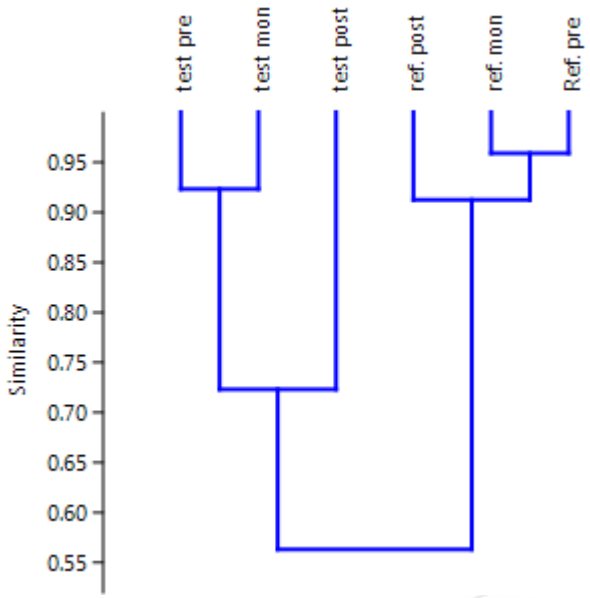

Figure 3: Dendogram of Bray-Curtis cluster analysis of two study stations in three seasons.

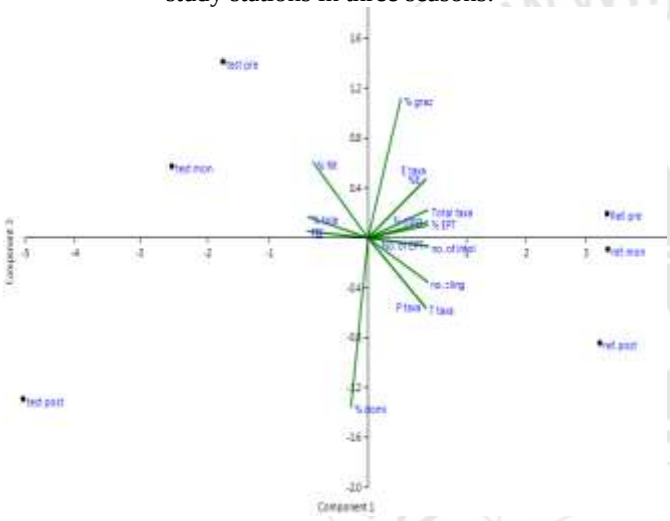

Figure 4: Biplot of 15 benthic metrics in reference site and test site of all the three seasons.

PC	Eigenvalue	% variance
1	12.66	84.43
2	1.32	8.82
3	0.87	5.83
4	0.12	0.79
5	0.02	0.13

Eigen values and percentage of variation in benthic metrics of Palode region

Based on the Eigen values screen plot (fig.3), 15 variables including benthic metrics were reduced into five main factors (factor 1, 2,3,4 and 5). The first factor corresponding to the largest Eigen value (12.66) accounts for approximately 84.43% of the total variance. The second factor corresponding to the second eigen value (1.32) accounts for 8.82% of the total variance. The third factor corresponding to the third eigen value (0.87) elucidate 5.83% of the total variance. The fourth and fifth factors registered very low Eigenvalues, 0.12 and 0.02 respectively.

This investigation revealed that reference site was mostly dominated by aquatic insects that have high sensitivity scores and there was also higher EPT diversity observed upstream than at the downstream sites. The occurrence of highly sensitive families upstream signifies a healthy aquatic environment (Motebang *et.al.*, 2017) and this may be attributed to less or minimal human activities. In the present investigation, origin of Vamanapuram river could be considered pure in nature due to less anthropogenic activities since it is protected by Reserve Forest Areas of Kallar forest ranges. The insect community assemblage was undisturbed due to the minimum of human interference. The insects collected form Kallar region was mainly composed of Ephemeroptera, Plecoptera and Trichoptera. The members of these families are particularly adapted to flowing water with a depth of less than one meter and sensitive to pollution. This region provides well oxygenated water with sufficient organic food sources aquatic insects. River origin showed comparatively high level of taxa richness in all the seasons.

In Palode segment the insect community assemblage was seriously hampered by anthropogenic activities like dumping of kitchen waste, hotel waste, market waste, hospital wastes, sand mining etc. Palode segment was the most notable segment for the reduced number of EPT taxa throughout the study period. Reduction of EPT at test site indicates that contaminants continuously flowing through the river in all seasons and get accumulated due to stagnant nature of water body during premonsoon. The aquatic insect communities of test site of Palode segment was occupied by highly tolerant taxa such as Chironomidae and Culicidae. Hilsenhoff's Family Biotic Index of this station provides alert on the severe deterioration of water quality.

4. Conclusion

Since river is the major source of water for human population, care must be taken to maintain its quality. Palode region of Vamanapuram river showed significant reduction of pollution sensitive taxa in all the three season and this implies considerable level of pollution in all seasons. Survival of aquatic insect population is severely hampered due to anthropogenic pressure. Government must pay immediate attention to safe guard this precious freshwater ecosystem and ensure pollution free water to the population that relies upon this river.

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