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Seasonal Study of Zooplanktonic Diversity of River Narmada, Jabalpur Region (M.P) India

Deepika Saini[1], K K Dube[2]

[1]Department of Zoology, Govt. M.H college of Home Science For Women, Jabalpur (M.P)

[2]Department of Zoology, Retired Professor, Govt. Science College, Jabalpur (M.P)

Abstract: ***The current studies intends to provide an overview of zooplanktonic species richness of Narmada river. The studies are carried out in 5 prefix sampling stations of river Narmada from October 2011 to September 2012 in Jabalpur region which is one of the most famous city of Madhya-Pradesh, also called as Mahakoushal. The water samples were collected every month for the qualitative and quantitative analysis of zooplanktons .Seasons are categorized as Oct-Jan as winters, Feb.-May as summers and June-Sept as Rainy season. Zooplanktons are cellular metazoans in the water bodies ranging in size from about 0.05µmm to 0.1µmm.They provide food for many fishes and therefore, play a vital role in the food chain of ponds ,tanks and rivers. In Zooplanktons ,13 species were recorded belonging to 5 different groups(Protozoa, Copepoda, Ostracoda, Cladocera and Rotifera). Copepoda was observed to be the most dominating group with 4 species and Cyclops as the most dominating species .Whereas, protozoa was observed to be the least dominating group with 3 species and Vorticella as the most dominating species. Zooplanktonic abundance was recorded to be in peak during Summer season whereas declined in monsoon and remained intermediate in winters. In the seasonal studies of zooplanktonic species ,the order of dominance (as per total density)was observed to be as ,Copepoda>Cladocera>Rotifera>Ostracoda>Protozoa.***

Keywords: Zooplanktons, Narmada River, Jabalpur Region, dominance, diversity

1. Introduction

Rivers are the main source of drinking water, besides their usage in agriculture, washing etc. Water pollution in India has come to a critical point. Domestic waste, industrial waste and other household wastes are directly discharged into the river. Major constituents of aquatic organisms is the plankton- Zooplankton and Phytoplankton. Plankton population is greatly affected by physical and chemical properties of water, Sharma and Diwan[1] . Rivers play a major role in assimilating or carrying industrial and municipal waste water, manure discharge and run off which are responsible for river pollution, Toman et al.,[2].Aquatic life depends upon the planktonic population. Any change in the quality of water directly affects its planktonic populations i.e ,they serve as a good indicators of health of aquatic ecosystem. Their dominance and seasonality are highly variable in different water bodies. zooplanktons are sensitive indicators of pollution in comparison with phytoplanktons,Umadevi,2013[3].Jabalpur .The major role in pollution is played by Ernst Wallace Shaw Wallace Gelatin Company ,which is situated between sampling stations 4 and 5.As this Gelatin factory is directly discharging its waste to the nearby ghats thus creating pollution and affecting the planktonic quality too.

2. Material and Methods

2.1 Study Area

The present studies are carried out from October 2010 to September 2011 in 5 different sampling stations of river Narmada at Jabalpur region(M.P), India, namely (S-1) Lamhetaghat (16 km away from the city headquarters, (S-2) Laxminarayanghat ($17^{1/2}$ km away from the city headquarters), (S-3) Gograghat (19 km away from the city headquarters), (S-4) Saraswatighat (20 km away from the city headquarters) and the last one (S-5) Bhedaghat (21 km away from the city headquarters). These all sampling sites are situated at the bank of river Naramada and are surrounded by large number of small villages. Hence, dumping wastes and ritual performances can be seen here frequently

2.2 Sample Collection and Analysis

Zooplanktons were collected from all the sampling stations (S-1, S-2, S-3, S-4, S-5) of river Narmada for qualitative and quantitative analysis. For this methods, plankton net was used as planktonic sampling device. The plankton net is cone shaped having a circular metal ring at one end and collecting graduated tube on the other end. For qualitative and quantitative analysis of planktons, 50 lit. of water sample was pass out from the plankton net and filter is collected in the graduated tube attached to the lower end of. plankton net. Filter is than collected in 25 ml of vial and kept for sedimentation by the addition of lugol's iodine for zooplanktons and preserved with 5% formaldehyde solution. The supernatant liquid is taken out with the help of pipette without disturbing the settled planktons and the remaining sample is further concentrated upto 5 ml depending upon the number of planktons present. For qualitative and quantitative analysis of planktons ,Drop count method is preferred. This method involves plankton enumeration in one drop of concentrated sample taken on aside with cover slip using standard calibrated dropper. This slide is then put under the inverted research microscope (Leincamake DMIL) with 10×10 magnification. Planktons are counted species wise identification of plankton was done by using standard literature of Needham and Needham [4] and Adoni et, al., [5]. Keeping in view, Every day the water quality is changing, which in turn changes the abundance and succession of Zooplanktons in a set of samples collected from 5 ghats of river Narmada, Jabalpur region(M.P)India.

Map 1: Jabalpur region showing sampling stations

3. Photographs

(A) Station -1: Lamhetaghatghat

(B) Station-2: Laxmi Narayan Ghat

(C) Station-3: Gogragha

(D) Station-4: Saraswati Ghat

(E) Station-5: Bhedaghat

(F) Sample Collection (Gograghat)

4. Results and Discussion

Fourteen taxa of Zooplanktons were recorded from different stations of river Narmada including ,3 of Cladocera and 1 of Ostracoda.3 of protozoa,3 of Rotifera,4 of Copepoda. Total Zooplankton population of river Narmada varied from 498-106 noL-1.Total Zooplankton population of river Narmada showed a decline from station S-1 to station S-5. In the research period of one year i.e, October 2011 to September 2012, Zooplanktons are cellular metazoans in the water bodies ranging in size from about 0.05µmm to 0.1µmm.They provide food for many fishes and therefore, play a vital role in the food chain of ponds ,tanks and rivers. In Zooplanktons, 13 species were recorded belonging to 5 different groups(Protozoa, Copepoda, Ostracoda, Cladocera and Rotifera). Copepoda was observed to be the most dominating group with 4 species and *Cyclops* as the most dominating species .Whereas, protozoa was observed to be the least dominating group with 3 species and *Vorticella* as the most dominating species. Zooplanktonic abundance was recorded to be in peak during Summer season whereas declined in monsoon and remained intermediate in winters. In the seasonal studies of zooplanktonic species, the order of dominance (as per total density) was observed to be as ,Copepoda>Cladocera>Rotifera>Ostracoda>Protozoa.

Zooplankton species were collected from the surface(S) and bottom(B) of all prefix sampling stations(Table 1,2,3,4)

1) Copepoda

Copepoda is the first main dominant group of Zooplanktons. This group is represented by species *Cyclops, Nauplius larvae, Diaptomus and Mesocyclops*. During my study period in the year from October 2011 to September 2012, maximum density recorded for Copepoda at different stations was observed as-

S-1 = S = 1529 nos/l, B = 1007 nos/l
S-2 = S = 1632 nos/l, B = 986 nos/l
S-3 = S = 1424 nos/l, B = 959 nos/l
S-4 = S = 1567 nos/l, B = 992 nos/l
S-5 = S = 1599 nos/l, B = 999 nos/l

Cyclops species was dominant throughout the year with maximum range of 60 organism per litre in the month of Feb. 2012 at station (S-3) on the surface while *Nauplius Larvae* was observed to be minimum with lower range of 14 organisms per litre in the month of June 2012 at S-2 in the bottom and absent at some places. Similar summer maxima of Zooplanktons population is reported by George (1966)[6].

2) Cladocera

During my study period, **Cladocera** was the second dominant group. The group density observed for this group for the year 2011-12 was-

S-1 = S =1370 nos/l, B = 792 nos/l
S-2 = S =1406 nos/l ,B = 81nos/l
S-3 = S = 1406 nos/l, B = 863 nos/l
S-4 =S = 1417 nos/l B = 822 nos/l
S-5 = S = 1386 nos/l, B = 809 nos/l

The number of species was maximum in summers and declined gradually during monsoon. Out of all the observed species *Daphnia* was dominating throughout the years with the maximum range of 63 organisms per litre in the month of March 2012 at S-5 on the surface whereas *Eurycerus* was observed in lesser amount within the maximum range of 12 org/l in the month of June 2012 at station S-5 at the bottom.

3) Rotifera

Rotifera was observed to be the third dominant group .The species observed in the group are – ***Branchious sp., Asplanchna sp.*** and ***Keratella.***

The maximum density recorded in year 2010-11 was-

S-1 = S = 1206 nos/l, B = 738 nos/l
S-2 = S = 1230 nos/l, B = 768 nos/l
S-3 = S = 1226 nos/l, B = 745 nos/l
S-4 = S = 1243 nos/l, B = 745 nos/l
S-5 = S = 1176 nos/l, B = 728 nos/l

In the research period, *Branchionus* species was dominating with the maximum range of 60 organisms per litre in S-3(surface)in the month of April 2012. *Keratella* was observed in lesser amount and observed to be absent in many months. Bhandarkar et.al.,(2008)[7] studied the observation on species diversity of Branchious (Rotifer) from Kalikar pond, Brahmapuri Distt. Chandrapur Maharastra, Salaskar.

4) Ostracoda

Ostracoda is the fourth dominating group with Cypris as the most dominating species. Maximum density in the first year Oct. 2011 to Sept. 2012 was observed as-

S-1 = S = 460 nos/l, B = 276 nos/l
S-2 = S = 426 nos/l, B = 256 nos/l
S-3 = S = 470 nos/l, B = 302 nos/l
S-4 = S = 469 nos/l, B = 302 nos/l
S-5 = S = 466 nos/l, B = 284 nos/l

In **Ostracoda,** *Cypris* was found to be dominant with the maximum range of 46 organism per litre in the month of April 2012 at S-1 on the surface.

5) Protozoa

The commonly observed species of protozoans are Amoeba, paramecium and Vorticella. During my study period Protozoa was observed to be the fifth dominating group. Maximum density in the first year Oct. 2010 to Sept. 2011 was observed as-

S-1 = S = 99 nos/l, B = 89 nos/l
S-2 = S = 103 nos/l, B = 79 nos/l
S-3 = S = 84 nos/l, B = 89 nos/l
S-4 = S = 80 nos/l, B = 84 nos/l
S-5 = S = 107 nos/l, B = 107 nos/l

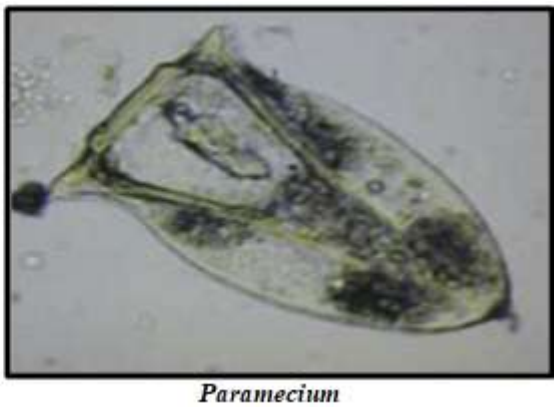
In **Protozoa**, Vorticella was found to be dominant with the maximum range of 08 organism per litre in the month of April 2012 at S-3 at the bottom. Paramecium and Amoeba are observed in fewer number and are observed to be absent at some places.

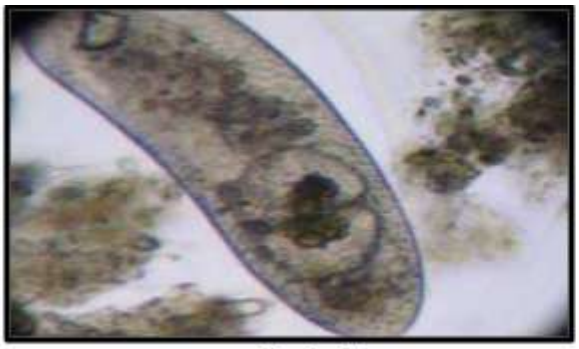
From the data recorded in this research duration of October 2010 to September 2011, it is clear that the Copepoda is the most dominating group with *Cyclops* as the most dominating species in river Narmada. The total plankton count/ml is minimum in rainy season whereas higher in summers. This data is further supported by taking a reference of data collected by Jyoti Sharma et. al., [8] Tayor and Deepti[9] also reported that Zooplanktons grows and multiply best during months, when the temperature is high and having longer photoperiod. High summer growth of Zooplanktons may also be due to progressively increasing water temperature and nutrients in water that are responsible for high amount of Zooplankton growth during summer season. Similar studies are reported by Sudha Summarwar [10]. A decline in the number of planktons with the influx of effluents was also recorded by many authors, Malhotra et.al., 2014[11]; Bhatnagar et,al.,2013[12]In seasonal variations it is observed that different zooplanktonic groups are observed (as per total density as follows)-

Copepoda>Cladocera>Rotifera>Ostracoda>Protozoa

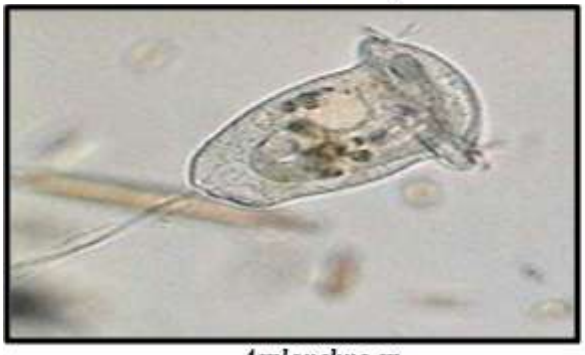
Few Zooplanktons Recorded In River Narmada

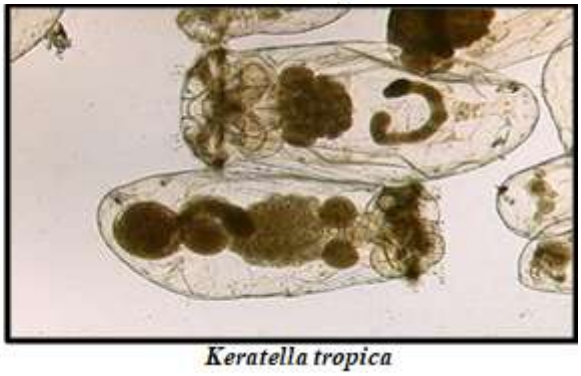

Amoeba sp.

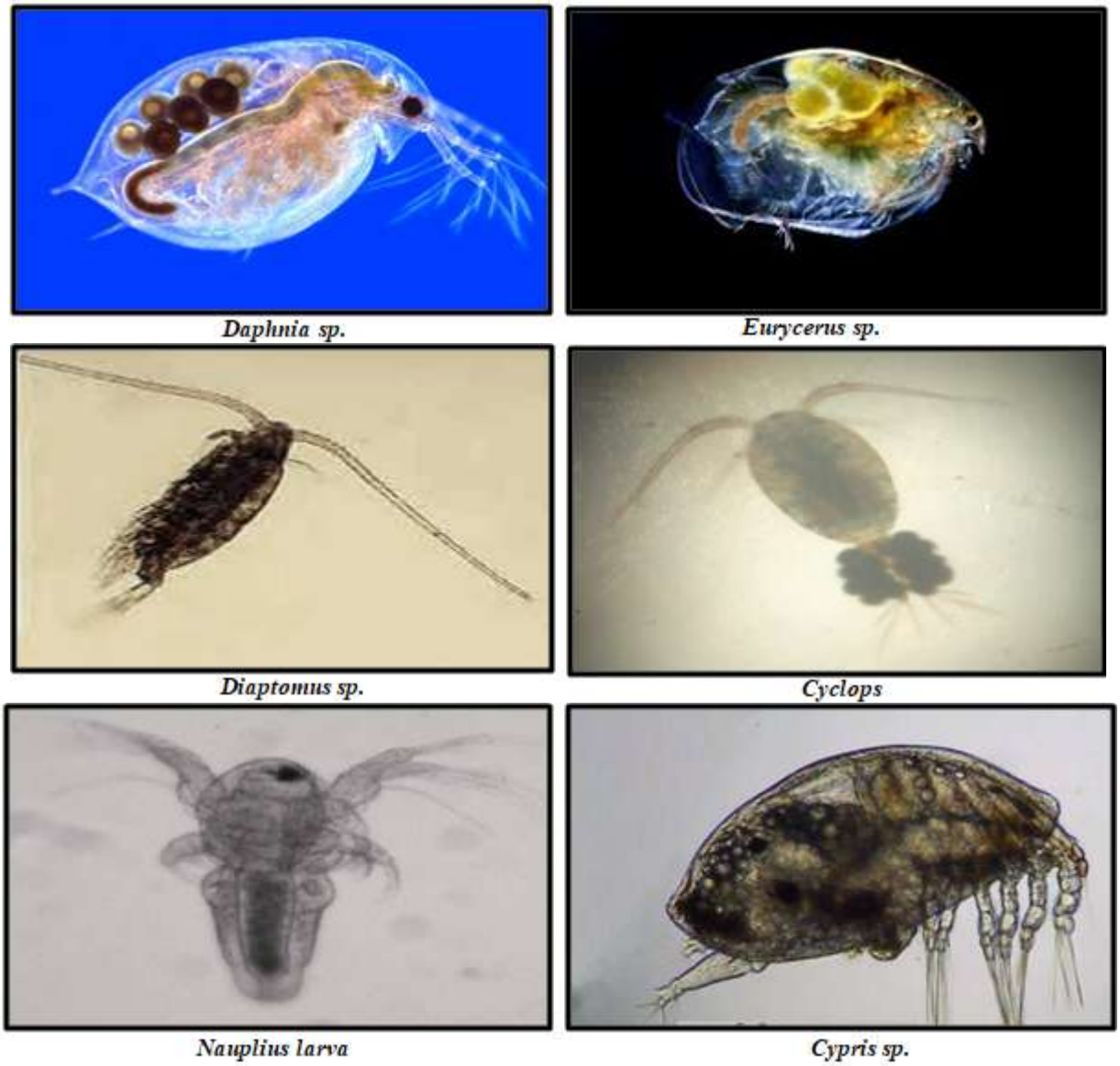

Paramecium


Vorticella sp.


Branchionus sp.


Asplanchna sp.


Keratella tropica



5. Conclusion

Though Narmada is a river with rich biodiversity, but as per my findings the diversity was observed to be low in station S-4 and S-5 as these both stations are getting effluents from the nearby Gelatin Factory, which is adversely affecting its aquatic ecosystem, yet River Narmada has a very rich biodiversity but values are declining at the points of influx of effluents. So, in order to manage the pollution load of Narmada river ,it is highly suggested that various sewage treatments and industrial treatment plants should be used before the discharge of effluents in nearby ghats.

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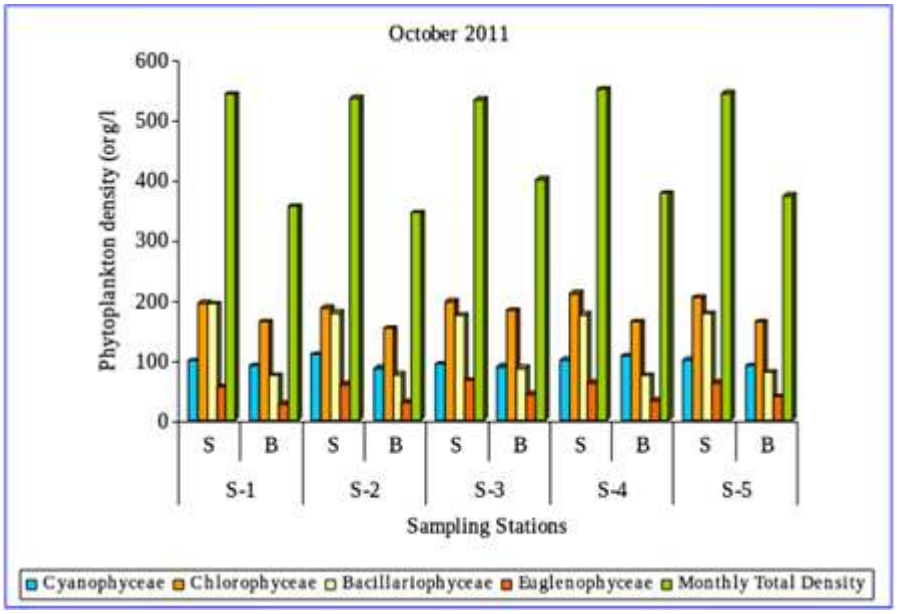
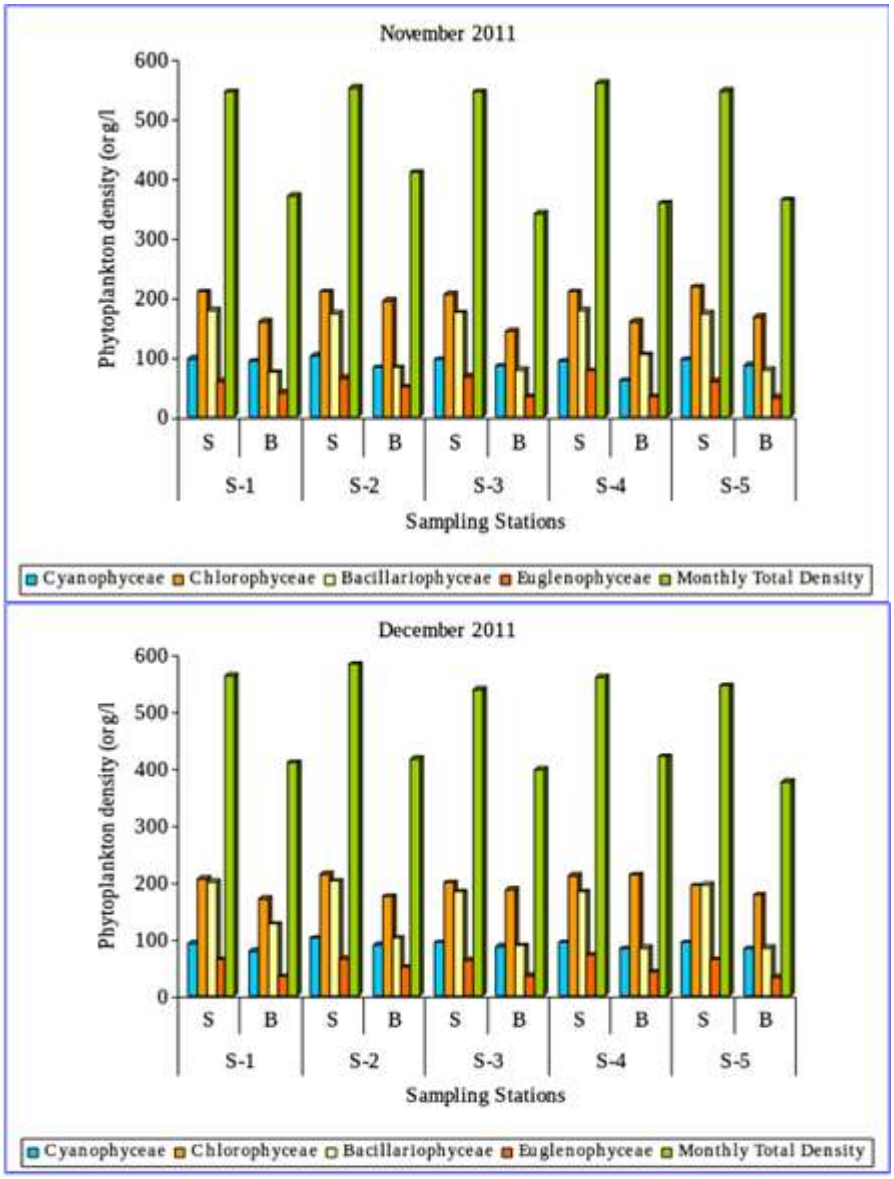
Table 1: Seasonal variation in Zooplankton density (org/l) at 5 different sampling stations of river Narmada (October 2011– Dec. 2011)

Zooplankton	October 2011										November 2011										December 2011									
	S-1		S-2		S-3		S-4		S-5		S-1		S-2		S-3		S-4		S-5		S-1		S-2		S-3		S-4		S-5	
Date	10th		11th		12th		13th		14th		10th		11th		12th		13th		14th		10th		11th		12th		13th		14th	
PROTOZOA	**S**	**B**	**S**	**B**	**S**	**B**	**S**	**B**	**S**	**B**	**S**	**B**	**S**	**B**	**S**	**B**	**S**	**B**	**S**	**B**	**S**	**B**	**S**	**B**	**S**	**B**	**S**	**B**	**S**	**B**
Amoeba	-	2	2	-	1	3	2	-	-	-	1	2	4	2	-	-	2	-	2	1	4	2	2	1	-	1	-	2	-	1
Paramecium	-	1	4	2	2	1	3	1	2	1	4	2	-	2	4	2	4	3	2	4	1	2	-	3	2	-	-	-	-	-
Vorticella	3	2	6	3	4	6	6	8	4	8	2	4	8	4	3	5	5	7	5	8	2	5	3	5	-	3	4	3	8	5
Total	**3**	**5**	**12**	**5**	**7**	**10**	**11**	**9**	**6**	**9**	**7**	**8**	**12**	**8**	**7**	**7**	**11**	**10**	**9**	**13**	**7**	**9**	**5**	**9**	**2**	**4**	**4**	**5**	**8**	**6**
ROTIFERA																														
Branchionus species	44	18	44	26	42	26	38	19	40	20	39	20	35	24	40	20	45	24	35	26	40	22	46	23	47	26	44	19	40	25
Asplanchna species	25	20	24	20	28	20	26	15	24	17	25	15	28	18	28	18	27	16	24	18	26	20	22	20	27	22	28	22	29	18
Keratella	34	16	36	22	32	40	36	18	32	19	28	14	27	15	30	20	34	17	32	21	32	18	34	18	34	20	33	24	33	20
Total	**103**	**54**	**104**	**68**	**102**	**86**	**100**	**52**	**96**	**56**	**92**	**49**	**90**	**57**	**98**	**58**	**106**	**57**	**91**	**65**	**98**	**60**	**102**	**61**	**108**	**68**	**105**	**65**	**102**	**63**
CLADOCERA																														
Daphnia	48	29	46	24	45	26	42	26	45	28	42	22	44	26	44	20	48	24	44	28	46	25	49	26	50	28	48	27	45	22
Eurycerus	28	18	30	18	27	22	30	15	32	24	28	18	25	16	27	20	30	25	24	19	22	21	30	17	28	20	30	25	30	14
Diaphanosoma	32	18	32	20	34	24	35	20	39	20	35	29	38	20	35	28	33	22	30	24	37	17	32	20	38	28	37	28	31	23
Total	**108**	**65**	**109**	**62**	**106**	**72**	**107**	**61**	**116**	**72**	**105**	**69**	**107**	**62**	**106**	**68**	**111**	**71**	**98**	**71**	**110**	**63**	**111**	**63**	**116**	**76**	**115**	**80**	**106**	**59**
OSTRACODA																														
Cypris	36	22	34	20	34	20	38	28	36	20	32	21	40	26	38	25	35	18	32	27	33	22	38	25	38	25	40	26	37	28
Total	**36**	**22**	**34**	**20**	**34**	**20**	**38**	**28**	**36**	**20**	**32**	**21**	**40**	**26**	**38**	**25**	**35**	**18**	**32**	**27**	**33**	**22**	**38**	**25**	**38**	**25**	**40**	**26**	**37**	**28**
COPEPODA																														
Diaptomus	17	12	30	16	28	16	32	14	27	15	26	21	34	20	28	15	30	18	28	18	27	15	37	22	29	15	30	18	33	22
Cyclops	24	18	46	28	40	24	45	25	40	24	48	26	42	28	46	24	40	24	42	36	40	30	44	30	45	25	42	24	48	35
Nauplius larvae	20	17	29	20	22	15	24	18	29	15	26	18	25	18	26	24	22	20	28	19	30	17	27	22	20	30	25	20	22	24
Mesocyclops	12	14	24	18	28	16	30	22	30	24	34	17	34	20	29	22	27	25	25	20	22	23	23	15	28	24	30	15	30	18
Total	**73**	**61**	**129**	**82**	**134**	**71**	**131**	**79**	**126**	**78**	**134**	**82**	**135**	**86**	**129**	**85**	**119**	**87**	**123**	**93**	**119**	**85**	**131**	**89**	**122**	**94**	**144**	**77**	**133**	**99**
Monthly Total Density	**323**	**207**	**388**	**237**	**383**	**259**	**387**	**229**	**380**	**235**	**370**	**229**	**384**	**239**	**378**	**243**	**382**	**243**	**353**	**269**	**367**	**239**	**387**	**247**	**386**	**267**	**408**	**253**	**386**	**255**

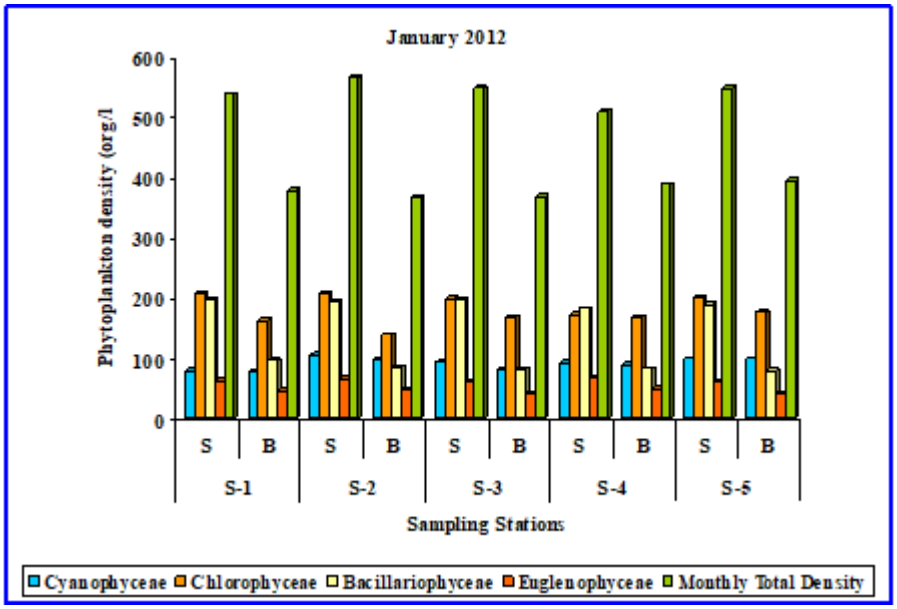


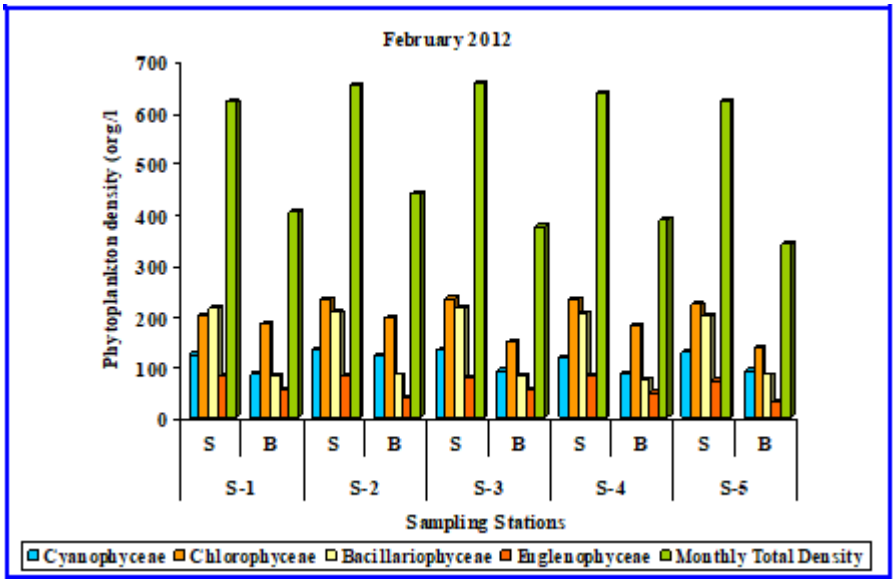


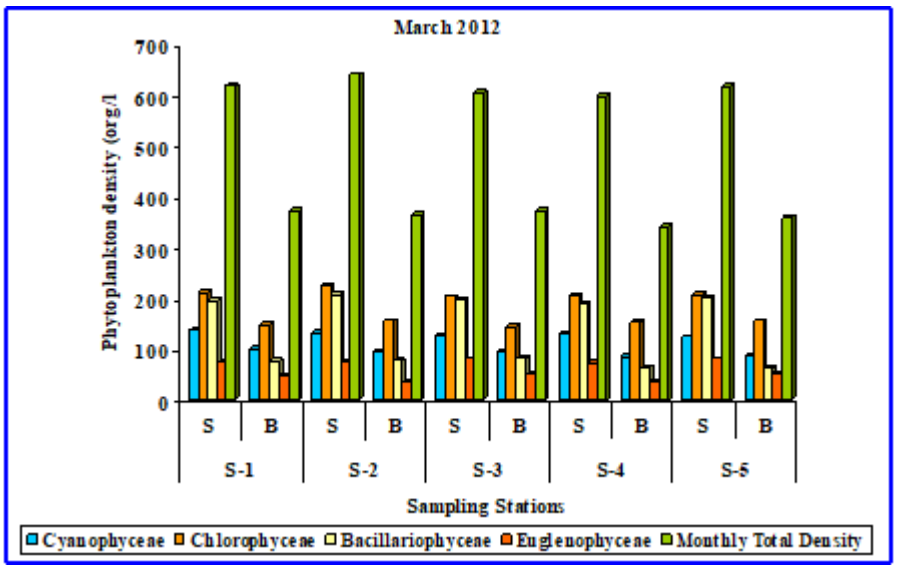
Graph 1(A, B, C): Graph showing seasonal variation in phytoplankton density (org/l) at 5 different sampling stations of river Narmada (Oct. 2011 to Dec. 2011)

Table 2: Seasonal variation in Zooplankton density (org/l) at 5 different sampling stations of river Narmada (Jan. 2012 - March. 2012)

Zooplankton	January 2012										February 2012										March 2012									
Date	S-1 10th		S-2 11th		S-3 12th		S-4 13th		S-5 14th		S-1 10th		S-2 11th		S-3 12th		S-4 13th		S-5 14th		S-1 10th		S-2 11th		S-3 12th		S-4 13th		S-5 14th	
PROTOZOA	**S**	**B**	**S**	**B**	**S**	**B**	**S**	**B**	**S**	**B**	**S**	**B**	**S**	**B**	**S**	**B**	**S**	**B**	**S**	**B**	**S**	**B**	**S**	**B**	**S**	**B**	**S**	**B**	**S**	**B**
Amoeba	3	2	5	2	-	3	2	-	4	-	2	-	1	-	1	2	-	2	-	2	2	-	1	-	1	1	2	-	2	1
Paramecium	2	-	-	2	1	-	-	-	3	-	-	3	-	1	-	-	1	-	3	-	3	2	-	3	2	1	2	-	2	-
Vorticella	5	2	4	6	2	3	4	-	4	8	2	4	3	-	-	3	8	5	4	6	2	4	8	4	2	4	5	2	6	5
Total	**10**	**4**	**9**	**10**	**3**	**6**	**6**	**-**	**11**	**8**	**4**	**7**	**4**	**1**	**1**	**5**	**9**	**7**	**7**	**8**	**7**	**6**	**9**	**6**	**5**	**6**	**9**	**2**	**10**	**6**
ROTIFERA																														
Branchionus species	44	22	40	18	42	20	38	15	42	24	52	24	54	24	60	20	57	36	52	27	50	23	57	36	54	26	59	28	58	20
Asplanchna species	27	16	23	19	26	14	28	17	24	14	36	22	37	24	29	18	33	22	32	26	30	24	32	26	30	16	36	20	36	20
Keratella	25	15	29	14	23	18	26	19	26	12	29	20	29	18	28	20	31	24	26	17	26	18	29	20	29	18	29	15	27	20
Total	**96**	**53**	**92**	**51**	**91**	**52**	**92**	**51**	**92**	**60**	**117**	**66**	**120**	**66**	**116**	**58**	**121**	**82**	**110**	**70**	**106**	**65**	**118**	**82**	**113**	**60**	**124**	**63**	**121**	**60**
CLADOCERA																														
Daphnia	46	24	44	24	45	24	44	28	45	24	58	28	59	32	60	28	62	26	60	32	59	26	60	32	58	25	62	30	63	32
Eurycerus	30	16	29	20	26	20	29	18	32	20	36	20	34	20	34	26	38	24	35	24	36	19	38	20	36	20	37	20	34	12
Diaphanosoma	36	18	30	16	32	16	32	16	34	25	44	24	44	18	44	28	40	32	46	26	42	20	40	26	46	28	43	26	42	20
Total	**112**	**58**	**103**	**60**	**103**	**60**	**105**	**62**	**111**	**69**	**138**	**72**	**137**	**70**	**138**	**82**	**140**	**82**	**141**	**82**	**128**	**65**	**138**	**78**	**140**	**73**	**142**	**76**	**139**	**64**
OSTRACODA																														
Cypris	38	24	34	18	38	17	37	34	24	22	42	28	40	18	44	22	42	28	44	23	45	20	40	15	46	34	40	28	42	30
Total	**38**	**24**	**34**	**18**	**38**	**17**	**37**	**24**	**34**	**22**	**42**	**28**	**40**	**18**	**44**	**22**	**42**	**28**	**44**	**23**	**45**	**20**	**40**	**15**	**46**	**34**	**40**	**28**	**42**	**30**
COPEPODA																														
Diaptomus	28	24	29	14	26	12	24	16	25	16	37	20	38	20	38	24	34	22	35	24	38	20	36	20	35	24	33	20	36	20
Cyclops	45	32	42	18	42	22	45	28	42	20	54	20	59	32	60	28	54	30	54	30	52	28	54	30	54	25	58	30	58	24
Nauplius larvae	22	18	24	16	24	16	28	20	20	18	34	28	33	18	32	24	38	26	36	18	32	25	36	20	33	20	30	16	36	20
Mesocyclops	26	18	24	18	22	16	23	17	24	16	26	15	29	15	26	14	26	19	27	20	26	14	26	14	26	16	28	18	28	16
Total	**121**	**92**	**119**	**66**	**114**	**66**	**120**	**81**	**111**	**70**	**151**	**83**	**159**	**85**	**156**	**90**	**152**	**97**	**152**	**92**	**148**	**87**	**152**	**84**	**148**	**85**	**149**	**84**	**158**	**80**
Monthly Total Density	**377**	**231**	**357**	**205**	**349**	**201**	**360**	**218**	**359**	**229**	**452**	**256**	**460**	**240**	**455**	**257**	**464**	**296**	**454**	**275**	**434**	**243**	**457**	**265**	**452**	**258**	**464**	**253**	**470**	**240**



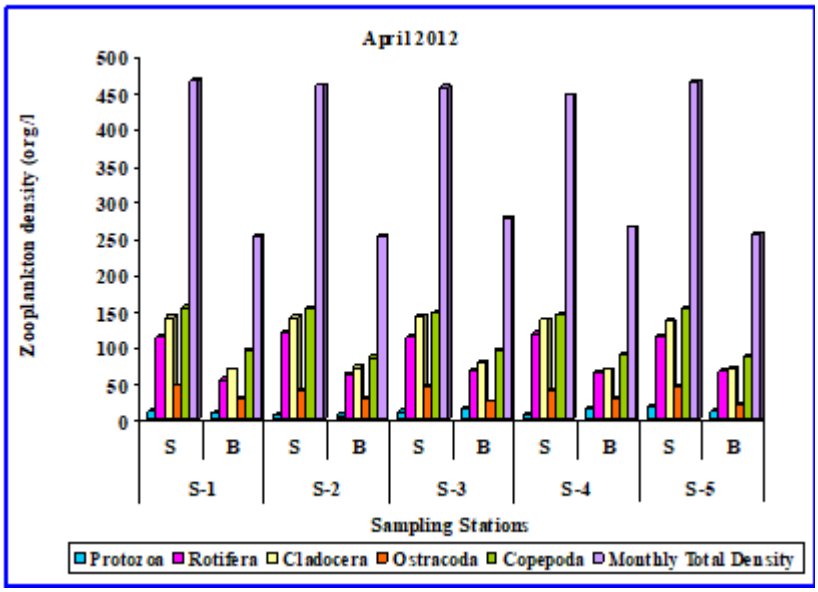


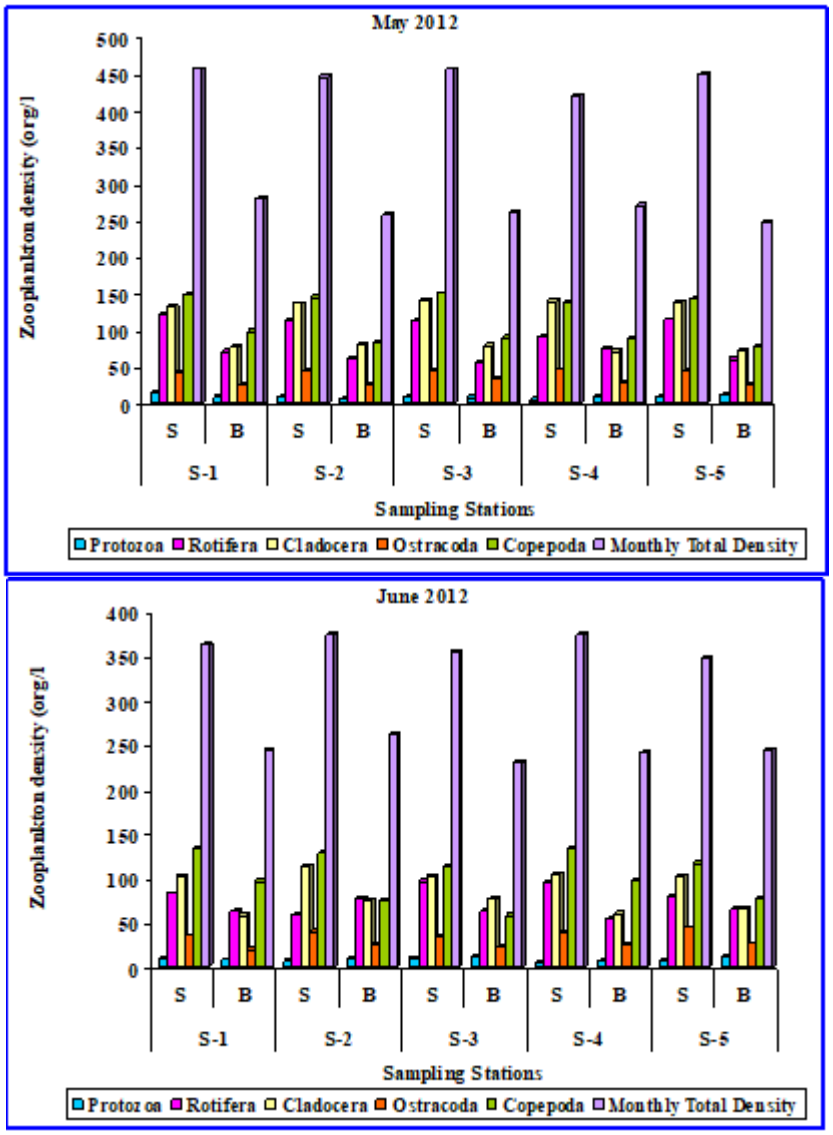


Graph 2(A, B): Graph showing seasonal variation in phytoplankton density (org/l) at 5 different sampling stations of river Narmada (Jan. 2012 to March. 2012)

Table 3: Seasonal variation in Zooplankton density (org/l) at 5 different sampling stations of river Narmada (April 2012 – June 2012)

Zooplankton Date	April 2012										May 2012										June 2012									
	S-1		S-2		S-3		S-4		S-5		S-1		S-2		S-3		S-4		S-5		S-1		S-2		S-3		S-4		S-5	
	10th		11th		12th		13th		14th		10th		11th		12th		13th		14th		10th		11th		12th		13th		14th	
PROTOZOA	**S**	**B**	**S**	**B**	**S**	**B**	**S**	**B**	**S**	**B**	**S**	**B**	**S**	**B**	**S**	**B**	**S**	**B**	**S**	**B**	**S**	**B**	**S**	**B**	**S**	**B**	**S**	**B**	**S**	**B**
Amoeba	6	-	2	3	3	4	4	6	6	4	4	3	3	-	3	2	2	2	2	3	2	2	-	2	2	4	-	3	3	2
Paramecium	4	2	3	2	5	2	2	4	4	2	2	-	2	4	5	-	1	3	4	3	3	-	3	-	4	-	4	3	4	2
Vorticella	2	6	2	-	2	8	-	5	8	6	8	6	4	2	-	5	2	4	3	5	4	6	4	8	4	8	-	-	-	8
Total	**12**	**8**	**7**	**5**	**10**	**14**	**6**	**15**	**18**	**12**	**14**	**9**	**9**	**6**	**8**	**7**	**5**	**9**	**9**	**11**	**9**	**8**	**7**	**10**	**10**	**12**	**4**	**6**	**7**	**12**
ROTIFERA																														
Branchionus species	54	20	58	20	60	30	55	26	56	24	52	26	54	26	55	28	52	24	56	24	36	24	38	32	38	26	36	20	38	24
Asplanchna species	32	14	36	24	30	18	38	20	30	24	36	25	32	16	30	12	38	26	34	20	23	19	28	20	26	18	25	18	24	15
Keratella	28	20	26	18	24	18	26	18	28	18	33	20	27	20	27	15	30	24	24	16	24	20	27	25	32	18	34	16	27	26
Total	**114**	**54**	**120**	**62**	**114**	**66**	**119**	**64**	**114**	**66**	**121**	**71**	**113**	**62**	**112**	**55**	**90**	**74**	**114**	**60**	**83**	**63**	**59**	**77**	**96**	**62**	**95**	**54**	**79**	**65**
CLADOCERA																														
Daphnia	59	24	60	24	57	24	58	28	58	26	56	28	58	26	57	26	56	28	60	25	38	20	40	24	39	24	38	18	35	27
Eurycerus	38	24	35	20	37	28	33	15	36	24	34	25	38	26	42	24	40	20	35	28	28	18	35	23	28	24	30	18	30	12
Diaphanosoma	44	20	46	28	48	26	46	25	42	20	42	24	40	28	42	28	44	23	44	20	36	20	39	28	35	29	36	24	38	26
Total	**141**	**68**	**141**	**72**	**142**	**78**	**137**	**68**	**136**	**70**	**132**	**77**	**136**	**80**	**141**	**78**	**140**	**71**	**139**	**73**	**102**	**58**	**114**	**75**	**102**	**77**	**104**	**60**	**103**	**65**
OSTRACODA																														
Cypris	46	28	40	28	45	24	40	28	44	20	42	25	44	26	45	32	46	28	44	26	35	20	40	25	34	22	39	24	44	26
Total	**46**	**28**	**40**	**28**	**45**	**24**	**40**	**28**	**44**	**20**	**42**	**25**	**44**	**26**	**45**	**32**	**46**	**28**	**44**	**26**	**35**	**20**	**40**	**25**	**34**	**22**	**39**	**24**	**44**	**26**
COPEPODA																														
Diaptomus	37	24	33	20	36	24	33	24	37	20	32	26	35	26	35	24	32	18	36	20	32	24	38	18	29	20	32	28	26	18
Cyclops	56	24	52	26	50	32	52	28	59	28	53	26	46	20	56	22	52	28	50	24	48	30	42	26	49	24	43	40	44	26
Nauplius larvae	34	26	38	24	34	26	36	25	30	24	35	26	31	22	33	25	30	20	32	18	25	18	28	14	-	-	26	15	22	18
Mesocyclops	27	20	30	15	26	14	24	12	27	15	28	20	32	16	26	18	35	22	25	15	29	24	20	17	36	14	32	14	24	15
Total	**154**	**94**	**153**	**85**	**146**	**96**	**145**	**89**	**153**	**87**	**148**	**98**	**144**	**84**	**150**	**89**	**139**	**88**	**143**	**77**	**134**	**96**	**128**	**75**	**114**	**58**	**133**	**97**	**116**	**77**
Monthly Total Density	**467**	**252**	**461**	**252**	**457**	**278**	**447**	**264**	**465**	**255**	**457**	**280**	**446**	**258**	**456**	**261**	**420**	**270**	**449**	**247**	**363**	**245**	**375**	**262**	**356**	**231**	**375**	**241**	**349**	**245**



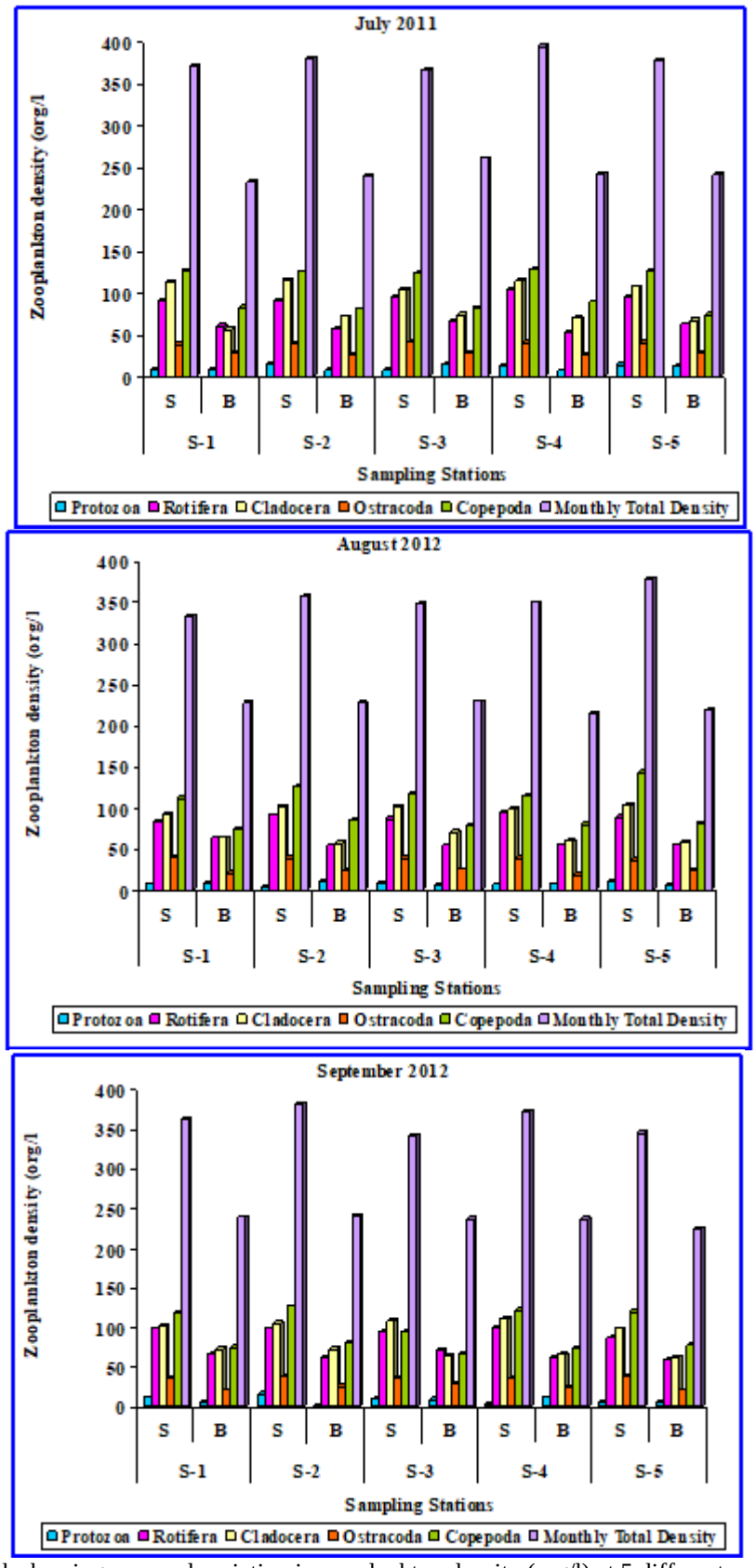


Graph 3 (A, B, C): Graph showing seasonal variation in zooplankton density (org/l) at 5 different sampling stations of river Narmada (April 2012 to June 2012)

Table 4: Seasonal variation in Zooplankton density (org/l) at 5 different sampling stations of river Narmada (July 2012 – Sept. 2012)

Zooplankton	July 2012										August 2012										September 2012									
	S-1		S-2		S-3		S-4		S-5		S-1		S-2		S-3		S-4		S-5		S-1		S-2		S-3		S-4		S-5	
Date	10th		11th		12th		13th		14th		10th		11th		12th		13th		14th		10th		11th		12th		13th		14th	
PROTOZOA	**S**	**B**	**S**	**B**	**S**	**B**	**S**	**B**	**S**	**B**	**S**	**B**	**S**	**B**	**S**	**B**	**S**	**B**	**S**	**B**	**S**	**B**	**S**	**B**	**S**	**B**	**S**	**B**	**S**	**B**
Amoeba	2	3	1	2	2	-	2	2	3	-	3	-	-	2	-	3	3	2	2	-	4	2	3	2	3	2	4	1	3	-
Paramecium	3	-	5	-	2	-	-	-	4	6	1	4	1	2	2	-	3	-	-	3	2	2	5	-	2	4	-	5	-	-
Vorticella	4	8	4	5	8	5	3	2	-	5	2	4	2	6	5	2	-	4	8	2	5	2	8	-	4	2	-	5	2	6
Total	**9**	**11**	**10**	**7**	**12**	**5**	**5**	**4**	**7**	**11**	**6**	**8**	**3**	**10**	**7**	**5**	**6**	**6**	**10**	**5**	**11**	**6**	**16**	**2**	**9**	**8**	**4**	**11**	**5**	**6**
ROTIFERA																														
Branchionus species	36	25	39	28	39	18	36	20	34	18	34	26	38	24	34	15	35	18	35	20	38	22	40	26	38	20	36	20	34	22
Asplanchna species	28	20	26	18	26	20	27	20	22	14	23	16	25	16	24	18	28	20	24	18	28	26	24	16	32	26	30	18	24	17
Keratella	32	40	32	20	32	18	35	28	28	20	26	20	27	14	27	20	30	15	28	15	32	18	34	20	24	25	34	24	28	19
Total	**96**	**75**	**97**	**66**	**97**	**56**	**98**	**68**	**84**	**52**	**83**	**62**	**90**	**54**	**85**	**53**	**93**	**53**	**87**	**53**	**98**	**66**	**98**	**62**	**94**	**71**	**100**	**62**	**86**	**58**
CLADOCERA																														
Daphnia	38	24	40	25	40	24	40	24	36	25	37	26	40	20	36	24	38	16	38	24	39	26	38	20	34	26	38	20	38	20
Eurycerus	29	20	30	15	30	15	27	15	26	18	25	15	26	18	28	20	26	18	28	15	27	20	30	24	35	20	34	20	25	14
Diaphanosoma	34	18	36	24	34	27	40	27	36	23	30	22	34	18	36	25	34	25	36	18	35	26	36	28	39	18	39	26	34	28
Total	**101**	**62**	**106**	**64**	**104**	**66**	**107**	**66**	**98**	**66**	**92**	**63**	**100**	**56**	**100**	**69**	**98**	**59**	**102**	**57**	**101**	**72**	**104**	**72**	**108**	**64**	**111**	**66**	**97**	**62**
OSTRACODA																														
Cypris	38	26	40	28	34	29	38	28	35	20	39	20	38	22	38	24	38	18	36	22	35	20	38	25	36	28	36	24	38	20
Total	**38**	**26**	**40**	**28**	**34**	**29**	**38**	**28**	**35**	**20**	**39**	**20**	**38**	**22**	**38**	**24**	**38**	**18**	**36**	**22**	**35**	**20**	**38**	**25**	**36**	**28**	**36**	**24**	**38**	**20**
COPEPODA																														
Diaptomus	29	18	33	17	30	24	28	14	26	18	27	14	32	18	28	15	22	17	38	24	27	18	32	16	30	24	28	20	28	16

Cyclops	40	28	44	25	45	26	40	26	44	28	38	26	39	26	44	26	44	25	42	24	42	24	40	26	40	25	42	24	42	24
Nauplius larvae	22	16	24	20	20	18	17	12	25	18	24	18	28	20	24	18	27	17	28	12	22	18	24	20	24	16	28	17	27	18
Mesocyclops	27	20	30	24	28	15	14	10	28	24	22	15	26	20	20	18	20	19	34	20	27	14	30	18	-	-	23	12	22	10
Total	**118**	**82**	**131**	**86**	**123**	**83**	**99**	**62**	**123**	**88**	**111**	**73**	**125**	**84**	**116**	**77**	**113**	**78**	**142**	**80**	**118**	**74**	**126**	**80**	**94**	**65**	**121**	**73**	**119**	**78**
Monthly Total Density	**362**	**256**	**384**	**251**	**370**	**239**	**347**	**228**	**347**	**237**	**331**	**226**	**356**	**226**	**346**	**228**	**348**	**214**	**377**	**217**	**363**	**238**	**382**	**241**	**341**	**236**	**372**	**236**	**345**	**224**



Graph 4(A,B,C): Graph showing seasonal variation in zooplankton density (org/l) at 5 different sampling stations of river Narmada (July 2012 to Sept 2012)