Bio-assessment of the Baldi River by determining Zooplankton biodiversity

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Abstract

Zooplankton biodiversity of Baldi River was analysed at three locations (S_1-S_3) from November 2018 – October 2019 by using standard methods. WHO limits was used to determine the water quality. All the physico-chemical parameters of Baldi River except hardness were within acceptable limit of WHO. Results showed an increased concentration in physico-chemical parameters like turbidity, total dissolved solids, nitrates and phosphates have adverse impact on the density of zooplankton at S_2 where maximum anthropogenic pressures were recorded. Zooplankton was observed in order rotifers > cladocerans > protozoans > copepods. Lower values of diversity indices were recorded at S_2 showed this site was most polluted as compared to other locations. Overall, the values of Shannon Weiner diversity index, Margalef's index and Simpson diversity index showed that the Baldi River was moderately polluted.

Keywords: Diversity indices, Mountain River, physico-chemical parameters, zooplankton biodiversity

1. Introduction

Rivers and streams are the primary source of water for both humans and freshwater ecosystems [1]. Zooplankton are important component of these freshwater ecosystems. Zooplankton is microscopic, free floating and occurred in all fresh water ecosystems [2]. Rotifers, caldocerans, copepods and protozoa are the major groups of zooplankton [3].They transfer energy from lower to higher tropic level [3]. Fluctuations of zooplankton in lotic ecosystem are regulated by a combination of various physico-chemical and biological factors [4].The knowledge of zooplankton abundance, species diversity and specific distribution is helpful in understanding the trophodynamics and trophic progression of water bodies [5]. Due to their short life span, the zooplankton response quickly to the changes in the physico - chemical properties of the aquatic environment [6] and used as bioindicators [7]. Biological assessment can be used as the basis for management programs, restoring and maintaining the chemical, physical and biological integrity of freshwater ecosystem. Therefore, the present study was conducted to investigate

water quality of Mountain River Baldi with the help of relation between physico-chemical parameters and zooplankton.

2. MATERIALS AND METHODS

Mountain River Baldi is one of the important tributaries of the Song River flowing in Doon Valley of Central Himalayas, India. The Baldi meets with the Song River at Maldevta (Dehradun) after covering a distance of 14 km. (Fig. 1). Three sampling sites on the Baldi River were identified on the basis of level of anthropogenic pressures (Dumping of organic waste, addition of municipal waste water from point and non point sources *etc*) at different sites. Regular monthly sampling was undertaken between 08:00 hrs to10:00 hrs at each sampling site from November 2018 to October 2019 spreading into three seasons (November to February = winter season, March to June = summer season and July to October = monsoon season). Five replicates for water samples and zooplankton samples were obtained for each parameter including both for physico-chemical parameters and biological (zooplankton) parameters. The results were integrated and recorded.

All the physico-chemical parameters were analysed by standard methods[8]

For zooplankton, one litre of sample water was collected 10 cm depth from surface water and passed through silk plankton net of mesh size 35 µm. All the samples were immediately fixed with 4% formalin solution .Identification of zooplankton taxa was made according to [9],[10] for Protozoa and all zooplankton taxa.

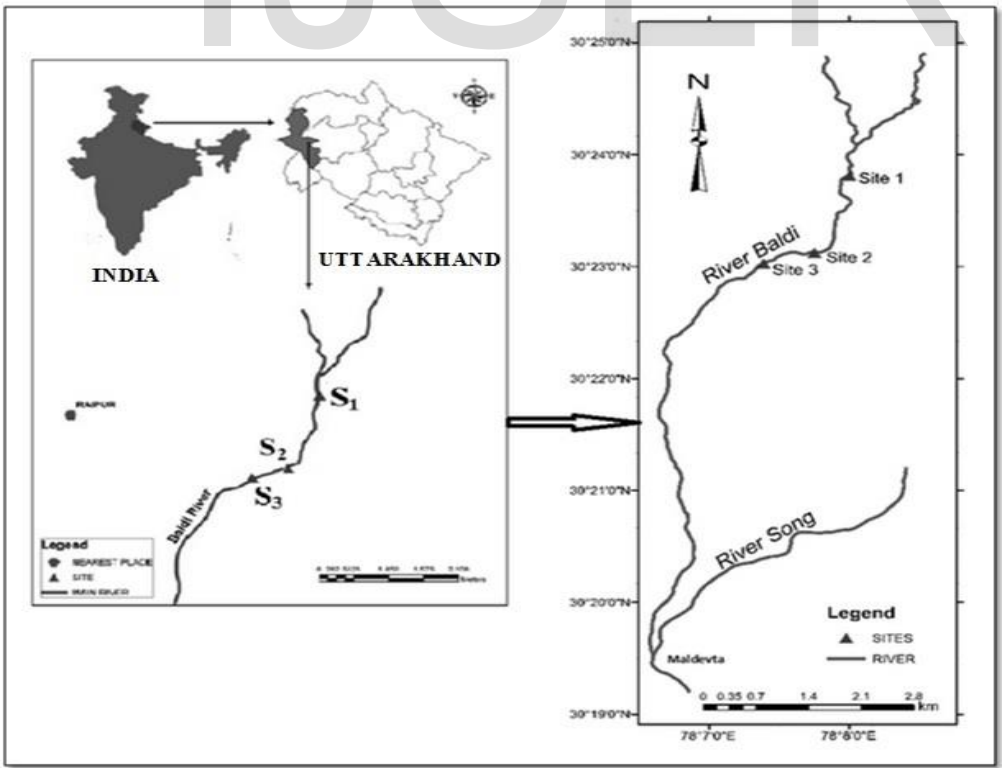

Fig. 1 Map of the study area showing locations of sampling sites on the Baldi River

3. RESULTS

Physico-chemical parameters

Monitoring the physico-chemical parameters is very important for studying the influence of these parameters on the distribution of various components of biodiversity in river. A summary of physico-chemical parameters recorded in Baldi River is presented in Table 1. Water temperature was recorded lower (18.14 ± 4.14˚C) at S_1 than (18.29 ± 4.14˚C) at S_2 and S_3. Transparency was observed higher (0.28 ± 0.11 m) at S_1 and lowest (0.18 ± 0.11 m) at S_2. Transparency was recorded maximum during winter months (November to February) and minimum during monsoon (July to October). Water velocity was found highest (0.79 ± 0.13 $m.s^{-1}$) at S_1 and lowest (0.32 ± 0.13 $m.s^{-1}$) at S_3. Peak water velocity was recorded during monsoon season. TDS was calculated higher (132.49 ± 81.03 mg. l^{-1}) at S_2 than other two sites. Conductivity, Turbidity and TDS was recorded maximum at S_2 and seasonally, maximum in monsoon months (July to October). High (8.56 ± 1.28mg.l^{-1}) Dissolved oxygen was recorded at S_1 and lowest (7.09 ± 1.00 mg. l^{-1}) at S_2. Maximum DO was recorded in winter season and minimum during monsoon season. pH was observed higher (7.76 ± 0.07) at S_1 and lower (7.56 ± 0.07) at S_2. Alkalinity was recorded higher (67.64 ± 18.54 mg. l^{-1}) at S_1 and lowest (60.19 ± 16.02 mg. l^{-1}) at S_2. Nitrates and phosphates were recorded higher at S_2 and lowest at S_1. Sulphates in Baldi River was recorded higher (3.08±0.44 mg. l^{-1}) at S_2 and lowest at S_1 (1.62±0.43 mg. l^{-1}).

Table 1 A summary of physico-chemical parameters (Mean ± S.D) recorded in Baldi River during the period from November 2018 - October 2019

Parameters	S_1	S_2	S_3	WHO limits
Water temperature (˚C)	18.19±4.11 (10.6-25)	18.29±4.14 (10.7 -25.1)	18.29±4.14 (10.7 -25.1)	-
Water velocity (m s^{-1})	0.79±0.13 (0.63-1.02)	0.52±0.13 (0.39-0.75)	0.23±0.11 (0.15-0.55)	-
Transparency (m)	0.29±0.11 (0.12-0.42)	0.19±0.12 (0.0-0.32)	0.32±0.13 (0.05-0.34)	-
Conductivity (mS cm^{-1})	0.400±0.03 (0.372-0.463)	0.610±0.03 (0.578-0.667)	0.510±0.03 (0.478-0.567)	1.5
Turbidity (NTU)	40.49±33.15 (2-99)	52.48±37.12 (8-115)	43.51±33.14 (5-101.5)	-
Total dissolved solid (mg l^{-1})	106.38±73.64 (30-236)	132.49±81.03 (45-272)	127.62±80.99 (40.5-267)	1000
pH	7.76±0.07 (7.66-7.88)	7.58±0.09 (7.48-7.82)	7.69±0.08 (7.58-7.84)	6.5-8.5
Dissolved oxygen(mg l^{-1})	8.56±1.28 (6.68-10.32)	7.09±1.00 (6.14-8.52)	8.06±1.28 (6.18-9.82)	5.0
Alkalinity (mg l^{-1})	67.64±18.54 (40-95)	60.19±16.02 (38.5-84.6)	63.19±16.02 (41.5-87.6)	200
Calcium (mg l^{-1})	68.33±13.85 (45-102)	64.92±14.07 (35-97)	60.35±15.878 (30-95)	100
Total Hardness (mg l^{-1})	165.33±29.06 (135-198)	156.42±29.31 (124-187)	150.56±30.16 (120-185)	300
Magnesium (mg l^{-1})	45.08±26.36 (15-52)	38.56 ±26.33 (12-46)	32.15 ±27.03 (10- 42)	50
Nitrates (mg l^{-1})	0.07±0.01 (0.058-0.095)	0.09±0.01 (0.072-0.115)	0.080±0.01 (0.062- 0.095)	50
Phosphates (mg l^{-1})	0.04±0.02 (0.015-0.070)	0.05±0.02 (0.028-0.080)	0.040±0.02 (0.018-0.070)	1.5
Sulphates (mg l^{-1})	1.62±0.43 (1.12-2.32)	3.08±0.44 (2.6-3.72)	2.46 ±0.44 (1.91-3.10)	250
Sodium (mg l^{-1})	9.5±0.88 (8.3-10.8)	10.36±0.5 (9.4-11.3)	9.84±0.50 (8.88-10.78)	200
Potassium (mg l^{-1})	3.91±0.4 (3.3-4.5)	3.98±0.43 (3.34-4.55)	3.92±0.45 (3.24-4.52)	12

Zooplankton:

Composition and density

During study period, sixteen zooplankton species were recorded from Baldi River represented by Rotifers (6 species), Cladocera (4 species), Copepoda (3 species) and Protozoa (3 species). 12 species of zooplankton was recorded with density of 100 ind.l^{-1} at S_1. Ten species of zooplankton with density of 70 ind.l^{-1} were recorded at S_2 . However, eleven species of zooplankton with density of 80 ind.l^{-1} were recorded S_3 (Table 2). Maximum density of zooplankton in Baldi River was recorded in December-February, winter season in India and minimum density recorded during July- August, the months of monsoon season in India

(Figure 2). The abundance of zooplankton recorded in Baldi River in sequence of Rotifers > Cladocera > Protozoa > Copedoda.

Table 2 Checklist of zooplankton taxa (mean density in ind.l^{-1}) recorded in Baldi River during November 2018 - October 2019

Zooplankton	**S_1**	**S_2**	**S_3**
ROTIFERA			
Trichocerca sp.	12	3	6
Keratella valga	10	7	8
Brachionus angularis	8	0	0
Enteroplea sp.	11	0	0
Asplanchna brightweli	8	6	7
Mytilina sp.	9	6	7
CLADOCERA			
Daphnia magna	0	8	8
Alona guttata	9	0	7
Ceriodaphnia reticulata	9	5	7
Simocephalus vetulus	7	7	8
COPEPODA			
Diaptomus gracilus	8	0	8
Cyclops bicuspidatus	8	0	0
Macrocylops albidus	0	6	0
PROTOZOA			
Arcella sp.	0	10	6
Bursaria sp.	3	0	0
Vorticella convallaria	0	12	8
Total	100	70	80

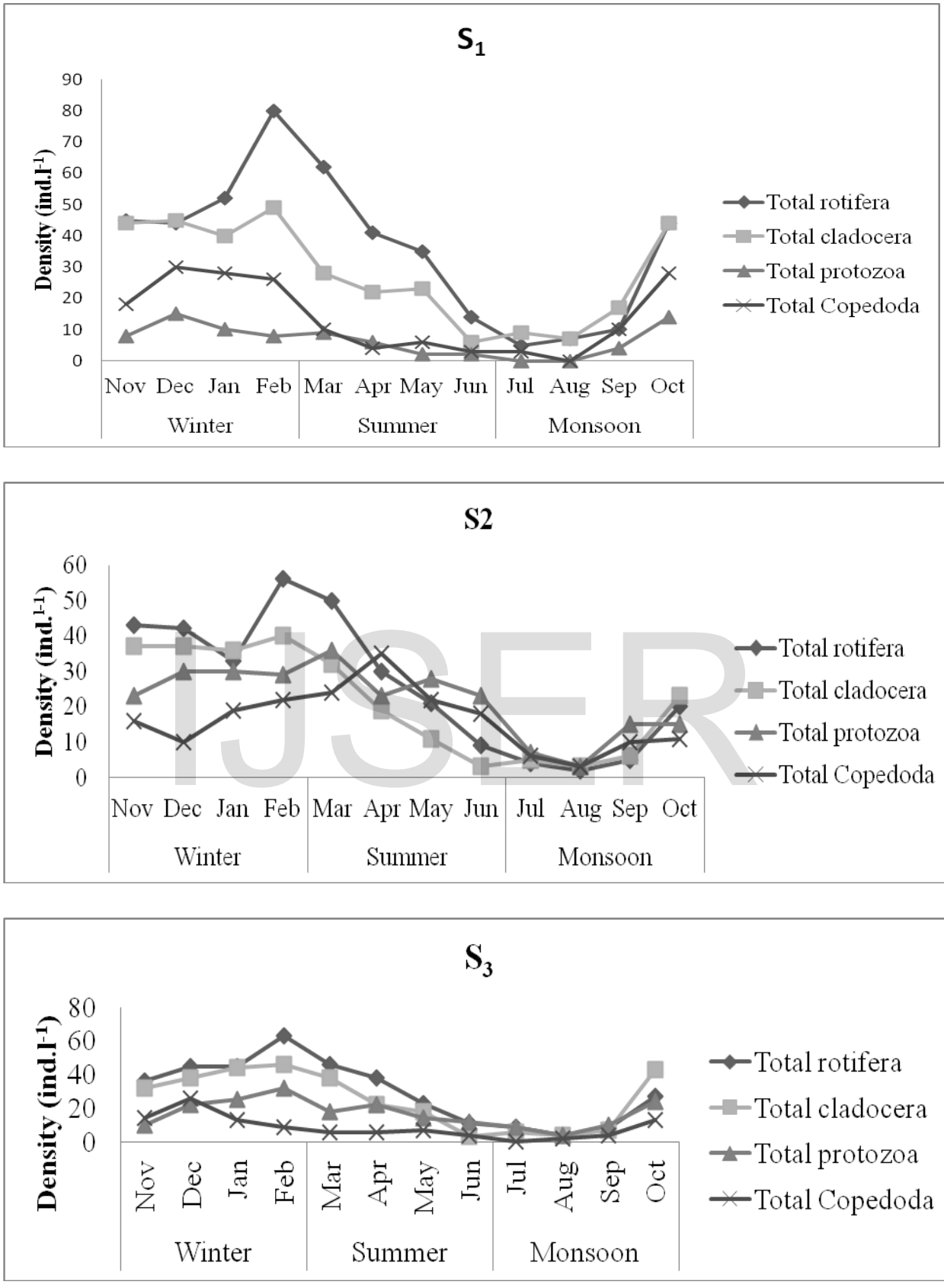

Figure. 2 Monthly composition of zooplankton in the Baldi River during November 2018- – October 2019

Diversity indices

Shannon-Weiner diversity index was recorded highest (2.363) at S_1 and lowest (2.179) at S_2. Highest value (2.426) of Margalef index was observed at S_1 and lowest value (2.274) at S_2. Simpsons diversity index followed the same trend (Table 3). Seasonally, maximum diversity indices were recorded in winter season and minimum during monsoon season

Table 3 Diversity Indices recorded at three sampling sites of River Baldi from November 2018-October 2019

Diversity Indices	S_1	S_2	S_3
Number of Taxa	12	10	11
Number of Individuals (ind. l^{-1})	100	70	80
Simpson Diversity Index (1-D)	0.895	0.870	0.883
Shannon- Weiner Diversity Index	2.363	2.179	2.276
Margalefs Index	2.426	2.274	2.400

4. DISCUSSION

Zooplankton density and composition

16 species of zooplankton from four different groups were recorded in Baldi River. The fluvial ecosystem of Baldi River is not very rich in zooplankton. High water velocity and narrow width of river do not promote stable zooplankton community [11]. Minimum density of zooplankton was found at S_2 during the present study. It may be due to high anthropogenic activities like dumping of organic waste, bathing using soap, washing clothes by detergents, addition of municipal waste water from point and non point sources, untreated sewage from restaurants and lodges at this site which leads to degradation in water quality and reduction in zooplankton density and diversity. Water quality at particular site influences zooplankton abundance and biomass [12]. Rotifers were recorded as dominant group of zooplankton under present study. Rotifers were the dominant component because they have versatile capacity to survive in different environmental conditions [13]. Zooplankton community of Baldi River found in order of Rotifers > caldocerans > protozoans > copepods.

Diversity indices

Diversity indices are considered as a good indicator of pollution level in aquatic ecosystem [14]. Shannon Wiener diversity index value greater than 3 indicates clean water. A value in the range of 1 to 3 indicates moderately polluted conditions and value less than 1 indicates heavy polluted condition [14]. The Shannon - Wiener diversity index value of Baldi River ranged from of 2.179- 2.363 which indicates a moderate pollution level in the Baldi River. Higher values of Margalef index are the indication of less pollution and lower values indicate higher pollution level. Margalef index of Baldi River ranged between 2.274- 2.426 indicating

moderately polluted river. Minimum values of diversity indices were recorded at S_2 in the Baldi River indicated that S_2 was most disturbed and polluted site during study period.

Relation between physico-chemical parameters and zooplankton

Zooplanktons prefer water temperature from 13.5˚C to 32˚C for their suitable development [15]. The range of water temperature (10.6 - 25.1˚C) of Baldi River was recorded within this range. The water of Baldi River was alkaline throughout the study period. Alkaline water is important for the growth of zooplankton [16]. Rotifers and copepods have shown negative correlation with turbidity under the present period. Similar results reported from Karanja River, India [17]. Rotifera, caldocera and copepoda have shown positive correlation with hardness in Baldi River. Rotifera and cladocera have negative correlation with pH in Baldi River. Similar finding was reported in Kapila River, India [18]. Rotifers have positive correlation with dissolved oxygen in the Baldi water. Positive correlation between DO and rotifers was also recorded in Yamuna River, India [19].

Table 4. Pearson' s correlation coefficient compared between physico-chemical parameters and zooplankton community in River Baldi from November 2018-October 2019

	WT	WV	TRNS	CON	TUR	TDS	pH	DO	Alk	Ca	Hard	Mg	Nit	Phos	Sul	Na	K
RO	-.759**	-.927**	.890**	-.549	-.892**	-.886**	-.864**	.938**	-.947**	.912**	.840**	.719**	-.904**	-.957**	-.910**	-.848**	-.886**
CLA	-.804**	-.899**	.913**	-.721**	-.772**	-.742**	-.819**	.870**	-.798**	.775**	.727**	.636*	-.943**	-.868**	-.887**	-.761**	-.729**
PRO	-.565	-.829**	.764**	-.284	-.920**	-.926**	-.831**	.834**	-.817**	.870**	.916**	.899**	-.706*	-.787**	-.771**	-.860**	-.901**
COP	-.792**	-.797**	.793**	-.722**	-.645*	-.577*	-.748**	.771**	-.682*	.677*	.627*	.541	-.860**	-.748**	-.753**	-.685*	-.660*

**. Correlation is significant at the 0.01 level (2-tailed);
*. Correlation is significant at the 0.05 level (2-tailed).
Abbreviations : RO: Rotifera, CLA : Cladocera ; COP: Copepods, PRO : Protozoa, WT :Water Temperature, WV: Water velocity, Tr: Transparency, COND: Conductivity, Tur : Turbidity, TDS: Total dissolved solid ,pH, DO: Dissolved oxygen, Alk :Alkalinity, Ca: Calcium, Hard : Total Hardness, Mg :Magnesium, Ni :Nitrates, Phosp: Phosphates, Sul: Sulphates ,Na: Sodium, K: Potassium

The density of these species was recorded in order of $S_1>S_3>S_2$. Thus, the water quality and zooplankton distribution and composition have successfully assessed the health of the Baldi River of Central Himalayas.

5. CONCLUSION

The water quality of Baldi River was found within acceptable limits of WHO and is suitable for human use and growth of zooplankton species. The Upper stretch (S_1) of the Baldi River

was less polluted in comparison to other downstream site. However, the S_2 (middle stretch) of Baldi River was influenced by disturbances reflected in terms of high values of TDS, turbidity and nutrients (nitrates and phosphates), low DO concentration and minimum density of zooplankton.. Rotifers were found to be dominant component of zooplankton in Baldi River which is characteristic of less polluted freshwater ecosystem. The various diversity indices indicated the status of health of Baldi River. Overall study provides a base line data on the prevailing condition of the freshwater ecosystem of the Baldi River.

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