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EVALUATION OF MACROBENTHIC INVERTEBRATES IN THE LONGITUDINAL PROFILE OF A RIVER (TAWI), ORIGINATING FROM SHIVALIK HILLS

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Abatract

During the present investigative studies of the longitudinal profile of River Tawi, great variation in the distribution of macrobenthic invertebrate fauna was observed in the upstream and downstream sections. Analytical study of longitudinal profile of River Tawi revealed the presence of 52 taxa predominantly belonging to Phylum Annelida, Arthropoda and Mollusca. Amongst these 3 phyla, Phylum Arthropoda dominated both qualitative and quantitative dominance over the other two phyla. Upstream sections of the River were found to be pristine or nearly pristine in nature whereas downstream sections were observed to be highly polluted. Ephemeropterans, Plecopterans and Trichopterans which are commonly known as pollution sensitive species were found to be numerically abundant in the upstream sections and recorded to be totally absent in the downstream sections. On the other hand pollution tolerant species of order Coleoptera, Odonata, Diptera, and class Oligochaeta were present in greater number in the downstream sections. Numerical abundance of *Chironomous* sps. and *Tubifex* sps. throughout the experimental period reflected the anthropogenic stresses of the River in its downstream sections.

Key words: - Longitudinal profile, macrobenthic invertebrate, upstream, downstream, anthropogenic

INTRODUCTION

Rivers are the most important freshwater resources because of their support and maintenance of macro and micro ecosystems. These riverine systems carry water from the mountains to the sea, furling the water cycle, coupling land, ocean and the atmosphere [14]. Social, economic and political development of mankind has in the past, been largely related to the availability and distribution of freshwater contained in riverine systems.

Rivers serve as sources of water for recreational activities such as bathing, fishing and are also the most suitable media to clean, disperse, transport and dispose off wastes like domestic and industrial wastes, mine drainage waters, irrigation returns etc. [17].

Until recently, deterioration of water bodies by pollution was not a serious problem because human populations were small, lived in scattered communities and the wastes were dumped into rivers were subjected to dilution and natural self-purification [15]. With ever increasing population and industrialization, however, human societies affect rivers and their ecosystem structure and functioning in an ever alarming way [25]. Urban centers put huge amounts of organic and synthetic waste into the rivers with little or no treatment. Uncontrolled agriculture, excessive fertilizers and pesticide application alter rivers and their ecological integrity thus deteriorating the riverine ecosystems [17].

Macrobenthic invertebrate assemblages are among the most frequently used biological tools for environmental impact assessment having their own specific advantages. The presence or absence of macrobenthic invertebrates has been considered to be a good indicator of both chronic and episodic impact of anthropogenic influences to river condition and other aquatic environment [24]. In the backdrop of this longitudinal profile of River Tawi was carried out by dividing the whole stretch of river into five stations.

MATERIAL AND METHODS

Study area

This study which was carried out in September 2008 to August 2009 covered the riverine system of the Tawi River (Fig. 1) in the district of Jammu; J&K. River Tawi drains through the vicinity of Jammu division lies between 74° 50’ and 33° 30’N latitude. The river is also very liable to floods which occur at the time of the periodical rains of summer and in the season of more irregular winter rains. The water of River Tawi is the sole source of drinking water for the inhabitants of Jammu city. Besides, river water is also used for irrigation, recreation, sewage disposal, fishing etc.

In order to assess the distribution of macrobenthic invertebrate fauna along the longitudinal profile of River Tawi, four stations were selected. Station I (Chenani) and Station II (Jhajjar Kotli) instituted in the upstream section of the river were entirely pollution free without any human interference whereas station III (Vikram Chowk) was present in the vicinity of the city which was highly exposed to several anthropogenic activities including municipal and domestic sewage and agricultural runoff, dredging, bathing, washing etc. Station IV (Miran Sahib) in the downstream receives agricultural runoff along with industrial discharges coming from the two drainages thus polluting the river. So, stations III and IV experienced very high degree of human interference.

Physico-chemical determinations

The seasonal variations of the physico-chemical factors of water were studied from September 2008 to August 2009. Monthly samples were collected from various sites in the early hours (7.00 am-9.00 am) of the day during first week of every month. Utmost care was taken to avoid spilling of water and bubbling of air during sampling in iodine treated polyethylene bottles. All the physico-chemical characteristics of water were determined at the sampling sites, while others were analysed in the laboratory within 4 to 8 hrs. The water and Air temperature was recorded by a mercury bulb thermometer, Depth by a meter rod, Transparency by secchi disc, dissolved oxygen, free carbon dioxide, pH, carbonates, bicarbonates calcium and magnesium were analyzed [1]. pH of the water was determined by using a portable pH meter (Hanna, model HI 98130). Dissolved Oxygen of the water was determined by Sodium azide modification of Winkler's method [1]. Free Carbon Dioxide (FCO_2) was estimated by titrimetric method recommended[1]. Carbonates and bicarbonates were estimated [1]. Argentometeric method using potassium chromate as indicator was adopted for the estimation of chloride (A.P.H.A, 1985). Calcium and Magnesium, the estimation of Ca^{++} and Mg^{++} was done by the method [1, 11]. Nitrates and Phosphates were estimated [1]. Estimation of BOD and COD was done following [2].

The bottom soil samples were collected using an Ekman dredge having an area of 232 cm2. The soil samples collected were sieved immediately using no. 40 mesh size sieve (256 mesh per cm^2). The organisms retained were segregated and their abundance was calculated as number per square meter [12, 34]. Preserved samples of macrobenthic invertebrates were identified [2, 22, 33]. The abundance of these organisms was calculated as number per square meter by applying the following formula;

N=O/A.S x 10,000 Welch (1948)

Where,

N = no. of macrobenthic organisms/m^2

O = no. of organisms counted

A = area of metallic samples in square meter

S = no. of samples taken at each stations

STATISTICAL ANALYSIS OF DATA:

Diversity indices:

To understand a particular biotic community it is very important to work out certain indices. Different diversity indices such as species diversity (Shannon Weiner, Simpson and Menhinick's), richness (Marglef's), dominance (dominance and Berger-Parker) and equitability were calculated by using Biostat software.

Spearman's Correlation matrix:

The correlation matrix was used because it standardizes the data and minimized variation caused by different scales of the environmental variables. Correlation analysis (Proc Corr; SAS Institute 1996) was used to determine which taxa and environmental variables had significant loadings for their respective ordinations. Correlation analysis was also used to determine if and how eigenvectors from the invertebrate and environmental ordinations were related.

Dendrograms were prepared using software SPSS Ver. 16.0.

Table-1: Diversity of macrobenthic invertebrate across the longitudinal section of River Tawi

Organisms	**Station-I**	**Station-II**	**Station-III**	**Station-IV**
Lumbriculus sps.	-	+	+++	+++
Tubifex sps.	-	++	+++	+++
Branchiura sps.	-	-	++	+++
Erpobdella sps.	++	-	-	-
Aelosoma sps.	-	-	++	-
Limnodrillus sps.	-	-	+	++
Tabanus sps.	-	-	+	++
Pentanura sps.	-	+	+	-
Chironomous sps.	-	+	+++	+++
Culicoides sps.	-	-	++	+
Probezzia sps.	-	-	++	-
Psychoda sps.	-	+	+++	-
Eristalis sps.	-	-	++	+++
Chaoborus sps.	-	+	-	+
Dolophilodes sps.	+	-	-	-
Limniphilus sps.	++	-	-	-
Capnia sps.	+	-	-	-
Pteronarcys sps.	++	-	-	-
Ephemerella sps.	-	+	+	-
Habrophlebia sps.	++	-	-	-
Epeorus sps.	+	-	-	-
Cordulia sps.	+	-	-	-
Hydropsyche sps.	-	+	-	-
Sympetrum sps.	-	++	-	-
Callibaetis sps.	-	+	-	-
Baetis sps.	-	-	++	+
Caenis sps.	-	+	++	-
Cynigma sps.	-	+	-	-
Hydroglyphus flammulatus	-	-	++	-
H. signatellus	-	-	++	-
H. pendjabensis	-	-	+	-
Ephemerella sps.	+	-	-	-
Erythemis sps.	+	-	-	-
Crocothemis sps.	+	-	-	+
Perithemis sps.	-	-	++	-
Dromogomphus sps.	-	+	+	-
Ophiogomphus sps.	-	-	+	+
Progomphus sps.	-	-	++	-
Chimarra sps.	+	-	-	-
Enallagma sps.	-	-	++	+
Berosus pulchellus	-	+	+++	-
Laccophilus sharpi	-	-	+	-
Neohydrocoptus subvittulus	-	-	+	-
Laccobius sps.	-	+	+	-
Enochrus sps.	-	-	+	-
Hydrometra sps.	-	+	-	-
Laccophilus sps.	-	+	-	-
Helochares sps.	-	-	+	-
Berosus sps.	-	-	+	+
Corixa sps.	-	+	+++	-
Sphaerodema molestum	-	-	++	-
Plea sps.	-	-	++	-
Macrobrachium sps	+	+	-	-
Lymnaea auricularia	+	+	-	-
Corbicula cashmiriensis	++	++	-	-
Lymnaea accuminata	-	+	+	++
Physa acuta	-	-	++	+++

Table-2: Pearson's Correalation coefficient of Macrobenthic invertebrates and selected parameters of different stations along the longitudinal profile of River Tawi

	Annelida	Arthropoda	Mollusca
A.t	0.326	0.951**	0.357
W.t	0.310	0.787**	0.534*
FCo2	0.378	0.388	0.720*
DO	0.407	0.623*	0.855*

Station-I (Chennani)

	Annelida	Arthropoda	Mollusca
A.t	0.256	0.174	0.083
W.t	0.072	0.395	0.147
FCo2	0.040	0.081	0.237
DO	0.289	0.891*	0.301

Station-II (Jhajjar Kotli)

	Annelida	Arthropoda	Mollusca
A.t	0.223	0.226	0.981**
W.t	0.319	0.221	0.945**
FCo2	0.205	0.443	0.697*
DO	0.196	0.284	0.701*

Station-III (Vikram Chowk)

	Annelida	Arthropoda	Mollusca
A.t	0.245	0.194	0.434
W.t	0.133	0.328	0.576*
FCo2	0.936*	0.828*	0.407
DO	0.734*	0.425	0.134

Station-IV (Miran Sahib)

Table-3: Seasonal variations of the diversity indices along the longitudinal profile of River Tawi

	Station-I	Station-II	Station-III	Station-IV
Taxa	16	14	12	9
Individuals	2808	3006	3996	2367
Dominance	0.254-0.093	0.261-0.081	0.66-0.210	0.760-0.204
Shannon indx	2.489-1.859	2.759-1.839	1.838-0.623	1.851-0.650
Margalef	1.889-1.228	2.724-1.623	1.326-1.118	1.321-1.03
Equitability	0.964-0.748	0.926-0.697	0.798-0.260	0.803-0.282

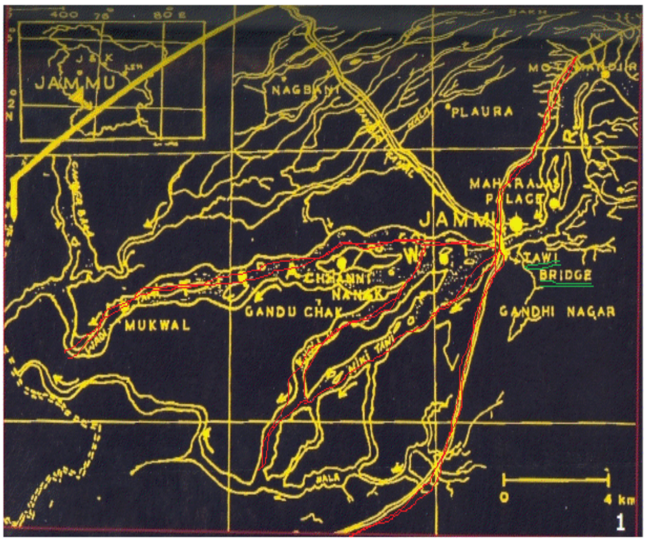

Fig. 1: Map of River Tapi (Sawhney, 2008)

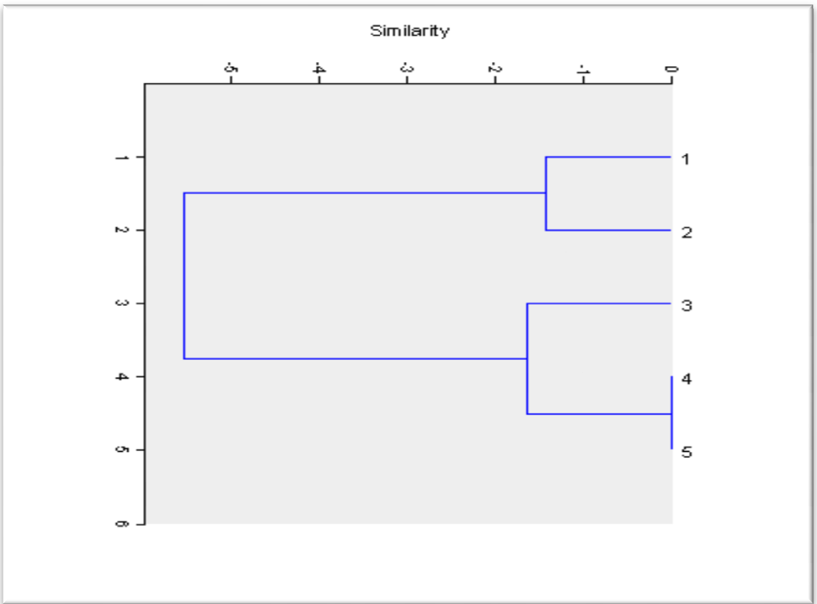

Fig. 2: Dendrogram of cluster analysis showing the similarity in different stations of River Tawi along the longitudinal profile with respect to the macrobenthic invertebrates and Physico-chemical parameters.

RESULTS AND DISCUSSION

Four stations were selected along the longitudinal profile of River Tawi in the vicinity of Jammu City. Investigative study of longitudinal profile of River Tawi revealed the presence of 57 taxa (Table-1) predominantly belonging to Phylum Annelida, Arthropoda and Mollusca. Amongst these 3 phyla, Phylum Arthropoda dominated both qualitative and quantitative dominance over the other two phyla during the present investigations in River Tawi. Similar type of dominance by Phylum arthropoda in other water bodies have reported earlier by many workers [8, 27, 32].

A perusal of table (table-1) indicated that quantitatively and qualitatively there is a decrement in the diversity and density of macrobenthic invertebrates along the longitudinal profile of River Tawi (fig-1). Such a decrement in diversity may be attributed to the increased influx of pollution load and human interference that may tend to alter the biotic characteristics of River Tawi water besides altering the abiotic feature of water.

Class Insecta of Phylum Arthropoda recorded their maximum contribution to the total macrobenthic invertebrate faunal diversity. Interestingly station wise analysis of data regarding prevalence of macrobenthic invertebrate fauna promulgated that 3 species of Trichoptera and 1 *sps.* of Plecoptera were restricted only to station I in the upstream sections of River Tawi whereas order Ephemeroptera exhibited a decreasing trend from station I to station III and was found to be absent in station IV.

Presence of Trichoptera, Plecoptera and Ephemeropotera in upstream may be attributed to increased oxygen content, low depth, less organic load, less human activities. The abundance of Trichoptera, Plecoptera and Ephemeropotera thus indicates that the upstream sections of River Tawi were relatively free from pollution. The present findings thus indicates that Arthropods (Trichoptera, Plecoptera and Ephemeropotera) were found to establish a positive correlation values with DO ($p \leq 0.05$; r= 0.62) (table-2). The above observations are in conformation with the findings of other authors who also explained the similar type of positive relationship among the arthropods (Trichoptera, Plecoptera and Ephemeroptera) and water of the aquatic systems in which they are inhabiting [3, 7, 8, 18, 20, 27].

Order Odonata, Hemiptera, Coleoptera and Diptera recorded an increase in their population from upstream to the downstream sections of the River. This may be due to the adaptations of the individuals to live in moderate polluted waters [6, 32].

A look at the table 1, reveals that the Order Diptera chiefly comprised of 5 species out of which *Chironomous sps.* was the dominant group and recorded its highest number in the highly polluted sections of River Tawi. It is well documented that the family chironomidae is considered to be a pollution tolerant families of Order Diptera which may be due to the presence of haemoglobin pigment that helps them to collect oxygen directly from the atmosphere. The statistical analysis of the data reveals that all these observations thus explain the significant negative correlation between Arthropoda and DO ($p \leq 0.05$, r= -0.525) and a significant positive correlation with FCO_2 ($p \leq 0.05$, r= +0.828) (Table-2) in the downstream sections of River Tawi.

In addition to this other plausible reasons of increment in Dipteran population in the downstream sections of River Tawi may be due to reduced flow of water, high nutrient load, increased human interference and increased decomposition. numerical abundance of dipterans in the downstream sections of the water bodies have also been reported by many workers n their respective works [3, 8, 10, 29].

Phylum Anneida was represented by two classes viz:- Hirudinea and Oligochaeta. Class Hirudinea with one *sps.* was present in station II only whereas Class Oligochaeta with 4 *sps.* were recorded only from the downstream stations. According to Brinkhurst [5], Oligochaetes are more encountered in grossly polluted and organically enriched water bodies with low oxygen. Organically enriched downstream station (IV) favour the colonization of Oligochaetes. Above observations thus confirms the significant negative correlation of Oligochaetes with DO ($p \leq 0.05$, r= -0.734) (table-2) and thus get confirmation from the findings of different worker s [4, 19, 28, 30, 35, 36].

Phylum Mollusca which contributed only 2 *sps.* of Class Gastropoda and 1 *sps.* of Class Bivalvia also exhibited variation in the longitudinal profile of River Tawi. It was observed that they also followed the same trend of increased number from upstream to downstream sections of River Tawi. Gastropods prefer substrates with decomposed organic matter or macrophytes in the water [22]. Their number was found to be highest in station IV which may be due to availability of suitable habitats, organically enriched soft bottom and slow water currents.

No significant correlation was observed between Phylum Mollusca and DO or FCO_2 and these findings substantiate with the findings of earlier workers [13, 21, 23, 26, 31].

In station I values of different biological indexes (table-3) varied from shannon's species diversity index (H= 2.489 to H= 1.859), species richness (d= 1.889 to d= 1.228), equitability index (E= 0.964 to E= 0.748) and dominance (D= 0.254 to 0.093). Station II recorded shannon's diversity (H= 2.759 to H= 1.839), species diversity (d= 2.724 to 1.623), equitability (E= 0.926 to E= 0.697) and dominance (D= 0.261 to D= 0.081). Values of indexes recorded in station III varied from shannon's diversity index (H= 1.838 to H= 0.623), species diversity (d= 1.36 to d= 1.118), equitability (E= 0.798 to E= 0.260) and dominance (D= 0.66 to D= 0.210). In station IV shannon's diversity index was found to be (H= 1.851 to H= 0.650), species richness (d= 1.321 to d= 1.03), equitability (E= 0.803 to E= 0.282) and dominance (D= 0.760 to D= 0.204). Shannon's diversity index, species richness and equitability index values exhibited their higher values at the upstream stations (I and II) whereas their lower values were obtained from the downstream stations (III and IV). Contrary to this higher values of dominance index values were recorded from the downstream sections and its lower values were observed in the upstream sections.

High values of diversity indexes in the upstream sections of River Tawi reflected the stability of the physical and chemical characteristics of the river in the upstream sections. On the other hand low values of diversity found in the downstream sections may be due to the increased influence of human activities.Increased diversity and species richness values in the upstream sections due to habitat heterogeneity and increased dominance index values in the downstream human impacted sections [16, 19, 35, 36].

Also, dendrogram (fig-2) of cluster analysis using macrobenthic invertebrate data revealed that staion I and station II are similar. This may be due to the reason that these stations are least affected by the pollution so exhibits nearly similar macrobenthic invertebrate fauna. On the other hand station III and IV originated from the different branch among which station IV and V were overlapped. Plausible reasons for the separate clad for station III is that station III is moderately polluted. Station IV being separate thus proved to be highly polluted station.

CONCLUSION

River Tawi is found to be under high impact and is impaired in the downstream sections. On the other hand, the river water is used for a variety of purposes such as irrigation, cattle drinking and domestic purposes. As the human population continues to grow, it will contribute significantly towards the process of river biodegradation. This biosurvey of the macrobenthic invertebrate fauna gives an important insight into the health of the river and appends the knowledge and understanding of the management strategies involving biomonitoring as a significant tool in the river restoration studies.

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