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Some observations of Zooplankton composition and abundance in river Damodar during winter season.
Algunas observaciones de la composición y abundancia de Zooplancton en el río Damodar durante la temporada de invierno.

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ABSTRACT

The investigation has been made to examine the hydrological condition of the studied area (some physicochemical parameter of water, zooplankton community and its diversity).During the study it was observed that the trend of variation of water temperature was from 15.9ºc to17.5ºc. pH was found to alkaline ranging from 8.5 to 9.1. During the study there was a fluctuation in O_2 level from 3.2 mg/lit. to 5.2 mg/lit. Free CO_2 was found to be higher throughout the study with a variation from 14 to 18 mg/lit.
In the study of Zooplankton, Cladocera and Rotifera were chiefly present comprising mostly of *Daphnia* sp, *Rotaria* sp., *Brachionus* sp. and *Cyclops* spp. Besides theae groups of species Copepoda was also present. A total of 10 genera including one larval form were found during study. Among 10 genera only 5 were dominant (*Daphnia* sp., *Rotaria* sp., *Brachionus* sp., *Mesocyclops* sp. and nauplius larvae), within these dominant species the most dominant were *Daphnia* sp., *Rotaria* sp. and *Brachionus* sp. which occur more than three times during study. While the community study was concerned it was found that the species richness ranged from 0.734 to 1.17, Evenness from 0.911 to 0.975 and Shannon-Wiener index value was varied between 1.85 and 2.43. The mean values of them were 0.924, 0.939 and 2.25 respectively.

Keywords:- Hydrology, Physicochemical, Zooplankton ,abundance, Diversity Indices, winter.

RESUMEN

La investigación se ha realizado para examinar la condición hidrológica del área de estudio (algún parámetro fisicoquímico del agua, comunidad de zooplancton y su diversidad). Durante el estudio se observó que la tendencia de variación de la temperatura del agua fue de 15.9ºc a 17.5ºc. Se encontró que el pH era alcalino entre 8.5 y 9.1. Durante el estudio hubo una fluctuación en el nivel de O_2 de 3.2 mg / litro. a 5.2 mg / litro. Se encontró que el CO_2 libre era más alto a lo largo del estudio con una variación de 14 a 18 mg / litro. En el estudio de zooplancton, Cladocera y Rotifera estuvieron presentes principalmente, que comprenden principalmente *Daphnia* sp., *Rotaria* sp., *Brachionus* sp. y *Cyclops* spp. Además de theae también estuvieron presentes grupos de especies Copepoda. Durante el estudio se encontraron un total de 10 géneros, incluida una forma larvaria. Entre los 10 géneros solo 5 fueron dominantes (*Daphnia* sp., *Rotaria* sp., *Brachionus* sp., *Mesocyclops* sp. Y nauplius larvae), dentro de estas especies dominantes las más dominantes fueron *Daphnia* sp., *Rotaria* sp. y *Brachionus* sp. que ocurren más de tres veces durante el estudio. Si bien el estudio de la comunidad estaba preocupado, se encontró que la riqueza de especies varió de 0.734 a 1.17, la uniformidad de 0.911 a 0.975 y el valor del índice de Shannon-Wiener varió entre 1.85 y 2.43. Los valores medios de los mismos fueron 0.924, 0.939 y 2.25 respectivamente.
Palabras clave: - Hidrología, Fisicoquímico, Zooplancton, abundancia, Índices de diversidad, invierno.

INTRODUCTION

Water the most vital resource for all kinds of life on earth, is adversely affected both qualitatively and quantitatively by human activities. Although the inland fresh water of India is only a small fraction of the total available water (Central water commission, India, 1988), which has its direct relevance to mankind being utilized directly or indirectly for man's various need. The increase in population coupled with unplanned urbanization and industrialization has seriously polluted the water bodies to such an extent that these have become unfit for various uses and are diminishing gradually. An undesirable substance is discharge regularly into the water through surface runoff that degrades the water quality which is defined in terms of the chemical, physical and biological contents of water (Lawson, 2011, Shukla, *et al*., 2013).The aspect information of water quality and states of affected living organisms of water bodies are necessary for implementation of any management strategies.

The study of water bears a great significance from practical perspective. Limnological investigation will be incomplete until and unless we consider the zooplanktonic biota, which occupy a very unique position in the food chain of water body. The flow of energy, recycling and movement of nutrients from the autotrophs to higher trophic levels in the ecosystem is principally made by this micro zoobiota. Not only that some of them may help natural ecosystem to maintain its healthy condition (Caroni and Irvine, 2010; Kehayias *et al*.,2014). Besides the role in the aquatic food chain, zooplankton also act as effective biomonitors to provide an effective interpretation of the ecological status of the water body as they are highly sensitive to anthropogenic impacts and environmental fluctuation (Jeppesen *et al*., 2011; Kar and Kar, 2013). A change in the physicochemical parameters in aquatic ecosystems brings a corresponding change in the relative composition and abundance of organisms living in the water; therefore, they can be used as a tool in monitoring aquatic ecosystems, hence, zooplankton have been considered as biological indicator organisms (Jose, *et al*., 2015; Smitha*, et al.*, 2013) so the knowledge of abundance and interrelationship between zooplankton and the physicochemical parameters of the water body is very essential.

In water quality management as well as in public health engineering the limnological knowledge in an indispensable prerequisite. Therefore, importance of ecological studies of aquatic ecosystem is indeed very obvious. However with a view to understand the ecology of zooplankton the study was done.

MATERIALS AND METHODS

Study area:- The Damodar, one of the main tributary of river Ganga, is 563 km long, rain fed torrential river, flows through one of the richest mineral belts in the world. In West Bengal, India it receives industrial pollutants through Thamla nallah at Durgapur region beside it is also receiving pollutants through some drains from Bengal paper mills (Raniganj) and Durgapur Steel Plant (Waria).

The present programme was started in October, 2017 and continued up to March, 2018 for 6 months in river Damoder near Durgapur barrage. The collection of water and Zooplankton were done fortnightly between 8 am and 10 am in the morning of the sampling day.Fortnightly data were pooled together as fortnightly average. Tables and Figures representing the variation of biotic and abiotic parameters have been drawn accordingly.

Hydrology

Collection of water sample:- Water sample were collected from the river covering the less disturbed area by directly deeping polythene bottles, washed without detergents, rinsed with10% HCl, then with distilled water and dried at 95ºC before use. For the estimation of dissolved oxygen the sample was collected in 250 ml glass stoppered bottles taking precaution and replacing the stopper tightly under water.

Analysis of water:-_The physicochemical parameters of water studied are water temperature, pH, dissolved oxygen (O_2), carbon dioxide (CO_2). All the analysis of water samples were done according to the procedure stated by APHA (1995).

Zooplankton:- Zooplankton was collected by filtering 50 lit. of water, collected from the sub-surface through a bolting silk net (mesh size 25µ). It was concentrated into 100 ml and preserved in the field with 8% formalin. Zooplankton was counted with the help of Sedgwick-Rafter plankton counting cell. Three or sometime four such counts were done for each sample and counts were pooled and coted as monthly average. Computation for the number of individuals/lit. was worked out by the formula as suggested by Welch (1948).

$$\text{Total Zooplankton (n)} = \frac{(a \times c)}{L}$$

n=No. of Zooplankton/lit. of water
a=No. of Zooplankton in all count
c=Vol. of original concentration of sample in ml.
L=Vol. of original water sieved in lit.

Community analysis:- Following indices have been used to quantify species richness and heterogeneity of the Zooplankton.

1) Species richness (Odum, 1983):-

$$d = (S-1)/\log_2 N$$

S=No. of species
N=total no. of individuals.

2) Shannon-Wiener index (Pielou, 1975)

$$\overline{H} = -\sum_{i=1}^{S} \frac{ni}{N} \log 2 \frac{ni}{N}$$

ni =no. of individuals in i^{th} species
N= total no. of individuals.

3) Evenness index (Pielou, 1966)

$$J = \overline{H}/\log_2 S$$

$\overline{H}$=Shannon diversity
S=total no. of species

RESULTS

Physico-chemical parameters:- Result of Physicochemical parameters of water depicted in Table-1.

Water temperature:- During the entire study the minimum and maximum water temperature was 15.9ºC and 17.9ºC respectively (Table -1). Here a bimodal peak has been noticed (Fig.-1).

pH:- Maximum (9.1) and minimum (8.5) pH were obtained during study (Table-2). Here also a bimodal trend of peak was observed (Fig.- 1).

Dissolved Oxygen:- Throughout the study it was found that the value of dissolved oxygen was more than 3 mg/lit. with a minimum of 3.2mg/lit. and a maximum of 5.2mg/lit. (Table-1).

Carbon dioxide:- It is evident from the study that the value of Carbon dioxide varied from 14mg/lit to 18mg/lit.(Table-1).

Table-1:- Variations of different physico- chemical parameters during study.

	October	November	December	January	February	March
Temperature	17.9	17.7	16.2	15.9	17.7	17.5
pH	8.8	9.1	8.9	8.8	8.9	8.5
Dissolved Oxygen	5.2	4.6	3.2	5	4.8	4.6
Carbon dioxide	14	15.6	18	14	18	16.6

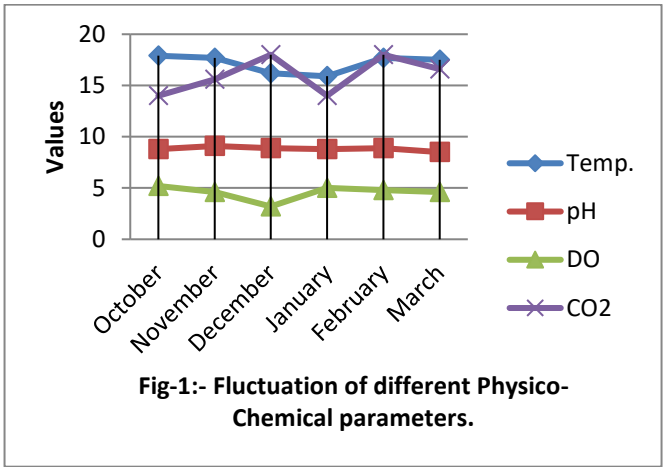

Fig-1:- Fluctuation of different Physico-Chemical parameters.

Zooplankton:- A total of 10 genera including one larval form were found during study. Among 10 genera 6 are dominant *(Daphnia sp, Rotaria sp, Brachionus sp, Mesocyclops sp, Microcyclops sp* and nauplius larvae), within these dominant species the most dominant are *Daphnia* sp., *Rotaria* sp. and *Brachionus* sp. (Table-2).

Brachionus sp:- Here this species was recorded during entire study except December,2017, with a minimum of 3ind/lit. and a maximum of 7 ind/lit.(Table-1). Here only one peak was observed (Fig -2).

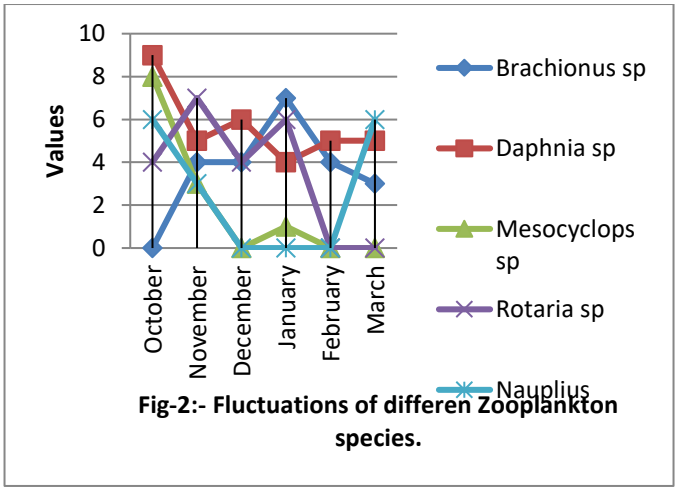

Fig-2:- Fluctuations of differen Zooplankton species.

Daphnia sp:- This species was recorded during the entire study period with a minimum of 4 ind/lit. in January,2018 and a maximum of 9ind/lit. in october, 2017 (Table-2). During study it shows a trimodal type of peaks Fig.-2.

Rotaria sp:- This species was recorded in 4 occasions during study with a minimum of 4 ind/lit. and a maximum of 7 ind/lit. (Table-2). It shows two peaks (Fig.-2).

Other three dominant species *Mesocyclops* sp., *Microcyclops* sp. and nauplius larvae were occur occasionally.(Thble-2).

Total Zooplankton:- It varied from16 ind/lit. to 27ind/lit. throughout the study and shows two peaks (Fig.-3).

Table-2:-Variations of Zooplankton (ind/lit.) during study.

	October	November	December	January	February	March
Brachionus sp.	0	4	4	7	4	3
Daphnia sp.	9	5	6	4	5	5
M*esocyclops* sp.	8	3	0	1	0	0
Rotaria sp.	4	7	4	6	0	0
Microcyclops sp.	0	0	7	4	0	0
Moinadaphnia sp.	0	0	0	0	4	0
Diaptomus sp	0	0	3	0	1	0
Cypris sp.	0	0	0	0	3	0
Gastropus sp.	0	0	0	2	0	2
Nauplius	6	3	0	0	0	6
Total	27	22	24	24	19	16

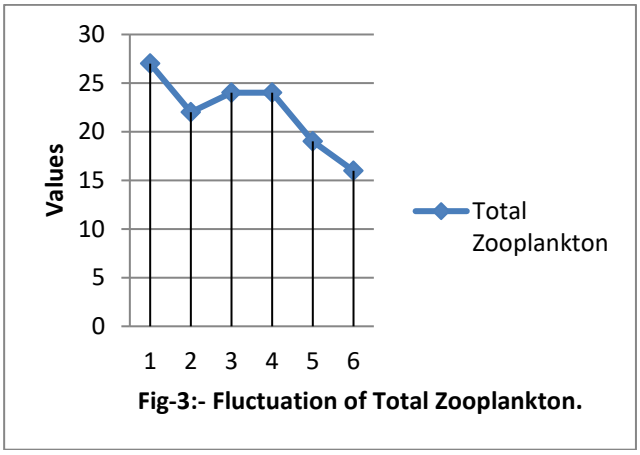

Fig-3:- Fluctuation of Total Zooplankton.

Community Analysis

Species richness (di):- Here the highest value (1.087) was recorded in January, 2018 and the lowest (0.629) in October, 2017 with a mean of 0.868. (Table-3). In this study the values showed two peaks (Fig.- 4).

Evenness index (j):- These values ranged from 0.597 to 1.01 with the mean of 0.867 (Table-3). Throughout the study the values showed two peaks (Fig-4).

Shannon-Wiener index ($\overline{H}$):- Here this index varied from 1.25 to 2.64 with a mean of 1.99 (Table-3). The value showed only one peak (Fig.-4).

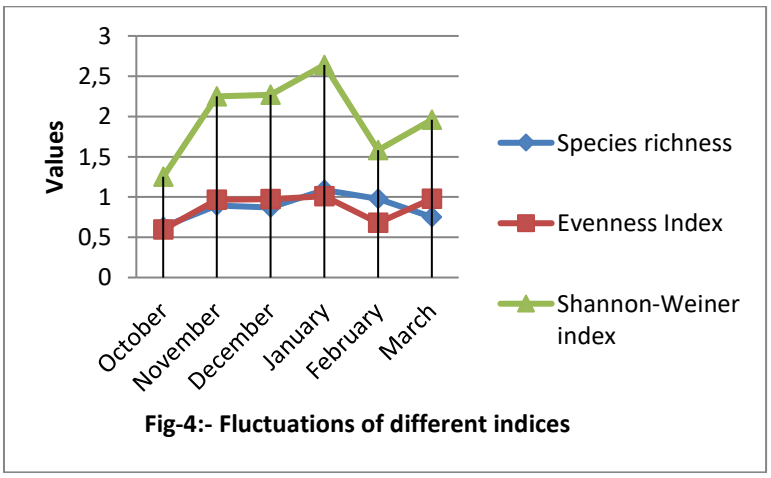

Fig-4:- Fluctuations of different indices

Table-3;-Variations of different indices during study.

	October	November	December	January	February	March
Species richness	0.629	0.895	0.869	1.087	0.976	0.75
Evenness Index	0.597	0.966	0.972	1.01	0.679	0.977
Shannon-Weiner index	1.25	2.25	2.27	2.64	1.58	1.96

DISCUSSION

An aquatic ecosystem whether its productivity is sufficient to grow and sustain the standing population of biota is measured by the assessment of the biological productivity of it. The plankton diversity means the numbers of different abundant and rare species in the community which is very high in natural ecosystem, whereas it is very low in physically or human controlled ecosystem. The changes in the abundance of zooplankton in every aquatic ecosystem are governed by the changes of environmental condition (Manicom *et al*., 2018). Environment undergoes continuous but more or less definite seasonal variation, which of course, dependent on several physicochemical characteristics of water.

Temperature and its diurnal and seasonal variations directly affect the metabolic and physiological activities and life process of aquatic organism. Temperature is a universal factor and a slight change in it might affect the hydrochemistry and biological relations in the organisms of water body (Khuhawar and Masto, 1995) which largely depends on the changes in the solar radiations.

It is also one of the master limiting factors that might limit the distribution of life in it (Manickam *et al.,* 2017), which in any water body mostly depends upon its morphometry, extent of solar radiations and density of planktonic substances (Harney *et al.*, 2013). Under the regime of good climatic condition of West Bengal the water temperature during study was found always above 15ºC which is favourable for healthy growth of most of the aquatic organisms.

pH of water provides an index of the general chemical environmental conditions of any aquatic ecosystem(Goldman and Horne, 1983). Natural waters have an alkaline pH, which varies in most of the cases from 6 to 9 (Chapman, 1992). In the present study also the pH was alkaline in nature, perhaps due to discharge of industrial pollutants through Thamla nallah at Durgapur region, some drains of Bengal paper mills (Raniganj) and Durgapur Steel Plant (Waria) along with the removal of CO_2 during photosynthesis (Jakhar and Rawat, 2003).

Dissolved O_2 level in natural water is an indicator of water quality, depends on the physical, chemical, and biochemical activities in the water body. The variation of O_2 in the present study found between 3.2 mg/lit. to 5.2 mg/lit. Such variations were also reported by Kulshrestha *et al*., 1989. Self purification of any water body is a direct function of the O_2 concentration in its water. The O_2 content of water is the result of both photosynthetic activity as well as wind action. The higher values of O_2 probably due to higher rate of photosynthetic activity followed by lower temperature. The high O_2 concentration during winter are largely attributed to low temperature rather than photosynthesis as low temperature has greater capacity to hold more O_2 (Narasimman et al., 2018). On the other hand lower values of O_2 are probably due to reduced solar radiation and photoperiod followed by reduction of photosynthesis (Manicham et al., 2018).

Increase of free CO_2 in the natural waters take place following respiratory activities which gets reduced due to photosynthesis (Sreenivasan,1963). Higher level of free CO_2 during study may be due to its influx through industrial waste of Bengal paper mills (Raniganj) and Durgapur Steel Plant (Waria) in the form of carbonic acid (Patra, 2002).

The O_2 and CO_2 are reciprocal to each other in the ecosystem. The O_2 content are closely linked with CO_2 cycle and higher values of free CO_2 generally coincided with

minimum O_2 content (Welch, 1952). In the present study CO_2 also follow the above contention.

Species diversity seems to be depends on species richness i.e. different types of species and their numerical strength and species evenness i.e. a measure which qualifies as to how even species are in terms of their number (Frutos *et al*., 2009; Mukhopadhyay *et al.,* 2007). The species diversity can be measured by using various diversity indices - the mathematical expressions based on species abundance data. The species diversity can be measured separately either as species richness or evenness or diversity as a whole.

In the present study 10 genera including one larva were identified. From the present observation it appears that the fresh water of the Indian subcontinent possibly have fewer species which is in agreement with Zulikha *et al*., 2013, Bhavan *et al.,* 2015. In the present study some peaks and troughs were noticed with much variations. Same types of observations was also reported by some Indian workers like Manickam et. al., 2015 and Manickam *et al*., 2018. It is also apparent that in case of some species the amplitude of rise and fall in quantity is not large enough to produce more than minimal change in the total zooplankton production, while in others; the change was so great that a wave of development of a single species may be sufficient to dominate in the whole zooplankton community. Here also this type of changes was noted.

According to Bhavan *et al*., 2015 a number of independent physical, chemical and biological factors of an ecosystem have influence on the variation and succession of planktonic organisms. In the present study too, the influence of physicochemical factors on the occurrence and abundance of total population were noticed. In the present study the limiting effect of pH on zooplankton is not clearly understood, though pH is important determinants of occurrence of species Schwerdtfeger (1975).

The changes in the seasonal abundance of zooplankton in every aquatic ecosystem are principally governed by the changes of environmental conditions. It is of the opinion that the alterations produced in the physical and chemical status of any aquatic ecosystem are recognizable through the elasticity in their community structure (Jose *et al.,* 2015).

The effect of stress on the distribution and abundance of Zooplankton is the best measured system by diversity indices. The biological assessment of the natural system using various indices has been advocated by Wilhm and Dorris, 1968, Margalef, 1972, Maguran, 1988 and many others.

Shannon's diversity index ($\overline{H}$) seems to be dependant on sum of the effect of interaction between the number of species and their relative abundance.

There are two important components of species diversity which influence the Shannon's diversity greatly:-

a) Species richness(di)
b) Evenness(j)

The Species richness is simply the total number of species, while Evenness is the measure of competition among the species (Odum, 1971). In almost all the times during study the values are less than 1 except January, 2018. A fall in the magnitude of 'di' indicates presence of some perturbations. On the other hand evenness also shows the similar result.

The values of Shannon diversity vary according to the variations of 'di' and 'j'. According to Wilhm and Doris (1968) the values of $\overline{H}$ during study (between 1 and 3) indicates moderately polluted condition of the river Damodar.

CONCLUSION

In conclusion it is quite judicious to mention the view of Pennak (1949) that the cycles of abundance of plankton are highly variable from species to species within an aquatic ecosystem and even from one to another. Interpretation of zooplankton community structure must considered competitive interactions among species Biotic and abiotic factor does not operate independently. From holistic view point both direct chemical effect and

indirect effect by altered predatory and competitive interactions may be expected to influence the seasonal variations in the abundance of zooplankton community.

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