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Impact of Regulation on the Physico-Chemical Features and Zooplanktonic Diversity of Central Himalayan River Tawi in Udhampur (J&K) INDIA

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ABSTRACT

Flow of river's become impeded and are regulated due to construction of dam. This brings about change in abiotic and biotic factors compared to unregulated river. The post-impoundment physical, chemical and biological parameters of the parent river Tawi (upstream, within reservoir and downstream) were analysed for the first time and data thus generated was compared to reveal influence of Chenani Hydroelectric dam on this regulated river. It was observed that the water temperature, pH, transparency and carbon dioxide content of the parent river were influenced by the dam and significant differences in these parameters were observed among the main zones sampled. The zooplanktonic community of river Tawi was also influenced by variations in abiotic features and its highest planktonic diversity was recorded in reservoir (lentic zone) of dam due to reduced water current, higher transparency and long resident time where as downstream river exhibited low diversity due to lotic conditions.
Keywords: Physico-chemical parameters, impoundment, zooplankton, lotic, lentic.

INTRODUCTION

Man started to build dams and canals a long time ago by influencing the natural flow regime. In 2600 BC, the first large dam (14 meters height, 113 meters crest length) was build at Sadd et Kafara in Egypt in the Garawi ravine facing Memphis [1]. Dam construction and reservoir itself has variable impacts such as social, economical, geophysical as well as impacts on water quality, climate, flora and fauna. The damming of a river has been called as a cataclysmic event in the life of a riverine ecosystem [2]. Most of the world's large rivers are fragmented by dams. Increased fragmentation produced an exponential decline in the likelihood of persistence, but no extinction threshold to suggest a minimum viable length of river [3]. The unique spatial features of rivers suggest that the process of habitat fragmentation and its effects differ from those of other ecosystems. In rivers, fragmentation is not random. Fragmentation is a purposeful goal that must be achieved to realize the economic and social benefits of hydropower and flood control. Because large rivers played, and continue to play, such an important role in the development of human societies, they are among the most intensively fragmented ecosystems that exist.

Scientists have assessed 227 of the major river basins in the world and showed that 37% of the large rivers are strongly affected by fragmentation and altered flows, 23% are moderately affected and 40% are unaffected. This has played a major role in the rapid decline in freshwater biodiversity worldwide.

Over the past three decades, the scientific community has advanced our understanding of rivers and helped us to realize the significant negative impacts that dams have on river systems. The physical habitat is critically important to river ecosystem and can change more easily and more quickly than in most other ecosystems [4]. Dams disrupt a river's natural course and flow, alter water temperature in the stream, redirect river channels, transform floodplains, and disrupt river continuity. These dramatic changes often reduce and transform the biological make-up of rivers, isolating populations of fish and wildlife and their habitats within a river. So keeping above mentioned impacts of regulation of river by dam, the present study was carried out in river Tawi to generate data about the impact of damming on its physico-chemical parameters and zooplanktonic diversity both qualitatively and quantitatively.

MATERIAL AND METHODS

Study area

River Tawi is a high altitude Himalayan river that originates from base of Kali Kund glacier and adjoining area southwest of Bhadarwah in Doda District of J&K. The study area of river lies 32°56' North to 75°09' East at an elevation of 624m above sea level. In the present study 3 stations were selected viz station I near the reservoir feeder canal interface in the river Tawi (lotic), Station II in the Chenani hydroelectric reservoir (lentic) and station III downstream in the release canal (lotic).

Physico chemical parameters analysis

The present study was carried out from September 2011 to August 2012 and periodic sampling was done at the sampling sites. Physical parameters like air and water temperature, transparency, pH. DO, FCO2, carbonates and bicarbonates were analysed on the spot. Whereas for the analysis of calcium, magnesium and chlorides, samples were taken in laboratory and calculated following standard methodology [5, 6].

Zooplankton sampling and analysis:

Zooplankton were collected by filtering 25 litres of water through standard plankton net (77 mesh bolting silk) and the samples were fixed in 5% of formalin and identified by keys and monographs [7-9]. By transferring 1ml sub sample from each of the samples to the Sedgewick-Rafter counter and counting of cells within 10 squares of the cells, chosen randomly and analysis was done on a Sedgwick-Rafter counting cell, under compound microscope.

$$N = \frac{A \times 1000 \times C}{V \times F \times C}$$

Where, N= Number of zooplankton cells or units per litre of water, A= Total number of zooplankton counted, C= Volume of final concentration of the samples in ml, V=Volume of a field in cubic mm, F= Number of fields counted, L= Volume of original water in litres.t

RESULTS

The monthly variations in the physico-chemical parameters in the study area during the study period of 1 year from Sept. 2012 to Aug. 2013 are shown in the figure 1 (a-i). There were similar seasonal variations in the physico-chemical parameters in all three selected stations. Both air and water temperature decreased from summer to winter and vice-versa. There were significant seasonal variations in water transparency. Higher transparency was seen during post monsoon season and least during monsoon season. pH of water remained alkaline throughout the study period in all the stations. Dissolve oxygen is indirectly proportional to water temperature and ranged from 4.75mgl-1 to 9.62mgl-1. Increased in concentration of DO was observed from summer to winter and vice-versa. DO bear inverse relationship with FCO_2 as a result its value increased during summer and decreased in winter season. Bicarbonates concentration increased from winter to summer. The chloride content decreased from monsoon to winter season. Both calcium and magnesium contributes to the total hardness. Higher concentration of calcium was seen in summer and least in pre winter. Magnesium conc. Showed opposite variation to that of calcium.

Table 1: Mean value and their standard deviation of various physico chemical parameters in three study area.

Parameters	Station 1 (Upstream)	Station 2 (Dam)	Station 3 (Downstream)
Air temp.	27.80 ± 6.88	27.79 ± 6.89	27.80 ± 6.88
Water temp.	17.41 ± 5.83	17.46 ± 5.81	17.55 ± 5.75
Transparency	210.58 ± 109.38	209.91 ± 110.03	209.50 ± 110.30
pH	8.36 ± 0.102	8.37 ± 0.158	8.37 ± 0.224
Dissolved O2	7.76 ± 1.65	7.77 ± 1.64	7.76 ± 1.64
Free CO2	3.95 ± 1.57	3.95 ± 1.58	3.94 ± 1.58
Bicarbonates	118.78 ± 20.35	118.76 ± 20.42	121.91 ± 18.38
Chloride	8.12 ± 4.47	8.24 ± 4.14	8.26 ± 4.37
Calcium	69.44 ± 12.31	70.07 ± 12.24	70.56 ± 12.08
Magnesium	56.92 ± 22.53	57.26 ± 22.71	56.04 ± 21.68

Table 2: Monthly variations in zooplanktons diversity in station 1 (upstream lotic)

S.no	Name of species	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Total
A.	**Protozoa (Rhizopoda)**													
1	*Centropyxis aculeate*	-	-	-	1	-	-	-	-	-	5	1	-	7
2	*Nebela collaris*	2	1	2	-	-	-	-	3	-	-	-	-	8
3	*Arcella vulgaris*	-	-	-	-	-	-	-	6	5	-	3	-	14
4	*Euglena gracilis*	2	1	2	4	3	2	4	6	5	9	-	-	38
5	*Trinema enchelys*	-	2	3	3	-	4	-	6	-	8	-	-	26
	Amoeba sp	-	-	-	-	-	-	-	-	-	-	-	-	0
B.	**Ciliate**													
1.	*Paramecium sps*	-	-	-	-	-	-	-	-	-	-	-	-	0
2.	*Euglypha ciliate*	-	2	-	-	-	2	3	3	1	3	-	-	14
3	*Vorticella convallaria*	7	3	4	3	6	3	5	7	6	6	-	-	50
C	**Rotifera**													
1	*Lepidella ovalis*	-	-	1	-	-	-	-	1	3	4	-	-	9
2	*Colurella adriatica*	-	-	-	-	-	-	-	-	-	-	-	-	0
3.	*Monostyla lemaris*	-	-	-	1	-	-	-	1	3	3	-	-	8
4.	*Cephalodella intuta*	-	-	-	-	-	2	-	2	3	3	-	-	10
	Branchionus angularis													
D	**Cladocera**													
1.	*Daphnia similis*	-	-	-	2	-	1	-	3	3	3	-	-	12
2	*Alona monacantha*	-	4	2	5	4	2	4	5	4	5	-	-	35
3	*Alona costata*	-	3	4	3	6	1	5	6	4	6	-	-	38
	Copepod													
1.	*Eucyclops agilis*	-	-	-	-	1	2	1	2	3	5	-	-	14
2.	*Mesocyclops*	-	-	-	2	-	1	1	3	3	2	-	-	10
3.	*Nauplius larva of copepod*	1	6	3	4	-	1	3	5	3	6	-	1	32

Atmospheric temp. ranged from 16.4^{0}C to 37^{0}C at all the study. Higher water temp. was recorded in upstream 9.7^{0}C to 24.8^{0}C (lotic), then lower in dam 9.5^{0}C to 24^{0}C and little more lower in downstream 9.5^{0}C to 23.8^{0}C. There is significant difference in transparency between lotic and lentic zone. More transparency was observed in dam as compared to both upstream and downstream. Values of water transparency ranged from 45cm to 423cm, from 44cm to 429cm and from 45cm to 421cm in upstream, reservoir and downstream respectively. pH of water remained alkaline throughout the study period and its value ranged from 8.2 to 8.5, 8.1 to 8.7 and 8.1 to 8.7 in upstream, dam and downstream respectively. High value of pH (8.7) was noticed in dam in the month of July (summer season). Dissolved oxygen ranged from and was found higher in winter at all the stations. Dissolved oxygen concentration ranged from 4.75 mgl-1 to 9.60 mgl-1, 4.87 mgl-1 to 9.62 mgl-1 and 4.86 mgl-1 to 9.58 mgl-1 in upstream, dam and downstream respectively. FCO_2 was present throughout the year and was found higher in lentic zone (dam). It doesn't show any particular seasonal trend. Carbonates were absent throughout the year so alkalinity was mainly by bicarbonates. Bicarbonates concentration ranged from 86 mgl-1 to 145.4 mgl-1 in upstream,82 mgl-1 to 145.6 mgl-1 in dam and 82 mgl-1 to 145.4 mgl-1 in downstream. Chlorides were present and its mean value were 8.12 ± 4.47 in upstream, 8.24 ± 4.14 in dam and 8.26 ± 4.37 in downstream as shown in table 1. Calcium level did not show any definite trend in variations in the lotic and lentic zone of river Tawi. Magnesium was found higher in dam throughout the year except during Jan. and Feb.

Table 3: Monthly variations in zooplanktons diversity in station 2 (in dam lentic)

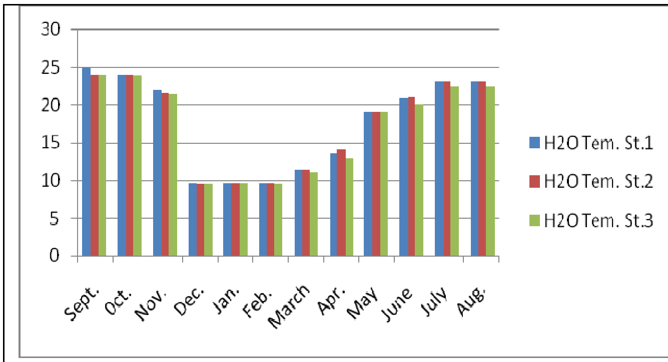
S.no	Name of species	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Total
A.	**Protozoa (Rhizopoda)**													
1	*Centropyxis aculeate*	1	4	7	8	6	4	-	3	7	9	-	-	49
2	*Nebela collaris*	2	6	5	9	2	3	-	5	5	2	-	-	38
3	*Arcella vulgaris*	-	2	1	-	-	1	1	6	8	9	6	-	34
4	*Euglena gracilis*	-	3	12	15	1 4	15	12	8	16	18	-	-	122
5	*Trinema enchelys*	-	7	2	7	5	1	-	3	2	7	-	-	34
6	*Amoeba sp.*	-	-	-	-	-	-	2	-	-	3	-	-	5
B.	**Ciliate**													
1.	*Paramecium sps*	-	-	-	-	-	-	-	-	-	1	-	-	1
2.	*Euglypha ciliate*	-	3	1	-	2	3	3	2	3	4	-	-	21
3	*Vorticella convallaria*	4	1	2	4	6	5	8	8	10	11	-	-	59
C.	**Rotifera**													
1	*Lepidella ovalis*	6	9	6	2	-	-	-	3	4	3	-	-	33
2	*Colurella adriatica*	1	2	4	-	2	-	3	3	4	3	-	-	22
3.	*Monostyla lemaris*	2	6	-	-	-	-	-	1	8	5	-	-	22
4.	*Cephalodella intuta*	-	4	-	-	2	2	3	3	4	3	-	-	21
5	*Branchionus angularis*	-	-	-	-	-	-	-	-	1	-	-	-	1
D	**Cladocera**													
1.	*Daphnia similis*	-	-	3	5	-	-	-	2	3	4	-	-	17
2	*Alona monacantha*	-	1	2	-	2	7	1	4	5	8	-	-	30
3	*Alona costata*	-	3	3	-	1	5	1	3	5	5	-	-	26
	Copepod													
1.	*Eucyclops agilis*	-	2	4	4	2	5	-	1	3	6	-	-	27
2.	*Mesocyclops*	-	4	7	1	1	4	-	4	5	4	-	-	30
3.	*Nauplius larva of copepod*	2	3	5	6	-	-	-	2	3	7	-	-	28

Monthly variations in population density and percentage composition of zooplanktons in three selected stations viz. upstream, Chenani dam and downstream are shown in table 2 to 4 and figure 2 to 4 respectively. The result of plankton diversity indicates that faunal diversity is higher in lentic zone of Rivers Tawi (in dam) compare to lotic portion. Higher density of zooplanktons was observed in dam i.e. 45.21% followed by downstream of river Tawi 31.41% and least in upstream zone 23.36%. However qualitatively downstream had the least no. of species, representing only 11 species of zooplanktons. Qualitatively zooplanktons were represented by 5 groups viz. Protozoa, Ciliate, Rotifera, Cladocera and Copepoda. Qualitatively group Protozoa was the dominant among all and represented by 5 species viz *Centropyxis aculeate, Nebela collaris, Trinema enchelys, Euglena gracilis, Arcella vulgaris* in station I, 6 species viz. *Centropyxis aculeate, Nebela collaris, Trinema enchelys, Euglena gracilis, Arcella vulgaris and Amoeba sp.* in station II and 3 species viz. *Trinema enchelys, Euglena gracilis and Arcella vulgaris* in station III.

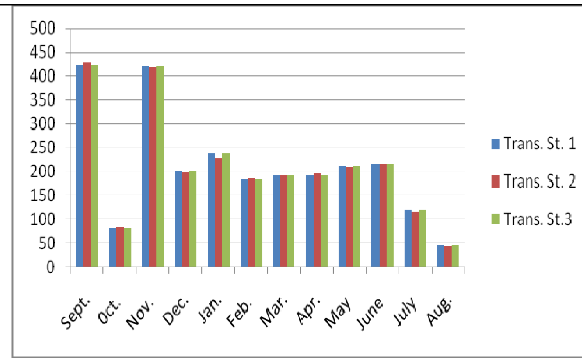
Table 4: Monthly variations in zooplanktons diversity in station 3 (downstream lotic)

S.no	Name of species	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Total
A.	**Protozoa (Rhizopoda)**													
1	*Centropyxis aculeate*	-	-	-	-	-	-	-	-	-	-	-	-	0
2	*Nebela collaris*	-	-	-	-	-	-	-	-	-	-	-	-	0
3	*Arcella vulgaris*	-	-	-	-	1	1	1	7	4	9	3	-	26
4	*Euglena gracilis*	0	2	5	10	13	3	8	10	13	24	-	-	89
5	*Trinema enchelys*	2	11	15	11	8	9	11	12	5	14	-	-	100
6	*Amoeba sp.*	-	-	-	-	-	-	-	-	-	-	-	-	-
B.	**Ciliate**													
1.	*Paramecium sps*	-	-	-	-	-	-	-	-	-	-	-	-	0
2.	*Euglypha ciliate*	-	-	-	-	1	2	3	3	3	5	-	-	17
3	*Vorticella convallaria*	4	-	2	5	2	7	5	6	4	12	-	-	45
C.	**Rotifera**													
1	*Lepidella ovalis*	-	-	-	-	-	-	-	-	-	-	-	-	0
2	*Colurella adriatica*	-	1	2	-	-	1	-	5	2	-	-	-	11
3.	*Monostyla lemaris*	-	3	-	-	-		-	4	5	-	-	-	12
4.	*Cephalodella intuta*	-	-	-	-	-	-	-	-	-	-	-	-	0
5	*Branchionus angularis*	-	-	-	-	-	-	-	-	-	-	-	-	0
D	**Cladocera**													
1.	*Daphnia similis*	-	-	-	-	-	-	-	-	-	-	-	-	0
2	*Alona monacantha*	-	6	4	3	2	-	7	3	3	2	-	-	30
3	*Alona costata*	-	8	5	2	7	4	5	3	4	-	-	-	37
4														
	Copepod													
1.	*Eucyclops agilis*	-	-	6	4	2	1	1	3	3	9	-	-	29
2.	*Mesocyclops*	-	-	-	-	-	-	-	-	-	-	-	-	0
3.	*Nauplius larva of copepod*	-	4	2	1	2	4	2	3	5	12	-	-	35

Group Rotifera was the second dominant and represented by 3 species viz. *Lepidella ovalis, Monostyla lemaris and Cephalodella intuta*. in station I, 5 species viz *Lepidella ovalis, Colurella adriatica, Branchionus angularis, Monostyla lemaris* and *Cephalodella intuta*. in station II and 2 species *Colurella adriatica* and *Monostyla lemaris* in station III.



(a)



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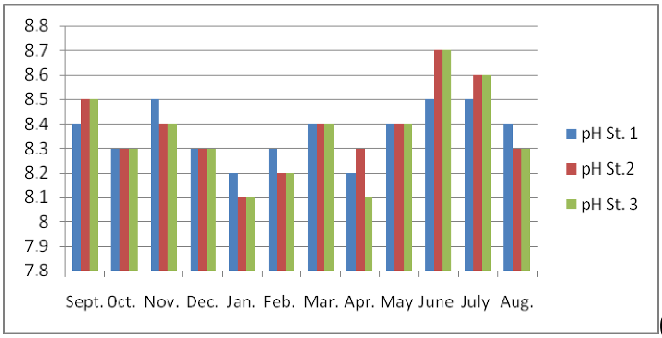

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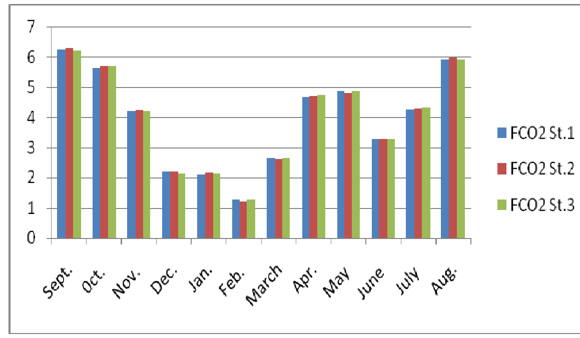

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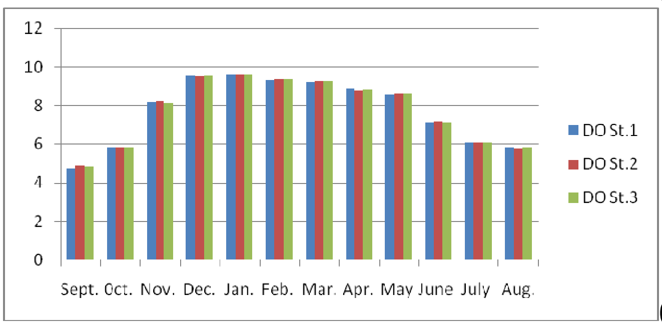

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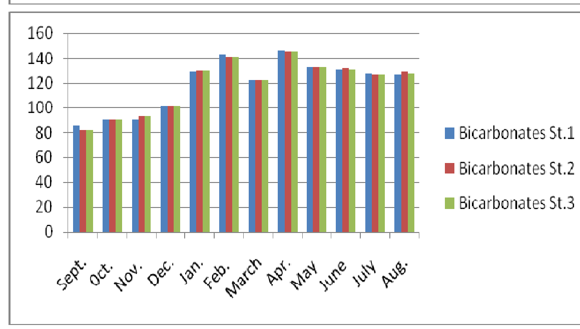

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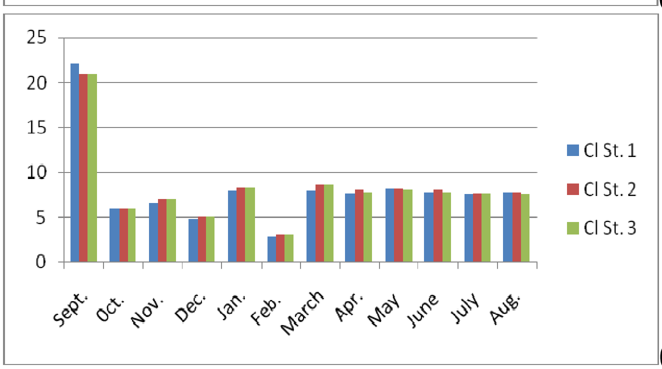

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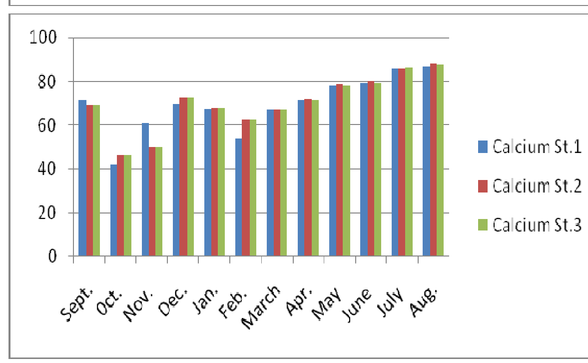

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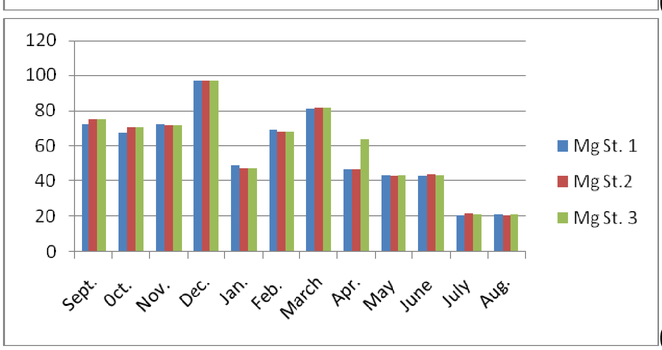

(i)

Figure 1:
a. Showing monthly variation in some physico-chemical parameter of three selected stations during study period.
b. Showing variation in Transparency
c. Showing variation in pH
d. Showing monthly variation in FCO_2
e. Showing monthly variation in DO
f. Showing monthly variation in bicarbonates.
g. Showing monthly variation in chlorides
h. Showing monthly variation in calcium.
i. Showing monthly variation in magnesium.

Cladocera was the third dominant group represented by 3 species viz. *Daphnia silmilis, Alona monocantha* and *Alona costata* each in station I and station II and only 2 species viz. *Alona monocantha* and *Alona costata* in station III.

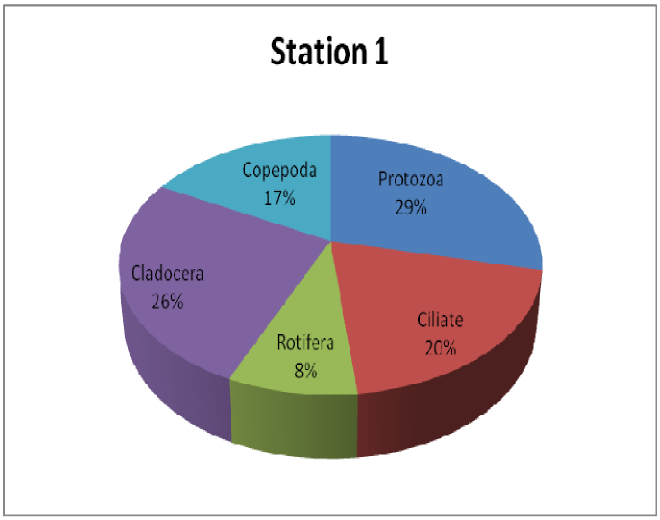

Figure 2. Percentage distribution of different groups of zooplanktons in station 1

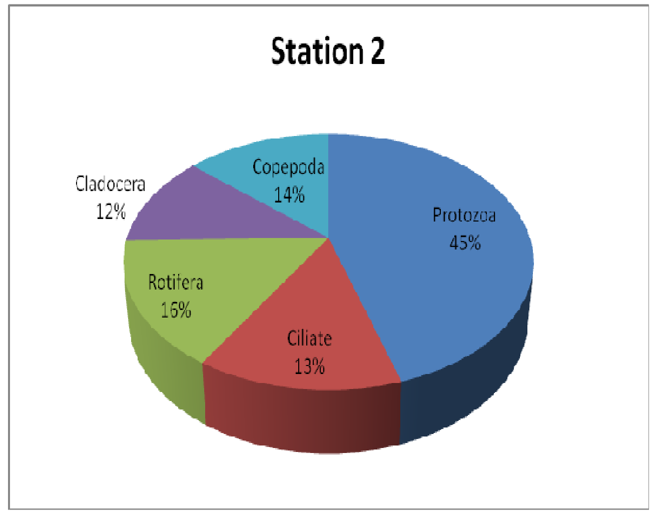

Figure .3. Percentage distribution of different groups of zooplanktons in station 2

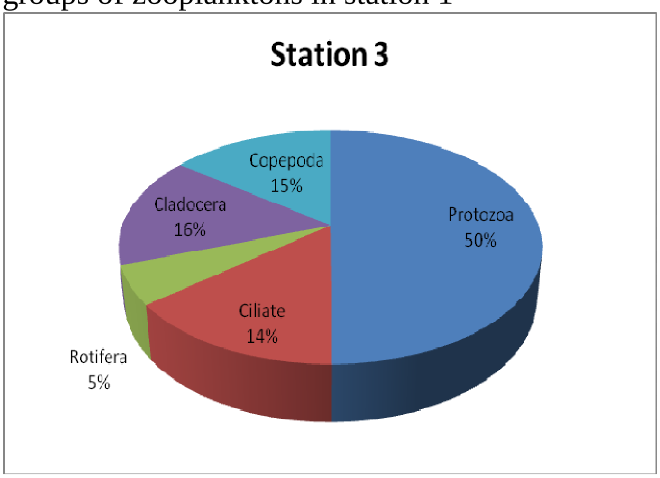

Figure 4. Percentage distribution of different groups of zooplanktons in station 3.

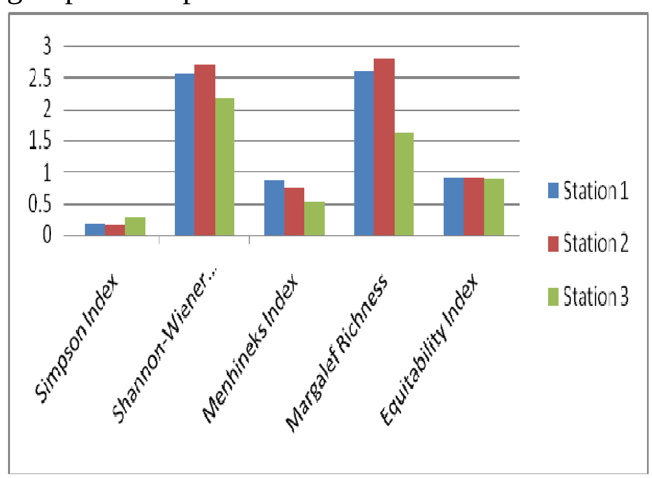

Figure 5. Showing diversity, richness and evenness index's in three selected stations.

Group Copepoda was at fourth place and was represented by 3 species viz. *Eucyclops agilis, Mesocyclops leukartii* and Nauplius larva of Copepod each in station I and station II and 2 species viz. *Eucyclops agilis* and Nauplius larva of Copepod in station III. Ciliate was the fifth dominant group among all and was represented by 2 species each viz. *Euglypha ciliate* and *Vorticella convallaria* in station I and station III and 3 species viz. *Paramecium sp., Euglypha ciliate* and *Vorticella convallaria* in station II.

DISCUSSION

The physico-chemical parameters viz. water temperature, transparency and free CO2 were observed to be significantly different between lotic and lentic zones of the Chenani dam. Water temperature followed atmospheric temperature. Maximum value of both air and water temperature in the month of June may be attributed to the increased photoperiod and longer day length whereas minima acquired in December may be due to shorter photoperiod and shorter day length. Further atmospheric temperature of an area also depends upon its altitudinal and longitudinal location [10-12]. According to FWPCA (1967), temperature, a catalyst, a depressant, an activator, a stimulator, a controller, a killer is one of the most important and influential water quality characteristics to life in water. The water in downstream which is drawn from the bottom of dam is cooler as compare to its surface layer. The increase in surface water temperature observed in lentic portions of rivers at all season is due to surface heating and lesser mixing of the water unlike in lotic part where water current is fast and turbulent, thus allowing an even distribution of heat throughout water column.

Factors affecting transparency of water are silting, free swimming microscopic organisms and suspended organic matter [13]. The waters of Chenani hydroelectric dam became more turbid in monsoon due to silt being washed in with rain waters. This pattern in transparency was also observed [14]. pH do not followed any uniform trend between lotic and lentic zones [15]. The higher pH recorded in winter in some sites and lower in others may be attributed to increase and decrease in biogenic activities of the system.

Higher dissolved oxygen recorded in lotic stretch of stream during winter is due to lower water temperature compare to monsoon and lentic part as observed in this study and by several others [16, 17]. Also fast flow of lotic portion allowed replenishment of oxygen. Higher dissolved oxygen during winter might also be due to photosynthetic activities of phytoplankton’s.

The higher concentration of bicarbonates recorded during summer may be due to low water level due to higher rate of evaporation. Concentration of chlorides found higher in monsoon season due to weathering of rocks and higher evaporation rate [18, 19]. The values of calcium was higher in dam except during Sept. and Nov. when it was found higher in upstream due to rain. The maxima in winter was due to its great solubility at low temperature [20]. Winter rise in concentration of Mg^{2+} had also been noticed [21, 22].

Quantitatively a total of 1392 individuals of zooplanktons were collected from all the three study sites. Out of these, 630 individuals from station II, 439 individual from station III and 325 from station 1. The higher zooplanktonic diversity in lentic portion of Chenani dam reservoir area is due to favourable environment and long resident time period unlike the riverine zones where fast current and higher turbidity affect growth. Similar results were also given by [23]. Qualitatively, 19 species of zooplanktons were founded in station II (Chenani hydroelectric dam), 16 species in station I (upstream) and only 11 species in station III (downstream).

The maximum number of Protozoans, Cilates, Rotifers, Cladocerans and Copepods were reported in June and the minimum during August, September and October. Summer rise in quantitative count of total zooplankton may be attributed to increased number of phytoplanktons , organic matter and bacterial richness, at higher temperature, on which they were known to feed [24- 28]. Low temperature, rise in pH, low bicarbonate, Ca, Mg and total hardness favouring winter highest Protozoan peak in a reservoir [29]. Further minima in zooplanktons population in August and September was due to dilution effect caused by monsoon rain.

The species diversities, richness and equitability index’s were analysed using the following indices of Shannon-Wiener index (H') [30], Simpson index (I) [31], Margalef's index (R_1) [32] and Evenness index (E) [33]. Analysis of data revealed that maximum species diversity and richness in term of Shannon-Wiener index (H') and Margalef's index (R_1) were found in station II (dam) and least in station III (downstream) as shown in figure 5. Simpson index is inversely proportional to Shannon-Weiner dominance index so higher value of Simpson index was seen in Station III and lower in station II.

Thus, the overall effect of the dam on the river Tawi has been to cause changes in physicochemical parameters that led to increase in zooplankton density and presence of some immigrant species in the reservoir (lentic zone). In contrast downstream, the numbers and diversity is least.

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REFER ENCES

[1] Schinitter, N. J. 1994. A history of Dam: the useful pyramids. Balkema publ., Rotterdam, The Neitherland.
[2] Gup, T. 1994. Dammed from here to eternity: dams and biological integrity." *Trout.* 35: 14-20.
[3] Jager, H. I. 2000. Predicting the viability of fish populations in a modified riverine environment. Ph.D. Dissertation, University of Tennessee, Knoxville, pp. 255.
[4] Power, M. E. R. J. Stout, C. E. Cushing and I. R. Wais. 1988. Biotic and abiotic control in river and stream communities *J. North Am. Benthol. Soc*, 7: 456-479.
[5] APHA. 1995. Standard methods for the examination of water and waste water. American Public Health Association, American Water Works Association and Water Environment Federation, Washington.
[6] Trivedy R.K. and P.K. Goel. 1986. Chemical and biological methods for water pollution studies. Environmental publications, Aligarh.
[7] Ward, H.B. and G. C. Whipple. 1959. Freshwater Biology, Jhon Willey and Sons.Inc. New York, London, 2: 12- 48.
[8] Mellanby, H. 1963. Animal life in Freshwater, Cox and Wyman Ltd. London, 6: 78-101.
[9] Tonapi, G.T. 1980. Freshwater animals of India, Oxford and IBH Publishing Co. New Delhi, 110001.
[10] Chourasia, S.K. and A. D. Adoni. 1985. Zooplankton dynamics in a shallow eutropic lake, In Proc. Nat. Symp. Pure and Appl. Limnology (Ed. A.D. Adoni). Bull. Bot. Soc. Sagar, 32: 30-39
[11] Ramanibai, P.S. and S. Ravichandran. 1987. Limnology of an urban pond at Madras, *Indian, Poll. Res.*, 6: 77-81.
[12] Ambasht, R.S. and Shardendu. 1989. Morphometry and Physicobiotic characters of Varanasi ponds, Proc. Nat. Acad, Sci. India, 59(B): 421-426.
[13] Bamforth, S. 1958. Ecological studies on the planktonic Protozoa of a small artificial pond. *Limnology of Oceanography* 3, pp. 398-412.
[14] Agarwal, N. K. and B.L. Thapliyal. 2005. Preimpoundment hydrological study of Bhilangana River from Tehri Dam reservoir area in Uttaranchal. *Enviromental Geochemistry* 8: 143-148.
[15] Umadevi .T. 2013 Limnological Investigation and Zooplankton Diversity of Karanja River,

Karnataka International Journal of Science and Research (IJSR), 2(3): 133-136.
[16] Gurumahum, S. D., P. Daimari, B. S. Goswami, A. Sakar and M. Choudhury. 2000. Physico chemical qualities of water and plankton of selected rivers in *Meghalaya.Journal Inland Fisheries Society of India* 34: 36 - 42.
[17] Kaushik, S. S. Sharma, and D. N. Saksena. 1989. Physico-chemical factors and the aquatic insect density of a pond receiving cotton mill effluents at Gwalior, *India, J. Ecol.*, 16(1): 64-67.
[18] Dhamodharan, T. and S. Suresh. 2005. Pollution Research 24(1): 239-342.
[19] Basant, K. S. A. Murugan and B. N. Chaudhary. 2011. Seasonal variation of physico-chemical properties of Kamala basin of Darbhanga district, Bihar, *Inter.Jou. of Adva. Biol. Res.,* 1(1): 123-125.
[20] Wetzel, R. G. 1975. Limnology, W.B. Saunders CO., Philadephia.
[21] Seghal, H. S. 1980. Limnology of Lake Surinsar, Jammu, with referances to zooplankton and fishery prospects, Ph.D Thesis, university of Jammu.
[22] Kumar, S. 1990. Limnology of Kunjwani Pond, Jammu with referances to Plankton and Macrophites. M.Phil Dissertation, submitted to university of Jammu.
[23] Chouhan Pushpa and R. R. Kanhere. 2013. Diversity of Zooplankton in Barwani Tank of West Nimar, MP, India *Research Journal of Animal, Veterinary and Fishery Sciences* 1(3): 7-13.
[24] Zutshi, N. 1992. Effects of Jammu city sewage water on abiotic and biotic factor of the river Tawi, Jammu Ph. D. Thesis, University of Jammu, India.
[25] Sladeck, V. 1983. Rotifers as indictors of water quality, *Hydrobiol.* 100: 169-201.
[26] Sharma, J. 1999. Effect of Industrial wastes and sewage on abiotic and biotic (Plankton and Macrophytes) components of Behlol nullah, Jammu. Ph. D thesis, University of Jammu, Jammu.
[27] Wetzel, R. G. 2001. Limnology, Lake and River Ecosystems, Published by Academic Press, a Harcourt Science and Technology Company, USA.
[28] Mohan V.C., K. K. Sharma and A. Sharma. 2013. Seasonal Variations and Diversity of Zooplanktons Community Structure in Chenani Hydroelectric Reservoir, its Feeding Channel and River Tawi, Udhampur, J&K, India *International Research Journal of Biological Sciences* 2(4): 37-43.
[29] Dutta, S. P. S., S. Kumar. and V. Kumari. 1991. Seasonal fluctuationsin protozoan in Kunjwani pond, Jammu, Geobios, New Reports 10(2): 121-124.
[30] Shannon, C. E and W. Weaver. 1949. The mathematical theory of communication, University Illinois Press, Urbana, IL, 117.
[31] Simpson, E. H. 1949. Measurement of diversity, Nature, London 163-681.
[32] Margalef, R. 1968. Perspectives in ecological theory, University Chicago Press, Chicago, Illinois, 111.
[33] Pielou, E. C. 1975. Ecological diversity, John Wiley, New York, 165.