Macro-benthic diversity in relation to water quality status of Song River, Dehradun, Uttarakhand, India.

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Abstract: Aquatic macro invertebrates are used in fresh water quality assessment to identify the environmental stress resulting from a variety of anthropogenic disturbances. They also play a significant role in the food chain of an ecosystem. Monthly survey of macro benthic community diversity and water quality assessment at 3 sampling stations was done from December, 2015 to May, 2016 in Song river of Doon Valley, District Dehradun. Phylum Arthropoda was found to be most dominating (52%), followed by Phylum Mollusca (22%) and Phylum Annelida (19%). Order Hemiptera was the most diverse group represented by a maximum of 5 genera. Shannon-Wiener diversity index was also calculated. The water quality also depicted a temporal variability pattern.
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Key Words: Macro-invertebrate, Song River, Water quality, Physico- chemical parameters.

1. Introduction

Freshwater macro-vertebrates are one of the most threatened taxonomic groups because of their high sensitivity to the quantitative and qualitative alteration of aquatic habits. Benthic microfauna are those organisms that live on or inside the deposits at the bottom of the water bodies **(Barnes and Hughes 1988, Idowu and Ugwumba 2005).** Macro-benthic invertebrates are useful bio-indicators provides more accurate understanding of changing aquatic conditions than chemical and microbiological data, which at least give short-term fluctuations, **(Ikomi et. al; 2005)**. Obtaining representative benthic invertebrate samples is an important consideration for both ecological and bio monitoring studies that require the collection of multiple replicate samples from numerous sites **(Barbour and Gerritsen 1996).** Processing this large amount of material is often a limiting factor in benthic research. Benthic invertebrate samples are a subset of the River population that can be used to make inferences about the community. Benthic invertebrates are consumers of basal resources (algae, biofilms, organic matter), and secondary consumers. They are the link from basal resources to higher trophic levels, including fishes. Benthic invertebrates are often sampled in aquatic monitoring programs because they are diverse, generally sedentary, and are responsive to environmental alterations. More importantly they are good indicators of ecosystem productivity and health. Therefore, the present study is aimed towards the assessment of benthic macroinvertebrate diversity in relation to water quality of Song River, Dehradun.

2. Material And Methods

The area selected for the present work is 'Doon Valley'= Dehradun valley, the longitudinal intermontane valley (80 km x 25 km), situated between outer and lesser Himalaya. Confined between River Ganga in the East and River Yamuna in the West, it geographically lies between 29° 50'-30° 30' N Latitude and 77° 35'- 78° 20' E Longitude (area lying between the West bank of river Ganga and East bank of river Yamuna).

Districts of Pauri-Garhwal in the South-East, Saharanpur in the South, Chakrata in the Northwest and the state of Himachal Pradesh in the South-West form the respective boundaries of the area. Ganga and Yamuna, the two principal rivers, bordering the valley in the South-East and the North-West, respectively, from the two distinct drainage systems.

Song is another perennial tributary of Ganga (arising from Surkanda peak at an elevation of about 9000 m above msl) in Tehri Garhwal district. In its upper course, the river flows parallel to the North-East boundary of the valley and after receiving water of the perennial tributaries Baldi and Bandal at right angles near Maldeota village **(Wadia, 1939)**, it flows through a wide-opened valley in the North-South direction. After traversing about 40 kms in the valley, it finally confluences with Ganga in Raiwala. Besides, Song also forms a deferred junction with Suswa near Kans Rao forest.

In order to assess the temporal variability pattern in the macro invertebrate as well as water quality, three sampling stretches were selected – Upper Stretch (US), Middle Stretch (MS) and the Lower Stretch (LS) [Fig.1].

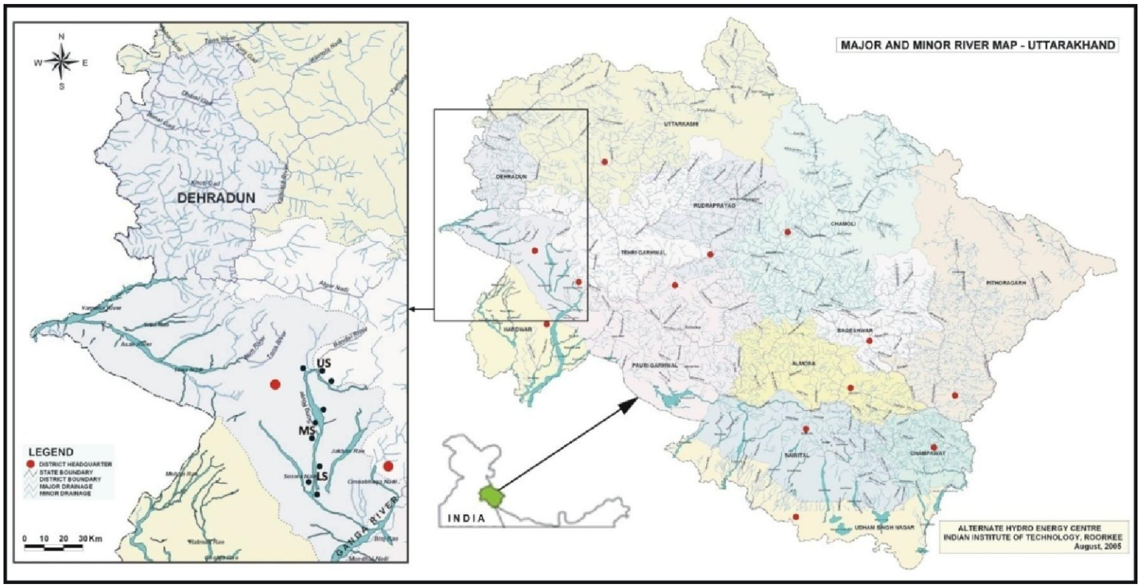

Fig. 1 Sampling stations on Song River, District Dehradun.

Macro-invertebrates were collected by enclosing $1m^2$ stream area with fine - meshed hapa and sweeping the area completely so that substratum of $1m^2$ area is enclosed. The bottom stones, pebbles *etc.,* in the enclosure were disturbed and overturned so that the benthic fauna residing beneath them also gets washed with the water current and thus collected in the enclosure. These were then collected with the help of fine forceps in each site. The organisms were then brought to the laboratory for separation and identification. Preservation was done in 4% formalin and identification was done into generic / group level with the help of standard literature **(Tonapi, 1980; Macan, 1960; APHA, 2005).** All coarse material was sorted, counted, and identified.

Water samples were collected from each sampling site, twice a month from three separate spots using Von Dorn Water Sampler and BOD bottles. All the three samples were mixed together to obtain a grab sample. They were analyzed in the laboratory by following the standard methods **(Trivedy and Goel, 1984 and APHA, 2005).** Of the selected physical and chemical parameters studied, all the physical and some chemical ones were determined on the spot and the rest were determined in the laboratory depending upon the requirement.

3. Results And Discussion

A total of 32 macro-benthic taxa were identified during the study period which is presented in Table 1. **Order Hemiptera** was the most diverse group represented by a maximum of 5 genera. **Phylum Arthropoda** was found to be most dominating (52%), followed by Phylum Mollusca (22%) and Phylum Annelida (19%) [Fig. 2].

Table-1. Checklist of macrobenthic diversity of Song River:

S. N.	Classified List	Sampling Stations		
		S_1	S_2	S_3
	Phylum: Platyheliminthes			
1.	*Dugesia*	+	+	+
	Phylum: Nematoda			
2.	*Paradoxorhabitidis*	-	-	+
	Phylum: Annelida **Class: Hirudinea** **Order: Rhynchobdellidae** **Family: Hirudidae**			
3.	*Hirudenaria*	+	-	+
4.	*Haemophis*	+	-	+

S. N.	Classified List	Sampling Stations		
		S_1	S_2	S_3
5.	*Hirudo*	-	-	+
	Family: Ichthyobdellidae			
6.	*Piscicola*	-	-	+
	Family: Glossiphonidae			
7.	*Glossiphonia*	-	-	+
	Order: Plesiophora **Family: Tubificidae**			
8.	*Tubifex*	-	-	+
	Phylum: Arthropoda **Class: Crustacea** **Subclass: Malacotraca** **Order: Decapoda**			
9.	*Macrobrachium*	+	+	+
10.	*Carcinus*	+	-	+
	Class: Insecta **Order: Ephemeroptera**			
11.	*Ephemerella*	-	-	+
12.	*Heptagenia*	+	+	+
	Order: Odonata			
13.	*Aeshna*	+	+	+
14.	*Libelluilla*	+	-	+
15.	*Lestes*	+	+	+
	Order: Trichoptera			
16.	*Hydropsyche*	-	-	+
	Order:Hemiptera			
17.	*Gerris*	+	-	+
18.	*Ranatra*	+	-	-
19.	*Nepa*	-	-	+
20.	*Belostoma*	-	+	+
21.	*Corixa*	-	+	+
	Division: Endoptrygota **Order: Coleoptera**			
22.	*Psephanus*	-	-	+
23.	*Cybister*	+	-	+
24.	*Gyrinus*	+	+	+
	Order:Diptera			
25.	*Tipula*	-	-	+
	Phylum: Mollusca **Class: Gastropoda**			
26.	*Lymnaea*	+	+	+
27.	*Thiara*	-	-	-
28.	*Indoplanorbis*	+	+	+
29.	*Gyraulus*	+	+	+
30.	*Bithynia*	+	+	+
	Class:Pelecypoda			
31.	*Unio*	+	+	+
32.	*Anodonta*	+	+	+

+ = Present, - =Absent

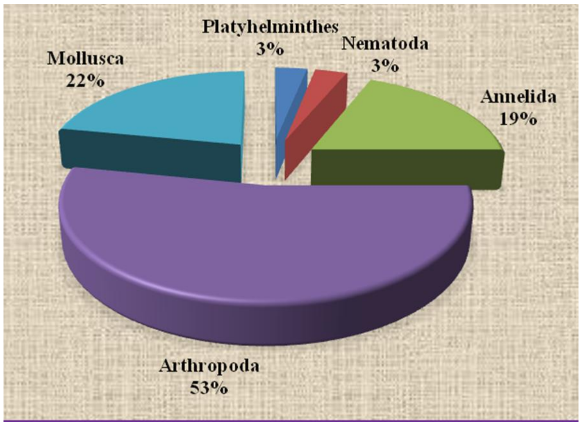

Fig. 2 Graph showing composition of Macro invertebrates of Song River

Table-2. Month – wise Shannon Weiner Diversity Index Values

	US	MS	LS
December	3.0	1.5	2.2
January	2.0	1.7	1.9
February	1.8	0.9	2.7
March	2.2	0.1	3.3
April	2.8	0.1	3.9
May	3.4	0.1	3.6

The month – wise values of Shannon Weiner Diversity Index is presented in Table 1. The value was found to be maximum during the month of April (3.8798) at Lower Stream whereas minimum during the month May (0.0548) at Middle Stream section. [Table-1].

The results of physicochemical parameters recorded at selected sampling sections were depicted in Table 1. The water temperature was recorded minimum (9.0ºC) during December, 2015 at upstream and maximum (27.0ºC) during May, 2016 at Lower Stream sites. Seasonal changes in water temperature in rivers closely follow seasonal trends in mean monthly air temperature and daily time scales and among locations due to climate, extent of streamside vegetation and the relative importance of groundwater inputs. The hydraulic characteristics, chiefly width, depth, velocity and discharge increases towards downstream. River Song showed increase in size as one proceeds downstream, because tributaries and groundwater add to the flow. However, diversion, channelization of water for agricultural activities, construction, etc., alter the shape and dimensions of the stream system. The concentration of dissolved oxygen (DO) was recorded lowest (8.0 mg l-l) at MS and highest (14.0mg l-l) at US.

Table-2. Mean ±SD and range of physico-chemical parameters recorded at different sampling sections in River Song during present study:

Physicochemical parameters	**Up Stream (US)**			**Mid Stream (MS)**			**Lower Stream (LS)**		
	Mean	**±SD**	**Range**	**Mean**	**±SD**	**Range**	**Mean**	**±SD**	**Range**
Air temperature (ºC)	22.25	7.05	10.0–36.0	23.17	6.5 9	14.0–36.0	24.42	6.80	15.0–37.0
Water Temperature (ºC)	15.17	4.53	9.0–21.0	17.50	5. 45	10.0–26.0	17.92	5.58	12.0–27.0
Mean width (m)	4.13	1.96	1.96–8.20	4.43	2.24	2.5–9.0	5.13	2.38	3.1–9.8
Mean depth (m)	0.90	0.21	0.65–1.30	0.84	0.23	0.60–1.20	0.75	0.28	0.44–1.20
Current velocity (m s^{-1})	0.43	0.22	0.22–0.92	0.45	0.29	0.15–0.89	0.46	0.27	0.19–0.98
Discharge (m3 s^{-1})	2.33	2.93	0.37–8.53	2.64	3.25	0.23–9.07	2.88	3.76	0.29–11.52
Dissolved oxygen (mg l^{-1})	11.67	1.07	10.0–14.0	11.00	1.28	8.0–12.0	9.0	0.6	8.0–10.0
Carbon dioxide (mg l^{-1})	0.81	0.28	0.44–1.56	0.92	0.30	0.66–1.56	0.79	0.44	0.44–1.78
Alkalinity (mg l^{-1})	24.17	6.34	15.0–35.0	28.75	6.44	20.0–45.0	31.25	7.72	25.0–55.0
TDS (g l^{-1})	0.30	0.29	0.07–0.98	0.35	0.31	0.09–0.99	0.39	0.41	0.08–1.26
pH	7.59	0.24	7.1–7.8	7.57	0.32	7.2–8.2	7.80	0.43	7.2–8.5
E. Conductivity (S/cm)	252.50	13.53	235.0–265.0	291.42	16.60	264.0–314.0	298.67	14.80	278.0–328.0
Chloride (mg l^{-1})	17.15	5.18	12.8–28.4	23.58	2.02	18.0–26.0	30.58	7.54	15.0–42.0
Total Hardness (mg l^{-1})	57.50	8.91	46.0–72.0	45.43	11.39	29.0–74.0	36.75	16.31	24.0–78.0

4. Discussion

The water quality of rivers, streams and lakes changes with the seasons and this has profound influence on the population density of aquatic plants and animals. The geography and the topography of an area also affect the water quality of that area. Anthropogenic activities, natural processes e.g. erosion, weathering, geochemical and geological characteristics of the environment as well as the ever increasing population of the world have kept changes in natural water bodies). As a result, physical, chemical and biological parameters that influence water quality keep changing. Therefore, regular quality monitoring of water bodies to ascertain these changes from time to time is necessary.

Whitton (1975) mentioned the same that values of less than 1 are interpreted as heavily polluted, 1-3 as moderately polluted and more than 3 as clean water. Shannon-wiener diversity index ($\overline{H}$) almost near to 3 for phytoplankton suggests that water is good for growth of phytoplankton in water body (Ali et al., 2005). During the study period it was observed that in Song river Shannon-Wiener index calculated indicated that the water fall in the range of polluted to clean water.

Important physical and chemical parameters that affect the natural water quality are temperature, pH, Turbidity, Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), alkalinity, nutrients (Nitrate-N, Phosphate-P), etc.. These parameters are limiting factors for the survival of aquatic organisms (flora and fauna).

In general, the relation between the sampling area and number of species observed is well known (Arrhenius 1921), but the relation between the area of freshwater environment (lake, pond, or catchment area) and diversity is not obvious at all. The results obtained by Davies et al. (2008) suggest that species richness depends more on habitat type than on habitat size. It seems that the application of a measure commonly used in ecology — species density (number of species per area unit) is problematic in the biological assessment of freshwaters where comparisons between environments are required. The heterogeneity and discontinuity of the aquatic environments are their typical features — highest diversity is noted at margins of slowly flowing and standing waters (Principe and Corigliano 2006). The ratio of littoral-zone area to whole-water-body area is not constant, which makes the relation between area and biological diversity unclear.

Stream discharge is an intensively studied biodiversity influence (Dewson et al. 2007). Moore and Palmer’s (2005) results show that taxa richness of stream macrofauna depends on riparian forest cover, however, their taxonomic resolution made for an insufficient surrogate for species diversity (noninsect taxa identified to class or order).

Benthic invertebrate surveys often take place on rivers having deceptive and rapidly changing flows. Conditions can change abruptly, especially near hydro-electric dams. Contacting power generation authorities in advance to obtain information about changes in flow is highly recommended.

The results of physicochemical parameters recorded at selected sampling sections were depicted in Table 1. The water temperature was recorded minimum (9.0ºC) during December, 2015 at upstream and maximum (27.0ºC) during May, 2016 at Lower Stream sites. Seasonal changes in water temperature in rivers closely follow seasonal trends in mean monthly air temperature and daily time scales and among locations due to climate, extent of streamside vegetation and the relative importance of groundwater inputs. The hydraulic characteristics, chiefly width, depth, velocity and discharge increases towards downstream. River Song showed increase in size as one proceeds downstream, because tributaries and groundwater add to the flow. However, diversion, channelization of water for agricultural activities, construction, etc., alter the shape and dimensions of the stream system (Brookes, 1988). The concentration of dissolved oxygen (DO) was recorded lowest (8.0 mg l-l) at MS and highest (14.0mg l-l) at US. DO may change seasonally and daily in response to shifts in temperature. High summer temperatures permit high microbial respiration, with the result that the downstream average partial pressure of CO2 is about 20 times the atmospheric value (Kempe *et al*. 1991). Higher activities of organisms during summer might also reduce oxygen content of water. At upstream sites with turbulent and relatively low water temperature that has received limited pollution and diffusion maintains oxygen and CO2 near saturation. Photosynthetic activity in highly productive (e.g., vegetation and fallen leaves) settings can elevate oxygen to supersaturated levels. In general, DO and free carbon dioxide in water are reciprocal to each other. The free CO2, pH alkalinity and conductivity also increases towards the downstream sites during different seasons (Table 1). High levels of organic waste can reduce oxygen concentrations below life-sustaining levels and CO2 can be elevated from ground water inputs or biological activity (e.g., respiration) and high anthropogenic activities may add to the alkalinity at LS.

In general, the conductivity increases towards drop in elevation (Kasangaki *et al*., 2008). Differences in conductivity result mainly from the concentration of the charged ions in solution, and to a lesser degree from ionic composition and temperature (Allan and

Castillo, 2007). Rock weathering, other natural sources, and anthropogenic inputs must account for the majority of dissolved ions (e.g., chloride) in river water (Berner and Berner, 1987) which may influence the extent of chloride in river water. The total hardness is determined by cations that form insoluble compounds with soap and it correlated with calcium, alkalinity, and pH (Allan and Castillo,2007) and it was recorded minimum (24.0 mg l-l) and maximum (78.0 mg l-l). The peak total dissolved solids (TDS) during monsoon depend on geological characters of watershed, rainfall and amount of surface runoffs. Influvial ecosystems, key abiotic features of the environment are usually those related to current, substrate, temperature, and sometimes water chemistry variables such as alkalinity and dissolved oxygen. Many factors influence the composition of river water, and as a consequence it is highly variable in its chemical composition. However, the geography and the topography of an area also affect the water quality of river. Anthropogenic activities, natural processes e.g. erosion, weathering, geochemical and geological characteristics of the environment as well as the ever increasing population of the world have kept changes in natural water bodies constant (Adefemi and Awokunmi, 2010).

5. Conclusion

As the human population continues to grow, it will contribute significantly towards the process of river biodegradation. This bio survey of the macro benthic invertebrate fauna gives an important insight into the health of the river and appends the knowledge and understanding of the management strategies involving bio monitoring as a significant tool in the river restoration studies.

The ambiguity of conclusions about the relations between diversity of macro benthos and particular environmental factors compelled specialists to improve the existing methods of biological assessment or to develop new methods. The traditional diversity indices are unsuitable for monitoring biodiversity and multivariate indices are sensitive to errors and noise in the data. Their alternative method, however (species intactness based on Buckland's arithmetic mean index), can only be applied in regularly and intensively assessed environments.

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