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# Assessment of water quality parameters and zooplankton assemblage in River Tons (a tributary of river Yamuna in Uttarakhand, India)

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## ABSTRACT

The assessment of physico-chemical parameters of River Tons (a tributary of River Yamuna in Uttarakhand India) and their influence on zooplankton composition and abundance were investigated at three stations for one year from August 2011 to July 2012. The diversity was not high and only four groups of zooplankton were found which includes Protozoa with ten genera, Rotifera with eleven genera, Copepoda with six genera and Ostracoda with two genera only. Rotifera was dominating followed by protozoa, copepoda and ostracoda. The total zooplankton was more prevalent at site I during the study period. The physico-chemical factors and habitat conditions of River Tons strongly influence the generic composition and population density of zooplankton. Hence it is important to prevent the ecological conditions of River Tons and any water ecosystem for the better status of zooplankton and other aquatic diversity. 

## INTRODUCTION

Zooplankton are small animals that float freely in the water column of lakes, rivers and oceans and whose distribution is primarily determined by water currents and mixing. Zooplankton plays a pivotal role in aquatic food webs because they are important food for fish and invertebrate predators and they graze heavily on algae, bacteria, protozoa, and other invertebrates. They are rarely important in rivers and streams because they cannot maintain positive net growth rates in the face of downstream losses. These communities are highly sensitive to environmental variation. As a result, changes in their abundance, species diversity, or community composition can provide important indications of environmental change or disturbance[19]. Several factors usually contribute to the establishment of zooplankton communities in a river, among which are good water quality, presence of nutrients, physico-chemical factors of water, availability of phytoplankton, hydrological characteristics of the river and river ageing. Once established, zooplankton assemblage usually influences energy flow through classical food chain, nutrient cycling and community population dynamics within the riverine ecosystem. This ecological niche has also made them key actors in their top down grazing effect (trophic cascade) on the bottom up forces which plays pivotal roles in biomanipulation for restoration purposes[6]. The present study was aimed to investigate the zooplankton composition of River Tons and the influence and effect of water quality parameters on these communities with a view to understand the contribution of the zooplankton community to the river productivity, and also managing the zooplankton population in their natural settings for sustainable fisheries and ecosystem balance.

## MATERIAL AND METHODS

### Study area

The River Tons is the largest tributary of the Yamuna and flows through Garhwal region in Uttarakhand, touching Himachal Pradesh. Its source lies in the 20,720 ft (6,315 meters) high in Bandarpunch mountain and is one of the most major perennial Indian Himalayan rivers. The origin of Tons river is at the convergence of two feeder streams - the Supin river rises from the Northern part of the Tons catchment near the Himachal Pradesh and Uttar Pradesh border and the Rupin river rises from a glacier at the head of the famous Har-Ki-Dun valley in the North-North Eastern part of the Tons catchment. These two feeder streams converge near the mountain hamlet of Naitwar and the channel downstream of Naitwar is known as Tons River. The river flows along a V shaped valley. The river carries more water than the Yamuna itself and meets it below Kalsi near Dehradun, Uttarakhand. The Tons flows into the Yamuna River after crossing into the Sub-Himalaya Sequence. Along with Ganges, it has now become a major destination for water-based adventure sports like white-water rafting in Uttarakhand.

### Sampling strategy

Physico-chemical characteristics of the water body were sampled monthly from three stations namely Garhi cant (S1), Tapkeshwar Temple (S2) and Selaqoi (S3). Sampling was done from August 2011 to July 2012. Triplicate surface water samples were collected in 1-litre plastic water bottles and analyzed for temperature, conductivity, TDS, pH, total alkalinity, total hardness, calcium, magnesium, chloride, dissolved oxygen, chemical oxygen demand, phosphate and nitrate according to the standard methods for the examination of water and waste water[3] and Khanna and Bhutiani[13] procedures. Zooplankton, samples were collected from all the 3 stations with the help of plankton net of bolting silk no. 25 with a mesh size of 55 μm attached with a collection tube at the base of net. For this a known volume (10 l) of water was filtered through the planktonic net and sample was collected inside the collection tube. The sample was then transferred in sterilized tubes of 250 ml capacity and preserved in 4% Lugol's solution or formal dehyde solution[22]. Transportation of water samples were as per standard methods. Identification was done only to generic level using keys compiled by Edmonson[8], Whitford and Schumacher[24] Jeje and Fernando[12]. Statistical analyses of the results were done to investigate the correlation and level of dependence between the total zooplankton with the physico-chemical factors.

## RESULTS

### Physico-chemical factors

The mean annual variation in the water temperature of the three stations is presented in TABLE 1. The temperature ranged between the lowest of 18.33±2.42 ºC obtained from Station 1 and the highest of 19.66±2.22 ºC obtained from station 3. Dissolved oxygen fluctuated between lowest annual mean of 8.69±0.72 mg/L obtained from site 3 and the highest annual mean of 9.97±0.52 mg/L recorded from site 1 (TABLE 1). Chemical Oxygen Demand (COD) varied between 5.13±0.48 mg/L and 7.24±0.71 mg/L from site 1 to site 3. COD was significantly higher at the station 3. The total alkalinity fluctuated between annual mean of 134.83±6.49 mg/L at S3 and 495.16±45.53 mg/L at S1 (TABLE 1). The total hardness value in the river which is the sum of calcium and magnesium hardness concentrations was found to be significantly higher at station 2. The calcium and magnesium was also recorded highest in concentration at S1 and S2. Station 3 showed significantly low concentration of total hardness, calcium and magnesium than the other two stations. The mean annual range of the total hardness (148.25±6.64 mg/L to 274.75±14.86 mg/L), calcium hardness (51.66±6.96 mg/L to 56.61±7.77 mg/L) and magnesium hardness (23.60±1.50 mg/L to 53.96±2.45 mg/L) are presented in TABLE 1. The highest annual mean concentration of nitrate recorded was 1.307±0.32 mg/L obtained from Station 2. A decrease was observed with the lowest concentration of 0.82±0.24 mg/L recorded from Station 3. Nitrate was higher in the summer and monsoon season and the order of magnitude in the concentration among the stations was station 2> 1 >3. Phosphate was recorded in higher concentration than nitrate. It ranged between 0.920±0.33 mg/L to 1.58±0.13 mg/L (TABLE 1). Like nitrate, phosphate concentration was also significantly higher in monsoon season. In the present study pH was found alkaline in nature ranging from 7.6±0.17 at S3 to 8.3±0.12 at S2. The annual mean variations in electrical conductivity followed a trend S2<S3<S1. The station 2 recorded the lowest value of conductivity (0.449±0.095 ìmho/cm) and station 1 recorded the highest variation and concentration of conductivity (0.533±0.063 ìmho/cm) during the study. TDS was recorded with the highest value of (400.0±190.69 mg/L) at S3 and lowest of (291.66±116.45 mg/L) at S1 (TABLE 1). Both electrical conductivity and TDS showed significant differences in their concentrations among the seasons and stations. The two factors were statistically higher during the rainy season. Chloride concentration was recorded highest of 37.59±6.06 mg/L at S1 and lowest of 32.02±4.17 mg/L at S3 (TABLE 1). However variations were significant in seasons and months as well as stations.

**TABLE 1: Annual average variation for physico-chemical parameters in river tons in 2011-2012**

| Parameters | Site 1 | Site 2 | Site 3 |
|---|---|---|---|
| Temperature °C | 18.33±2.42 | 18.58±2.60 | 19.66±2.22 |
| Conductivity μmhocm$^{-1}$ | 0.533±0.063 | 0.449±0.095 | 0.495±0.034 |
| TDS mg/l | 291.66±116.45 | 316.66±119.34 | 400.0±190.69 |
| pH | 8.14±0.116 | 8.3±0.12 | 7.6±0.17 |
| Total alkalinity mg/l | 495.16±45.53 | 479.58±45.33 | 134.83±6.49 |
| Total Hardness mg/l | 260.16±15.23 | 274.75±14.86 | 148.25±6.64 |
| Calcium mg/l | 56.61±7.77 | 53.56±5.24 | 51.66±6.96 |
| Magnesium mg/l | 49.66±2.01 | 53.96±2.45 | 23.60±1.50 |
| Chloride mg/l | 37.59±6.06 | 35.58±5.59 | 32.02±4.17 |
| D.O mg/l | 9.97±0.52 | 9.50±0.45 | 8.69±0.72 |
| C.O.D mg/l | 5.13±0.48 | 6.13±0.49 | 7.24±0.71 |
| Phosphates mg/l | 1.45±0.43 | 0.920±0.33 | 1.58±0.13 |
| Nitrates mg/l | 1.09±0.34 | 1.307±0.32 | 0.82±0.24 |

**±: Standard deviation**

## Zooplankton species composition

Twenty nine genera of zooplankton were identified from the river Tons. They belong to Protozoa (Ten genera), Rotifera (Eleven genera), Copepoda (Six genera) and Ostracoda (Two genera only). The Rotifera constituted the largest group ranging from 99.83±55.02 (Unit/L) at S3 to 170.75±79.68 (Unit/l) at S1 (TABLE 2) and making 42% at S1, 40% at S2 and 39% at S3 of the zooplankton population (Figure 1, 2, 3). This was followed by the protozoa which was found with the highest number of 141.83±64.54 (Unit/L) at S1 and lowest of 76.16±43.71 (Unit/L) at S3 (TABLE 2) and contributing to the total zooplankton population with the percentage of 34%, 38% and 30% respectively at S1, S2 and S3 (Figures 1, 2, 3). The Copepoda was recorded (18%, 18%, 26%) having density between 57.91±32.60 to 72.41±32.64 Unit/L. The density of Ostracoda ranged between 12.25±8.37 to 24.41±10.90 Unit/L (TABLE 2) making the contribution of 6%, 5% and 4% (Figures 1, 2, 3) only to total zooplankton population. The genera belonging to protozoa include *Actinophrys, Actinosphaerium, Euglena, Paramecium, Peridinium, Campenella, Epistylis, Vorticella, Arcella* and *Diffugia* (TABLE 3). The genera belonging to rotifera include *Keratella, Nolthoca, Rotatoria, Testudinella, Ascomorpha, Trichocera, Philodina, Asplanchna, Pompholix, Brachionus* and *Polyarthra.* The genus *Cyclops, Diaptomus, Daphnia, Bosmina, Helobdella* and *Nauplius Stages* were recorded from River Tons belonging to copepoda. Only two genera *Cypris* and *Stenocypris* were found belonging to ostracoda (TABLE 3). A total of 409.40±66.35 (Unit/L), 319.06±53.77 (Unit/L) and 252.74±37.00 (Unit/L) (TABLE 2) of zooplankton was recorded at S1, S2 and S3 of River Tons during the study period.

**TABLE 2 : Annual average variation in zooplankton (unit/l) at different sampling sites in river tons in 2011-2012**

| Zooplankton | Site I | Site II | Site III |
|---|---|---|---|
| Protozoa | 141.83±64.54 | 121.08±49.49 | 76.16±43.71 |
| Rotifera | 170.75±79.68 | 126.16±60.31 | 99.83±55.02 |
| Copepoda | 72.41±32.64 | 57.91±32.60 | 64.50±34.85 |
| Ostracoda | 24.41±10.90 | 13.91±7.32 | 12.25±8.37 |
| Total Zooplankton (Unit/l) | 409.40±66.35 | 319.06±53.77 | 252.74±37.00 |

**±: Standard deviation**

**TABLE 3 : Zooplankton species composition of River Tons**

| Zooplankton | | | |
|---|---|---|---|
| **Protozoa** | **Rotifera** | **Copepoda** | **Ostracoda** |
| 1.Actinophrys<br>2.Actinosphaerium<br>3.Euglena<br>4. Paramecium<br>5. Peridinium<br>6.Campenella<br>7. Epistylis<br>8. Vorticella<br>9. Arcella<br>10. Diffugia | 1.Keratella<br>2.Nolthoca<br>3.Rotatoria<br>4. Testudinella<br>5. Ascomorpha<br>6. Trichocera<br>7. Philodina<br>8.Asplanchna<br>9. Pompholix<br>10. Brachionus<br>11. Polyarthra | 1.Cyclops<br>2. Diaptomus<br>3. Daphnia<br>4. Bosmina<br>5. Helobdella<br>6.Nauplius Stages | 1.Cypris<br>2. Stenocypris |

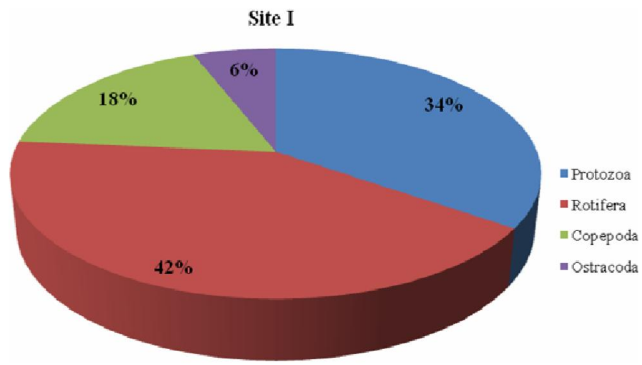


**Figure 1**

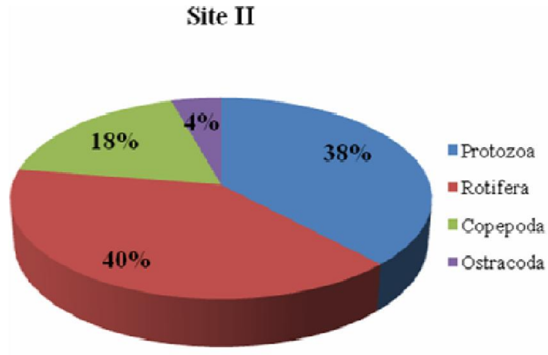


**Figure 2**

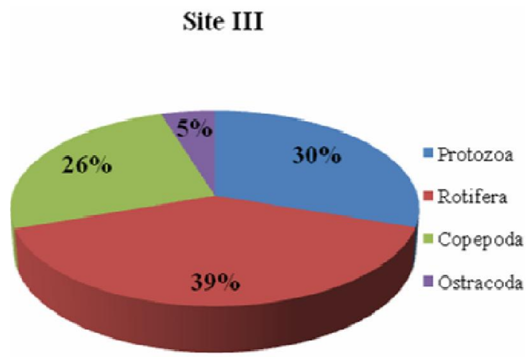


**Figure 3**

## Relation between zooplankton density and physico-chemical parameters

In the present study the zooplankton showed a negative relation with temperature, TDS and COD and showed a positive relation with conductivity, total alkalinity, calcium, chloride and DO (TABLE 4). However the protozoa, rotifera and ostracoda showed a positive relation with pH, total hardness and magnesium but copepoda was negatively correlated with pH, hardness and magnesium ($r = -0.167$, $p < 0.05$), ($r = -0.053$, $p < 0.05$) and ($r = -0.079$, $p < 0.05$) (TABLE 4). Protozoa and rotifera showed a negative relation with phosphate but copepoda and ostracoda was positively correlated with phosphate ($r= 0.723$, $p < 0.01$) and ($r = 0.209$, $p< 0.05$). Nitrate was also positively correlated with all the zooplankton except copepoda ($r = -0.397$, $p < 0.05$). The relation between zooplankton and physico-chemical factors was significant in all the seasons and months and revealed that weak relations were recorded as compared to those with significant positive correlations.

**TABLE 4: Correlation between zooplankton groups and physico-chemical parameters of River Tons**

| | Temperature | Conductivity | TDS | pH | Total alkalinity | Total hardness | Calcium | Magnesium | Chloride | D.O | C.O.D | Phosphate | Nitrate |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Protozoa | -0.990 | 0.256 | -0.995 | 0.860 | 0.962 | 0.913 | 0.941 | 0.902 | 0.999 | 0.998 | -0.984 | -0.390 | 0.714 |
| Rotifera | -0.880 | 0.578 | -0.900 | 0.628 | 0.806 | 0.713 | 0.999 | 0.695 | 0.953 | 0.955 | -0.984 | -0.040 | 0.424 |
| Copepoda | -0.228 | 0.994 | -0.271 | -0.16 | 0.090 | -0.053 | 0.651 | -0.079 | 0.405 | 0.411 | -0.519 | 0.723 | -0.397 |
| Ostracoda | -0.736 | 0.761 | -0.765 | 0.416 | 0.635 | 0.517 | 0.965 | 0.495 | 0.849 | 0.853 | -0.910 | 0.209 | 0.187 |

## DISCUSSION

The zooplankton assemblage in River Tons was attributed to several biotic and abiotic factors interacting together. These include nutrients, food availability and river physico-chemistry. The twenty nine genera of the zooplankton found consisting of Protozoa (Ten), Rotifera (eleven), Copepoda (six) and Ostracoda (two) could be described as diversified to some extent. The zooplankton genera found in the river agrees with the observations of Rocha *et al.*[17] about zooplankton assemblages in River Tons. The dominance of Rotifera was not unexpected as both the latter and former has been reported by Jeje and Fernando[12], Egborge and Tawari[9], Akin-Oriola[2] as the most dominant zooplankton group most aquatic ecosystems. The high population density of the rotifers could be attributed to their parthenogenetic reproductive patterns and short developmental rate under favourable conditions[16], their morphological variations called cyclomorphosis and adaptations[23] and their ability to feed on different food type. The dominance of rotifers was due to its preference for warm waters as highlighted by Dumont[7] and Segers[20]. The relatively low abundance of copepoda and ostracoda was as a result of the hydrodynamics of the river such as the low water volume short residence time and its morphometry. The highest population of zooplankton at Site 1 may be due to the presence of food (phytoplankton) on which they graze. The low genera abundance of ostracoda and copepods has also been documented in other water bodies by[14]. The dominance of protozoa after rotifera among the zooplankton could have arisen due to their large bodied size which enables it to graze on large quantities and diverse forms of phytoplankton. High zooplankton population at S1occurred due to their effective grazing on phytoplankton. The high population density and biomass of zooplankton during the winter and rains was traced to high population of phytoplankton food source which were highly abundant in the river during the two seasons. According to Rocha *et al.*[17], increase in primary production (phytoplankton), tends to be followed by increase in zooplankton number and biomass. Muylaert *et al.*[15] also corroborated the finding that zooplankton biomass usually reaches their peak during the rains in reservoirs. Apart from food source, low predation by fish during the rains as a result of their breeding could also have encouraged high population of the zooplankton. High fish predation, less availability of food source, high temperature during summer period could be responsible for the decline in zooplankton during the dry season. Achembach and Lampert[1] have emphasized these factors as been responsible for zooplankton biomass reduction. Food resource (bottom-up forces)[5], ability to adapt to food conditions and less predation (top down forces)[18] may be the reasons for the significant abundance of Rotifers in the river. The absence of most of the genera in these stations could have occurred as a result of patchiness or dispersal. Dispersal has been noted to play a major role in structuring zooplankton population and communities[21]. The correlations of the zooplankton with nitrate and phosphate may not necessarily be a direct relationship of the zooplankton utilizing the nutrients, but could be attributed to the dependence of the phytoplankton (which serves as food for the zooplankton) on these nutrients. High temperature in the dry season may account for the negative correlation with temperature. This observation showed the preference of zooplankton assemblage to low temperature in the river, thus playing a vital role in the zooplankton assemblage of the river. This scenario has been reported by Hulyal and Kaliwal[11]. Alkaline pH was also found to favour zooplankton growth and abundance in the river as seen from the positive correlation with alkalinity and pH. Byars had reported that zooplankton prefer alkaline waters. Both conductivity and total dissolved solids resulted in low zooplankton growth and abundance. These findings of does not agree with the results of Hujare[10]. The water of River Tons was hard; however the positive correlation was recorded with zooplankton. This type of correlation has been reported by Hulyal and Kaliwal[11]. The zooplankton community composition of the river showed to be productive and will support a diverse species and population of fishes at S1 and S2 but the station 3 was not suitable in terms of physico-chemistry and low zooplankton assemblage. The assemblage was strongly influenced by the physico-chemical factors which showed the water quality to be fairly good at S1 and S2. Temperature, food abundance, nutrients were some of the factors that could limit zooplankton growth, composition and abundance in the river. Maintenance of good water quality in the River Tons will enhance the zooplankton community structure and population dynamics and this will be a great advantage for fish production in the river since the energetic trophic foundations for fish would have been well established.

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