
Chapter 05: Plankton

Chapter – 05

Plankton

5.1 INTRODUCTION

Plankton is the chief food resource of fishes. The term ’’plankton’’ is derived from the Greek word ‘’plankton’’ which means ‘’wanderer’’ (mostly microscopic) in the oceans, rivers, lakes, reservoirs, ponds and other bodies of water. The planktons have variously grouped depending on their size and nature stated by Gochhait and Nayak (1990c). The plankton animals are known as zooplankton and plankton plants are known as phytoplankton (APHA, 2008). The energy flows in an aquatic ecosystem from primary producer of phytoplankton to the consumer of zooplankton through the food chain. Analysis of the physico-chemical parameters like temperature, pH, DO, free CO_2, alkalinity, hardness, salinity, nitrate, phosphate serve as a bases for the biological productivity of any aquatic environment (Nag and Gupta , 2014). There is an interrelationship between the physico-chemical parameters of natural water bodies, plankton population and their seasonal variation. The productivity of the natural water bodies depends on the physico-chemical parameters of the aquatic ecosystem. The maximum production is obtained when the physico-chemical qualities remain in optimum level (Pathak and Khan, 2013). Plankton is minute pelagic organism that drift and float passively with the current in a sea, lake, river and other water body.

In ecological point of view, zooplankton influences all the functional aspects of an aquatic ecosystem such as food chains, food webs, energy flow and cycling of matter (Sinha et al., 2002). The plankton plants are as unicellular, colonial and filament forms as stated by Krupke et al., (2014). The present study was made to observe the plankton diversity and their seasonal variation to understand the ecological health of the ponds water bodies.

5.2 MATERIALS AND METHODS

Zooplankton and phytoplankton are collected, preserved and identified, Jhingran (1975), Anand (1980), Adoni et al., (1985) and APHA (2008).

During winter, summer, monsoon and post-monsoon period the surface water sample has been collected in the morning between 8 a. m. to 9 a. m. The planktons were collected by plankton net of standard bolting silk cloth no. 25 (mesh size 64 micrometre) for different stations from 100 litre water sample using by a plastic bucket of 10 litre capacities. All the filtered content was then transferred to 100 ml glass container. Finally the planktons were preserved in 4% of formalin solution and few drops of glycerine added to it. The sample was thereafter taken to the laboratory for qualitative and quantitative analysis. Supernatant plankton was removed from free water and sedimentary plankton was counted by Sedge wick rafter type counting cell (1 ml capacity) and then the planktons were identified under compound microscope using keys books, literature of Smith (1950), and monographs of Edmondson (1959), Needham and Needham (1978), Battish (1992), Persson et al., (1998), Sharma and Pandey (1998) and Desikachary (1959), Philipose (1960), Anand (1980), Turner (1982), Adoni et al., (1985) Ling and Tyler (1986), APHA (2008) and with the help of experts of Vidyasagar University, West Bengal, India. The planktons were identified as per standard methodology recommended by Fritsch (1931) and Jana (1973).

Plankton

Microscope

Photo plate no. III

Laboratory work
(Plankton identification)

Analysis of plankton on seasonal basis Gäärder and Grän (1927)

Counting and calculation in detail

Sedimentary planktons ware counted by Sedge wick rafter counting cell which provides a known volume and area of the counting cell is 50 × 20 mm with 1 mm depth to hold 1 ml of the sample under a cover slip. Before placing the sample of the counting cell, it was well shaken for homogeneous mixture. After shaking the sample of 1 ml was quickly drawn with the help of a pipette and poured the plankton counting cell. The entire organism counted and the data represented in the text were average value of counting. The planktons were identified as per species distribution and tabulated accordingly. The planktons were done by using Microscope (Model- ZEISS AX10) fitted with a Cannon camera (Model A590IS).

$$\text{Nos. of plankton/l} = \frac{\text{Nos..of plankton per ml of concentrated} \times \text{Total vol. of plankton concentrate}}{\text{Vol.of original water filtered in litres}}$$

(Nos.of plankton / l = Numbers of plankton per litre; Vol.= Volume)

Identification of plankton was done under microscope following books, keys and literature of Smith (1950), Desikachary (1959), Philipose (1960), Anand (1980), Turner (1982), Ling and Tylor (1986), Persson (1998) and with the help of experts of Vidyasagar University, West Bengal, India.

Community analysis (Gupta and Banerjee, 2012a)

Plankton community analysis has been done by using the indices like species richness, Shannon-Weaver diversity index, dominance index. Several statistical approaches were adopted as suggested by Shannon-Weaver index, 1963; Margalef's index, 1968; Dominance index, 1996 applying the following formula for the said purpose and counting was made and the data represent in the text were mean values of counting. The planktons were identified species wise and tabulated accordingly as per report of Edmondson (1974).

Shannon – Weaver index (H') of general biodiversity

Species diversity indices (H') were calculated using C. E. Shannon-Weaver, 1994 formula.

The Shannon-Weaver diversity indices to explain the diversity of plankton. It is calculated from the proportional abundance of pi of each species (abundance of the species/total abundances, noted here as $pi = ni / N$

$H' = \sum (ni / N)$

Where ni = Total number of individuals of each species here each group.

N = Total number of individuals of all species here all groups.

Berger Parker index of Dominance (C): $C = \sum (ni / N)^2$

Where ni= Total number of individuals of each species here each group;

N = Total number of individuals of all species here all groups;

Evenness index (e): $e = H' / \log S$

Where H' = Shannon-Weaver Index,

S = number of species;

Margalef Species richness index (R): $R = S – 1/ \text{In}\ (n)$

Where S = number of species

N = total number of individuals observed in the sample

Simpson's Index of dominance and probability: $D=1-\left(\frac{\sum n(n-1)}{N(N-1)}\right)$

Where, n = the total number of organism of a particular species
N = the total number of organisms of all species

Statistical Analysis

The statistical analysis of plankton availability, dominance, diversity, richness index has been done using with the help of Stat plus 2009 software and Microsoft Excel Data Analysis (2007).

5. 3: RESULTS

Zooplankton density and diversity of cultural ponds (Pl.-IV)

Six major groups like Rotifera, Copepoda, Cladocera, Protozoa, Ostracoda and Amphipoda represented the zooplankton population of the study water body showing in (Table-4 to 7). In this natural water body, Copepoda was present and was the dominant group only. Copepodas were abundant in the monsoon season than other seasons.

Several zooplankton species are served as (Ahmad et al., 2011). Data obtained from the study indicates that a total nos. of 31 zooplankton species were identified and recorded comprising 10 species of Rotifera, 6 species of Copepoda, 3 species of Protozoa, 2 species of Ostracoda, 1 species of Amphipoda and 9 species of Cladocera. Total zooplankton population was contributed by Rotifera (21.67%), Copepoda (33.78%), Protozoa (11.91%), Ostracoda (8.05%), Amphipoda (1.14%) and Cladocera (23.45%) in first year, November, 2014 to October, 2015 in (Table-4). In second year of November, 2015 to October, 2016, it was observed that total nos. of 31 zooplankton species were identified and recorded comprising 10 species of Rotifera, 6 species of Copepoda, 3 species of Protozoa, 2 species of Ostracoda, 1 species of Amphipoda and 9 species of Cladocera. Total zooplankton population was contributed by Rotifera (29.17%), Copepoda (41.67%), Protozoa (9.72%), Ostracoda (6.32%), Amphipoda (0.86%) and Cladocera (12.26%) in second annual cycle in (Table-5). It was counted 1578 and 2088 numbers of zooplankton in two years respectively during the study.

A distinct seasonal composition has been observed. *Brachionus* sp., *Asplanchna* sp., *Keratella* sp., *Filinia* sp., *Anuraeopsis* sp. under Rotifera was abundant. Among Copepoda *Nauplii*, *Diaptomus* sp., *Paracyclops* sp., *Microcyclops* sp., *Eucyclops* sp., *Paracyclops* sp. under Copepoda was rich in number. *Daphnia* sp., *Ceriodaphnia* sp., *Bosmina* sp., *Moina* sp., *Alona* sp., *Chydonus* sp. under Cladocera; *Amoeba* sp., *Difflugia* sp., *Arcella* sp. under Protozoa; *Cypris* sp., *Cyprinotus* sp. under Ostracoda; *Hyperia* sp. under Amphipoda group were the dominant species.

SPECIES ABUNDANT OF ZOOPLANKTON DURING STUDY PERIOD

1. *Mesocyclops hyalinus*

2.*Nauplii* sp

3. *Diaptomus pallidus*

4.*Cyclops* sp.

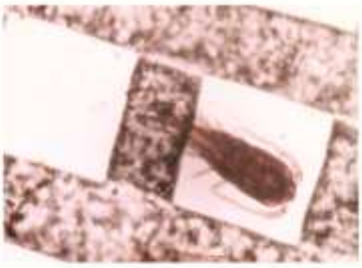
5.*Cyclops* sp.

6. *Microcyclops* sp.

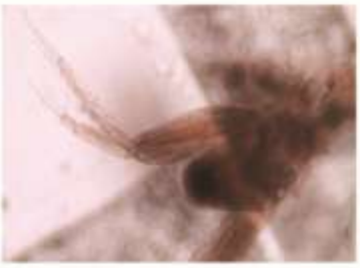
7. *Crustacean artemia*

8. *Mesocyclops* sp.

9. *Diaphanocoma* sp.



10. *Nauplii* sp



11. *Brachionus bideniata*

12. *Cypris* sp.

13. *Diaptomus leptopus (Nauplii)*

Photo plate no. IV

Table – 4

Monthly variations in zooplankton classes (Nos./L) in culture ponds

Zooplankton abundance (Nos./Litres) in 100 litre volume of water sample during the study period from November, 2014 to October, 2015

Months	**Availability of Zooplanktonic Groups (Nos./L)**						
	Rotifera	**Copepoda**	**Cladocera**	**Protozoa**	**Ostracoda**	**Amphipoda**	**Total**
Nov., 2014	46	95	37	22	20	0	220
Dec., 2014	59	19	39	13	21	0	151
Jan., 2015	32	47	110	8	27	0	224
Feb., 2015	40	42	39	3	10	0	134
Mar, 2015	23	7	16	17	4	5	72
April, 2015	35	34	28	9	4	6	116
May., 2015	15	86	18	15	10	0	144
June, 2015	30	65	39	19	9	7	169
July, 2015	10	49	9	16	5	0	89
Aug., 2015	14	38	10	25	5	0	92
Sept., 2015	31	26	15	20	9	0	101
Oct., 2015	7	25	10	21	3	0	66
TOTAL	**342**	**533**	**370**	**188**	**127**	**18**	**1578**
Percentage	**21.67%**	**33.78%**	**23.45%**	**11.91%**	**8.05%**	**1.14%**	**100%**

Table – 5

Monthly variations in zooplankton classes (Nos./L) in culture ponds

Zooplankton abundance (Nos. /Litres) in 100 litre volume of water sample during the study period from November, 2015 to October, 2016

Months	**Availability of Zooplanktonic Groups (Nos./L)**						
	Rotifera	**Copepoda**	**Cladocera**	**Protozoa**	**Ostracoda**	**Amphipoda**	**Total**
Nov., 2015	35	104	24	22	11	0	196
Dec., 2015	83	28	34	18	17	0	180
Jan., 2016	37	39	34	14	18	0	142
Feb., 2016	58	54	22	7	13	0	154
Mar, 2016	91	34	12	14	13	2	166
April, 2016	55	71	51	19	8	9	213
May., 2016	102	139	24	23	14	0	302
June, 2016	38	98	20	15	10	7	188
July, 2016	29	85	7	6	3	0	130
Aug., 2016	45	63	9	23	3	0	143
Sept., 2016	20	69	9	17	18	0	133
Oct., 2016	16	86	10	25	4	0	141
TOTAL	**609**	**870**	**256**	**203**	**132**	**18**	**2088**
Percentage	**29.17%**	**41.67%**	**12.26%**	**9.72%**	**6.32%**	**0.86%**	**100%**

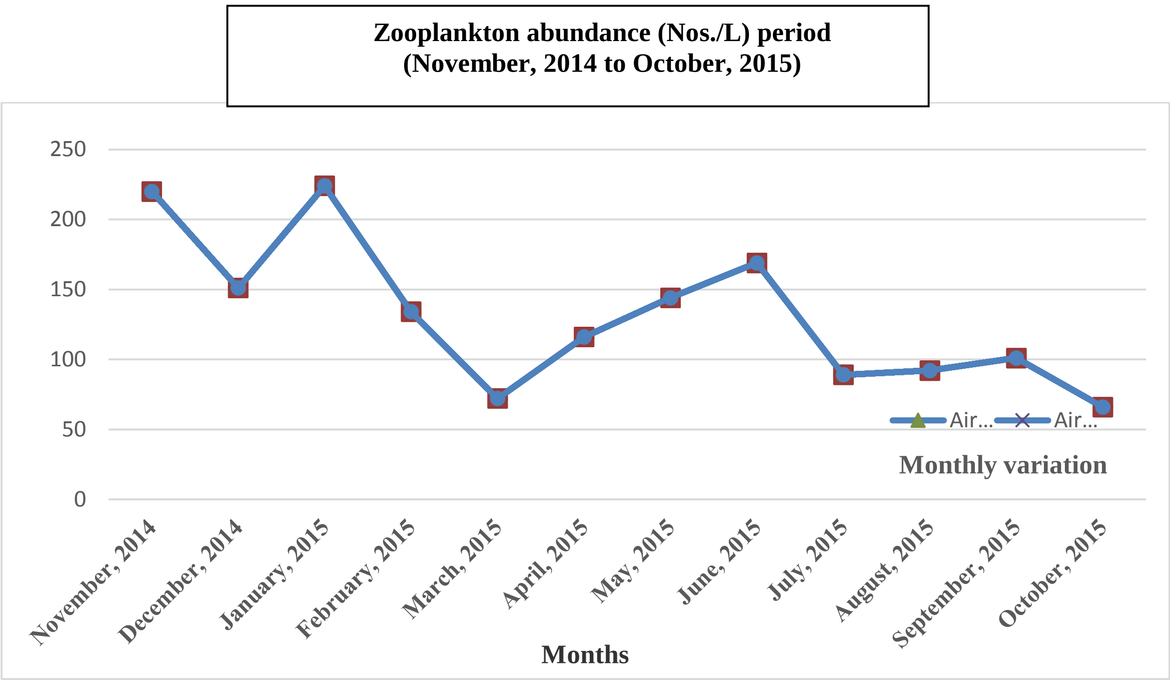


Fig.18: Line diagram showing monthly variations of Zooplankton density in 1st annual cycle

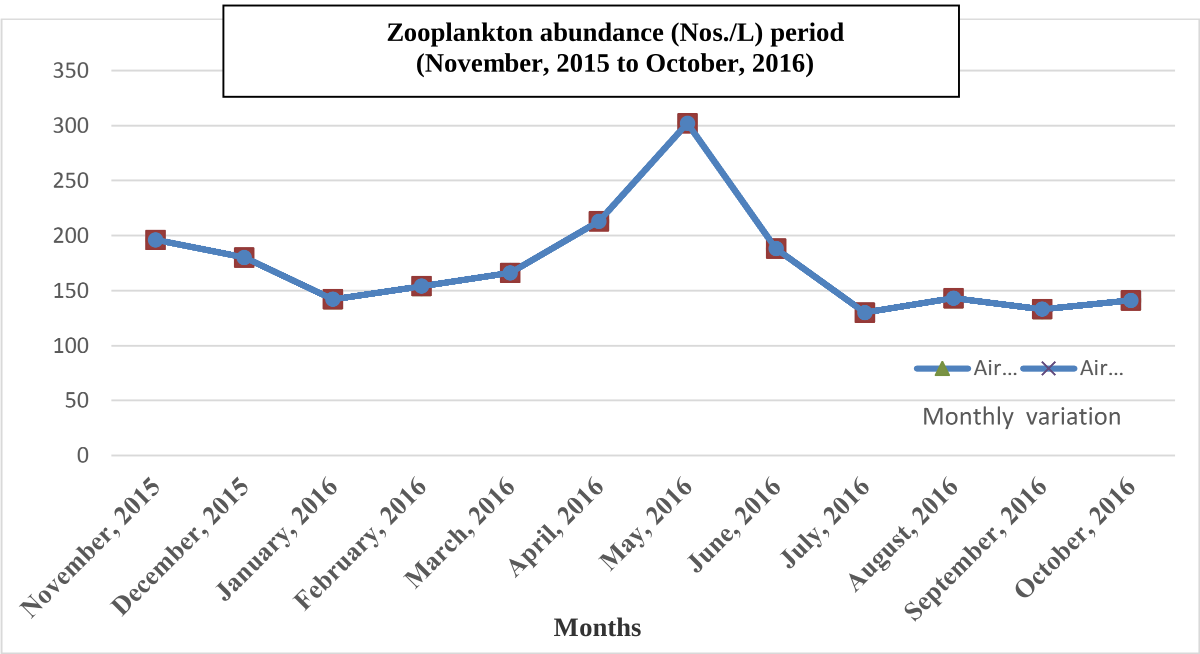


Fig.19: Line diagram showing monthly variations of Zooplankton density in 2nd annual cycle

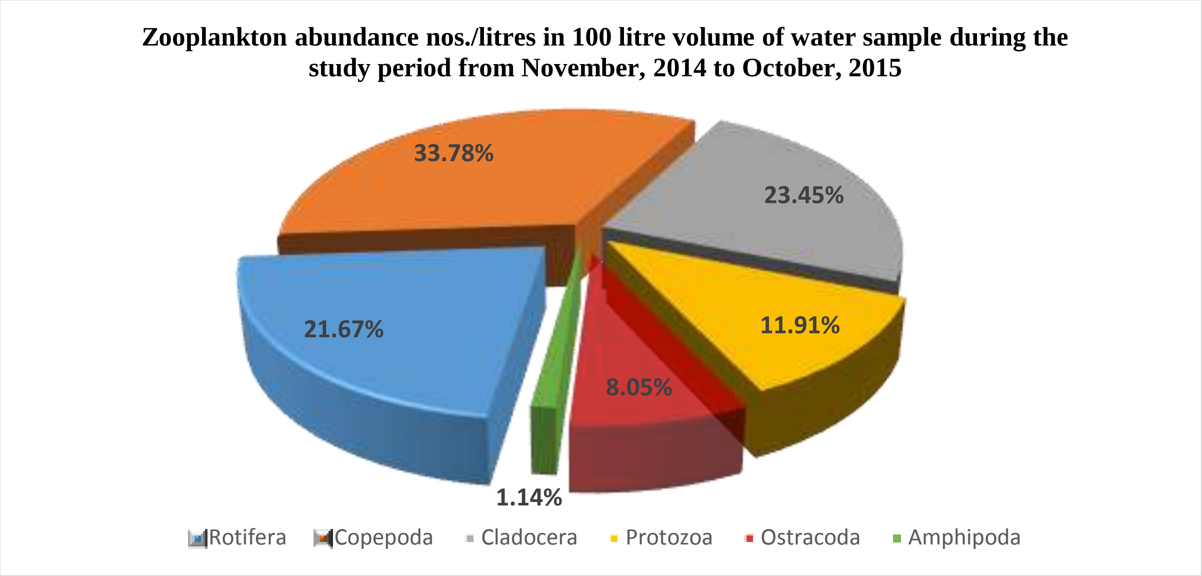


Fig.20: Pie diagram showing relative abundance of zooplanktonic groups in 1st annual cycle

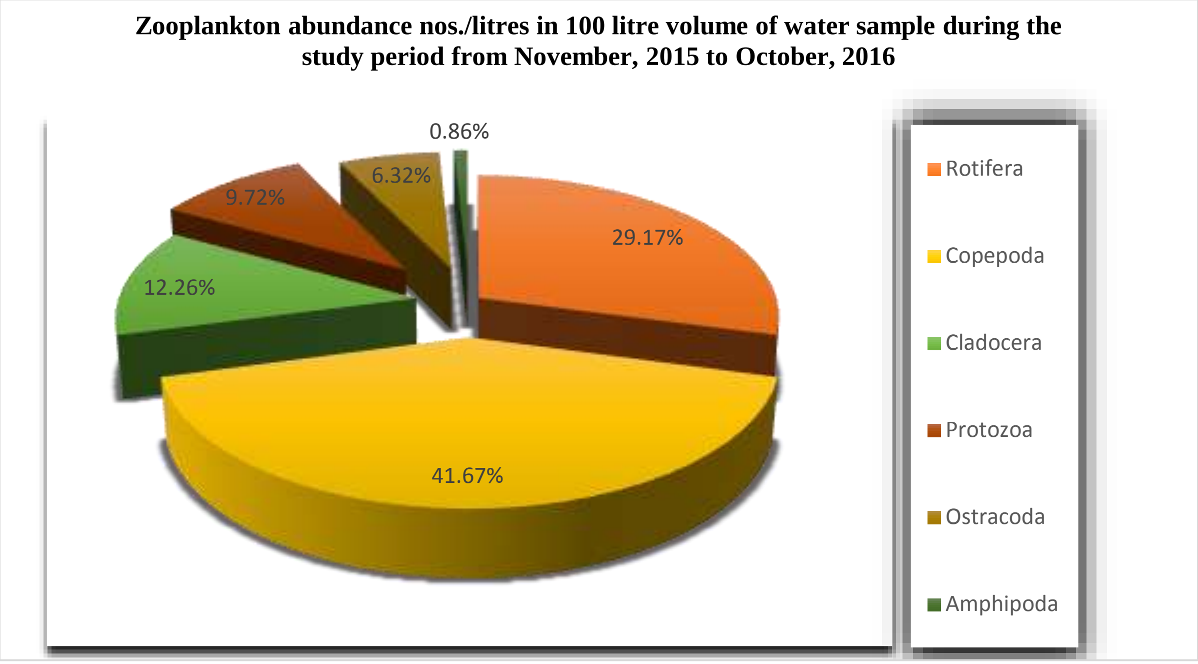


Fig. 21: Pie diagram showing relative abundance of zooplanktonic groups in 2nd annual cycle

Table- 6

Monthly abundance of Zooplankton (Nos./L) from November, 2014 to October, 2015

Sl. No	Months→	Nov' 14	Dec' 14	Jan' 15	Feb' 15	Mar' 15	Apr' 15	May' 15	Jun' 15	Jul' 15	Aug' 15	Sep' 15	Oct' 15
	Taxa ↓												
	Rotifera												
1	*Brachionus caudatus*	2	3	0	0	0	0	0	17	4	1	0	0
2	*Brachionus havanaensis*	3	6	0	18	9	0	0	1	1	1	0	0
3	*Brachionus falcatus*	1	1	0	0	0	0	0	1	0	0	0	1
4	*Asplanchna priodonta*	4	5	18	7	3	15	1	1	1	0	3	1
5	*Asplanchna multiceps*	16	18	0	0	0	4	3	1	1	2	3	0
6	*Keratella quadrata*	4	5	2	6	3	2	1	0	0	1	4	1
7	*Keratella tropica*	4	6	9	8	4	6	2	0	0	1	8	1
8	*Synchaeta oblonga*	2	4	3	1	2	3	5	2	0	3	6	1
9	*Filinia terminalis*	0	0	0	0	2	2	1	0	0	0	0	0
10	*Anuraeopsis fissa*	10	11	0	0	0	3	2	7	3	5	7	2
	TOTAL	**46**	**59**	**32**	**40**	**23**	**35**	**15**	**30**	**10**	**14**	**31**	**7**
	Copepoda												
1	*Nauplii*	18	5	8	7	2	11	9	10	12	13	10	11
2	*Diaptomus denticornis*	13	1	6	3	2	3	17	9	10	4	0	2
3	*Diaptomus pallidus*	10	1	7	3	0	0	14	1	0	0	0	1
4	*Paracyclops fimbriatus*	23	4	7	8	1	11	21	22	7	3	3	5
5	*Microcyclops varicans*	14	2	11	12	2	6	15	12	11	11	8	2
6	*Eucyclops serrulatus*	17	6	8	9	0	3	10	11	9	7	5	4
	TOTAL	**95**	**19**	**47**	**42**	**7**	**34**	**86**	**65**	**49**	**38**	**26**	**25**

Table- 6

Monthly abundance of Zooplankton (Nos./L) from November, 2014 to October, 2015													
Sl. No	**Months→**	**Nov’ 14**	**Dec’ 14**	**Jan’ 15**	**Feb’ 15**	**Mar’ 15**	**Apr’ 15**	**May’ 15**	**Jun’ 15**	**Jul’ 15**	**Aug’ 15**	**Sep’ 15**	**Oct’ 15**
	Taxa ↓												
	Protozoa												
1	*Amoeba proteus*	17	6	5	1	10	5	7	8	10	11	9	14
2	*Difflugia* sp.	5	7	3	2	7	4	8	11	6	14	4	5
3	*Arcella* sp.	0	0	0	0	0	0	0	0	0	0	7	2
	TOTAL	**22**	**13**	**8**	**3**	**17**	**9**	**15**	**19**	**16**	**25**	**20**	**21**
	Ostracoda												
1	*Cypris* sp.	20	0	0	0	1	0	3	4	2	3	0	2
2	*Cyprinotus* sp.	0	21	27	10	3	4	7	5	3	2	9	1
	TOTAL	**20**	**21**	**27**	**10**	**4**	**4**	**10**	**9**	**5**	**5**	**9**	**3**
	Amphipoda												
1	*Hyperia macrocephala*	0	0	0	0	5	6	0	7	0	0	0	0
	TOTAL	**0**	**0**	**0**	**0**	**5**	**6**	**0**	**7**	**0**	**0**	**0**	**0**
	Cladocera												
1	*Daphnia longiremis*	2	2	20	2	1	4	1	3	0	1	1	1
2	*Daphnia ambigua*	4	5	12	5	0	2	2	9	2	3	2	4
3	*Daphnia geleata*	2	2	20	2	0	1	1	1	2	1	2	1
4	*Daphnia pulex*	2	4	13	0	1	1	3	1	0	0	0	0
5	*Cerlodaphnia reticulata*	4	3	22	5	3	6	8	3	1	2	1	0
6	*Bosmina fatalis*	4	4	13	7	4	4	3	12	1	1	3	0
7	*Moina micrura*	0	0	0	0	0	0	0	5	0	1	2	2
8	*Alona affinis*	9	8	10	8	5	6	0	5	0	0	2	1
9	*Chydorus* sp.	10	11	0	10	2	4	0	0	3	1	2	1
	TOTAL	**37**	**39**	**110**	**39**	**16**	**28**	**18**	**39**	**9**	**10**	**15**	**10**

Table - 7

Monthly abundance of Zooplankton (Nos./L) from November, 2015 to October, 2016

Sl. No	Months→	Nov’ 15	Dec’ 15	Jan’ 16	Feb’ 16	Mar’ 16	Apr’ 16	Mar’ 16	Jun’ 16	Jul’ 16	Aug’ 16	Sep’ 16	Oct’ 16
	Taxa ↓												
	Rotifera												
1	*Brachionus caudatus*	7	3	0	0	0	0	0	11	7	5	0	0
2	*Brachionus havanaensis*	2	13	0	14	8	0	0	6	5	0	0	0
3	*Brachionus falcatus*	1	5	0	0	0	0	0	2	0	0	0	0
4	*Asplanchna priodonta*	3	3	4	0	13	11	0	2	3	4	2	1
5	*Asplanchna multiceps*	2	4	9	17	0	12	20	0	3	3	3	1
6	*Keratella quadrata*	4	5	12	0	21	2	16	0	0	0	0	0
7	*Keratella tropica*	3	13	12	11	20	12	17	0	0	2	8	2
8	*Synchaeta oblonga*	3	9	0	2	17	11	18	4	0	4	3	2
9	*Filinia terminalis*	0	13	0	14	12	4	13	6	0	9	2	2
10	*Anuraeopsis fissa*	10	15	0	0	0	3	18	7	11	18	2	8
	TOTAL	**35**	**83**	**37**	**58**	**91**	**55**	**102**	**38**	**29**	**45**	**20**	**16**
	Copepoda												
1	*Nauplii*	40	16	12	18	12	22	42	33	28	28	22	30
2	*Diaptomus denticornis*	13	1	3	2	6	10	21	11	17	9	18	13
3	*Diaptomus pallidus*	5	0	2	7	0	0	23	1	0	0	0	3
4	*Paracyclops fimbriatus*	22	4	11	17	9	24	31	29	19	4	17	15
5	*Microcyclops varicans*	12	3	5	2	7	7	11	13	9	9	12	8
6	*Eucyclops serrulatus*	12	4	6	8	0	8	11	11	12	13	0	17
	TOTAL	**104**	**28**	**39**	**54**	**34**	**71**	**139**	**98**	**85**	**63**	**69**	**86**

Table- 7

Monthly abundance of Zooplankton (Nos./L) from November, 2015 to October, 2016

Sl. No	Months→	Nov' 15	Dec '15	Jan '16	Feb' 16	Mar' 16	Apr' 16	May' 16	Jun' 16	Jul' 16	Aug '16	Sep' 16	Oct' 16
	Taxa ↓												
	Protozoa												
1	*Amoeba proteus*	12	5	3	3	8	7	3	4	3	5	9	11
2	*Difflugia* sp.	10	13	11	4	6	12	20	11	3	18	5	10
3	*Arcella* sp.	0	0	0	0	0	0	0	0	0	0	3	4
	TOTAL	**22**	**18**	**14**	**7**	**14**	**19**	**23**	**15**	**6**	**23**	**17**	**25**
	Ostracoda												
1	*Cypris* sp.	11	0	0	0	3	0	7	8	1	2	0	3
2	*Cyprinotus* sp.	0	17	18	13	10	8	7	2	2	1	18	1
	TOTAL	**11**	**17**	**18**	**13**	**13**	**8**	**14**	**10**	**3**	**3**	**18**	**4**
	Amphipoda												
1	*Hyperia macrocephala*	0	0	0	0	2	9	0	7	0	0	0	0
	TOTAL	**0**	**0**	**0**	**0**	**2**	**9**	**0**	**7**	**0**	**0**	**0**	**0**
	Cladocera												
1	*Daphnia longiremis*	4	8	10	4	1	7	7	2	0	2	2	1
2	*Daphnia ambigua*	2	3	4	3	0	4	5	5	1	1	1	1
3	*Daphnia galleata*	3	3	2	5	0	1	4	1	2	1	1	2
4	*Daphnia pulex*	3	2	9	0	2	7	3	2	0	0	1	0
5	*Cerlodaphnia reticulata*	3	3	3	2	2	4	2	2	1	1	1	0
6	*Bosmina fatalis*	2	3	2	2	1	2	3	3	0	0	1	0
7	*Moina micrura*	0	0	0	0	0	0	0	5	0	2	0	2
8	*Alona affinis*	3	7	4	3	4	16	0	0	1	1	1	3
9	*Chydorus* sp.	4	5	0	3	2	10	0	0	2	1	1	1
	TOTAL	**24**	**34**	**34**	**22**	**12**	**51**	**24**	**20**	**7**	**9**	**9**	**10**

Total Rotifera

This group is represented by 10 species belonging to 12 genera. The occurrence of Rotifera was highest, 59 nos./l out of 151 nos. of total zooplankton in December, 2014 and lowest, 7 nos./l out of total zooplankton 66 in October, 2015 in 1st annual cycle. Whereas highest, number of Rotifera was 102 nos./l out of total zooplankton nos. 302 in May, 2016 and lowest was 16 nos./l out of 141 nos. of total zooplankton in October, 2016 in 2nd annual cycle in (Table, 4 to 7). Among Rotifera, *Brachionus* sp., *Asplanchna* sp., *Keratella* sp., *Synchaeta* sp., *Filinia* sp., *Anuraeopsis* sp. were the dominant genera which were found all over the study period.

Total Copepoda

Among Copepoda *Nauplii* sp., *Diaptomus* sp., *Paracyclops* sp., *Microcyclops* sp., *Eucyclops* sp. was rich in number during the monsoon period and minimum in post-monsoon period under group Copepoda. This group was represented by 6 species belonging to 12 genera. High incidence of Copepoda was recorded in the month of November, 2014, 95 nos./l out of total zooplankton 220 nos./l, while low density was noticed in the month of March, 2015, 7 nos./l out of total zooplankton 72 nos./l in 1st annual cycle. Similarly it was observed that highest number of Copepoda was 139 nos./l out of total zooplankton 302 nos./l in the month of May, 2016 and lowest number was 28 nos./l out of total zooplankton 180 nos./l in the month of December, 2015 in 2nd annual cycle in (Table-4 to 7).

Total Cladocera

In the present study, Cladocera group was occupied by 9 species belonging to 12 genera. The population was highest in number 110 nos./l out of total zooplankton 224 nos./l in the month of January, 2015 and lowest in number 9 nos./l out of total zooplankton 89 nos./l in the month of July, 2015 in 1st annual cycle. On the other hand, in 2nd annual cycle the peak was observed 51 nos./l out of total zooplankton 213 nos./l in April, 2016 but very low number 7 nos./l out of total zooplankton 130 nos./l in July, 2016 in (Table-4 to 7).

Total Protozoa

The highest density 25 nos./l out of total zooplankton 92 nos./l was found in the month of August, 2015 and lowest, 3 nos./l in the month of February, 2015 in 1st annual cycle. Similarly the highest number was 25 nos./l out of total zooplankton 141 nos./l in October, 2016 and lowest number was 6 nos./l out of total zooplankton 130 nos./l in July, 2016 in 2nd annual cycle in (Table-4 to 7). *Arcella* sp., *Amoeba* sp., *Difflugia* sp. were the dominant genera under this group.

Total Ostracoda

Cypris sp. and *Cyprinotus* sp. were the representative of Ostracoda group which was found highest in number, 27 nos./l out of total zooplankton 224 nos./l in January, 2015 and lowest, 3 nos./l out of 66 nos./l in October, 2015 in 1st annual cycle. In 2nd annual cycle, highest number was found 18 nos./l out of total zooplankton 133 nos./l in September, 2016 and lowest number, 3 nos./l out of total zooplankton 143 nos./l in August, 2016 in (Table-4 to 7).

Total Amphipoda

Only one species is *Hyperia macrocephala*. The highest number was 7 nos./l out of 169 nos./l in June, 2015 and lowest number was 5 nos./l out of total zooplankton 72 nos./l in March, 2015 in 1st annual cycle. In 2nd annual cycle the peak value was 9 nos./l out of total zooplankton 213 nos./l in April, 2016 while lower value was 2 nos./l out of total zooplankton 166 nos./l in March, 2016 in (Table-4 to 7).

Phytoplankton density and diversity of cultural ponds (Pl.-V)

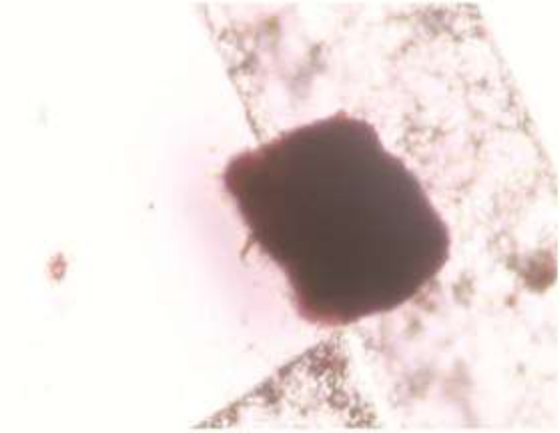
The total seven classes of phytoplankton comprises 25 species were identified and recorded comprising Chlorophyceae 7 species, Dinophyceae 2 species, Xanthophyceae 1 species, Bacillariophyceae 5 species, Charophyceae 3 species, Tribophyceae 2 species and Cyanophyceae 4 species.

The total phytoplankton population was contributed by Chlorophyceae (44.60%), Bacillariophyceae (19.16%), Cyanophyceae (19.87%), Charophyceae (5.46%), Tribophyceae (3.77%), Xanthophyceae (3.98%) and Dinophyceae (3.16%) in 1st year of November, 2014 to October, 2015 in (Table-8). In 2nd year of November, 2015 to October, 2016 it was observed that total nos. of 25 phytoplankton species were identified and recorded comprising 7 species of Chlorophyceae, 2 species of Dinopyceae, 1 species of Xanthophyceae, 5 species of Bacillariophyceae, 3 species of Charophyceae, 2 species of Tribophyceae and 4 species of Cyanophyceae. The total phytoplankton population was contributed by Chlorophyceae, 39.67%, Bacillariophyceae, 20.03%, Cyanophyceae, 18.06%, Charophyceae, 8.41%, Tribophyceae, 5.24%, Xanthophyceae, 4.08% and Dinophyceae, 4.51% in 2nd annual cycle in (Table-9). It was counted 1832 and 2082 number of phytoplankton in two years respectively during the study.

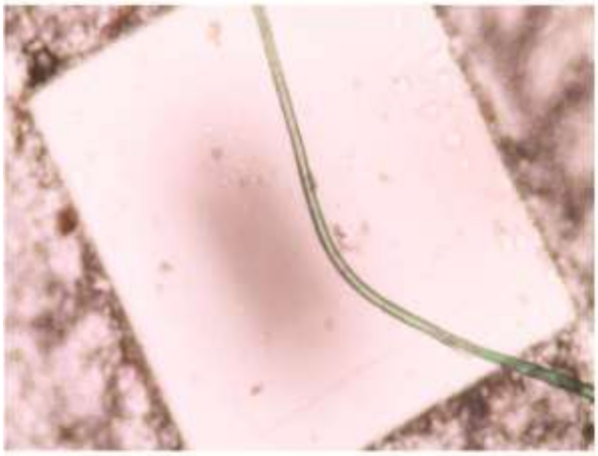
Different seasonal compositions have been observed. Among phytoplankton, Chlorophyceae is the dominant class and less number is the Xanthophyceae. Temperature is a key factor for the occurrence of phytoplankton as is observed in the present study period and reported by Jana (1973) and Chari (1980). In the present investigation it was observed that the phytoplankton temperatures have a positive correlation with temperature where maximum number of phytoplankton is observed during summer season and minimum during the monsoon season.

SPECIES ABUNDANT OF THE PHYTOPLANKTON DURING STUDY PERIOD

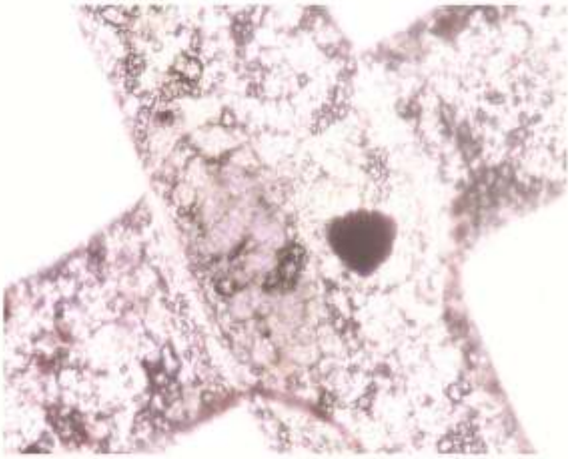
Computer work



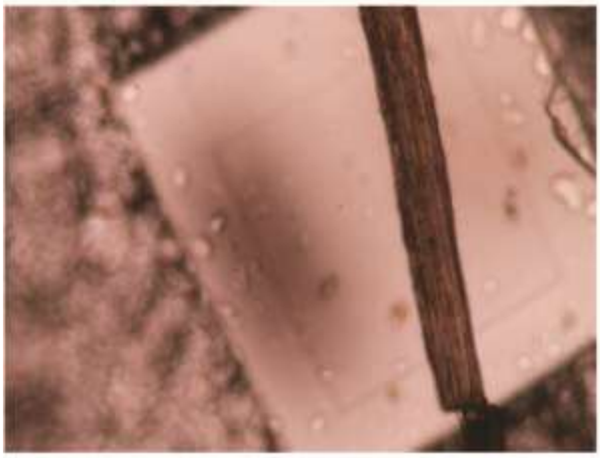
1. *Volvox globator*



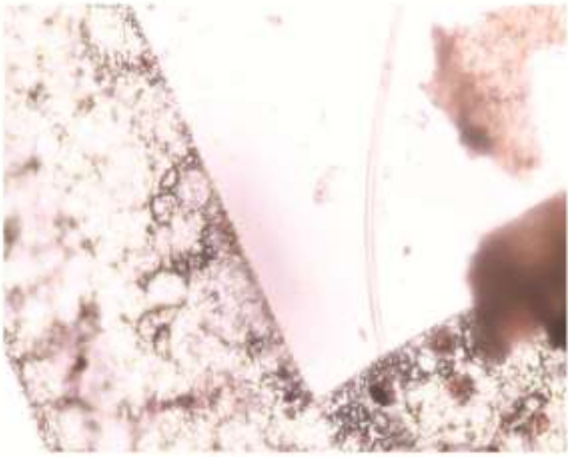
2. *Anabaena cricinalis*



3. *Botryococcus braunii*



4. *Synedraulna* sp



5. *Vouchera* sp.

Photo plate no. V

Table -8

Monthly variation in phytoplankton classes (Nos./L) in culture ponds

Phytoplankton abundance (Nos./Litres) in 100 Litre volume of water sample during the study period from November, 2014 - October, 2015 & November, 2015 - October, 2016

Months	Chlorophy-ceae	Bacillariophy-ceae	Cyanophy-ceae	Charophy-ceae	Tribophy-ceae	Xanthophy-ceae	Dinophy-ceae	Nos./ Litre
Nov., 2014	90	21	30	9	5	0	7	162
Dec., 2014	95	29	44	6	8	19	0	201
Jan., 2015	53	21	39	7	10	13	12	155
Feb., 2015	71	33	17	20	2	8	5	156
Mar, 2015	96	55	18	21	15	0	11	216
April, 2015	78	39	24	2	5	0	0	148
May., 2015	65	47	19	1	6	6	4	148
June, 2015	52	44	39	5	7	7	12	166
July, 2015	65	13	39	2	5	3	0	127
Aug., 2015	32	33	15	3	0	0	0	83
Sept., 2015	45	10	34	9	3	17	4	122
Oct., 2015	75	6	46	15	3	0	3	148
TOTAL	**817**	**351**	**364**	**100**	**69**	**73**	**58**	**1832**
Percent value (%)	**44.60%**	**19.16%**	**19.87%**	**5.46%**	**3.77%**	**3.98%**	**3.16%**	**100 %**

Table -9

Monthly variation in phytoplankton classes (Nos./L) in culture ponds

Months	Chlorophy-ceae	Bacillariophy-ceae	Cyanophy-ceae	Charophy-ceae	Tribophy-ceae	Xanthophy-ceae	Dinophy-ceae	Nos./ Litre
Nov., 2015	101	29	42	23	10	0	17	222
Dec., 2015	104	39	53	13	7	17	0	233
Jan., 2016	76	38	44	18	18	7	32	233
Feb., 2016	60	53	18	34	6	8	13	192
Mar, 2016	95	40	10	34	10	0	6	195
April, 2016	100	48	24	8	12	17	9	218
May., 2016	54	49	33	0	8	13	3	160
June, 2016	51	42	30	14	13	4	5	159
July, 2016	50	12	33	4	13	3	0	115
Aug., 2016	35	33	18	4	2	0	0	92
Sept., 2016	57	19	39	12	8	16	7	158
Oct., 2016	43	15	32	11	2	0	2	105
TOTAL	**826**	**417**	**376**	**175**	**109**	**85**	**94**	**2082**
Percent Value (%)	**39.67%**	**20.03%**	**18.06%**	**8.41%**	**5.24%**	**4.08%**	**4.51%**	**100 %**

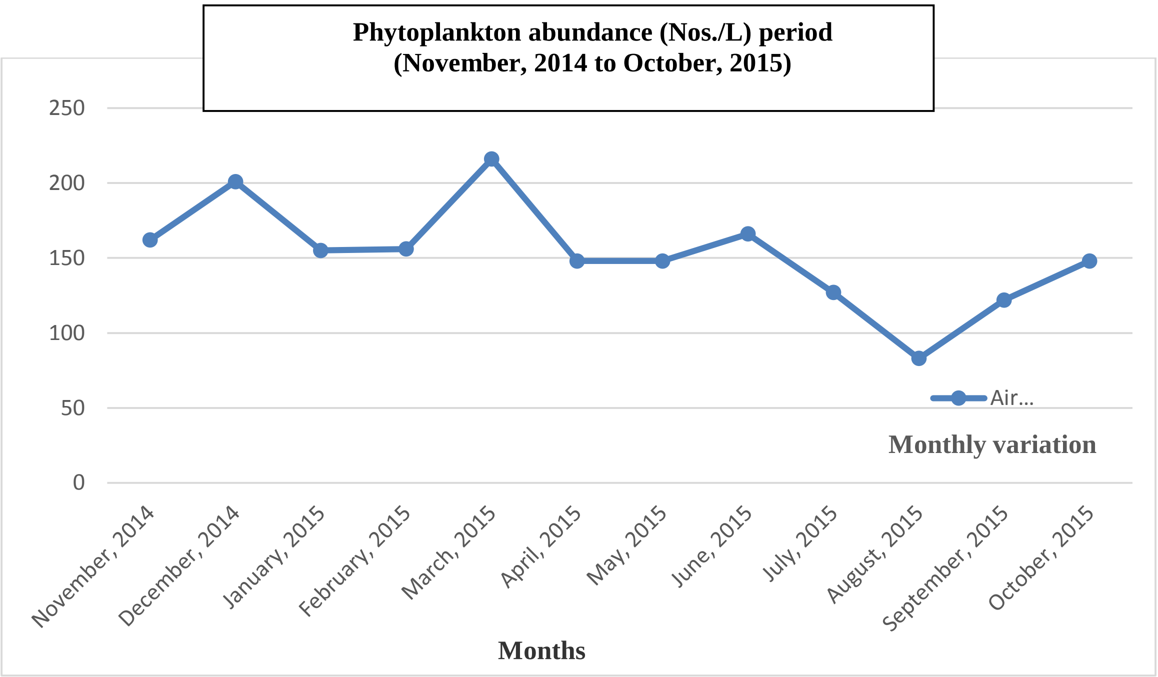


Fig.22: Line diagram showing monthly variations of phytoplankton density in 1st annual cycle

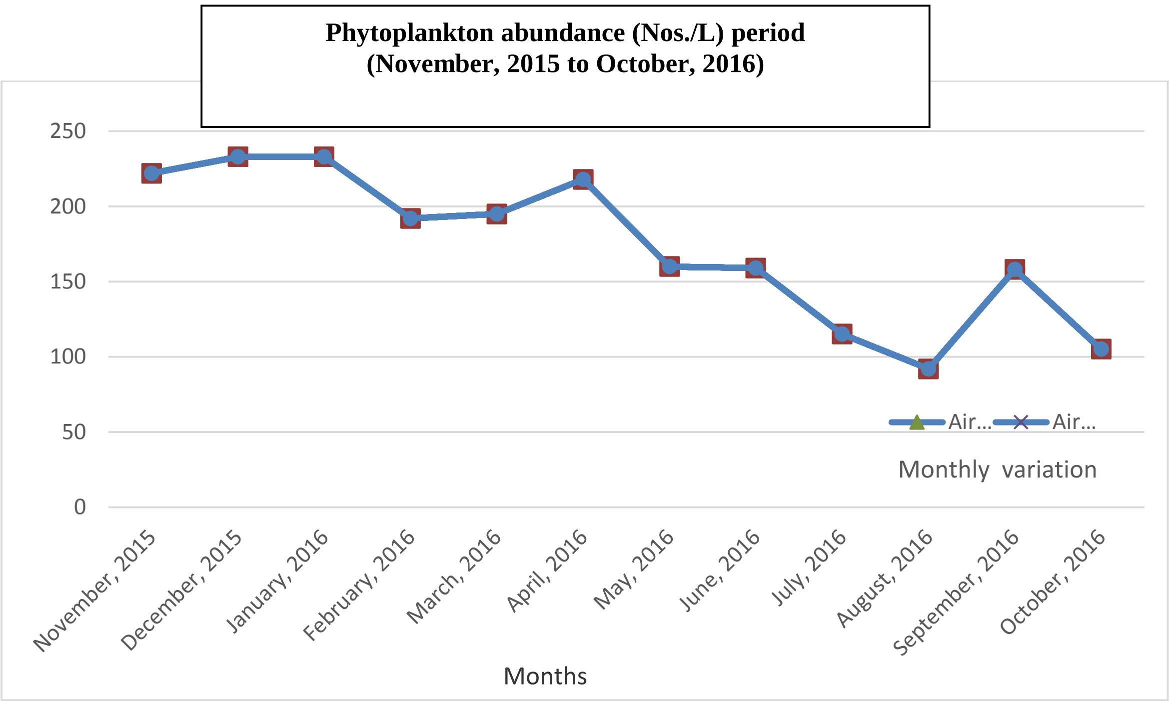


Fig.23: Line diagram showing monthly variations of phytoplankton density in 2nd annual cycle

Phytoplankton abundance nos./litres 100 litre volume of water sample during the study period from November, 2014 - October, 2015

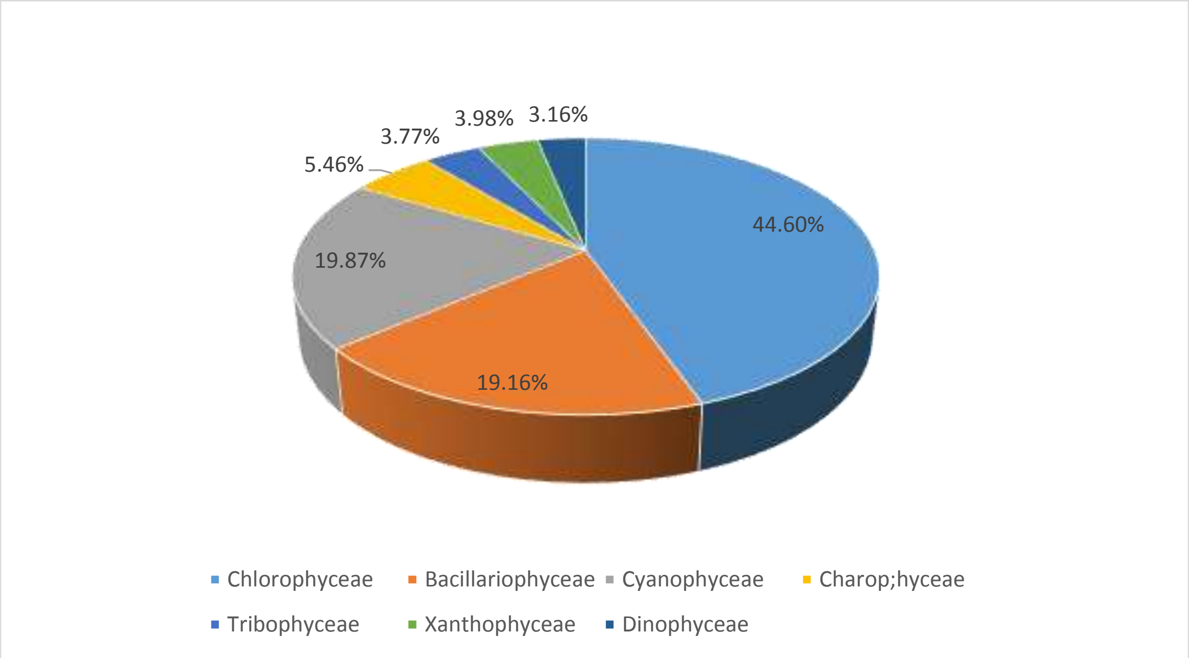


Fig. 24: Pie diagram showing percentage contribution of Phytoplankton population in 1st annual cycle

Phytoplankton abundance nos./litres 100 litre volume of water sample during the study period from November, 2015 - October, 2016

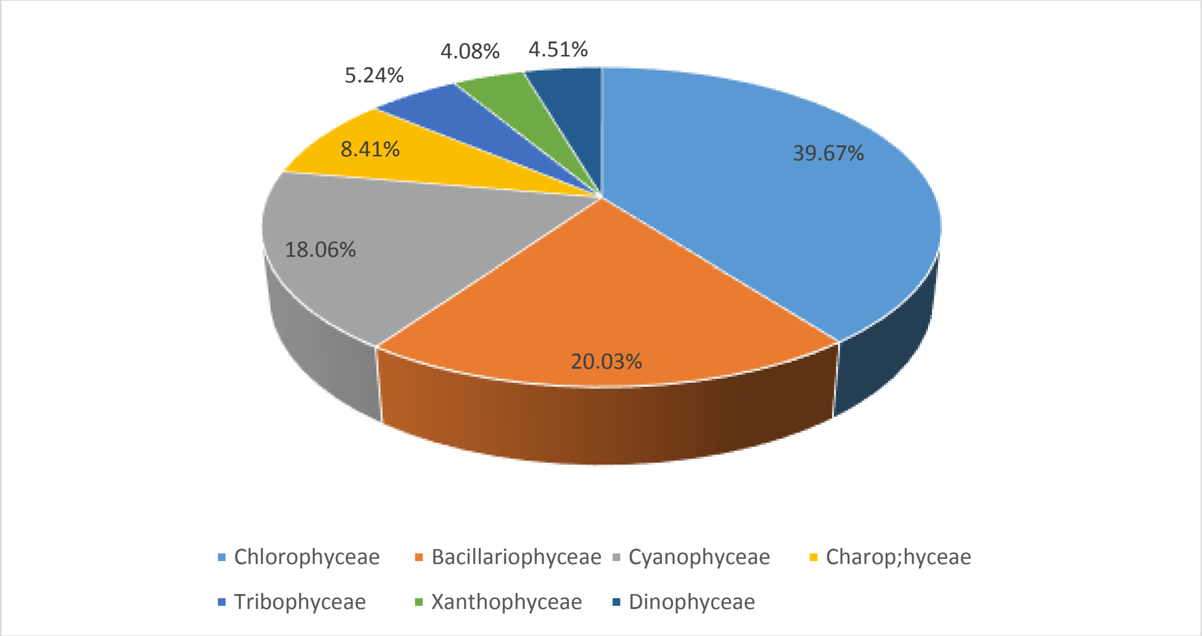


Fig. 25: Pie diagram showing percentage contribution of Phytoplankton population in 2nd annual cycle

Table- 10

Monthly abundance of Phytoplankton (Nos./L) from November, 2014 to October, 2015													
Sl. No	**Taxa ↓**	**Nov' 14**	**Dec' 14**	**Jan' 15**	**Feb' 15**	**Mar' 15**	**Apr' 15**	**May' 15**	**Jun' 15**	**Jul' 15**	**Aug' 15**	**Sep' 15**	**Oct' 15**
	Chlorophyceae												
1	*Oedogonium Coreateanatum*	12	10	8	16	17	13	12	17	9	6	6	15
2	*Chlorella vulgaris*	11	9	0	21	8	10	12	9	9	7	8	13
3	*Schizochlamys* sp.	17	13	7	6	21	18	22	19	17	7	0	18
4	*Asterococcus* sp.	11	14	9	15	16	16	0	0	10	3	7	8
5	*Volvox globator* sp.	14	18	16	0	0	0	0	0	0	3	4	5
6	*Eudarina* sp.	8	10	2	0	11	13	0	0	0	0	8	0
7	*Botryococcus* sp.	17	21	11	13	23	8	19	7	20	6	12	16
	TOTAL	**90**	**95**	**53**	**71**	**96**	**78**	**65**	**52**	**65**	**32**	**45**	**75**
	Dinophyceae												
1	*Ceratium* sp.	3	0	5	3	11	0	4	12	0	0	1	2
2	*Gymnodinium* sp.	4	0	7	2	0	0	0	0	0	0	3	1
	TOTAL	**7**	**0**	**12**	**5**	**11**	**0**	**4**	**12**	**0**	**0**	**4**	**3**
	Xanthophyceae												
1	*Vaucheria* sp	0	19	13	8	0	0	6	7	3	0	17	0
	TOTAL	**0**	**19**	**13**	**8**	**0**	**0**	**6**	**7**	**3**	**0**	**17**	**0**
	Bacillariophyceae												
1	*Nitzschla* sp.	5	3	9	10	13	11	17	11	2	12	4	4
2	*Diatoma vulgare*	7	6	8	11	0	16	22	9	2	10	2	1
3	*Synedra ulna*	1	3	2	3	15	6	8	3	0	0	2	1
4	*Navicula* sp.	7	14	2	4	16	4	0	12	9	11	2	0
5	*Gyrosigma* sp.	1	3	0	5	11	2	0	9	0	0	0	0
	TOTAL	**21**	**29**	**21**	**33**	**55**	**39**	**47**	**44**	**13**	**33**	**10**	**6**

Table- 10

Monthly abundance of Phytoplankton (Nos./L) from November, 2014 to October, 2015

Sl. No	Months→	Nov' 14	Dec' 14	Jan' 15	Feb' 15	Mar' 15	Apr' 15	May' 15	Jun' 15	Jul' 15	Aug' 15	Sep' 15	Oct' 15
	Taxa ↓												
	Charophyceae												
1	*Chara longifolia*	2	0	5	13	7	2	0	2	1	1	4	6
2	*Netrium* sp.	3	0	0	0	9	0	1	0	0	0	5	1
3	*Closterium* sp.	4	6	2	7	5	0	0	3	1	2	0	8
	TOTAL :	**9**	**6**	**7**	**20**	**21**	**2**	**1**	**5**	**2**	**3**	**9**	**15**
	Tribophyceae												
1	*Perone* sp.	4	5	6	1	15	4	2	7	5	0	1	3
2	*Tribonema* sp.	1	3	4	1	0	1	4	0	0	0	2	0
	TOTAL :	**5**	**8**	**10**	**2**	**15**	**5**	**6**	**7**	**5**	**0**	**3**	**3**
	Cyanophyceae												
1	*Microcystis aeruginosa*	7	15	13	0	4	9	5	2	1	0	12	21
2	*Anabaena* sp.	0	0	0	0	0	5	3	10	8	0	3	0
3	*Nostoc* sp.	10	13	9	8	5	0	0	13	15	11	7	9
4	*Oscillatoria* sp.	13	16	17	9	9	10	11	14	15	4	12	16
	TOTAL :	**30**	**44**	**39**	**17**	**18**	**24**	**19**	**39**	**39**	**15**	**34**	**46**

Table - 11

Monthly abundance of Phytoplankton (Nos./L) from November, 2015 to October, 2016

Sl. No	Months→	Nov’ 15	Dec’ 15	Jan’ 16	Feb’ 16	Mar’ 16	Apr’16	May’ 16	Jun’ 16	Jul’ 16	Aug ’16	Sep’ 16	Oct’ 16
	Taxa ↓												
	Chlorophyceae												
1	*Oedogonium coreatematum*	13	17	19	14	18	21	14	15	9	7	11	6
2	*Chlorella vulgaris*	9	7	0	6	11	11	6	6	5	7	8	11
3	*Schizochlamys* sp.	13	18	11	17	20	24	21	19	18	12	0	11
4	*Asterococcus* sp.	14	10	6	10	19	19	0	0	9	3	4	2
5	*Volvox globator*	20	21	20	0	0	0	0	0	0	3	7	2
6	*Eudorina* sp.	15	16	10	0	17	13	0	0	0	0	10	0
7	*Botryococcus* sp.	17	15	10	13	10	12	13	11	9	3	17	11
	TOTAL	**101**	**104**	**76**	**60**	**95**	**100**	**54**	**51**	**50**	**35**	**57**	**43**
	Dinophyceae												
1	*Ceratium* sp.	10	0	21	4	6	9	3	5	0	0	3	1
2	*Gymnodinium* sp.	7	0	11	9	0	0	0	0	0	0	4	1
	TOTAL	**17**	**0**	**32**	**13**	**6**	**9**	**3**	**5**	**0**	**0**	**7**	**2**
	Xanthophyceae												
1	*Vaucheria* sp	0	17	7	8	0	17	13	4	3	0	16	0
	TOTAL	**0**	**17**	**7**	**8**	**0**	**17**	**13**	**4**	**3**	**0**	**16**	**0**
	Bacillariophyceae												
1	*Nitzschia* sp.	8	6	8	9	11	13	10	6	2	4	2	1
2	*Diatoma vulgare*	10	11	13	15	0	21	19	19	7	18	6	5
3	*Synedra ulna*	4	5	4	5	16	14	9	8	0	0	7	5
4	*Navicula* sp.	5	10	3	2	13	0	0	9	3	11	4	0
5	*Gyrosigma* sp.	2	7	10	22	0	0	11	0	0	0	0	4
	TOTAL	**29**	**39**	**38**	**53**	**40**	**48**	**49**	**42**	**12**	**33**	**19**	**15**

Table - 11

Monthly abundance of Phytoplankton (Nos./L) from November, 2015 to October, 2016

Sl. No	**Months→**	**Nov' 15**	**Dec' 15**	**Jan' 16**	**Feb' 16**	**Mar' 16**	**Apr'16**	**May' 16**	**Jun'16**	**Jul' 16**	**Aug '16**	**Sep' 16**	**Oct' 16**
	Taxa ↓												
	Charophyceae												
1	*Chara longifolia*	2	0	12	17	9	8	0	2	1	0	3	7
2	*Netrium* sp.	11	0	0	0	12	0	0	0	0	0	9	0
3	*Closterium* sp.	10	13	6	17	13	0	0	12	3	4	0	4
	TOTAL	**23**	**13**	**18**	**34**	**34**	**8**	**0**	**14**	**4**	**4**	**12**	**11**
	Tribophyceae												
1	*Perone* sp.	8	3	7	1	10	12	1	13	3	0	2	2
2	*Tribonema sp.*	2	4	11	5	0	0	7	0	10	2	6	0
	TOTAL	**10**	**7**	**18**	**6**	**10**	**12**	**8**	**13**	**13**	**2**	**8**	**2**
	Cyanophyceae												
1	*Microcystis aeruginosa*	17	21	20	0	3	7	16	9	0	0	11	12
2	*Anabaena* sp.	0	0	0	0	0	7	7	5	6	0	9	0
3	*Nostoc* sp.	19	22	11	9	6	7	3	10	13	11	7	11
4	*Oscillatoria* sp.	6	10	13	9	1	3	7	6	14	7	12	9
	TOTAL	**42**	**53**	**44**	**18**	**10**	**24**	**33**	**30**	**33**	**18**	**39**	**32**

Total Chlorophyceae

Chlorophyceae was the dominant class. The occurrence of this group was highest, 4.96 nos./l in March, 2015 and lowest, 32 nos./l in August, 2015 in 1st annual cycle whereas in 2nd annual cycle, highest number was, 104 nos./l in December, 2015 and lowest number was, 35 nos./l in August, 2016 in (Table-8 to 11). The commonly occurring algae were *Chlorella* sp., *Oedogonium* sp., *Schizochlamys* sp., *Asterococcus* sp., *Volox* sp., *Botryococcus* sp. was found all over the year.

Total Bacillariophyceae

The occurrence of Bacillariophyceae was highest, 55 nos./l in March, 2015 and lowest, 6 nos./l in October, 2015 in 1st annual cycle whereas in 2nd annual cycle the highest member was, 53 nos./l in February, 2016 and lowest was, 12 nos./l in July, 2016 in (Table-8 to 11). *Nitzschia* sp., *Diatoma* sp., *Navicula* sp., *Synedra ulna*, *Gyrosigma* sp. was the dominant genera under the class Bacillariophyceae.

Total Cyanophyceae

The Cyanophyceae was highest in the month of October, 2015, 46 nos./l and lowest in the month of August, 2015, 15 nos./l in 1st annual cycle whereas in 2nd annual cycle, highest number was, 53 nos./l in December, 2015 and lowest number was, 10 nos./l in March, 2016 in (Table-8 & 11). *Microcystis* sp., *Anabaena* sp., *Nostoc* sp., *Oscillatoria* sp. were the dominant genera.

Total Charophyceae

The Charophyceae were *Chara* sp., *Netrium* sp., *Closterium* sp. The highest number was 20 nos./l in February, 2015 while 1 nos./l in May, 2015 was the lowest. In 2nd annual cycle, highest number was, 34 nos./l in March, 2016 and lowest was, 4 nos./l in July, 2016 in (Table-8 & 11).

Total Tribophyceae

Perone sp., *Tribonema* sp. were recorded under this class. It was maximum, 15 nos./l in March, 2015 and minimum, 3 nos./l in September, 2015 in 1st annual cycle. On the other hand, in 2nd annual cycle of the study period highest and lowest number of this class were 18 nos./l in January, 2016 and 2 nos./l in August, 2016 in (Table-8 & 11).

Total Xanthophyceae

Vaucheria sp. was the only member of this class. The maximum number was, 19 nos./l in December, 2014 whereas minimum was, 6 nos./l in May, 2015 in 1st annual cycle. In 2nd annual cycle maximum in number was, 17 nos./l in April, 2016 and minimum was, 3 nos./l in July, 2016 in (Table-8 & 11).

Total Dinophyceae

Ceratium sp., *Gymnodinium* sp. were the dominant genera of this class. The highest attendance was, 12 nos./l in January, 2015 and lowest attendance was, 3 nos./l in October, 2015 in 1st annual cycle. On the other hand, in 2nd annual cycle of the study period, highest and lowest number of this class were, 17 nos./l in November, 2015 and 2 nos./l in October, 2016 in (Table-8 & 11). It was not found throughout the year.

Community analysis of plankton

To analyse the community structure of plankton population in the cultural ponds, species diversity such as Simpson index of probability, Simpson index of dominance, Shannon-Weaver biodiversity index, Berger Parker Dominance index and Margalef richness index were studied.

Simpson index of dominance

Simpson index of dominance was found to vary within the range of 0.916237 to 0.941321 in 1st annual cycle. The value of dominance index was higher (0.941321) in September, 2015 and lower (0.916237) in January, 2015 with mean value (0.924847) in 1st year of study while in 2nd year of study the ups and downs range was (0.900708 to 0.939289) October, 2016 and December, 2015 with mean values 0.916373. Monthly variations of Simpson index of dominance for plankton of two annual cycles have been displayed in (Table-16 & 17).

Table- 12

Simpson dominance index of plankton

	1st Annual cycle	2nd Annual cycle
Minimum	0.916237	0.900708
Maximum	0.941321	0.939289
Mean	0.924847	0.916373

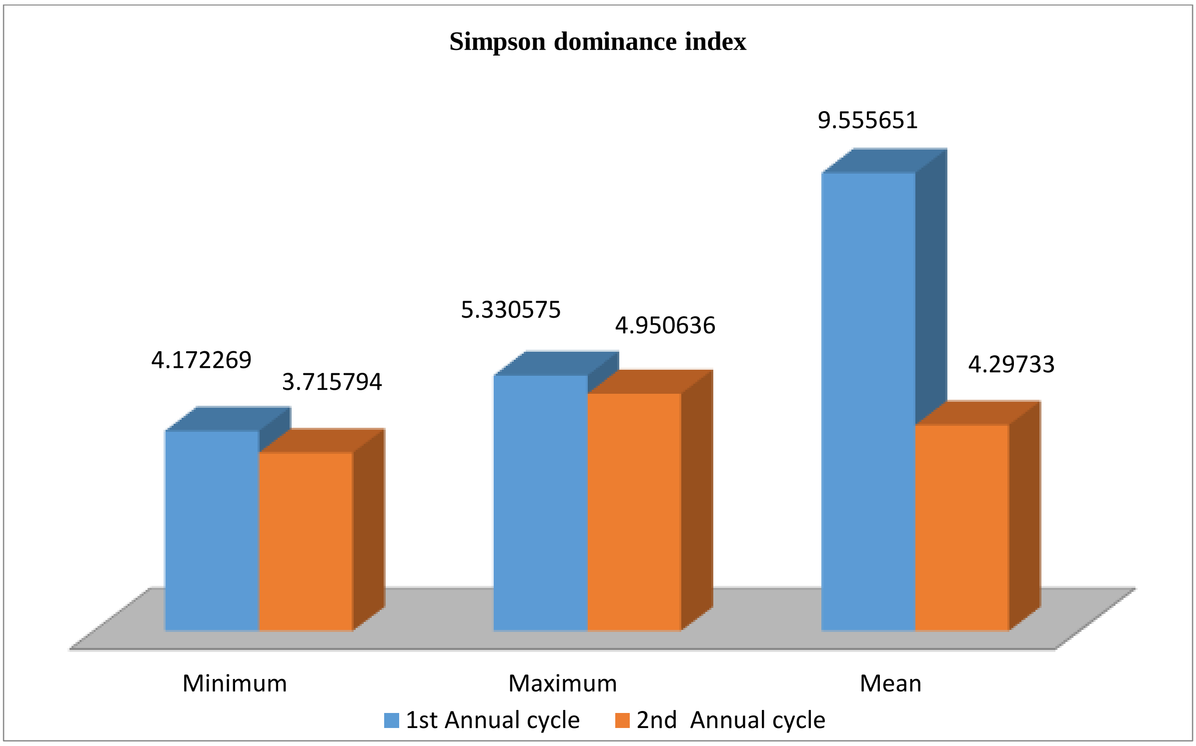


Fig. 26: Graphical representation showing comparison of Simpson dominance index of plankton of two annual cycles

Shannon - Weaver (1963) biodiversity index

In culture ponds, the Shannon-Weaver biodiversity index was found to vary within the range of 1.127746 -1.254478 with a mean values 1.2812309 in 1st annual cycle whereas in 2nd annual cycle ranged in between 1.049756-1.263826 with a mean values 1.15854. The tendency of lower diversity was noticed in the months of July, 2015 and July, 2016. The higher diversity was noticed in the months of April, 2015 and December, 2015. Monthly variations of Shannon-Weaver biodiversity index for plankton of two annual cycles have been displayed (Table-16 & 17).

Table- 13

Shannon-Weaver biodiversity index of plankton

	1st Annual cycle	**2nd Annual cycle**
Minimum	1.127746	1.049756
Maximum	1.254478	1.263826
Mean	1.2812310	1.15854

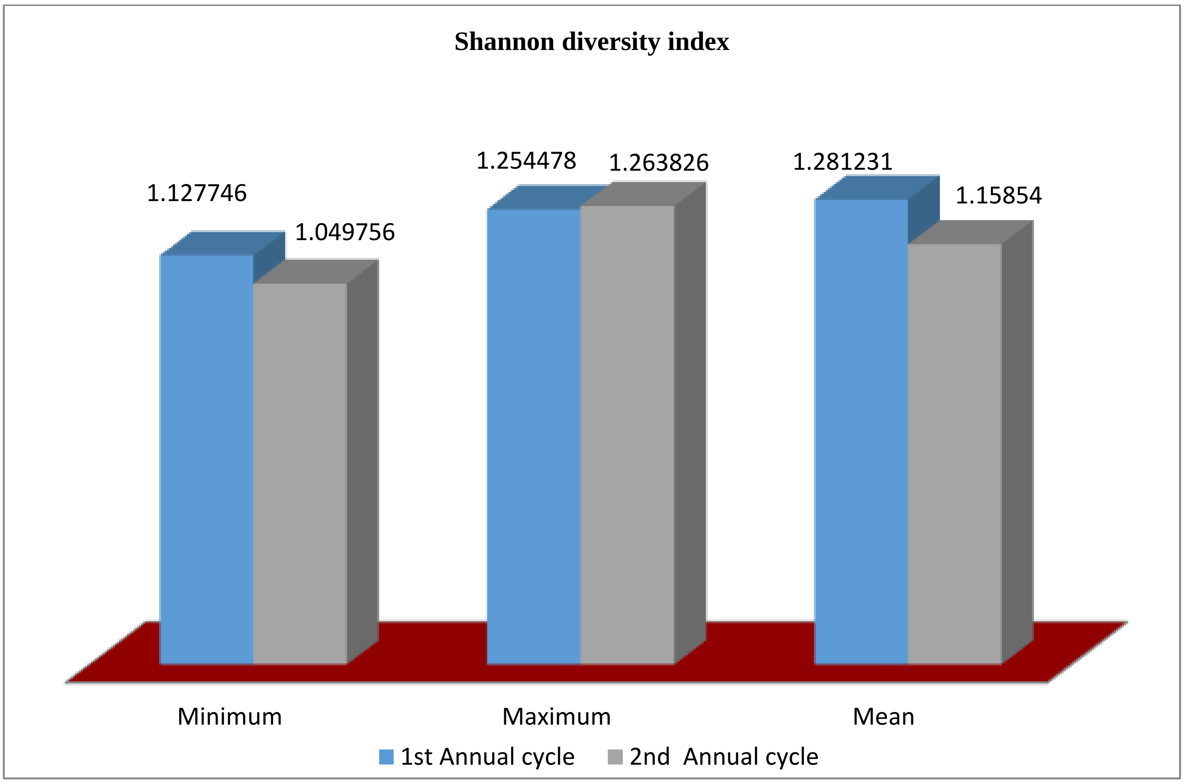


Fig. 27: Graphical representation showing comparison of Shannon diversity index of plankton of two annual cycles

Berger-Parker dominance index for plankton

The value of dominance index was higher (0.232558) in July, 2015 and lower (0.105263) in September, 2015 with mean values (0.165210) in 1st year of study while in 2nd year of study the ups and downs range was (0.220472) in July, 2016 to (0.108974) in December, 2015 with mean values (0.164530) for plankton of two annual cycles have been displayed in (Table-16 & 17).

Table- 14

Berger Parker dominance index of plankton

	1st Annual cycle	**2nd Annual cycle**
Minimum	0.105263	0.108974
Maximum	0.232558	0.220472
Mean	0.165210	0.164530

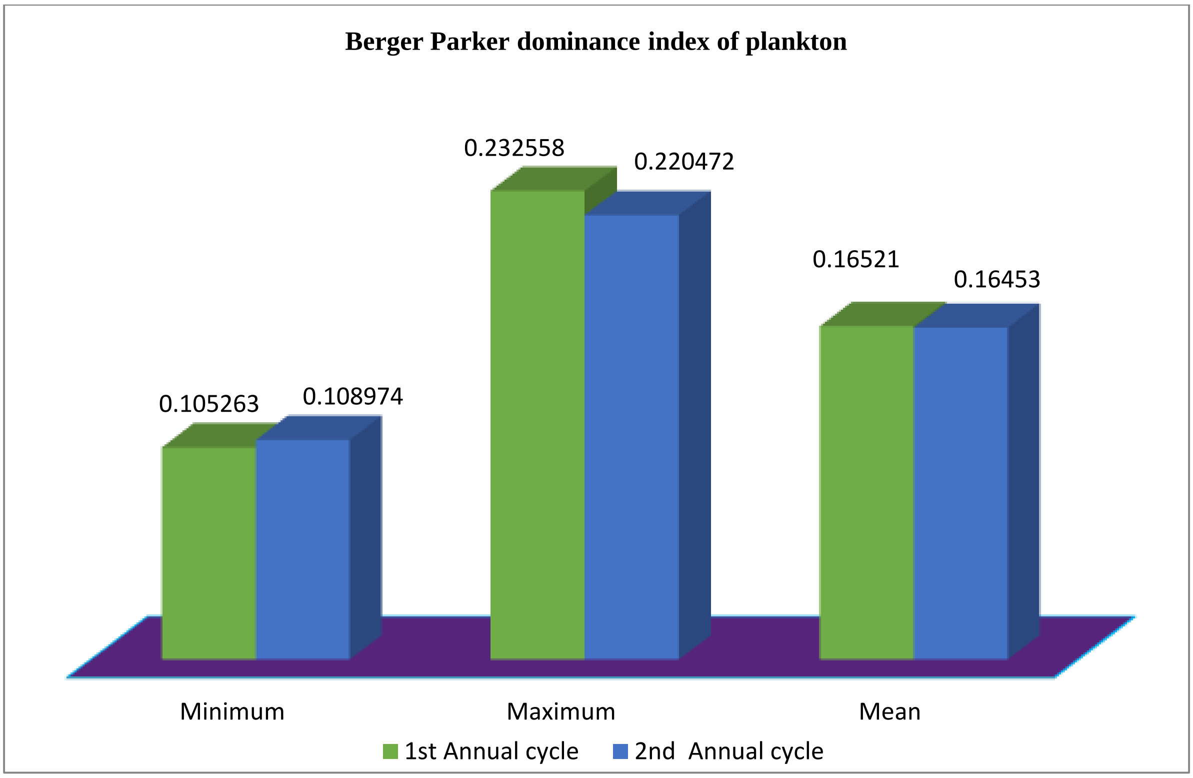


Fig. 28: Graphical representation showing comparison of dominance index of plankton of two annual cycles

Margalef (1968) richness index

Plankton species richness was found to be highest (5.330575) in the month of October, 2015 and lowest (4.172269) in the month of January, 2015 with mean values (9.555651) in 1st annual cycle. In the similar manner, it was observed that species richness value positioned in between (3.715794) in July, 2016 to (4.950636) in December, 2015 with mean values (4.29733) in 2nd annual cycle. Monthly variations of species richness for plankton of two annual cycles have been displayed in (Table- 16 & 17).

Table- 15

Species richness (Margalef, 1968)

	1st Annual cycle	**2nd Annual cycle**
Minimum	4.172269	3.715794
Maximum	5.330575	4.950636
Mean	9.555651	4.29733

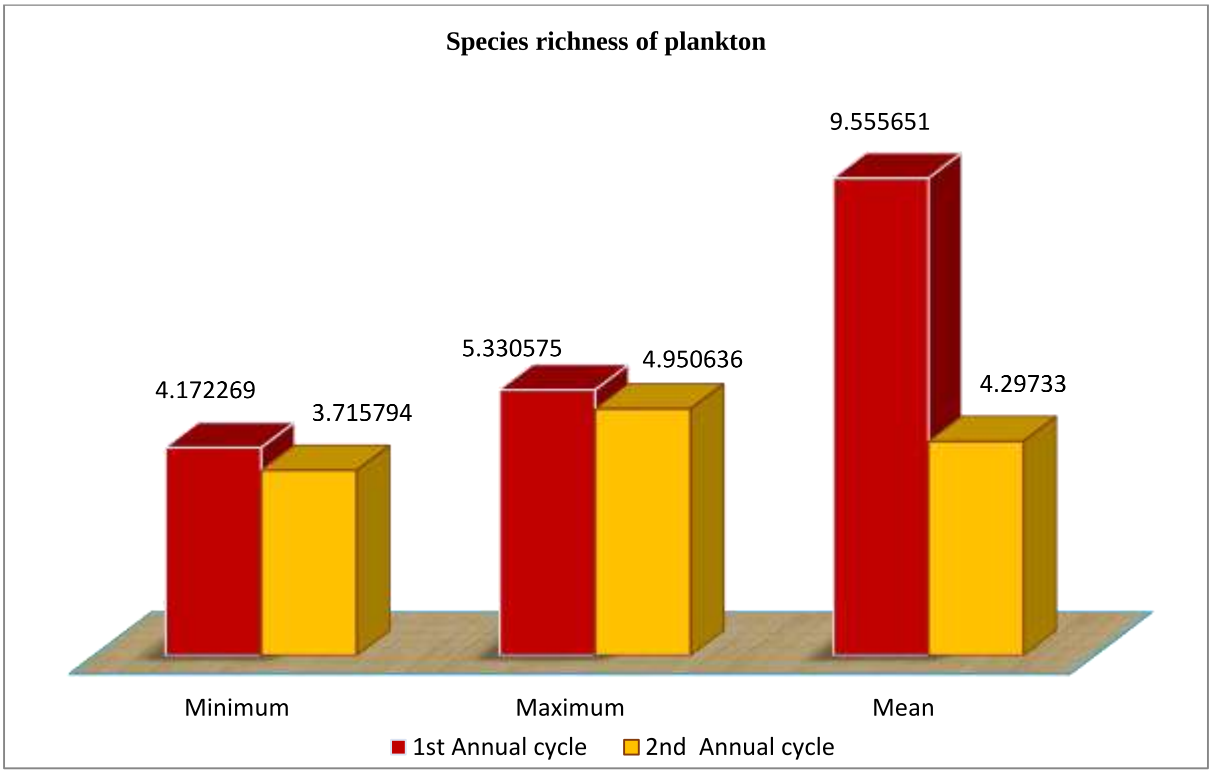


Fig. 29: Graphical representation showing comparison of species richness of plankton of two annual cycles

Table- 16

Statistical analysis of plankton diversity indices of culture ponds during (November, 2014 to October, 2015)

Time Month	Species richness	Total number of normalised individual	Average population size	Simpson index of probability	Simpson index of dominance	Shannon-Weaver biodiversity index	Berger Parker Dominance index	Margalef richness index
Nov.'14	26	199	7.653846	0.065682	0.934318	1.238857	0.115578	4.722947
Dec.'14	26	129	4.961538	0.068193	0.931807	1.251289	0.162791	5.144231
Jan.'15	20	95	4.75	0.083763	0.916237	1.129852	0.189474	4.172269
Feb.'15	21	102	4.857143	0.081538	0.918462	1.140485	0.176471	4.32435
Mar.'15	21	61	2.9	0.07213	0.9279	1.173	0.1639	4.865
Apr.'15	24	103	4.291667	0.060537	0.939463	1.254478	0.145631	4.962534
May'15	23	132	5.73913	0.082235	0.917765	1.154079	0.159091	4.50561
June'15	26	148	5.692308	0.068946	0.931054	1.221068	0.148649	5.002789
July'15	19	43	2.263158	0.083056	0.916944	1.127746	0.232558	4.785707
Aug.'15	23	89	3.869565	0.083504	0.916496	1.154394	0.157303	4.901266
Sep.'15	22	95	4.318182	0.058679	0.941321	1.226844	0.105263	4.611455
Oct.'15	23	62	2.695652	0.093601	0.906399	1.148692	0.225806	5.330575
Mean					0.924847	1.2812309	0.165210	9.555651

Table- 17

Statistical analysis of plankton diversity indices of culture ponds during (November, 2015 to October, 2016)

Time Month	Species richness	Total number of normalised individual	Average population size	Simpson index of probability	Simpson index of dominance	Shannon-Weaver biodiversity index	Berger Parker Dominance index	Margalef Richness index
Nov.'15	26	188	7.230769	0.084936	0.915064	1.201856	0.212766	4.774234
Dec.'15	26	156	6	0.060711	0.939289	1.263826	0.108974	4.950636
Jan.'16	20	98	4.9	0.08037	0.91963	1.130143	0.122449	4.143977
Feb.'16	21	139	60619048	0.083516	0.916484	1.126867	0.129496	4.053117
Mar.'16	21	159	7.571429	0.074596	0.925404	1.164863	0.132075	3.945626
Apr.'16	24	179	7.458333	0.064717	0.935283	1.235791	0.134078	4.433833
May'16	22	284	12.90909	0.073757	0.926243	1.180205	0.147887	3.717489
June'16	25	180	7.2	0.084295	0.915705	1.188958	0.183333	4.621644
July'16	19	127	6.684211	0.110611	0.889389	1.049756	0.220472	3.715794
Aug.'16	23	142	6.173913	0.0913	0.9087	1.142373	0.197183	4.439219
Sep.'16	22	132	6	0.09542	0.90458	1.10543	0.166667	4.300809
Oct.'16	23	137	5.956522	0.099292	0.900708	1.112372	0.218978	4.471562
Mean					0.916373	1.15854	0.164530	4.29733

■ **Yellow colour indicates minimum and** ■ **Blue colour indicates maximum variations.**

5.4 DISCUSSION

Zooplankton and phytoplankton play an important role in water, maintaining the biological balance and quality of water and fish food. Plankton density is sensitive to physical and chemical changes in water comprising the qualitative and quantitative fluctuation concerned with biological productivity. The pH, dissolved oxygen, alkalinity, phosphate, nitrate and other nutrients are responsible for phytoplankton production in the aquatic environment. In the study periods, it is found maximum number of zooplankton Copepoda and minimum Amphipoda whereas maximum number of phytoplankton Chlorophyceae and minimum Dinophyceae. According to Khattak et al. (2005), the species composition, biomass, relative abundance, spatial and temporal distribution of plankton are expressing of the environmental health or biological integrity of a particular water body.

Zooplankton density and diversity

The population of the zooplankton are four major groups as Rotifera, Copepoda, Cladocera, Protozoa and two minor groups as Ostracoda and Amphipoda are observed. 10 species of Rotifera, 6 species of Copepoda, 9 species of Cladocera, 3 species of Protozoa, 2 species of Ostracoda and 1 species of Amphipoda are identified. The parameters of water such as water temperature, alkalinity, phosphate, total inorganic nitrogen, dissolved oxygen, free carbon dioxide are good relation with the zooplankton.

Among Rotifera *Brachionus* sp., *Keratella* sp., *Asplanchna* sp., *Synchaeta* sp., *Filinia* sp., *Anuraeopsis* sp. were the dominant genera. The high incidence of Rotifera population was in between winter and summer season. High incidence of Copepoda was recorded *Nauplii* sp., *Diaptomus* sp., *Microcyclops* sp, and *Eucyclops* sp. Cladocera was the dominant group throughout the study period. *Daphnia* sp., *Ceriodapnia* sp., *Bosmina* sp., *Alona* sp. were the dominant genera. Maximum density was found in winter and summer season and low density in the season of monsoon and post-monsoon. *Amoeba* sp. and *Difflugia* sp. were the dominant genera under Protozoa. Ostracoda showed their highest population during the season of winter which indicate that it prefers low temperature and minimum population density during the season of monsoon. Plankton population was low in the season of monsoon due to high temperature, moderately high conductivity and low DO. Similar results were observed by Pathani and Mahar (2006). Water parameters like DO, pH, transparency have relationship with zooplankton richness which were observed in winter season provide favourable environment for the growth of plankton. This observation conform the result of Agarwal et al., (2005). The dominance of zooplankton were Copepoda > Rotifera > Cladocera > Protozoa > Ostracoda > Amphipoda respectively. The zooplankton species diversity of the ponds during study period is as follows:

Rotifera > Cladocera > Copepoda > Protozoa > Ostracoda > Amphipoda

Phytoplankton density and diversity

The eight classes of phytoplankton comprise 24 species; among which Chlorophyceae 7 species, Dinophyceae 2 species, Xanthophyceae 1 species, Bacillariophyceae 5 species, Charophyceae 3 species, Tribophyceae 2 species, Cyanophyceae 4 species represented the population respectively. The parameters of water such as water temperature, pH, total inorganic nitrogen, phosphate and hardness showed relation of the phytoplankton population. Phytoplankton population was high in winter season and low in the season of monsoon. Among Chlorophyceae *Oedogonium* sp., *Chlorella* sp., *Schizochlamys* sp., *Botryococcus* sp. were the dominant genera. This class showed negative relation with phosphate, total nitrogen and positive with pH. Rajagopal et al., (2010a) also reported the same pH. *Microcystis* sp., *Oscillatoria* sp., *Nostoc* sp. under Cyanophyceae; *Diatoma* sp., *Nitzschla* sp., *Synedra ulna* under Bacillariophyceae; *Chara* sp., *Closterium* sp., *Netrium* sp. under Charophyceae;

Perone sp., *Tribonema* sp. under Tribophyceae; *Ceratium* sp., *Gymnodinium* sp. under Dinophyceae and *Vaucheria* sp. under Xanthophyceae were the dominant genera. They were found throughout the study period. Transparency, pH, DO were high in winter season and provide favourable environment for the growth of plankton. The dominance of phytoplankton were Chlorophyceae > Cyanophyceae > Bacillariophyceae > Charophyceae > Tribophyceae > Dinophyceae > Xanthophyceae respectively. The Phytoplankton diversity during the study periods are as follows:

Chlorophyceae > Bacillariophyceae > Cyanophyceae > Charophyceae > Dinophyceae > Tribophyceae > Xanthophyceae.

The maximum number of zooplankton was observed during winter and summer season and minimum during monsoon and post-monsoon season. The maximum number of phytoplankton observed during summer season and minimum during the rainy season. The maximum DO has recorded during rainy season due to inflow of surrounding rain water after monsoon. Dissolved and total suspended solid were maximum in summer season due to the regular precipitation of water in the summer season.

Community assessment

Shannon-Weaver diversity index (H') is an important comment on the seasonal fluctuation of zooplanktons (Sibel, 2006). The H′ index was higher in winter while low in the month of summer. Such type of observation strengthens our finding by Ali et al., (2003) in Indus River, Pakistan. The higher value of Shannon-Weaver index of plankton community indicated greater species diversity. The greater species diversity means longer food chain**.** A number of inter specific interactions which reduces oscillations and to some extent increases the stability of the community (Ludwik and Reynolds, 1998). Based on Shannon-Weaver legislation, the aquatic environment is classified as very suitable when H′ is > 4, good quality, 4 to 3 moderate quality

3 to 2, poor quality 2 to 1 and very poor quality < 1. Species diversity decreases when stress increases in the environment and community dominated by a relatively few species indicates environmental stress Plafkin et al., (1989). Besides, a scale of pollution regarding species diversity with 3.0 to 4.5 slight, 2.0 to 3.0 slight, 1.0 to 2.0 moderate and 0.0 to 1.0 heavy pollution had been described by Staub et al., (1970). The Shannon index values in (Table-16 & 17) obtained during study period indicates favourable water quality, slight shifting of values which tend to slight pollution.

Higher species richness is characterized by longer food chain. The higher value of species diversity index suggests decreasing species richness with increasing trophic status (Vincent et al., 2012). In this ponds species richness is very high throughout the year when conditions more or less stable. The dominance index value of plankton community ranged from 0.105263 to 0.232558 in (Table-16 & 17). According to Whittaker, (1965) the value of dominance index is always higher where the community is dominated by a fewer number of species.