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TEMPORAL ZOOPLANKTON DIVERSITY IN RIVER GARGA OF BOKARO DISTRICT DURING THE YEAR 2012-2013

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ABSTRACT

Studies on seasonal variation of zooplankton at four sampling sites (G_1, G_2, G_3 and G_4) in Garga river were conducted during September 2012 to August 2013.A total of 29 species were found in the river. Among these 20 species belong to rotifera,5 species belong to copepoda, 2 species belong to cladocera whereas protozoa and ostracoda are represented by single species .Numerically rotifera was the dominant class throughout the study period. A season wise analysis showed maximum density of zooplanktons in summer and minimum density in monsoon. Based on the research work of several authors, certain zooplankton species have been established as pollution indicator such as *Branchionus angularis, B.calcyflorus, Filinia longiseta, Keratella cochlearis, Asplanchna sp., Ceriodaphniasp., Moina sp., Diaptomussp.,* etc. Results of present study show that the river is .more polluted at G_2 and G_3 as most of the pollution indicating species are present at both these sampling points.

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INTRODUCTION

Zooplanktons are minute animals that are non-motile or are very weak swimmers .They contribute significantly to biological productivity of freshwater ecosystem. They serve as good indicator of changes in water quality because it is strongly affected by the environmental conditions and it is quickly responded to changes in environmental quality (Gannon and Stemberger,1978). Zooplanktons play a major role in the functioning and the productivity of aquatic ecosystems through its impact on the nutrient dynamics and its key position in the food web,(Keister *et al*., 2012). Many species of zooplankton can be used as biological indicators for water pollution, water quality and eutrophication, (Bonnet and Frid, 2004). Zooplanktons are globally recognized as organisms that indicate pollution in aquatic environment (Yakubu *et al.,* 2000).

Many workers have studied the zooplanktons of fresh water bodies both in India and abroad Purushothama *et al*. (2011) studied the physico chemical profile and zooplankton community composition in Brahmana Kalasi tank, Sagara, Karnataka.

According to Aoyagui and Bonecker (2004) and Ayodele *et al*. (2006) properties of aquatic ecosystems determine the occurance, diversity and density of both flora and fauna in any given habitat.

The condition of Garga River has become pathetic due to various anthropogenic activities .The changing aquatic environment is the cause of growing concern and requires monitoring of surface water and the organisms inhabiting them. No significant work has been done so far on Garga River hence an attempt has been made to study the qualitative and quantitative aspects of different pollution indicating species of zooplanktonsThus the present paper deals with the presence of various pollution indicating species of zooplanktons, their diversity and seasonal variation in Garga river .The findings of the present study can be used as a reference for other researchers and statutory bodies to take remedial action to control pollution in the river Garga.

MATERIALS AND METHODS

Bokaro district is located in the state of Jharkhand in the Eastern part of India at 23º29¼N and 86°09¼E. It covers a geographical area of 2861 sq. km. River Garga is one of the tributaries of River Damodar, flowing along the southern and the eastern outskirts of the city. Garga is an important but highly polluted river due to discharge of industrial effluents and domestic sewage into it (Mallik *et al*., 2014). Manjappa *et al*. (2008) reported that due to anthropogenic activities, rapid industrial growth, domestic and agricultural activities of the region ,the river water is being polluted, which is the case with almost all major rivers of the country.

For the present study, four different sampling sites were chosen on Garga river. These are:

Site 1: $G_1 \rightarrow$ near Garga dam
Site 2: $G_2 \rightarrow$ near Bari Co-operative Colony
Site 3: $G_3 \rightarrow$ Chas (Kunwar Singh Colony)

Site 4: $G_4 \rightarrow$ Sector XI bridge (near the confluence of Garga and Damodar rivers)

Among all the four sites G2 and G3 are located amongst densely populated colonies while G1 and G4 are away from human settlement.

The present study was carried out in one calendar year starting from September 2012 to August 2013.Thus the calendar year was divided into four seasons .*viz*-

Post Monsoon	→	Sept to Nov.
Winter	→	Dec to Feb
Summer	→	Mar to May
Monsoon	→	June to Aug.

Water samples were collected monthly from all the four sites in the above mentioned four seasons.Arnott *et al*.(1998) indicate that sampling for plankton study should be undertaken at least monthly to account for 80%of the species observed annually.

Sample was collected from the surface and sub-surface as well. One 3L and a 4L pre-washed plastic containers were used for collection of water for filtering .Water was filtered through Plankton net of standard make .Sedgwick Rafter Counting Slide was used for quantitative analysis and qualitative enumeration of zooplanktons .The Sedgwick Rafter Chamber was calibrated before use .For calibration of chamber, the volume of the chamber was determined by weighing the (dry) slide and the coverslip (in g), then filling the chamber with distilled water and weighing it again: The difference between the weights is equal to the volume of the chamber in ml, assuming 1g of distilled water weighs 1ml. Such calibration confirms the accurate volume of Sedgwick Rafter Chamber. Counting a small no. of fields in several chambers can increase accuracy of Sedgwick Rafter Chamber (Woelkerling *et al*.,1976). Therefore each sample was analyzed by counting few fields in a counting chamber and then taking another sub-sample in another counting chamber after discarding the previous sub-sample.

The sample was left undisturbed and allowed to settle for 1-3 days. Staining is not required in this method because samples are preserved in Lugol's solution. Lugol's solution acts as a fixative-preservative-stain which enters the cell quickly and detection of zooplankton cell is easier by the enhanced contrast between organisms and the surrounding fluid (Helsinki Commission Report, 2003). Once the sample has settled, the top 150 mL of the sample was carefully removed with a syringe without penetrating the bottom 100ml.After siphoning off 150 mL sample, the remaining 100ml was mixed thoroughly to avoid clumping of cells. The first critical step in preparing a sample for microscopic analysis is homo genization of the sample. After homogenization of the concentrate, 1mL sub-sample was poured directly into Sedgwick Rafter C ounting chamber using a pipette .To ensure that large taxa arte not excluded, the end of the tip was cut off to widen the opening (to $\pm$2-3 mm). After sedimentation the chamber column is slid aside using a cover glass .This method involves settling a known volume of samples into a counting chamber. The zooplanktons were identified by following standard literatures and keys (Needham and Needham, 1977; APHA, 1998).

The Sedgwick Rafter counting chamber filled with 1 mL of the sub-sample was examined under the microscope (Pfiester *et al.,* 1980).

The number of plankton counted was converted to give a concentration per unit volume of sample as follows:

$$N = \frac{(a \times 1000).\ C}{V}$$

Where,

a is the number of plankton in one field of SR slide.

C is the volume of concentrate (mL)

V is the volume of water filtered/sampled (mL).

RESULTS AND DISCUSSION

Qualitative and quantitative analyses of zooplanktons at four stations represented by G_1, G_2, G_3 and G_4 in Garga river have been done in the four seasons *viz*.post-monsoon , winter, summer and monsoon in the year, 2012-2013. The results indicate that during summer season the density of zooplanktons were maximum and in monsoon the density was minimum. Bhowmic (1968) suggested that increase in zooplankton population in summer is due to higher concentration and increased photosynthetic activity .The majority of zooplankton population comprised of rotifers along the entire stretch of Garga river .A class-wise analysis of the recorded taxa showed relative abundance in the sequence, rotifers > copepoda > cladocera > protozoa > ostracoda in all the seasons. Chaurasia (1996) reported that the density of rotifers and their species diversity is highest in eutrophic condition.

G_1POST MONSOON 2012

Qualitative and quantitative analyses of zooplanktons in the Post Monsoon of 2012 is shown in Table 1. At this site the zooplankton density ranged from 84 U/L to 258U/L being maximum in the month of November and minimum in the month of September. This may be due to settling of rainwater and return of favorable condition(J Reeja *et al*., 2012). Zooplankton community comprised of 16 species belonging to Rotifera (9sps), Copepoda (4 sps) whereas Cladoceran, Ostracoda and Protozoa represented by single species.The relative percentage was found to be 47.5 % rotifers,28.4% copepod ,cladoceran 10%. protozoan 9.7% and ostracoda 4.4%.

G_1WINTER 2012-2013

Qualitative and quantitative analysis of zooplankton in winter 2012-13 is shown in Table 2. At this site Zooplankton density ranged from 159U/L to 189U/L being maximum in February and minimum in December. The population of zooplankton raises a bit higher level during winter season due to favorable environmental conditions and presence of excess of food in the form of bacteria and suspended detritus(Shivashankar and Venkataramana, 2013). The relative percentage was found to be rotifers 41.92%,copepod 36.53%, cladoceran 11.34%, protozoa 6.15% and ostracoda 4.03%.

Site 1: G_1SUMMER 2013

The results for qualitative and quantitative analysis of

Table 1: Qualitative and quantitative analyses of zooplanktons

ZooplanktonGroup	ZooplanktonSpecies	September	October	November
Rotifera	*Branchionus tridentatus*	6	8	10
	B.quadridentatus	7	8	11
	Filinia sp.	4	5	7
	Monostyla sp.	8	10	11
	Asplanchna sp.	6	8	10
	Tetramastix sp.	1	2	2
	Platiyas sp.	1	3	4
	Hexarthra sp.	2	2	5
	Colurella sp.	2	3	6
Protozoa	*Paramoecium*	10	11	10
Cladoceran	*Daphnia sp.*	8	12	12
Copepoda	*Mesocyclops sp.*	6	10	8
	Nauplius sp.	8	10	12
	Cyclops sp.	8	9	6
	Diaptomus sp.	3	5	6
Ostracoda	*Cypris sp.*	4	4	6
Total		84	110	126
Standard Deviation		2.56	2.90	2.95
Mean		5.25	6.87	7.87

Table 2: Qualitative and quantitative analysis of zooplanktons

ZooplanktonGroup	Zooplankton Species	December	January	February
Rotifera	*Branchionus tridentatus*	12	14	15
	B.quadridentatus	10	11	12
	Filinia sp.	6	5	8
	Monostyla sp.	12	11	12
	Asplanchna sp.	8	9	10
	Tetramastix sp.	5	6	6
	Platiyas sp.	4	5	6
	Hexarthra sp.	2	4	4
	Colurella sp.	5	8	8
Protozoa	*Paramoecium*	11	11	10
Cladoceran	*Daphnia*	18	18	21
Copepoda	*Mesocyclops sp.*	10	12	12
	Nauplius sp.	25	22	28
	Cyclops sp.	11	11	14
	Diaptomus sp.	14	16	15
Ostracoda	*Cypris sp.*	6	7	8
Total		159	172	189
Standard Deviation		5.52	5.06	5.86
Mean		9.94	10.75	11.81

All values are in units/litre

zooplankton in summer season is depicted in Table 3.The zooplankton population was found in the range of 210U/L to 258U/L, being minimum in March and maximum in May. In summer percentage of rotifers was highest at 50.56% followed by copepoda (29.74%), protozoa (8.49%), cladoceran (6.79%) and ostracoda (4.39%). Presence of rotifers is also an indication of eutrophic as observed by Saksena and Sharma (1981) in. Govind Sagar, Chhatri tank, Sawarkar sarovar and Matsya sarovar in Gwalior.

Site 1: G_1 MONSOON 2013

The results for qualitative and quantitative analysis of zooplankton in monsoon season is presented in Table 4.The zooplankton density was found in the range of 91U/L to 160U/L. August month recorded lowest density while June had the highest density of zooplanktons. Normally the monsoon is associated with lower population densities due to its dilution effect and decreased photosynthetic activity by primary producers (Joshi 2011). Percentwise distribution of zooplanktons were found to be as Rotifera -49.17%, Copepoda - 25%, Protozoa-11.26%, Cladoceran-9.61% and Ostracoda-4.94%.

Site 2: G_2POST MONSOON 2012

Qualitative and quantitative result of zooplankton analysis is presented in table -5.The zooplankton density ranged from 179U/L to 199U/L .September month recorded the minimum density while November showed maximum density .The percent composition was as follows-Rotifera-58.8%, Copepoda -19.36%, Protozoa-9.68%, Ostracoda-6.695 and Cladoceran-5.45%.

Site 2: G_2WINTER 2012-13

Qualitative and quantitative analysis of zooplankton is presented in Table 6. The density of zooplankton was in the range of 217U/L to 261U/L, being maximum in the month of

Table 3:Qualitative and quantitative analysis of Zooplankton

ZooplanktonGroup	Zooplankton Species	March	April	May
Rotifera	*Branchionus tridentatus*	15	16	18
	B.quadridentatus	20	20	20
	Filinia sp.	22	23	23
	Monostyla sp.	13	14	16
	Asplanchna sp.	11	12	14
	Tetramastix sp.	6	8	6
	Platiyas sp.	5	6	6
	Hexarthra sp.	5	8	10
	Colurella sp.	10	14	16
Protozoa	*Paramoecium*	15	20	25
Cladoceran	*Daphnia*	15	16	17
Copepoda	*Mesocyclops sp.*	14	20	22
	Nauplius sp.	24	24	26
	Cyclops sp.	14	15	16
	Diaptomus sp.	11	12	12
Ostracoda	*Cypris sp.*	10	10	11
Total		210	238	258
Standard Deviation		5.40	5.27	5.93
Mean		13.12	14.87	16.12

All values are in units/litre.

Table 4:Qualitative and quantitative analysis of Zooplankton

ZooplanktonGroup	Zooplankton Species	June	July	August
Rotifera	*Branchionus tridentatus*	12	10	8
	B.quadridentatus	10	8	7
	Filinia sp.	6	5	3
	Monostyla sp.	12	11	11
	Asplanchna sp.	8	8	6
	Tetramastix sp.	5	4	1
	Platiyas sp.	4	4	3
	Hexarthra sp.	6	4	2
	Colurella sp.	10	6	5
Protozoa	*Paramoecium*	20	11	10
Cladoceran	*Daphnia*	15	10	10
Copepoda	*Mesocyclops sp.*	15	8	8
	Nauplius sp.	8	5	3
	Cyclops sp.	12	9	8
	Diaptomus sp.	8	5	2
Ostracoda	*Cypris sp.*	9	5	4
Total		160	113	91
Standard Deviation		4.09	2.51	2.99
Mean		10.0	7.06	5.68

All values are in units/litre.

February and minimum in the month of December.Rotifers were the dominant class (61.42%), followed by Copepoda (18.24%), Protozoa (9.19%), Ostracoda (6.26%) and Cladoceran (4.87%). Dominance of Rotifer population signifies eutrophication. Similar results have been found by P Kumar *et al*. (2011) in Railway Pond, Sasaram, Bihar.

Site 2: G_2 SUMMER 2013

The results for zooplankton density in this season ranged from 265U/L to 298U/L, being maximum in the month of May and minimum in the month of March. The percentage composition of zooplanktons were found to be as Rotifers (63.92%), Copepoda (17.85%), Protozoa (8.09%), Ostracoda (5.83%) and Cladoceran (4.28%). The results are presented in Table 7.

Site 2: G_2MONSOON 2013

The results for zooplanktons density is presented in Table 8. In this season the zooplankton density was found maximum (170U/L) in the month of June and minimum (158U/L) in the months of July and August .The % composition was as follows-Rotifera (63.16%), Copepoda (16.46%), Protozoa (9.25%), Cladoceran and Ostracoda both at (5.55%).

Site 3:G_3POST MONSOON 2012

Qualitative and quantitative analysis of zooplanktons at this site in post monsoon is presented in Table 9. Altogether 14 genera were present at this site which comprised of Rotifera(7 sp.), Copepoda (3sp), Cladoceran (2sp.), Ostracoda and Protozoa represented by single species.Percentage wise composition was as follows Rotifers (61.6%), Copepoda (17.39%), Protozoa (8.88%), Cladoceran (8.31%) and Ostracoda (3.78%). The density of zooplankton ranged from

Table 5: Qualitative and quantitative result of zooplankton analysis

ZooplanktonGroup	Zooplankton Species	September	October	November
Rotifera	*B.angularis*	5	6	7
	B.calcyflorous	4	5	6
	B.mullleri	1	1	2
	Keratella Cochlearis	22	24	25
	Keratella tropica	24	28	30
	Filinia Brauchiata	11	10	11
	Hexarthra sp.	11	11	11
	Epiphanes Macrorus	25	26	28
Protozoa	*Paramoecium*	18	18	19
Cladoceran	*Daphnia*	11	10	10
Copepoda	*Mesocyclops sp.*	3	4	5
	Ceriodaphnia	14	15	16
	Diaptomus sp.	18	18	17
Ostracoda	*Cypris sp.*	12	14	12
Total		179	190	199
Standard Deviation		7.55	8.13	8.53
Mean		12.78	13.57	14.21

All values are in units/litre.

Table 6: Qualitative and quantitative analysis of Zooplankton

Zooplankton Group	Zooplankton Species	December	January	February
Rotifera	*B.angularis*	7	7	9
	B.calcyflorous	5	8	9
	B.mullleri	6	5	6
	Keratella Cochlearis	30	38	44
	Keratella tropica	30	33	35
	Filinia Brauchiata	12	13	14
	Hexarthra sp.	15	15	17
	Epiphanes Macrorus	25	28	30
Protozoa	*Paramoecium*	20	22	24
Cladoceran	*Daphnia*	11	12	12
Copepoda	*Mesocyclops sp.*	6	6	6
	Ceriodaphnia	16	17	18
	Diaptomus sp.	20	21	21
Ostracoda	*Cypris sp.*	14	15	16
Total		217	240	261
Standard Deviation		8.23	9.83	10.87
Mean		15.5	17.14	18.64

All values are in units/litre.

157U/L to 198U/L being minimum in the month of September and maximum in the month of November.

Site 3: G_3WINTER 2012-2013

Table 10 represents the zooplankton diversity in winter season which ranged from 229U/L to 259U/L. The percentage composition is as follows-rotifera (56.52%),copepoda (22.69%), cladoceran (8.96%), protozoa (8.15%) and ostracoda (3.66%). Maximum density was found in the month of February and minimum in the month of December.

Site 3: G_3SUMMER 2013

Table 11 represents the results of zooplanktonic diversity in summer months which had maximum density in the month of May (327U/L) and minimum in March (272U/L). Rotifers were the dominant class (58.15%) followed by copepod (18.86%), cladoceran (10.98%), protozoa (9.21%) and ostracoda (4.32%). According to Pathani and Upadhyay (2006) there is an.increase of zooplankton population from winter season which reaches maximum in summer.

Site 3: G_3MONSOON 2013

Monsoon months showed a decline in the zooplankton population, being in the range of 157U/L in August to 201U/L in the month of June .Percentage composition was as follows-rotifera (62.19%), copepoda (18.14%), protozoa (8.69%), cladoceran (7.93%) and ostracoda (3.02%).

Site 4: G_4POST MONSOON 2012

The results obtained at this site shows marked decline in the diversity of zooplanktons .Rotifers were represented by only five sp. whereas ostracoda was absent altogether.The zooplankton density ranged from 119U/L to 156U/L being maximum in the month of October and minimum in the month of September. Percentage composition showed rotifers (43.96%), copepoda (28.74%), protozoa (18.35%) and cladocera (8.93%).

Site 4: G_4WINTER 2012-13

Winter season also showed similar results like post monsoon. The zooplankton density ranged from 116U/L to 174U/L being maximum in the month of February and minimum in the month of December. Percent composition was rotifers

Table 7: Zooplankton density during May and March

ZooplanktonGroup	Zooplankton Species	March	April	May
Rotifera	*B.angularis*	10	11	12
	B.calcyflorous	7	10	12
	B.mullleri	7	8	9
	Keratella Cochlearis	45	46	50
	Keratella tropica	35	38	40
	Filinia Brauchiata	14	15	16
	Hexarthra sp.	18	18	20
	Epiphanes Macrorus	30	32	34
Protozoa	*Paramoecium*	24	22	22
Cladoceran	*Daphnia*	12	12	12
Copepoda	*Mesocyclops sp.*	8	9	10
	Ceriodaphnia	18	18	20
	Diaptomus sp.	21	22	24
Ostracoda	*Cypris sp.*	16	16	17
Total		265	277	298
Standard Deviation		10.87	11.05	11.74
Mean		18.93	19.78	21.28

All values are in units/litre.

Table 8: Zooplankton density

Zooplankton Group	Zooplankton Species	June	July	August
Rotifera	*B.angularis*	10	6	4
	B.calcyflorous	6	5	2
	B.mullleri	1	0	1
	Keratella Cochlearis	20	20	22
	Keratella tropica	24	26	28
	Filinia Brauchiata	10	8	8
	Hexarthra sp.	12	9	8
	Epiphanes Macrorus	28	24	25
Protozoa	*Paramoecium*	15	14	16
Cladoceran	*Daphnia*	10	8	9
Copepoda	*Mesocyclops sp.*	4	2	2
	Ceriodaphnia	10	12	8
	Diaptomus sp.	12	15	15
Ostracoda	*Cypris sp.*	8	9	10
Total		170	158	158
Standard Deviation		7.2	7.50	8.40
Mean		12.14	11.28	11.28

All values are in units/litre.

Table 9: Qualitative and quantitative analysis of Zooplanktons

Zooplankton Group	Zooplankton Species	September	October	November
Rotifera	*B.mulleri*	17	18	19
	B.plicatilis	16	18	25
	Keratella cochlearis	15	19	21
	Filinia terminalis	3	4	2
	Filinia longiseta	8	10	11
	Pompholyx sp.	18	19	20
	Polyarthra vulgaris	18	21	24
Protozoa	*Paramoecium*	15	14	18
Cladoceran	*Daphnia sp.*	4	5	6
	Moina sp.	8	10	11
Copepoda	*Mesocyclops sp.*	8	8	10
	Ceriodaphnia	15	17	17
	Nauplius	6	5	6
Ostracoda	*Cypris sp.*	11	6	8
Total		157	174	198
Standard Deviation		5.32	5.97	7.02
Mean		11.21	12.42	14.14

All values are in units/litre.

Table 10: Zooplankton diversity in winter season

Zooplankton Group	Zooplankton Species	December	January	February
Rotifera	*B.mulleri*	20	21	22
	B.plicatilis	26	26	28
	Keratella cochlearis	30	32	28
	Filinia terminalis	0	1	0
	Filinia longista	10	11	11
	Pompholyx sp.	24	25	26
	Polyarthra vulgaris	25	25	25
Protozoa	*Paramoecium*	18	20	22
Cladoceran	*Daphnia sp.*	8	10	12
	Moina sp.	10	12	14
Copepoda	*Mesocyclops sp.*	10	12	14
	Ceriodaphnia	28	30	33
	Nauplius	12	14	14
Ostracoda	*Cypris sp.*	8	9	10
Total		229	248	259
Standard Deviation		8.90	8.80	8.59
Mean		16.35	17.71	18.5

All values are in units/litre.

Table 11: Zooplanktonic diversity in summer months

Zooplankton Group	Zooplankton Species	March	April	May
Rotifera	*B.mulleri*	26	32	36
	B.plicatilis	28	32	31
	Keratella cochlearis	32	33	33
	Filinia terminalis	6	6	7
	Filinia longista	12	14	16
	Pompholyx sp.	28	32	34
	Polyarthra vulgaris	25	29	32
Protozoa	*Paramoecium*	25	32	26
Cladoceran	*Daphnia sp.*	12	16	18
	Moina sp.	15	18	20
Copepoda	*Mesocyclops sp.*	14	16	18
	Ceriodaphnia	28	28	30
	Nauplius	10	14	12
Ostracoda	*Cypris sp.*	11	14	14
Total		272	316	327
Standard Deviation		8.37	9.01	9.09
Mean		19.42	22.57	23.35

All values are in units/litre.

Table 12: Zooplankton population

Zooplankton Group	Zooplankton Species	June	July	August
Rotifera	*B.mulleri*	25	20	18
	B.plicatilis	18	16	15
	Keratella cochlearis	24	24	20
	Filinia terminalis	4	5	6
	Filinia longista	6	6	8
	Pompholyx sp.	28	18	18
	Polyarthra vulgaris	20	16	14
Protozoa	*Paramoecium*	16	16	14
Cladoceran	*Daphnia sp.*	6	5	3
	Moina sp.	12	8	8
Copepoda	*Mesocyclops sp.*	10	11	12
	Ceriodaphnia	18	15	14
	Nauplius	6	6	4
Ostracoda	*Cypris sp.*	8	5	3
Total		201	171	157
Standard Deviation		7.72	6.18	5.62
Mean		14.35	12.21	11.21

All values are in units/litre.

Table 13: Diversity of Zooplanktons

Zooplankton Group	Zooplankton Species	September	October	November
Rotifera	*B.tridentatus*	10	11	12
	B.quadridentatus.	14	18	20
	Asplanachna sp.	15	18	11
	Platyias sp	8	6	6
	Hexarthra sp.	8	11	14
Protozoa	*Paramoecium*	25	31	20
Cladoceran	*Daphnia sp.*	10	14	13
Copepoda	*Mesocyclops sp.*	8	14	11
	Nauplius	7	11	12
	Cyclops	6	8	10
	Diaptomus	8	14	10
Total		119	156	139
Standard Deviation		5.21	6.20	3.98
Mean		10.81	14.18	12.63

All values are in units/litre.

Table 14: Zooplankton density

Zooplankton Group	Zooplankton Species	December	January	February
Rotifera	*B.tridentatus*	14	16	14
	B.quadridentatus.	12	15	18
	Asplanachna sp.	8	12	14
	Platyias sp	8	10	10
	Hexarthra sp.	10	11	12
Protozoa	*Paramoecium*	22	22	28
Cladoceran	*Daphnia sp.*	12	18	21
Copepoda	*Mesocyclops sp.*	8	12	16
	Nauplius	6	14	10
	Cyclops	6	11	15
	Diaptomus	10	14	16
Total		116	155	174
Standard Deviation		4.35	3.39	4.95
Mean		10.54	14.09	15.81

All values are in units/litre.

Table 15:Zooplankton density

ZooplanktonGroup	Zooplankton Species	March	April	May
Rotifera	*B.tridentatus*	10	12	14
	B.quadridentatus.	12	12	16
	Asplanachna sp.	11	12	14
	Platyias sp	8	6	10
	Hexarthra sp.	11	12	15
Protozoa	*Paramoecium*	18	20	21
Cladoceran	*Daphnia sp.*	16	12	13
Copepoda	*Mesocyclops sp.*	12	10	10
	Nauplius	10	14	12
	Cyclops	11	12	15
	Diaptomus	8	10	14
Total		127	132	154
Standard Deviation		2.90	3.19	2.89
Mean		11.54	12	14

All values are in units/litre.

(41.34%), copepoda (31.01%), protozoa (16.17%) and cladocera (11.46%).

Site 4: G_4SUMMER 2013

The zooplankton density ranged from 127U/L to 154U/L, being maximum in the month of May and minimum in the month of March. The percentage of rotifers and copepods increased in summer while that of protozoa and cladocera declined. The order of percentage in this season was rotifers (42.37%), copepoda (33.41%), protozoa (14.28%) and cladoceran (9.92%).

Site 4: G_4MONSOON 2013

During monsoon the zooplankton density was maximum in themonth of June (148U/L) and minimum in the month of August (106U/L). The zooplankton density comprised of rotifer

Table 16: Zooplankton density during Monsoon

Zooplankton Group	Zooplankton Species	June	July	August
Rotifera	*B.tridentatus*	12	10	8
	B.quadridentatus.	16	12	10
	Asplanachna sp.	12	11	11
	Platyias sp	10	8	6
	Hexarthra sp.	14	10	12
Protozoa	*Paramoecium*	20	12	10
Cladoceran	*Daphnia sp.*	12	12	10
Copepoda	*Mesocyclops sp.*	8	6	6
	Nauplius	10	12	10
	Cyclops	18	14	11
	Diaptomus	16	13	12
Total		148	121	106
Standard Deviation		3.52	2.19	2.01
Mean		13.45	11	9.63

All values are in units/litre

(43.2%), copepoda (32.26%), protozoa (11.2%) and cladocera (9.06%).

All values are in units/litre

Since site G_2 and G_3 have maximum anthropogenic activities like disposal of solid waste ,bathing ,washing etc .,therefore maximum diversity of zooplanktons were reported there. Almost similar findings were noted in sewage pollution (Saha *et al*., 2000), in tropical and eutrophic reservoir (Calijuri *et al*., 2002), in river Suyal of Uttaranchal (Pathani and Mathur, 2006) and in hill stream Chandrabhaga of Garhwal Himalaya(Sharma *et al*., 2007).

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