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Correlation Aspects between Macroinvertebrates and Physicochemical Factors to Assess Water Quality of the River Vainganga

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Abstract: ***The present paper deals with qualitative and quantitative analysis of site wise and seasonal correlations between macroinvertebrate density and physicochemical parameters of the river Vainganga flowing through Gondia district in Maharashtra state, India. A total of 133 species comprising 71 families of 15 orders of Arthropoda, Mollusca and Annelida were recorded. The macroinvertebrate density and correlation coefficient were calculated using the software PAST-3. The density was recorded highest during winter followed by summer and least during monsoon. The upstream sites harbored more sensitive species than the downstream sites. The physicochemical parameters were found favorable for the growth of the macroinvertebrate fauna. Presence of diverse macroinvertebrate communities in the river Vainganga indicated a heterogeneous and stable habitat structure and reflected clean, acceptable and good water quality.***

Keywords: Correlation, density, macroinvertebrates, percent composition, Vainganga

1. Introduction

The water quality is defined as those physicochemical and biological characteristics of water which determine the acceptability of water (CPCB, 2005). The biota and water quality reflect an integration of the physical, chemical and anthropogenic processes occurring in a catchment area (Pedersen and Petersen, 1996). Human activities and pollution sources deteriorate water, limit the distribution of riverine species and regulate the ecological integrity of lotic ecosystems (Saunders *et al.,* 2002). A river is one of the richest sources of biological diversity and offers a plethora of dynamic biotic and abiotic factors. It also provides an environment quite different from lentic water bodies as their unidirectional flow produces many effects that determine the diversity of flora and fauna therein (Clegg, 1974). Once all the biotic and abiotic parameters are defined, the presence of a particular species in a habitat indicates that the given parameters are within the tolerance limits of the species and the species belongs to that ecosystem or habitat (Hellawell, 1986). Macroinvertebrates are proved to be the most promising biological indicators of water quality (Rosenberg and Resh, 1993). They occupy different types of habitats in sediment and water and influence their chemistry. They also contribute to complex food webs by serving as major food for fish and other organisms. Their presence or absence indicates the pollution stress and acceptability of the water to various purposes. Their life cycle, climate change, water flow, sediment type, riparian vegetation, habitats, anthropogenic activities, the tributaries pouring clean water and water quality determine their presence or absence at a site and during a season (Covich *et al.,* 1999 and Palit *et al,* 2013). Vainganga sub-basin is endowed with high forest cover and hence high bio-diversity in Maharashtra state (Patil *et al,* 2012). This river is known for its rich and unique biodiversity. It is the largest sub-basin of Godavari River. It has unique physical, chemical and geological features (Global Water Partnership, 2011). It receives waters from its tributaries, streams and many runoffs which can contaminate and affect biodiversity. In this view the present study was carried out to assess its water quality.

2. Materials and Methods

2.1 Study Area

The river Vainganga originates near Mundara village of Seoni district (M.P.) in the Satpura range. Its water is useful for all purposes. This study was carried out from February 2010 to January 2012 at five multi-habitat sites of the river between 21° 22'' to 21° 38'' N and 79° 47'' to 80° 29'' E. Site-I is situated near the village Dangorli. Here it enters Gondia district by forming confluence with the river Bagh. Site-II is situated near the village Dhapewada having congregation site. Site-III located near the village Chandori (Kh) and forms confluence with the river Bawanthadi. Site-III located near the village Chandori (Kh) and forms confluence with the river Bawanthadi. Site-IV is situated near the village Kawalewada having lift irrigation project. Site-V is situated near the village Ghatkuroda where it exits Gondia district.

2.2 Collection and Analysis of Data

Water samples were collected as per APHA (1998) guidelines for macroinvertebrates and physicochemical analysis monthly between 7 and 10 A.M. at each site. Macroinvertebrates were collected from slow moving waters, riffles, pools and vegetations with 1ft. deep area of 100 m^2, using D-frame pond net and a quadrate kick-net having 1 x 1 m area and 500 µm mesh size for 3 minutes. They were filtered and sorted out for identification (Ward and Whipple, 1959; Pennak,

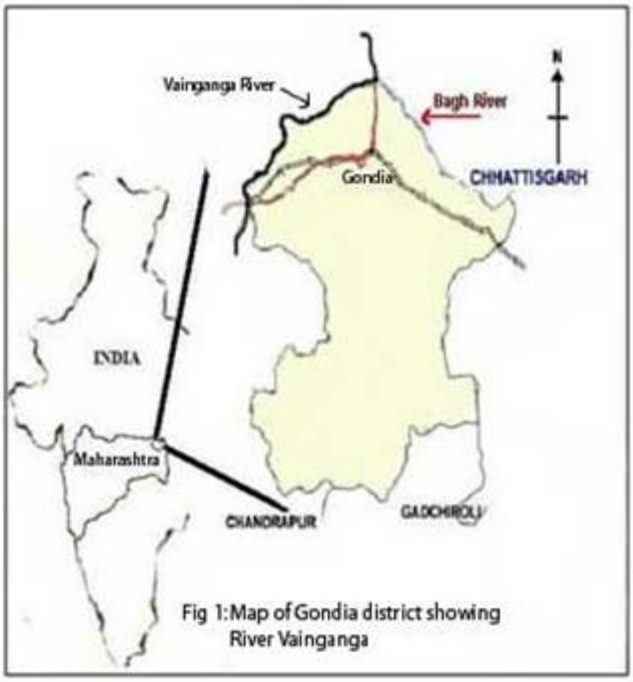

Figure 1: Map of river Vainganga

1989; Tonapi, 1980 and Naideu, 2005). Most of them were set free unharmed and alive in the river water to protect and conserve the biodiversity. A few of them were fixed in 4% formalin and then preserved in 70% alcohol. Statistical analysis was done by using PAST-3.

1. Results and Discussion

The seasonal and spatial variations among the macroinvertebrates were summarized in Tables 1 while Table 2 summarizes the correlations between macroinvertebrate taxa and the physicochemical parameters. A total of 62024 individuals belonging to 133 species from 71 families of 15 orders comprising 3 phyla were recorded during the study.

In the present study, maximum density of macroinvertebrate fauna during winter months might be due to their increased growth efficiency and the hydrological attributes (Ward and Standford, 1979). However, lowest density during monsoon was due to increased water temperature which enhanced the rate of organic decomposition brought by influx, increased dissolved and suspended solids, increased flow and high turbidity added by continuous inputs (Duran, 2006). This depletes the DO and increases BOD. Annelids favored anoxic conditions with polluted water as in monsoon (Takeda, 1999) while molluscans prefer soft and organically rich bottom, alkaline pH and high calcium with mesophytic vegetation to grow (Patil and Talmale, 2005 and Chakraborty and Das, 2006). Therefore they were found abundant during monsoon and early winter months while they burrow in soil during summer (Sharma and Chowdhary, 2011). The abundance in summer might be due to the availability of phytoplankton as food (Anderson and Sedell, 1979). The sensitive Ephemeropterans, Plecopterans, Trichopterans and Odonats dominated due to high DO and no pollution. This was evidenced by their positive correlation with pH, DO, Alkalinity and total hardness while negative correlation with temperature, EC and BOD. The pollution tolerant species favored the sluggish waters with high BOD, turbidity, temperature and low DO content as in monsoon. Therefore they showed positive correlation with BOD. However, DO exhibited weak positive correlation with Mollusca and weak negative with Annelida. Similar results were also observed Sunder and Subla (1986) and Dutta and Malhotra (1986). The lower density of tolerant species than the sensitive species indicated clean and non-polluted water (Olomukoro and Ezemorye, 2006). The nutrients and stream flow also affect the growth, production, distribution and abundance of macroinvertebrates (Hynes, 1970 and Brown and Brown, 1994). During monsoon, density decreases due to increased turbidity, agitation of bottom and killing or displacing biota by a high flow (Mesa *et al.,* 2012).

The density increased from upstream to downstream. The upstream sites harbored more sensitive species than downstream sites indicating comparatively cleaner upstream which might be due to clean water added by tributaries and runoffs along with little organic matter that slightly changed nutrients and other physicochemical factors downstream. This favored increase in density and diversity (Aura *et al.,* 2011).

2. Conclusion

The physicochemical parameters were within the permissible limits. The higher abundance of sensitive species and lower abundance of tolerant species in the river Vainganga indicated heterogeneous habitat structure and reflected clean water conditions. Ephemeroptera, Plecoptera, Trichoptera, Coleoptera and Odonata emerged as abundant, dominant faunal communities. The molluscs formed second most abundant group followed by least number of Annelids. All the sites remained uncontaminated and maintained mesotrophic condition. The diverse macroinvertebrate communities indicated healthier environment reflecting rich and stable ecosystem with pristine nature and very good water quality of the river Vainganga.

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Table 1: Density, rank and percent composition of the macroinvertebrate taxa recorded in the river Vainganga

Sr. No.	Taxon	Summer		Monsoon		Winter		Overall		Rank
		Density	%age	Density	%age	Density	%age	Density	%age	
1	Trichoptera	2343	12.8	733	5.4	3670	12.2	6746	10.9	4
2	Diptera	1067	5.8	800	5.9	1072	3.6	2939	4.7	8
3	Megaloptera	18	0.1	10	0.1	42	0.1	70	0.1	15
4	Ephemeroptera	3701	20.2	2520	18.6	5822	19.3	12043	19.4	1
5	Plecoptera	3530	19.2	1594	11.7	4823	16	9947	16	3
6	Coleoptera	1291	7	944	7	2695	9	4930	7.9	5
7	Hemiptera	2320	12.6	2583	19	5483	18.2	10386	16.7	2
8	Odonata	1452	7.9	571	4.2	1590	5.3	3613	5.8	7
9	Orthoptera	133	0.7	121	0.9	208	0.7	462	0.7	13
10	Arachnida	216	1.2	296	2.2	494	1.6	1006	1.6	12
11	Crustacea	603	3.3	564	4.2	813	2.7	1980	3.2	10
Total Arthropoda		**16674**	**90.8**	**10736**	**79.2**	**26712**	**88.7**	**54122**	**87**	
12	Gastropoda	988	5.4	1448	10.7	1830	6.1	4266	6.9	6
13	Bivalvia	450	2.5	769	5.7	1015	3.4	2234	3.6	9
Total Mollusca		**1438**	**7.9**	**2217**	**16.4**	**2845**	**9.5**	**6500**	**10.5**	
14	Oligochaeta	229	1.2	475	3.5	404	1.3	1108	1.8	11
15	Hirudinea	8	0	146	1.1	140	0.5	294	0.5	14
Total Annelida		**237**	**1.2**	**621**	**4.6**	**544**	**1.8**	**1402**	**2.3**	
Total Fauna		**18349**	**29.6**	**13574**	**21.9**	**30101**	**48.5**	**62024**		

Table 2: Pearson's correlation between macroinvertebrate groups and physicochemical Parameters

Sr. No.	Order	pH	Temp	EC	Alk	TH	DO	BOD
1	Trichoptera	0.66 ^{b}	-0.70 ^{b}	-0.11 ^{d}	0.68 ^{b}	0.45 ^{d}	0.90 ^{a}	-0.56 ^{c}
2	Diptera	0.57 ^{c}	-0.02 ^{d}	0.43 ^{d}	0.57 ^{c}	0.48 ^{d}	0.66 ^{b}	-0.53 ^{c}
3	Megaloptera	0.21^{d}	-0.65 ^{b}	-0.47 ^{d}	0.25 ^{d}	0.18 ^{d}	0.81 ^{a}	-0.11 ^{d}
4	Ephemeroptera	0.54 ^{c}	-0.59 ^{b}	-0.23 ^{d}	0.61 ^{b}	0.48 ^{d}	0.87 ^{a}	-0.49 ^{d}
5	Plecoptera	0.66 ^{b}	-0.64 ^{b}	-0.14 ^{d}	0.68 ^{b}	0.53 ^{c}	0.92 ^{a}	-0.51^{c}
6	Coleoptera	0.34 ^{d}	-0.84 ^{a}	-0.43 ^{d}	0.37 ^{d}	0.16 ^{d}	0.82 ^{a}	-0.22 ^{d}
7	Hemiptera	0.11 ^{d}	-0.66 ^{b}	-0.61 ^{b}	0.18 ^{d}	0.12 ^{d}	0.72 ^{a}	-0.04 ^{d}
8	Odonata	0.81 ^{a}	-0.44 ^{d}	0.08 ^{d}	0.84 ^{a}	0.74 ^{a}	0.71 ^{a}	-0.70 ^{a}
9	Orthoptera	0.13 ^{d}	-0.73 ^{a}	-0.57 ^{c}	0.22 ^{d}	0.16 ^{d}	0.75 ^{a}	-0.07 ^{d}
10	Arachnida	-0.02 ^{d}	-0.61 ^{b}	-0.60 ^{b}	0.05 ^{d}	-0.10 ^{d}	0.60 ^{b}	-0.14 ^{d}
11	Crustacea	0.17 ^{d}	-0.45 ^{d}	-0.48 ^{d}	0.28 ^{d}	0.32 ^{d}	0.60 ^{b}	-0.07 ^{d}
Arthropoda		**0.50^{c}**	**-0.72^{a}**	**-0.29^{d}**	**0.56^{c}**	**0.37^{d}**	**0.90^{a}**	**-0.42^{d}**
12	Gastropoda	-0.42 ^{d}	-0.52 ^{c}	-0.85 ^{a}	-0.36 ^{d}	-0.29 ^{d}	0.33 ^{d}	0.45 ^{d}
13	Bivalvia	-0.38 ^{d}	-0.35 ^{d}	-0.79 ^{a}	-0.31 ^{d}	-0.17 ^{d}	0.34 ^{d}	0.46 ^{d}
Mollusca		**-0.40^{c}**	**-0.50^{c}**	**-0.84^{a}**	**-0.34^{d}**	**-0.28^{d}**	**0.33^{d}**	**0.45^{d}**
14	Oligochaeta	-0.72 ^{a}	-0.17 ^{d}	-0.73 ^{a}	-0.67 ^{b}	-0.47 ^{d}	-0.13 ^{d}	0.87 ^{a}
15	Hirudinea	-0.71 ^{a}	-0.20 ^{d}	-0.82 ^{a}	-0.67 ^{b}	-0.49 ^{d}	-0.01 ^{d}	0.73 ^{a}
Annelida		**-0.71^{a}**	**-0.21^{d}**	**-0.78^{a}**	**-0.68^{b}**	**-0.48^{d}**	**-0.09^{d}**	**0.83^{a}**

^{a} denotes significance at 0.01% level; ^{b} denotes significance at 0.05% level; ^{c} denotes significance at 0.1% level and d denotes not significant.

Temp = Temperature, EC = Electrical Conductivity, Alk = Alkalinity,DO = Dissolved Oxygen and BOD = Biochemical Oxygen Demand

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