RESEARCH ARTICLE

Diversity of benthic macro-invertebrates in four tributaries of River Narmada in the central zone, India

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ABSTRACT

The present study examines the distribution of benthic macro-invertebrate fauna in the four seasonal tributaries of River Narmada in the central zone to evaluate the benthic macro-invertebrates community assemblages in predicting the water quality status. During the present investigation, total 8 sampling stations (two sampling stations on each tributary) were identified and from these stations 30 taxa of benthic macro-invertebrates were recorded. Among the major taxonomic composition phylum arthropoda was found at dominant (63%) position, whereas values of Shannon-Wiener diversity index was found between 1.12 – 2.10 which indicates moderate pollution status at all stations. Values of Pielou evenness index (0.67-0.96) showed equability in the apportionment of individuals among the species at all stations while, range of Margalef diversity index varied from 0.94 to 3.58 indicates extremely low species richness and low abundance with physically disturbed areas in poor condition of colonization by aquatic organisms.

Keywords- Benthic-macroinvertebrate, Tributary, Central Zone, River Narmada

INTRODUCTION

The benthic macro-invertebrates community of the lotic ecosystem, like other communities has a series of attributes that do not reside in its individual species components and have meaning only with reference to the community level of integration such as species diversity, growth in the form and structure, dominance, relative abundance and trophic structure. One of these attributes many of these or all, depending upon situation may be changed with the changing ecology of the water body concerned. Species are distributed individualistically according to their own genetic characteristics and population of most of the species tends to change gradually along the environmental gradients. Most species are not in obligatory associations with other species, which suggests that

association is formed with many combinations of species, and vary continuously in space and time. Hence, a study of benthic macro-invertebrates community composition and dynamics of different population of the community becomes a reliable source to provide the picture of environmental status and influence of changing limnology of the water body concerned (Bhandarkar and Bhandarkar, 2013).

Benthic macro-invertebrates perform a variety of functions in freshwater ecosystem. They have an important influence on nutrient cycle, primary productivity, decomposition and translocation of material (Wallace and Webster, 1996; Covich *et al.,* 1999). They are the most commonly used for bio-monitoring in lotic habitat worldwide (Bonada *et al.,* 2006). They play an important role in the mineralization and recycling of organic matter and are an important tool for improving and preserving water quality (Bilgrami and Munshi, 1985; Venkateswarlu, 1986). Alteration produced in the physical and chemical status of the riverine ecosystem becomes recognizable through elasticity of the community structure of the organisms (Wilhm and Dorris, 1968; Cairns and Dickson, 1971).

The aim of the present study was to measure the diversity of benthic macro-invertebrates in the four seasonal tributaries of River Narmada in the central zone. The Shannon index of species diversity of benthic macro-invertebrate in fact summarizes physico-chemical and hydrobiological information in a significant manner, condensing it in a single index.

MATERIALS AND METHODS

Study area

River Narmada is the fifth largest river of India covers central part of our country and originates from Amarkantak (Madhya Pradesh) flows into west direction to meet with the Gulf of Cambay in the Arabian Sea (Gujarat). The study area is located in the central zone of River Narmada which lies in Sehore district of Madhya Pradesh (Figure- 1). Here four seasonal tributaries join the main river from right bank and these tributaries were considered for the investigation. Base map of these tributaries is shown in Figure- 2. Details of four tributaries are mentioned below:

A. Chandni Nalla-

This seasonal tributary is located in the central zone of River Narmada between Shahganj and Jahanpur villages of Sehore and Raisen districts of Madhya Pradesh. This area has its own natural landscape and lies on the foot hills of Vindhyan mountain range. The total length of this nalla from its origin upto the confluence with River Narmada is 29.35 kms whereas, major basin area falls under agricultural land use and very little area falls under forest land cover.

B. Gadaria Nalla-

This is second seasonal tributary originates from Vindhyan hilly ranges. Maximum watershed of this nalla falls under dense forest land cover only few areas in dominated with agricultural land use near confluence with River Narmada. It joins the river from right bank between Jamuniya and Budhni Ghat villages. The total length of this nalla from its origin upto the confluence with River Narmada is 34.58 kms. Basin of this nalla falls in Sehore and Raisen districts of Madhya Pradesh.

C. Kaliyadeh Stream-

The third tributary which is considered for the study was Kaliyadeh stream. It originates from the Vindhyan range and converge with River Narmada between Mou Kalan and Holipura villages from right bank after covering a distance of 27.70 kms. This is a seasonal stream and two major industries have been established namely Vardhman and Trident inside its watershed area. Maximum watershed area is covered through dense forest vegetation and very little area is used for agricultural practice. Basin of this tributary lies in Sehore and Raisen districts of Madhya Pradesh.

D. Bhagner Stream-

This is the fourth and last seasonal tributary in the study area which joins the river in the central region. Basin of this tributary lies in Sehore district of Madhya Pradesh. Total length of this stream is 33.79 km from origin upto the confluence. Its watershed area initially lies under forest cover of Vindhyan range but as it travels to meet the river from right bank due to excessive human intervention forest cover has been changed into agricultural land use.

Sampling stations

During the present investigation, two samplings were conducted on each tributary from two identified sampling stations. Geographical locations of identified sampling stations are given in Table- 1. Two sampling

stations were chosen per tributary because of access and approach as well as good connection with road. Locations of sampling stations chosen for the study are shown in Figure- 3.

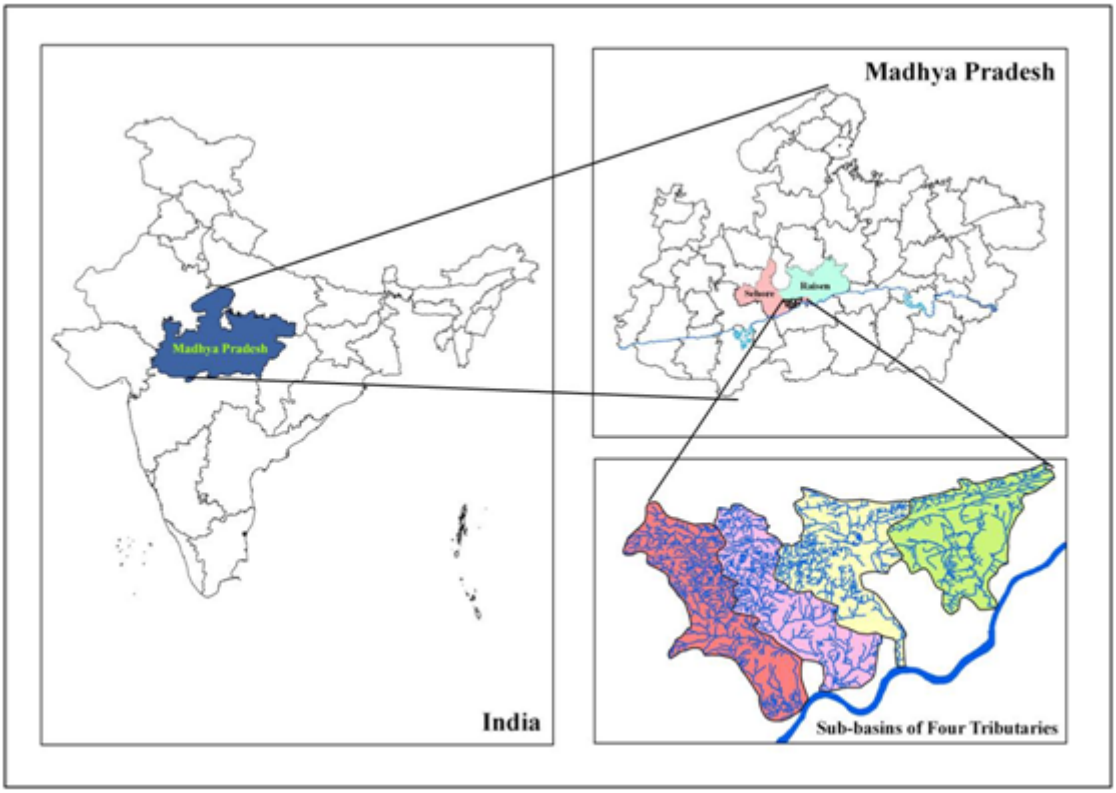

Figure- 1: Location map of the study area

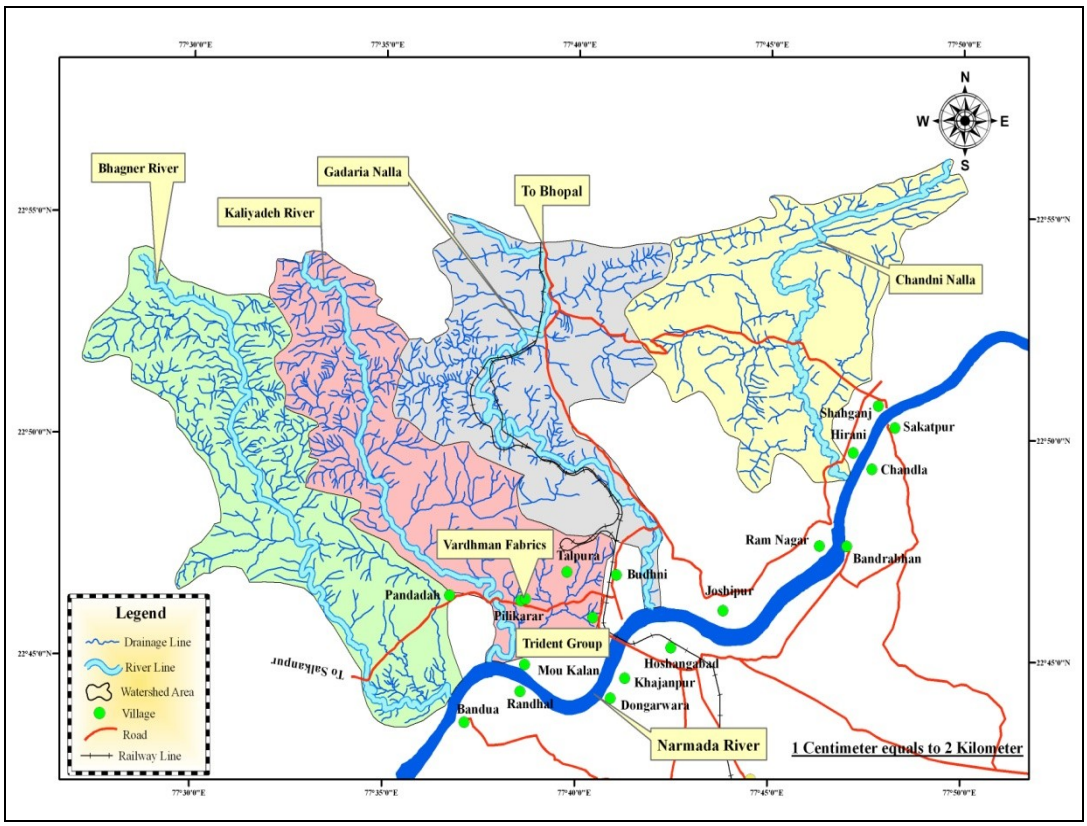

Figure- 2: Base map of the study area

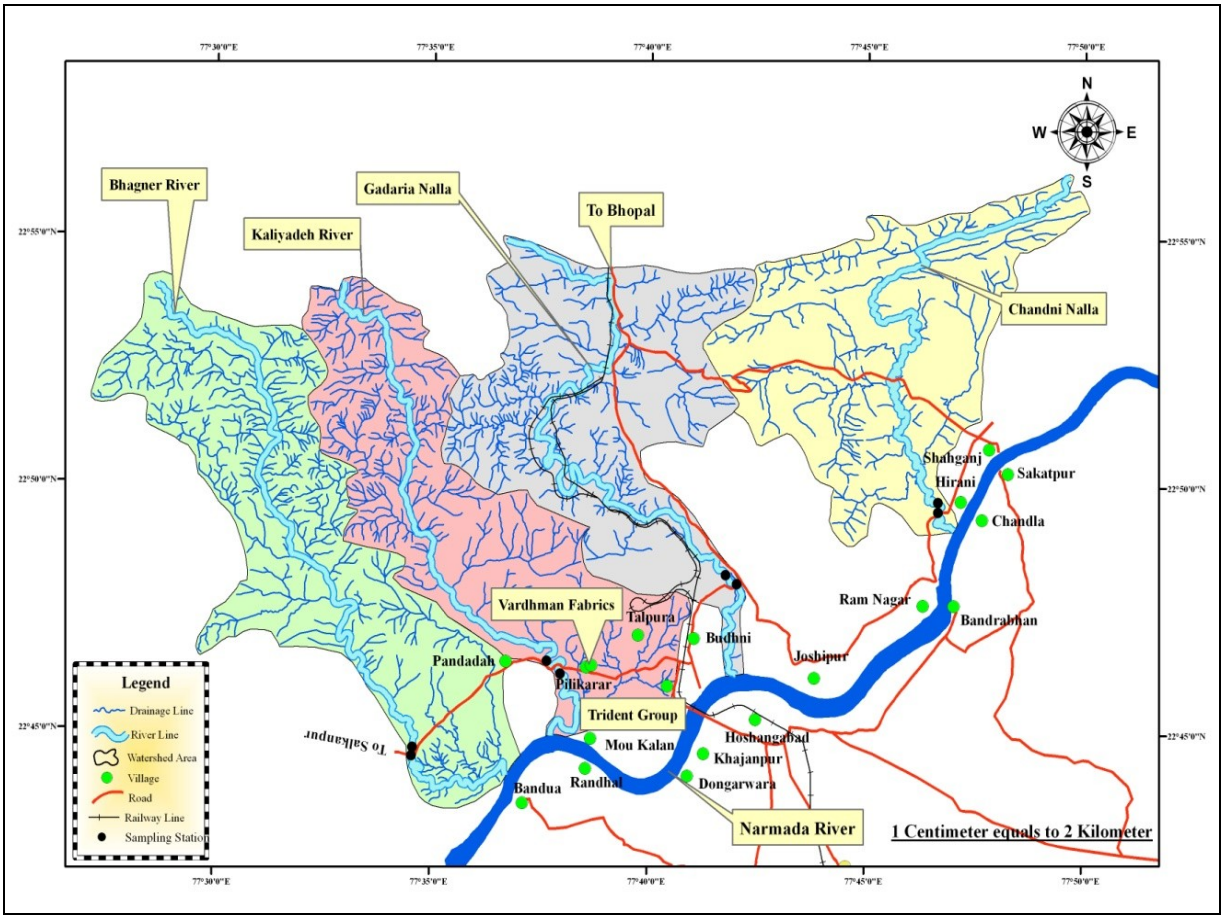

Figure- 3: Sampling stations of the study area

Table- 1: Geographical location of sampling stations

S. No.	Stream name	Sampling station	Station code	Longitude	Latitude
1	Chandni Nalla	First	CD- 1	77°46'40.86" E	22°49'30.43" N
		Second	CD- 2	77°46'43.45" E	22°49'35.68" N
2	Gadaria Nalla	First	GD- 1	77°42'2.7" E	22°48'0.7" N
		Second	GD- 2	77°41'47.01" E	22°48'11.29" N
3	Kaliyadeh Stream	First	KL- 1	77°37’ 45.91” E	22°46’ 24.17” N
		Second	KL- 2	77°37’ 54.88” E	22°46’ 20.81” N
4	Bhagner Stream	First	BH- 1	77°34′27.30″ E	22°44’29.78″ N
		Second	BH- 2	77°34′30.13″ E	22°43’31.31″ N

Collection, Sieving, Sorting, Preservation, Transportation and Identification of samples

Most of the sampling stations fall under shallow zone with macrophytic vegetation. So, for the collection of benthic macroinvertebrates D- frame net was used and some were collected directly from stones using forceps and brushes very carefully. Samples were sieved using 0.3 micron mesh size brass sieve and with utmost care these were sorted and kept safely in reagent grade wide mouth plastic screw bottle with 4% solution used as preservative to transport the sample carefully to the laboratory for further work.

In next step, identification of macroinvertebrates was done with the help of stereo microscope and hand lens with 6x zoom capacity to observe the finest details about the organisms. Available keys and monographs were used to identify fauna upto their lower taxonomic levels (Needham and Needham, 1962; Rao, 1989; McCafferty and Provonsha, 1998; Dey, 2007).

Statistical Analysis

Diversity of benthic macroinvertebrates was statistically treated with the help of Shannon-Wiener's diversity index (H'), Pielou's evenness index (J') and Margalef diversity index (d).

Shannon-Wiener's diversity index (H')

$$H' = -\Sigma [(n_i / N)*(\text{Log } N (n_i) / N)]$$

H': Shannon-Wiener Diversity Index
n_i: Number of individuals belonging to i species
N: Total number of individuals
LN: Natural Log base N of the number

Pielou's evenness index (J')

$$J' = H'/H'_{max}$$

J': Pielou evenness index
H': The observed value of Shannon index
H'_{max}: LN(S)
LN: Natural Log base N of the number
S: Total number of species

Margalef diversity index (d)

$$d = (S -1) / \text{LogN}(N)$$

d = Margalef Diversity Index
S = Total number of species
N = Total number of individuals
LN: Natural Log base N of the number

RESULTS AND DISCUSSION

A total of 30 taxa were found from eight sampling stations which belong to two phylum i.e. Mollusca and Arthropoda (Table- 2).

Phylum mollusca was represented by 2 classes i.e. Gastropoda and Bivalvia. Class gastropoda was represented by 2 orders, 4 families and 7 genera, whereas class Bivalvia was also represented by 2 orders, 3 families and 4 genera. Phylum arthropoda was represented by 3 classes i.e. Insecta, Crustacea and Arachnida. Class insecta was represented by 5 orders, 13 families and 17 genera, while class crustacea was represented by 1 order, 1 family and 1 genus, whereas class arachnida was represented by 1 order, 1 family and 1 genus.

In the present investigation, phylum arthropoda was found in dominant position with 63% followed by phylum mollusca with 37% occupancy in total faunal assemblage (Figure- 4). Dominance of arthropoda was also reported in River Narmada (Kumar and Vyas, 2014), in Morand River a sub-tributary of River Narmada (Sharma *et al.,* 2013), in Kalsi Dehradun segment of River Yamuna (Ishaq and Khan, 2013), in Ken River (Nautiyal and Mishra, 2013) and near water intake point in River Narmada (Vyas *et al.,* 2012).

In statistical procedure, values of Shannon-Wiener's diversity index ranged between 1.12 and 2.10 (Figure- 5). Minimum value of index was observed at station BR- 1 while maximum value was found at station GD- 1. Shannon is a sensitive indicator of pollution and its values do not fluctuated widely. This is an index applied to biological systems, by derived from a mathematical formula used in communication area by Shannon in 1948 (Mandaville, 2002). This is most preferred index among the other diversity indices and values are between 0.0 – 5.0. Results are generally in 1.5 - 3.5 and it exceeds 4.5 very rarely. In the present study, range of this index was recorded from 1.12 to 2.10 which indicate moderate pollution with altered habitat structure. Khan *et al.,* (2007) showed the diversity index ranging from 1.20 to 1.49 in their study on Mouri River, Bangladesh and Anbalagan *et al.,* (2004) observed values ranged 1.883 to 2.493 from 4 sampling stations of courtallam hills of Western Ghats. Wilhm and Dorris, (1966) proposed a relationship between species diversity and pollution status of sampling sites as; species diversity value greater than 3.0 is clean water, values in the range of 1.0-3.0 indicate moderate pollution and values less than 1.0 indicate heavy pollution. According to them, all the selected sampling stations fall under moderate pollution.

Pielou's evenness index values ranged from 0.67 to 0.96 (Figure- 6) and minimum was recorded at station KL- 2 whereas, maximum was observed at CN- 2. Another major component of species diversity is evenness which is originated from Shannon diversity index, proposed by Pielou (1966). Evenness denotes a balanced relation between species and individual richness of a sample. This numerical digit (0 to 1) expresses the absolute distribution of relative abundance of species at specific site. In the present investigation, range of evenness index varied from 0.67 to 0.96 showed equitability in the apportionment

of individuals among the species at all stations. Higher values of this index indicate a low concentration of dominance of species diversity at a specific site (Mukherji and Nandi, 2004).

Table- 2: List of benthic macro-invertebrates recorded during the study

S. No.	Taxa	Tributaries							
		Chandni Nalla		Gadaria Nalla		Kaliyadeh River		Bhagner River	
		Sampling Stations							
		1	2	1	2	1	2	1	2
Phylum	**Mollusca**								
Class	**Gastropoda**								
Order	**Mesogastropoda**								
Family	**Viviparidae**								
1	Bellamya *bengalensis*	-	-	+	+	+	+	+	+
Family	**Thiaridae**								
2	Thiara (Melanoides) *tuberculata* (Muller)	+	+	+	+	+	+	-	-
3	Tarebia *lineata* (Gray)	+	-	+	+	-	+	+	-
4	Tarebia *granifera* (Lamarck)	+	-	+	+	-	+	-	-
Order	**Basommatophora**								
Family	**Lymnaeidae**								
5	Lymnaea (Pseudusuccinea) *acuminata* (Lamarck)	-	-	-	-	+	-	-	-
Family	**Planorbidae**								
6	Gyraulus *convexiusculus* (Hutton)	-	-	+	-	-	+	-	-
7	Indoplanorbis *exustus* (Deshayes)	-	-	-	-	-	-	-	+
Class	**Bivalvia**								
Order	**Trigoinoida**								
Family	**Amblemidae**								
8	Parreysia (Radiatula) *occata* (Lea)	+	-	+	+	+	+	+	+
9	Parreysia *corrugata*	-	-	+	+	-	-	-	-
Family	**Unionidae**								
10	Lamellidens *marginalis*	-	-	+	+	-	-	-	-
Order	**Veneroida**								
Family	**Corbiculidae**								
11	Corbicula *striatella* (Deshayes)	-	-	+	-	-	-	-	-
Phylum	**Arthropoda**								
Class	**Insecta**								
Order	**Diptera**								
Family	**Tabanidae**								
12	Tabanus s*ps.*	-	-	-	-	+	-	-	-
Family	**Syrphidae**								
13	Eristalis *sps.*	-	-	+	+	-	-	+	+
Family	**Culicidae**								
14	Culex *sps.*	+	-	+	-	-	-	-	-

Table- 2: Continued…

S. No.	Taxa	Tributaries							
		Chandni Nalla		Gadaria Nalla		Kaliyadeh River		Bhagner River	
		Sampling Stations							
		1	2	1	2	1	2	1	2
Order	**Odonata**								
Family	**Gomphidae**								
15	Gomphus *sps.*	+	+	+	-	+	+	-	+
16	Octogomphus *sps*	-	+	-	-	-	-	-	-
17	Aphylla *sps.*	-	-	-	+	-	-	-	-
Family	**Cordulegastridae**								
18	Cordulegaster *sps.*	+	+	-	-	+	+	-	-
Family	**Coenagrionidae**								
19	Enallagma *sps.*	-	-	+	-	-	-	-	-
Order	**Hemiptera**								
Family	**Nepidae**								
20	Nepa *sps.*	-	-	-	+	+	-	-	-
21	Ranatra *sps.*	-	-	-	+	-	-	-	-
Family	**Corixidae**								
22	Sigara *Sps.*	-	-	-	-	+	+	-	-
Family	**Belestomatidae**								
23	Belostoma *sps.*	-	-	-	+	-	-	-	-
Order	**Ephemeroptera**								
Family	**Heptageniidae**								
24	Heptagenia *sps.*	-	-	-	-	-	+	-	-
Order	**Coleoptera**								
Family	**Haliplidae**								
25	Peltodytus *sps.*	-	-	-	+	+	-	-	-
Family	**Gyrinidae**								
26	Dineutus *sps.*	+	-	-	+	+	-	-	-
27	Gyrinus *sps*	+	+	-	-	-	-	-	-
Family	**Hydrophilidae**								
28	Berosus *sps.*	+	-	-	-	+	+	-	-
Class	**Crustacea**								
Order	**Decapoda**								
Family	**Palaemonidae**								
29	Palaemon *sps.*	+	-	-	+	+	+	-	-
Class	**Arachnida**								
Order	**Araneae**								
Family	**Pisauridae**								
30	Dolomedes *sps.*	-	-	-	-	-	+	-	-
Total		**11**	**5**	**13**	**15**	**13**	**13**	**4**	**5**

Table- 3: Values of Statistical Indices

Statistical Indices	Tributaries							
	Chandni Nalla		Gadaria Nalla		Kaliyadeh River		Bhagner River	
	Sampling Stations							
	CN- 1	CN- 2	GD- 1	GD- 2	KL- 1	KL- 2	BR- 1	BR- 2
Shannon Index (H')	2.06	1.55	2.10	1.91	1.92	1.72	1.12	1.14
Pielou Index (J')	0.86	0.96	0.82	0.71	0.75	0.67	0.81	0.71
Margalef Index (d)	2.45	2.06	2.97	3.58	3.15	2.87	0.94	1.20

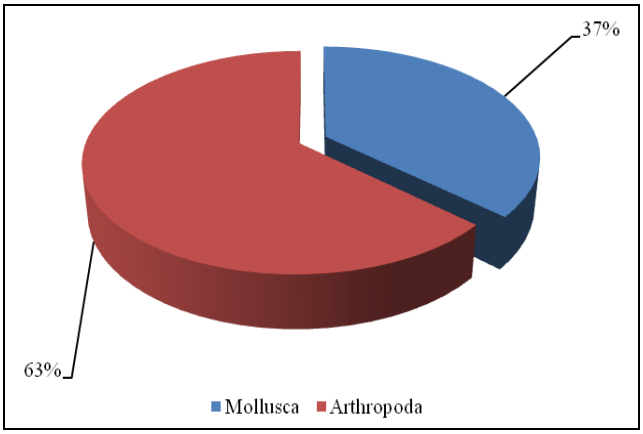

Fig. 4: Percent composition of major taxonomic groups

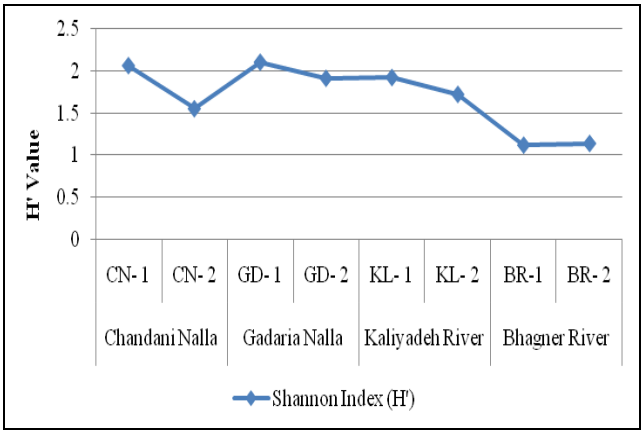

Fig. 5: Shannon-Wiener diversity index values at different stations

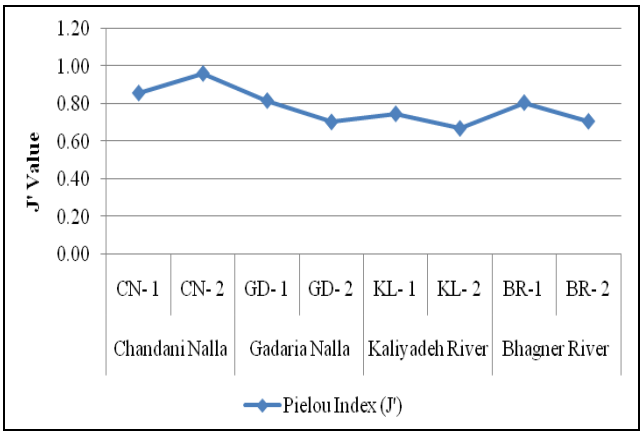

Fig.6: Pielou's evenness index values at different stations

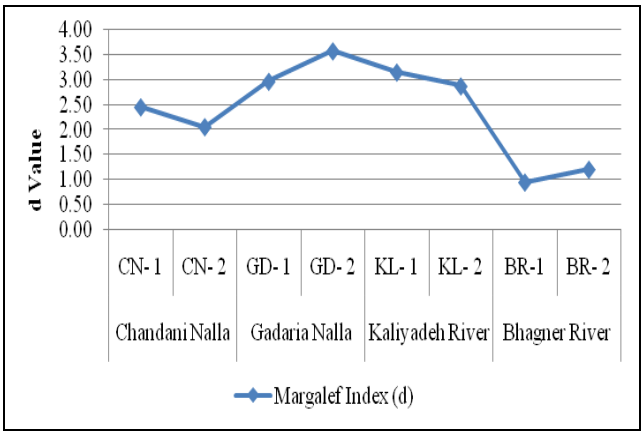

Fig. 7:Margalef diversity index values at different stations

The values of Margalef diversity index varied between 0.94 and 3.58 (Figure- 7). Minimum range of index was found at station BR- 1 while maximum was recorded at station GD- 2. Margalef diversity index which is a species richness index is expressed by simple ratio between total species and total number (or importance value N), the Margalef's diversity index are proposed by Margalef (1958), larger the index value the more health the body of water, when it tend towards 1.0, pollution is thought to increase and damage should be suspected. According to Margalef (1956) the higher diversity values reflect the suitability of habitat for the organism in one hand while on the other the high species diversity has been reported to be correlated with longer food chain and complex food web of the ecosystems and also more stable community. It has no limit value and it shows a variation depending upon the number of species. During the present investigation, range of this index varied from 0.94 to 3.58. Low index value was

observed during the present study indicates extremely low species richness and low abundance with physically disturbed areas in poor condition of colonization by aquatic organism (Bhandarkar and Bhandarkar, 2013).

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