CHAPTER VI

Plankton community
Chapter VI

Plankton community

Introduction

Floodplain wetlands are known as the biological supermarkets because of the extensive food chain and immensely rich biodiversity they support (Mitsch and Gosselink, 1993). Lakes, like the oceans and streams, have a great diversity of plants and animals. Those living as floaters or weak swimmers are known as plankton. Plankton are the microscopic aquatic forms having little resistance to currents. They are living, free-floating and remain suspended in open or pelagic waters/ ranging in size from single-celled picoplankton, which are < 5 µm in diameter, to colonial form having short life cycles. Planktons are predominant in lentic habitats (ponds, lakes and oceans) and large rivers with slow moving waters.

Plankton can be divided into three major size classes:

- **Phytoplankton**– microscopic plants
- **Zooplankton**– microscopic animals
- **Macrozooplankton**– larger fish eggs and larvae and pelagic invertebrates.

Plankton are often used as indicators of environmental and aquatic health because of their high sensitivity to environmental changes and short life span. Phytoplankton are being used as indicators of environmental conditions of water bodies because their population is especially sensitive to changes in nutrient levels and other water quality conditions due to their propensity to multiply rapidly in the right conditions. The productivity of any aquatic water body depends on the amount of plankton present in the said water body (Guy, 1992).

Zooplankton is an inseparable part of the aquatic ecosystem and they are useful indicators of fishery health because they are food source for organisms at higher trophic levels. They help in regulating algal and microbial productivity through grazing and in the transfer of primary productivity to fish and other consumers (Dejen *et al.*, 2004). Zooplankton exhibit complex responses to environmental variability through changes at the individual including physiological growth condition, population, migration, reproduction, and mortality, community composition and levels of organization. Therefore, zooplankton are considered indicators of water quality (Pinto-Coelho *et al.*, 2005). However, the responses of zooplankton to water quality variation are ecosystem and species dependent and vary within and between lakes (Ravera, 1996). Various groups of plankton (algae, diatoms and zooplanktons) are often used in the routine water quality monitoring in various aquatic ecosystems as biomonitoring is a central component of water resource management worldwide.
A large number of studies have been documented on the species composition, diversity and seasonal changes of phyto and zooplankton in relation to physicochemical characteristics of freshwater ecosystems of the world (Prowse and Talling, 1958; Melack, 1979; Wetzel, 1983; Moss and Balls, 1989; Islam, 1991; Nwankwo, 1998; Huovinen et al., 1999; Calijuri et al., 2002; Hirose et al., 2003; Battes, 2005; Nabour et al., 2005; Frankovich et al., 2006, Ouéda, et al., 2007; Onyema, 2007; Branes et al., 2007; Nabout and Nogueira, 2007; Akoma, 2008; Nwankwo et al., 2008; Olele and Ekelemu, 2008; Davies et al., 2009; Offem et al., 2009; Onyema, et al., 2009; Molisani et al., 2010; Okogwu, 2010). Information on the seasonal variation, species composition, distribution of phyto and zooplankton has been studied in other regions of Indian freshwater lentic water bodies (Munawar, 1970; Michael, 1968; Zafar, 1986; Yadava et al., 1987; Khan, 1987; Yadav and Dey, 1990; Wani, 1998; Sharma and Sharma, 1999; Bahura et al., 1993; Gupta and Sharma, 1993; Ahmad and Singh, 1993; Sinha et al., 1994; Acharjee et al., 1995; Sanjer and Sharma 1995; Nath, 1997; Kumar, 1997; Jana, 1998; Mukhopadhyays et al., 2000; Prakash et al., 2001; Sukumaran and Das, 2002; Khan, 2002, 2003; Chattopadhyay and Banerjee, 2007; Senthilkumar and Sivakumar, 2008; Sachidanandamurthy and Yajurvedi, 2008; Arora and Mehr, 2009). There is limited information on the seasonal dynamics of water quality parameters and plankton community of the aquatic systems of North east India (Gupta et al., 1994; Baruah and Das, 1997; Sharma and Lyngdoh, 2003; Duttagupta et al., 2004; Bhuiyan and Gupta, 2007; Sharma and Sharma 1999, 2000, 2001, 2005, 2008, 2009; Sharma, 2000, 2006, 2009, 2010; Laskar and Gupta, 2009, 2010, 2011). Detailed study on the water quality and hydrobiology of these floodplain lakes are very essential for routine monitoring which can be helpful for conserving and documenting the biodiversity for sustainable development of this region in particular.

In Cachar district, Barak valley, Assam there are 340 numbers of wetlands covering an area of 7188 ha which includes floodplain lakes and oxbow lakes. Floodplain lakes are one of the unique types of wetlands of great ecological and socio-economic importance providing livelihood to millions of people all over the world (FAO, 1997). Chatla wetland of Cachar district, Barak valley, Assam is one of them. There are 32 villages in and around Chatla Floodplain Lake where inhabitants are totally dependent on its water and resources particularly fish for their living (Laskar and Gupta, 2009).

The plankton dynamics of Chatla Floodplain Lake have not yet been thoroughly investigated and information on the species composition, seasonal variation and distribution of phytoplankton in Chatla Floodplain Lake is scanty, (Duttagupta et al., 2004; Bhuiyan and Gupta, 2007; Laskar and Gupta, 2009, 2010, 2011a, 2011b, 2011c). The local community is dependent on the fish resource of the floodplain lake. Apart from this, this water body also serves for the purpose of agriculture and other domestic activities. The Chatla basin had been a rich fishing ground and therefore a very important protein supplier to the community. But due to increase of population and anthropogenic input from the surrounding areas the floodplain ecosystem is facing several problems leading to
decline of fish population both in terms of density and diversity. Several species of fishes are becoming increasingly rare in Chatla. For the fisher folk of Chatla fishing is not enough for sustaining their family nowadays. Since both phyto and zooplankton are major food for surface feeding fishes and play key role in the food web of aquatic ecosystems study of plankton might throw light on the actual reason of decrease of diversity and density of fish population. The present study therefore aims to evaluate the temporal and spatial variation of density, abundance, diversity and distribution of phyto and zooplankton community of the Chatla floodplain lake in relation to different physical and chemical characteristics.

Review of Literature

River-floodplain systems, especially in the tropics, support high biological diversity and important fisheries (Welcomme, 1985, 1990; Lowe-McConnell, 1987). High biological diversity, both taxonomic and functional, is associated with high spatial complexity and the dynamic nature of aquatic, terrestrial and ecotonal habitats (Schiemer 1999; Ward et al., 1999; Robinson et al., 2002). In river floodplain systems, the hydrological regime is the key factor that promotes ecological functioning and determines biodiversity patterns (Neiff, 1990; Bunn and Arthington, 2002) and this regime is maintained mainly by the flood pulse (Junk et al., 1989). Densities of aquatic organisms increase over time as new individuals are recruited under productive flood conditions (Welcomme, 1985). The relationship between the physico-chemical parameters and plankton production in water bodies are of great importance in the management strategies of aquatic ecosystems (Edward and Ugwumba, 2010). Nutrient salts (NO$_3^-$, PO$_4^{3-}$, NH$_4^+$ and SiO$_2$) play an important role in the productivity of the aquatic ecosystem supporting the food chain for phyto-and zooplanktons as well as fish (Abdo, 2004; Yamamuro et al., 1993). The abundance and biovolume of both phyto and zooplankton are largely regulated by the resource base and tend to increase with the trophic state of the lake (Sommer, 1989; Canfield and Jones, 1996). Local streams were significant sources of nutrients to the floodplain (Schemel et al., 2004) and floodplain water becomes depleted in nutrients when connectivity is reduced (Van den Brink et al., 1993; Hein et al., 1999). Species composition and biomass of phytoplankton and zooplankton as well as population characteristics of single species indicate man-made environmental changes of lake ecosystems (Schindler, 1987). The total phytoplankton biovolume may serve as a rough indicator on the amount of food for herbivorous zooplankton (Kjellberg et al., 2001; Ogato, 2007). Half of the world's oxygen is produced via phytoplankton photosynthesis (Roach, 2004). Phytoplankton productivity and composition are influenced by the spatial and temporal dynamics of environmental factors (Sommers, 1989; Reynolds, 1989; Melack, 1996; Talling, 1986) dominated by the solar energy cycle (Patterson and Wilson, 1995). Phytoplankton plays a significant role in the aquatic food chain (Townsend et al., 2000; Miller, 2005; Conde et al., 2007, Mustapha, 2009). The knowledge of the algae in the aquatic environments could be useful in predicting the movement of herbivorous fishes (Ikusemiju and Olaniyan, 1977). Phytoplankton are integral components of freshwater wetlands, which
significantly contribute towards succession and dynamics of zooplankton and fish (Payne, 1997). There are several studies on species composition, diversity and seasonal changes of phytoplankton in relation to physicochemical characters on freshwater wetlands of the world (Wetzel, 1983; Islam, 1991; Zafar, 1986; Battes, 2005; Frankovich et al., 2006; Melack, 1979; Moss and Balls, 1989; Calijuri et al., 2002; Hirose et al., 2003; Hutchinson, 1967). The study of Schultze et al. (1995) has highlighted that each phytoplanktonic class has its own optimum conditions for growth. Hinder et al. (1999) concluded that the seasonal succession and community structure of the phytoplankton was distinctly different in the two years studies due to the variability in different meteorological conditions. Melo and Huszar (2000) recorded 203 taxa of phytoplankton in Amazonian floodplain (Batata Lake), and Train and Rodrigues (1997) observed 166 to 209 taxa in the Upper Paraná River. Nabout et al. (2005) recorded 292 taxa in the floodplain lakes of the Araguaia River, Brazi. Euglenoids have been implicated as biological indicator of pollution (Munawar, 1972). Abdel Baky (2001) concluded that organic matter within domestic sewage discharge give a suitable medium for the growth of Euglenophyta. El-Sherif and Gharib (2001) reported dominance of diatoms during winter and spring while Chlorophytes and Cyanoprokaryotes dominate during autumn and summer in Manzalah Lagoon. The predominance of Cyanophyta was due to the high N and P content of Hadous Drain water (Deyab et al., 2002). The variations of temperature are found to affect the periodicity diversity and succession of the phytoplankton group (Behrndt, 1990; Deyab, 2003). Deyab et al., (2002) reported that the vigorous growth of Cyanophyta is correlated with the increase of phosphorus of surface water, whereas, silica depletion leads to a replacement of the large diatoms by large Cyanophyta. Diatom favour nutrient rich environment particularly nitrates and reflect the average biological condition of water bodies (Frankovich et al., 2006; Passy, 2007). Turbidity controls the species composition and production of phytoplankton (De Seve, 1993; Bernot et al., 2004). Schemel et al. (2004) concluded that variation in flow and sources of water were major factors affecting phytoplankton biomass in floodplain water. Wojciechowska et al. (2005) found that the phytoplankton species diversity expressed by Shannon-Weaver and evenness indices was higher in June than in August in the two lakes (Jama Roma and Orchówek) of Bug Valley, Eastern Poland. The pH, transparency, DO, alkalinity and chloride favoured the growth of phytoplankton (Boney, 1983, Reynolds, 2006). Branes et al. (2007) found that the lake Oubeira (North-East Algeria) is very favourable for proliferation of the classes Chlorophyceae and Cyanophyceae. High temperature and nutrients (nitrate and phosphate) increased the photosynthetic activities of the phytoplankton thus increasing their population (Davies et al., 2008). Indabawa (2009) found that Nguru Lake, Yobe State Nigeria contains a variety of phytoplankton species which represent Cyanophyta, Chlorophyta and Cryptophyta. Wu and Kow (2010) concluded that the elevation in water hardness has played a selecting force in affecting the dominance of phytoplankton in Feitsui Reservoir, Taiwan.

A study made by Collos et al. (2001) in an equatorial Lake, Lac de Petit Saut, French, Guyana showed that NH$_4^+$ is taken up by phytoplankton. Strong negative correlation recorded between total Bacillariophyta and rainfall
(Nwankwo, 1996; Nwankwo and Onyema, 2003; Onyema et al., 2003) further highlights rainfall and associated floodwater conditions as key determinants of hydrology (Olaniyan, 1969). Onyema (2007) found strong positive correlation between total Bacillariophyta and water quality parameters like transparency, depth, TDS, salinity, nitrate-nitrogen, phosphate-phosphorus, sulphate, BOD, etc. in a polluted estuarine Creek in Lagos, Nigeria. Similar results have been recorded by Nwankwo (1998).

Cole (1975) noted that free CO$_2$ supply rarely limits the growth of phytoplankton. Alternately, the bicarbonates are utilized as a source of carbon by the photosynthetic activity of phytoplankton. According to Kilham and Kilham (1980) and Sommer (1981), Chlorococcus green algae exhibit ‘r’ developmental strategy requiring abundant nutrients and less light. Thus they cannot compete efficiently with cyanophytes which exhibit ‘k’ developmental strategy, having the capacity to survive and bloom even under conditions of high light intensities and low nutrients by exploiting nutrients at the bottom of the euphotic zone by buoyancy regulation of its gas vacuoles (Reynolds, 1984). The dominance of Dinoflagellate is very common in freshwater lakes due to their ability to compete with other phytoplankton by consumption of phosphorus and nitrogen (Pollingher, 1988). The development of phytoplankton blooms in eutrophic lakes is attributed to their ability to accommodate reduced nitrogen to phosphorus ratios, low edibility due to their large colony sizes (Barica, 1994; Paerl and Tucker, 1995). Sept and Reynolds (1995) showed that the phytoplanktonic production of water level was related to the temperature, the light and the nutrients. The higher species richness during post flood was observed by Garcia de Emiliani (1993).

Community structure, dominance and seasonality of phytoplankton in tropical wetlands are highly variable and are functions of nutrient status, water level, morphometry of the underlying substrate and other regional factors (Gopal and Zutshi, 1998; Zohary et al., 1998; Agostinho et al., 2001).

Studies on planktonic composition and morphometric, physical and chemical characterization of water bodies are necessary to obtain basic knowledge on the biodiversity in a given region (Rajagopal et al., 2010). Chattopadhyay and Banerjee (2007, 2008) worked on seasonal variation of plankton and their relationship with physico-chemical parameters of water in Krishnasayer Lake (Burdwan), West Bengal. Sharma and Lyngdoh (2003) made a study on the abundance and ecology of phytoplankton of a subtropical reservoir of Meghalaya (NE. India) and reported that high number of plankton in winter season might be linked to the favourable ecological conditions of the wetlands which enhance the growth of the species. This observation also coincided with the findings of Pendese et al. (2000).

Very few studies have documented on the surface water resources of Barak valley in relation to water quality (Gupta and Gupta, 1995; Das and Gupta, 2010, 2011) but the diversity and dynamics plankton in relation to physico-chemical properties of water is scanty (Dutta Gupta et al., 2004; Bhuiyan and
Gupta, 2007; Laskar and Gupta, 2009, 2010, 2011a, 2011b, 2011c) and no detailed work yet has been carried out on the seasonal variation, distribution and diversity of plankton community in Chatla Floodplain lake.

Diversity of planktonic organisms is quite high in fertile standing water bodies and responds rapidly to changes in the aquatic environment particularly in relation to silica and other nutrients (Eggs and Aksnes, 1992; Chellappa et al., 2008). The qualitative and quantitative studies of phytoplankton have been utilized to assess the quality of water (Adoni et al., 1985; Chaturvedi et al., 1999; Ponmanickam et al., 2007; Shekhar et al., 2008, Ahmad, 1996). Several phytoplankton species have served as a bioindicators (Vareethiah and Haniffa, 1998; Bianchi et al., 2003; Tiwari and Chauhan, 2006; Hoch et al., 2008). A number of studies have been carried out on ecological conditions of freshwater bodies and their relationship with physico-chemical parameters in various parts of India (Singh, 1960; Rana, 1991; Sinha and Islami, 2002; Singh et al., 2002; Tiwari and Chauhan, 2006; Ahmad and Siddiqui, 1995; Rana, 1996; Dadhich and Saxena, 1999; Rajagopal et al., 2006).

Domotharan et al. (2010) recorded high concentration of ammonia in Point Calimere coastal waters (South East coast of India) which they attributed to the death and subsequent decomposition of phytoplankton. Sharma and Capoor (2010) found a direct relationship of phyto and zooplankton with the water quality parameters during the rainy and winter seasons in a study on the lake water of Patna Bird Sanctuary, India. Literature on ecology of zooplankton population from different parts of India is available from the investigation of Sreenivasan (1967), Michael (1968), Mathivanan et al. (2007), Kudari and Kanamadi (2008) and many others.

The zooplankton in the surface water of a freshwater lake are those which are caught in a fine-meshed net towed slowly through the water column, and consist mainly of Protozoa, Rotifera, Cladocera, Copepoda, Decapoda, Branchiopoda and Ostracoda and a great variety of larval forms (Odum, 1971; Clinescari et al., 1998, Chattopadhyay and Barik, 2009). They are considered as an indicator of water quality (Pinto-Coelho et al., 2005; Smirnova, 1987; Andronikova, 1996; Murugan et al. 1998; Dadhich and Saxena, 1999; Ahmad, 1996; Contreras et al., 2009) because they help in regulating algal and microbial productivity through grazing and in the transfer of primary productivity to fish and other consumers (Dejen et al., 2004). They are second in tropic level as primary consumers and also as contributors to next tropic level (Qasim, 1977; Paggi and José de Paggi, 1990; José de Paggi, 1980; Koste and Robertson, 1983). Zooplankton possesses complex grazing behavior, and rates of particle capture may vary with size, shape, taste or surface charge of phytoplankton (Leman, 1988). Zooplankton possesses complex grazing behavior, and rates of particle capture may vary with size, shape, taste or surface charge of phytoplankton (Leman, 1988).

The responses of zooplankton to water quality variation are ecosystem and species dependent and vary within and between lakes (Ravera, 1996). The
great diversity of zooplankton species appears to reflect the wide range of pelagic and littoral biotopes, which differ in morphometry, presence or absence of macrophytes, productivity, trophic state and distance from pollution sources (Raspopov et al., 1996, Kurashov et al., 1996). Because of their short life-cycles, zooplanktons respond quickly to environmental changes, and hence their species composition and frequency of seasonal abundance fluctuate according to the changing status of the water (Gannon and Stemberger, 1978; Carmichael, 1981; Chattopadhyay and Banerjee, 2007; Sunkand and Patil, 2004; Islam, 2007). Byars (1960) reported that zooplankton preferred the alkaline nature of water. Chattopadhyay and Barik (2009) found that the relative abundance and frequency of occurrence of the net zooplankton species in a tropical freshwater lake Krishnasayer differed markedly (Chattopadhyay and Banerjee, 2007). Basu et al. (2010) showed that the important factors governing the abundance of zooplankton in Kamal Sayer Lake are DO, combined CO₂, nitrate and phosphate. Sharma (2010) concluded that Rotifera communities of Deepor Beel Assam, India are highly diverse.

High species richness and abundance of rotifers occur in floodplain ecosystems, and they play an important role in the food web. Kurasawa (1975) reported dominance of Copepoda in oligotrophic lakes and Cladocera or rotifera in eutrophic lakes. Rotifers are an important component of the zooplankton community because of their capacity to adapt to changes in environmental conditions, high intrinsic growth rates, and short time intervals of population renewal (Allan, 1976). Some of the rotiferans were reported as primary consumers that fed on various phytoplankton, whilst others were reported as raptorial predators that fed on bacteria and detritus (Winner, 1975; Boulin et al., 1999; Hakanson et al., 2003). Lal (1981), Masundire (1994) and Saxena (1982) recorded seasonality in rotifera population, the maximum being in summer and minimum in winter. Food availability and quality are important factors determining the abundance and composition of zooplankton communities in lakes (Sampaio and López, 1999). Rao et al. (1982) reported Protozoan as dominant group from Hutchamanakere located near Bangalore, India. The majority of ecological studies of rotifers show that limnological variables (e.g. DO and pH) have the greatest influence on the diversity of this group (Anderson et al., 2004). The rotifers were recorded as dominant group among the zooplankton in twenty six water bodies in and around Dharwad (Karnataka), India (Patil and Gouder, 1989). Segers et al. (1993) hypothesized that sub-tropical floodplain lake to be the world’s richest habitats for the rotifer diversity. The total crustacean zooplankton biomass is to a large extent controlled by the amount of algae (Rognerud and Kjellberg, 1990). In many Indian water bodies Copepoda was found dominant (Mitra and Patra, 1990; Shyam, 1991; Varghese and Naik, 1992). Das et al. (1996) reported that the abundance of Copepods indicated the stable aquatic environmental conditions in Lake Tasek, Garao hills, India. The Cladoceran maximum coincided with the relative increase of Chlorophytes whereas the rotifer maximum coincided with a bloom of diatoms (Edmondson, 1965; Dumont et al., 1975). Rotifer species diversity, the trophic structure of their assemblages and spatial distribution can be used as criteria for the evaluation of environmental heterogeneity and of the complexity of pelagic
communities (Telesh, 1999). Species diversity indices when correlated with physico-chemical parameters provide one of the best ways to detect and evaluate the impact of pollution on aquatic communities (Margalef, 1968). The Shannon-Weaver index of species diversity for the whole community tends to decrease as the water body becomes more eutrophic (Andronikova, 1996).

Biotic interactions between zooplankton and their food resources may also be an important driver of spatial and temporal patterns in zooplankton community structure (James et al., 2008).

**Materials and Methods**

Three replicate plankton samples were collected seasonally in post-monsoon (September-November), winter (December-February), pre-monsoon (March-May) and monsoon (June-August), from 10 (ten) selected sampling stations (Site 1 to 10) for a period of two years (from September 2006 to August 2008). 20 (twenty) litres of water samples were filtered each time, through standard plankton net (mesh size 40 μm) (Rejas, 2005; José de Paggi and Paggi, 2008; Fantin-Cruz et al., 2010; Deksne et al., 2010).

Samples from each sampling station were stored in 200 ml labeled wide-mouth bottle and preserved in 4% formaldehyde solution. Sample collection was carried out at 9:00 a.m. to 12.0 noon.

For quantitative estimation, preserved plankton samples were concentrated to 100 ml. From this, 1 ml of sample was again diluted to 10 ml for avoiding possible fractional values and from this 1 ml of sample was taken into the “Sedgwick Rafter” counting cell and observed under the microscope. The number of taxa occurred per ml of sample was converted into number per litre (no. l⁻¹) (density) using the following formula and abundance was calculated accordingly (Needham and Needham, 1962; Chellappa et al., 2008; Borges and Pedrozo, 2009).

\[ N (\text{no. l}^{-1}) = \frac{a \times 1000}{c} \]

Where, 
- \( a \) = total number of planktons occurred in 1ml of concentrated sample
- \( c \) = volume (ml) of concentrated sample
- \( l \) = original volume (ml) of water sample
- \( N \) = total no. of plankton per litre

For qualitative estimation, both phyto and zooplankton were identified using standard literature (Edmondson, 1959; Battish, 1992; Anand, 1998; Michael and Sharma, 1988).
Community structure: The community structure was analyzed using the Shannon-Wiener Index of Diversity ($H'$), Margalef’s species richness index (d), Evenness index ($J'$) and Berger-Parker index of dominance ($D_{BP}$) (Magurran, 2004).

**Shannon and Weiner diversity index ($H'$):** Shannon and Wiener (1949) diversity index ($H'$) given by the equation:

$$H' = - \sum P_i \log P_i$$

Where,

$H'$ = Diversity Index

$i$ = Counts denoting the $i^{th}$ species ranging from 1 – n

$P_i$ = Proportion that the $i^{th}$ species represents in terms of numbers of individuals with respect to the total number of individuals in the sampling space as whole.

**Species Richness Index (d):** The Margalef’s species richness index (d) (Margalef, 1951)

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

Where

$d$ = Margalef’s species richness Index

$S$ = Number of species in a population

$N$ = Total number of individuals in S species.

**Evenness Index or Species Equitability ($J'$):** Species Equitability or evenness (Pielou, 1969).

$$J' = \frac{H'}{\log S}$$

Where,

$J'$= Evenness Index

$H'$ = Shannon-Wiener Index

$S$ = Number of species in a population

**Berger-Parker index of dominance ($D_{BP}$):** It was calculated by the given equation—
**D_BP = N_{max}/ N** (Berger and Parker, 1970).

Where,

\[ N_{max} = \text{Highest number of individuals belonging to the } i^{th} \text{ species (dominant species)} \]

\[ N = \text{Total number of individuals of all species} \]

The Pearson correlation coefficient and one-way analysis of variance (ANOVA) among different physico-chemical parameters and plankton was computed using SPSS 12.0. and CCA among physico-chemical parameters and plankton were performed using BioDiversity Pro. Vs 2.0

**Results**

**Seasonal variation in the density, abundance and diversity of plankton**

The plankton community of Chatla floodplain lake represented by different groups of phytoplankton and zooplankton recorded at 10 sampling stations (station 1-JC, Station 2- BC, Station 3- DGK, Station 4- RB, Station 5- UB, Station 6- OW, Station 7- MB, Station 8- SAL, Station 9- GR and Station 10- BR) during September 2006 to August 2008 are presented in Fig. 74-81 and 82-89. A total of 96 taxa of plankton were recorded from Chatla Floodplain Lake, of which 60 are phytoplankton taxa (Table 15 and 17) and 36 are zooplankton taxa (Table 19 and 21).

**Phytoplankton**

The five major groups of phytoplankton encountered in the investigation period in different sites are Chlorophyceae, Cyanophyceae, Bacillariophyceae, Euglenophyceae and Dinophyceae. The density of total phytoplankton ranged from 5.16 to 236.0 no.l^{-1} x 10^2 and 4.34 to 117.83 no.l^{-1} x 10^2 in 2006-07 and 2007-08, respectively (Fig. 90 and 92).

**Fig.** 74-77 depict the spatial and temporal variation of density (no.l^{-1} x 10^2) of different groups of phytoplankton community (Chlorophyceae, Cyanophyceae, Bacillariophyceae, Euglenophyceae and Dinophyceae) in 10 different sampling stations of Chatla Floodplain Lake during post-monsoon 2006 to monsoon 2007.

**Fig.** 78-81 depicts the spatial and temporal variation of density (no.l^{-1} x 10^3) of different groups of phytoplankton community (Chlorophyceae, Cyanophyceae, Bacillariophyceae, Euglenophyceae and Dinophyceae) in 10 different sampling stations of Chatla Floodplain Lake during post-monsoon 2007 to monsoon 2008.

**Station 1 (JC)**
In this station, density of total phytoplankton ranged from 10.16 to 30.38 no.l⁻¹ x 10² and 4.5 to 12.83 no.l⁻¹ x 10² in 2006-07 and 2007-08 respectively. Highest was recorded in monsoon season and lowest in pre-monsoon season in 2006-07 (Fig. 90) while in 2007-08, it was recorded highest in post-monsoon season and lowest in pre-monsoon season (Fig. 92).

The density of Chlorophyceae was found to be highest among all the phytoplankton groups in all the season in 2006-07 ranging from 4.67 to 16.06 no.l⁻¹ x 10². In 2007-08 it did not show the same pattern. The density of Chlorophyceae ranged from 1.16 to 6.83 no.l⁻¹ x 10² in 2007-08. In 2006-07, density of Chlorophyceae was highest (16.06 no.l⁻¹ x 10²) in monsoon and lowest density was recorded in pre-monsoon (4.67 no.l⁻¹ x 10²) whereas in 2007-08, highest density (6.83 no.l⁻¹ x 10²) of Chlorophyceae was recorded in post-monsoon and lowest density was recorded in winter (1.16 no.l⁻¹ x 10²) (Fig. 74-81).

The density of Cyanophyceae ranged from 2.0 to 6.0 no.l⁻¹ x 10² and 0.5 to 5.83 no.l⁻¹ x 10² in 2006-07 and 2007-08, respectively. In 2006-07, highest density (6.0 no.l⁻¹ x 10²) of Cyanophyceae was recorded in monsoon and lowest density was recorded in post-monsoon (2.0 no.l⁻¹ x 10²) whereas in 2007-08, highest density of Cyanophyceae was found in post-monsoon (5.83 no.l⁻¹ x 10²) and lowest in winter (0.5 no.l⁻¹ x 10²) and totally absent in pre-monsoon (Fig. 74-81).

Bacillariophyceae ranged from 3.06 to 7.11 no.l⁻¹ x 10² and 0.16 to 1.83 no.l⁻¹ x 10² in 2006-07 and 2007-08 respectively. In 2006-07, highest density of Bacillariophyceae (7.11 no.l⁻¹ x 10²) was recorded in monsoon and lowest density was recorded in pre-monsoon (3.06 no.l⁻¹ x 10²) whereas in 2007-08, highest density of Bacillariophyceae (1.83 no.l⁻¹ x 10²) was recorded in pre-monsoon and lowest density was recorded in monsoon (0.16 no.l⁻¹ x 10²) (Fig. 74-81).

Euglenophyceae was found to be present only in monsoon 2006-07 (1.22 no.l⁻¹ x 10²) but in 2007-08 it was found to be present in winter (2.16 no.l⁻¹ x 10²) and pre-monsoon (0.83 no.l⁻¹ x 10²) and totally absent in rest of the seasons (Fig. 74-81).

Dinophytes were found to be present only in post-monsoon 2007-08 (0.16 no.l⁻¹ x 10²) and totally absent in rest of the season throughout the study period (Fig. 74-81).

Station 2 (BC)

In this station, density of total phytoplankton ranged from 16.11 to 24.39 no.l⁻¹ x 10² and 4.34 to 14.83 no.l⁻¹ x 10² in 2006-07 and 2007-08 respectively. Highest was recorded in monsoon season and lowest in pre-monsoon season in 2006-07 (Fig. 90) while in 2007-08, it was recorded highest in winter season and lowest in post-monsoon season (Fig. 92).
Among all the phytoplankton groups highest density of Chlorophyceae was recorded in all the seasons in both 2006-07 and 2007-08. Density of Chlorophyceae ranged from 8.72 to 12.28 no.l\(^{-1}\) x 10\(^2\) and 2.16 to 11.16 no.l\(^{-1}\) x 10\(^2\) in 2006-07 and 2007-08, respectively. In 2006-07, highest density of Chlorophyceae (12.28 no.l\(^{-1}\) x 10\(^2\)) was recorded in post-monsoon and lowest density was recorded in winter (8.72 no.l\(^{-1}\) x 10\(^2\)) whereas in 2007-08, it was found to be highest in winter (11.16 no.l\(^{-1}\) x 10\(^2\)) and lowest in post-monsoon (2.16 no.l\(^{-1}\) x 10\(^2\)) (Fig. 74-81).

Density of Cyanophyceae ranged from 3.34 to 7.61 no.l\(^{-1}\) x 10\(^2\) and 0.67 to 2.16 no.l\(^{-1}\) x 10\(^2\) in 2006-07 and 2007-08 respectively. In 2006-07, highest density of Cyanophyceae (7.61 no.l\(^{-1}\) x 10\(^2\)) was recorded in winter and lowest density (3.34 no.l\(^{-1}\) x 10\(^2\)) was recorded in pre-monsoon whereas in 2007-08, it was found to be highest in post-monsoon (2.16 no.l\(^{-1}\) x 10\(^2\)) and lowest in winter and monsoon (0.67 no.l\(^{-1}\) x 10\(^2\)) (Fig. 74-81).

Bacillariophyceae ranged from 2.5 to 7.28 no.l\(^{-1}\) x 10\(^2\) and 0.67 to 1.5 no.l\(^{-1}\) x 10\(^2\) in 2006-07 and 2007-08 respectively. In 2006-07, highest density of Bacillariophyceae (7.28 no.l\(^{-1}\) x 10\(^2\)) was found in monsoon and lowest density (2.5 no.l\(^{-1}\) x 10\(^2\)) was recorded in post-monsoon while in 2007-08, it was found to be highest in pre-monsoon (1.5 no.l\(^{-1}\) x 10\(^2\)) and lowest in monsoon (0.67 no.l\(^{-1}\) x 10\(^2\)) and totally absent in post-monsoon and winter (Fig. 74-81).

In this site, Euglenophyceae was found to be present only in monsoon (1.11 no.l\(^{-1}\) x 10\(^2\)) in 2006-07. However in 2007-08, it was ranged from 2.5 to 5.5 no.l\(^{-1}\) x 10\(^2\). Highest and lowest population was found in pre-monsoon (5.5 no.l\(^{-1}\) x 10\(^2\)) and winter (2.5 no.l\(^{-1}\) x 10\(^2\)) respectively and totally absent in rest of the season (Fig. 74-81).

Dinophytes were found to be totally absent throughout the study period except winter 2007-08 (0.5 no.l\(^{-1}\) x 10\(^2\)) but their population was found to be very less (Fig. 74-81).

Station 3 (DGK)

In this station, density of total phytoplankton ranged from 23.5 to 43.11 no.l\(^{-1}\) x 10\(^2\) and 6.0 to 29.5 no.l\(^{-1}\) x 10\(^2\) in 2006-07 and 2007-08 respectively. Highest was recorded in monsoon season and lowest in post-monsoon season in 2006-07 (Fig. 90) while in 2007-08, it was recorded highest in post-monsoon season and lowest in monsoon season (Fig. 92).

In this site, among all the phytoplankton groups density of Chlorophyceae was found highest in all the seasons in both the years. It ranged from 10.67 to 28.6 no.l\(^{-1}\) x 10\(^2\) and 3.67 to 16.34 no.l\(^{-1}\) x 10\(^2\) in 2006-07 and 2007-08 respectively. In 2006-07, highest density (28.6 no.l\(^{-1}\) x 10\(^2\)) was recorded in monsoon and lowest density was recorded in winter (10.67 no.l\(^{-1}\) x 10\(^2\)) whereas in 2007-08, it was found to be highest in post-monsoon (16.34 no.l\(^{-1}\) x 10\(^2\)) and lowest in pre-monsoon (3.67 no.l\(^{-1}\) x 10\(^2\)) (Fig. 74-81).
Density of Cyanophyceae ranged from 6.34 to 12.23 no. l$^{-1} \times 10^2$ and 0.83 to 10.34 no. l$^{-1} \times 10^2$ in 2006-07 and 2007-08 respectively. In 2006-07, highest density of Cyanophyceae (12.23 no. l$^{-1} \times 10^2$) was recorded in pre-monsoon and lowest density (6.34 no. l$^{-1} \times 10^2$) was recorded in post-monsoon whereas in 2007-08, it was found to be highest in post-monsoon (10.34 no. l$^{-1} \times 10^2$) and lowest in monsoon (0.83 no. l$^{-1} \times 10^2$) (Fig. 74-81).

Bacillariophyceae ranged from 4.56 to 9.67 no. l$^{-1} \times 10^2$ in 2006-07 and totally absent in all the seasons of 2007-08. In 2006-07, highest density of Bacillariophyceae (9.67 no. l$^{-1} \times 10^2$) was found in pre-monsoon and lowest density was recorded in post-monsoon (Fig. 74-81).

Euglenophyceae ranged from 0.61 to 1.23 no. l$^{-1} \times 10^2$ and 2.16 to 2.83 no. l$^{-1} \times 10^2$ in 2006-07 and 2007-08 respectively. In 2006-07, highest density of Euglenophyceae was recorded in monsoon (1.23 no. l$^{-1} \times 10^2$) and lowest density was recorded in post-monsoon (0.61 no. l$^{-1} \times 10^2$) whereas in 2007-08, it was found to be present only in post-monsoon (2.83 no. l$^{-1} \times 10^2$) and pre-monsoon (2.16 no. l$^{-1} \times 10^2$) and totally absent in rest of the seasons (Fig. 74-81).

Dinophytes were found to be present only in post-monsoon and winter in 2006-07 (1.11 no. l$^{-1} \times 10^2$ and 1.23 no. l$^{-1} \times 10^2$) and they were found to be totally absent in rest of the season throughout the study period (Fig. 74-81).

**Station 4 (RB)**

In this station, density of total phytoplankton ranged from 17.83 to 73.5 no. l$^{-1} \times 10^2$ and 34.0 to 110.67 no. l$^{-1} \times 10^2$ in 2006-07 and 2007-08 respectively. Highest was recorded in monsoon season and lowest in winter season in 2006-07 (Fig. 90) while in 2007-08, it was recorded highest in monsoon season and lowest in post-monsoon and pre-monsoon season (Fig. 92).

In this station, in 2006-07 among all the phytoplankton groups the density of Chlorophyceae was found to be highest in all the seasons except pre-monsoon, while in 2007-08 it was found to be highest in all the seasons except monsoon. Its density ranged from 9.5 to 43.5 no. l$^{-1} \times 10^2$ and 14.5 to 25.34 no. l$^{-1} \times 10^2$ in 2006-07 and 2007-08 respectively. In 2006-07, highest density of Chlorophyceae (43.5 no. l$^{-1} \times 10^2$) was recorded in monsoon and lowest density was recorded in winter (9.5 no. l$^{-1} \times 10^2$) while in 2007-08 highest density of Chlorophyceae was found in monsoon (25.34 no. l$^{-1} \times 10^2$) and lowest density in winter (14.5 no. l$^{-1} \times 10^2$) (Fig. 74-81).

The density of Cyanophyceae ranged from 4.34 to 12.16 no. l$^{-1} \times 10^2$ and 6.0 to 8.83 no. l$^{-1} \times 10^2$ in 2006-07 and 2007-08 respectively. In 2006-07, highest Cyanophyceae density (12.16 no. l$^{-1} \times 10^2$) was recorded in monsoon and lowest in pre-monsoon (4.34 no. l$^{-1} \times 10^2$) while in 2007-08, highest density of Cyanophyceae (8.83 no. l$^{-1} \times 10^2$) was found in post-monsoon and lowest in pre-monsoon (6.0 no. l$^{-1} \times 10^2$) and totally absent in monsoon (Fig. 74-81).
Bacillariophyceae ranged from 2.16 to 17.83 no.1$^{-1}$ x 10$^2$ and 2.5 to 79.16 no.1$^{-1}$ x 10$^2$ in 2006-07 and 2007-08 respectively. In 2006-07, highest density of Bacillariophyceae (17.83 no.1$^{-1}$ x 10$^2$) was found in pre-monsoon and lowest in winter (2.16 no.1$^{-1}$ x 10$^2$) while in 2007-08, it was found to be highest in monsoon (79.16 no.1$^{-1}$ x 10$^2$) and lowest in post-monsoon (2.5 no.1$^{-1}$ x 10$^2$) (Fig. 74-81).

Euglenophyceae ranged from 1.67 to 5.5 no.1$^{-1}$ x 10$^2$ and 2.0 to 13.0 no.1$^{-1}$ x 10$^2$ in 2006-07 and 2007-08 respectively. In 2006-07, highest density of Euglenophyceae (5.5 no.1$^{-1}$ x 10$^2$) was recorded in post-monsoon and lowest in winter (1.67 no.1$^{-1}$ x 10$^2$) whereas in 2007-08 highest density of Euglenophyceae was found in winter (13.0 no.1$^{-1}$ x 10$^2$) and lowest in post-monsoon (2.0 no.1$^{-1}$ x 10$^2$) (Fig. 74-81).

The density of Dinophyceae ranged from 1.34 to 3.5 no.1$^{-1}$ x 10$^2$ and 0.83 to 1.83 no.1$^{-1}$ x 10$^2$ in 2006-07 and 2007-08 respectively. In 2006-07, Dinophytes were found to be present only in post-monsoon (1.34 no.1$^{-1}$ x 10$^2$) and pre-monsoon (3.5 no.1$^{-1}$ x 10$^2$) while in 2007-08 it was found to be present in post-monsoon (1.83 no.1$^{-1}$ x 10$^2$) and monsoon (83 no.1$^{-1}$ x 10$^2$) and totally absent in rest of the seasons (Fig. 74-81).

Station 5 (UB)

In this station, density of total phytoplankton ranged from 94.34 to 236.0 no.1$^{-1}$ x 10$^2$ and 34.16 to 70.34 no.1$^{-1}$ x 10$^2$ in 2006-07 and 2007-08 respectively. Highest was recorded in post-monsoon season and lowest in winter season in 2006-07 (Fig. 90) while in 2007-08, it was recorded highest in winter season followed by pre-monsoon season and lowest in monsoon season (Fig. 92).

In this site the density of Chlorophyceae ranged from 32.67 to 134.34 no.1$^{-1}$ x 10$^2$ and 15.83 to 29.34 no.1$^{-1}$ x 10$^2$ in 2006-07 and 2007-08 respectively. In 2006-07, highest Chlorophyceae density (134.34 no.1$^{-1}$ x 10$^2$) was recorded in monsoon followed by post-monsoon (85.0 no.1$^{-1}$ x 10$^2$) and lowest density was recorded in winter (32.67 no.1$^{-1}$ x 10$^2$) while in 2007-08, it was found to be highest in post-monsoon (29.34 no.1$^{-1}$ x 10$^2$) and lowest in monsoon (15.83 no.1$^{-1}$ x 10$^2$) (Fig. 74-81).

The density of Cyanophyceae ranged from 13.0 to 42.34 no.1$^{-1}$ x 10$^2$ and 7.67 to 15.0 no.1$^{-1}$ x 10$^2$ in 2006-07 and 2007-08, respectively. In 2006-07, highest cyanophycean density (42.34 no.1$^{-1}$ x 10$^2$) was recorded in winter and lowest in pre-monsoon (13.0 no.1$^{-1}$ x 10$^2$) while in 2007-08, it was recorded highest in monsoon (15.0 no.1$^{-1}$ x 10$^2$) and lowest in post-monsoon (7.67 no.1$^{-1}$ x 10$^2$) (Fig. 74-81).

Bacillariophyceae ranged from 13.34 to 69.0 no.1$^{-1}$ x 10$^2$ and 0.83 to 29.0 no.1$^{-1}$ x 10$^2$ in 2006-07 and 2007-08, respectively. In 2006-07, highest density of Bacillariophyceae (69.0 no.1$^{-1}$ x 10$^2$) was found in pre-monsoon and lowest in winter (13.34 no.1$^{-1}$ x 10$^2$) while in 2007-08, it was recorded highest in pre-monsoon (29.0 no.1$^{-1}$ x 10$^2$) lowest in monsoon (0.83 no.1$^{-1}$ x 10$^2$). Higher
population of Bacillariophyceae was observed in 2006-07 than that of 2007-08 (Fig. 74-81).

The density of Euglenophyceae ranged from 0.67 to 106.83 no.l\(^{-1}\) x 10\(^2\) and 1.34 to 22.5 no.l\(^{-1}\) x 10\(^2\) in 2006-07 and 2007-08 respectively. In 2006-07, highest density of Euglenophyceae (106.83 no.l\(^{-1}\) x 10\(^3\)) was found in post-monsoon and lowest in monsoon (0.67 no.l\(^{-1}\) x 10\(^2\)) while in 2007-08, it was recorded highest in winter (22.5 no.l\(^{-1}\) x 10\(^2\)) and lowest in monsoon. Their population was found to be very less throughout the year in 2007-08 except winter (Fig. 74-81).

Dinophytes were found to be totally absent throughout the study period except post-monsoon 2007-08 (0.34 no.l\(^{-1}\) x 10\(^2\)) but their population was found to be very less (Fig. 74-81).

Station 6 (OW)

In this station, density of total phytoplankton ranged from 44.34 to 74.67 no.l\(^{-1}\) x 10\(^2\) and 45.5 to 117.83 no.l\(^{-1}\) x 10\(^2\) in 2006-07 and 2007-08 respectively. Highest was recorded in monsoon season and lowest in post-monsoon season in 2006-07 (Fig. 90) while in 2007-08, it was recorded highest in monsoon season and lowest in pre-monsoon season (Fig. 92).

In this site among all the phytoplankton groups the density of Chlorophyceae was found to be highest in all the seasons during 2006-07. In 2007-08 except winter it was found highest in all other seasons. Its density ranged from 14.16 to 48.83 no.l\(^{-1}\) x 10\(^2\) and 8.34 to 55.83 no.l\(^{-1}\) x 10\(^2\) in 2006-07 and 2007-08 respectively. In 2006-07, highest density of Chlorophyceae (48.83 no.l\(^{-1}\) x 10\(^3\)) was recorded in monsoon and lowest in winter (14.16 no.l\(^{-1}\) x 10\(^3\)) while in 2007-08, it was also found to be highest in monsoon (55.83 no.l\(^{-1}\) x 10\(^2\)) lowest in winter (8.34 no.l\(^{-1}\) x 10\(^2\)) (Fig. 74-81).

The density of Cyanophyceae ranged from 10.16 to 19.34 no.l\(^{-1}\) x 10\(^2\) and 13.34 to 25.67 no.l\(^{-1}\) x 10\(^2\) in 2006-07 and 2007-08 respectively. In 2006-07, highest density of Cyanophyceae (19.34 no.l\(^{-1}\) x 10\(^3\)) was recorded in pre-monsoon and lowest in monsoon (10.16 no.l\(^{-1}\) x 10\(^3\)) whereas in 2007-08, it was found to be highest in winter (25.67 no.l\(^{-1}\) x 10\(^2\)) and lowest in pre-monsoon (13.34 no.l\(^{-1}\) x 10\(^3\)). Higher density of Cyanophyceae was found in all the season in 2007-08 than that of 2006-07 except pre-monsoon (Fig. 74-81).

Bacillariophyceae ranged from 3.83 to 9.16 no.l\(^{-1}\) x 10\(^2\) and 3.5 to 35.83 no.l\(^{-1}\) x 10\(^2\) in 2006-07 and 2007-08 respectively. In both 2006-07 and 2007-08 highest density of Bacillariophyceae 9.16 no.l\(^{-1}\) x 10\(^2\) and 35.83 no.l\(^{-1}\) x 10\(^2\), respectively were recorded in monsoon and lowest (3.83 no.l\(^{-1}\) x 10\(^2\)) and 3.5 no.l\(^{-1}\) x 10\(^2\), respectively were recorded in post-monsoon (Fig. 74-81).

Euglenophyceae ranged from 0.67 to 9.0 no.l\(^{-1}\) x 10\(^2\) and 1.67 to 10.67 no.l\(^{-1}\) x 10\(^2\) in 2006-07 and 2007-08 respectively. In 2006-07, highest density of
Euglenophyceae (9.0 no. l⁻¹ x 10²) was found in winter and lowest in pre-monsoon (0.67 no.l⁻¹ x 10²) while in 2007-08, it was found to be highest in pre-monsoon (10.67 no.l⁻¹ x 10²) and lowest in monsoon (1.67 no.l⁻¹ x 10²). Density of Euglenophyceae was found to be same in monsoon of both the years (Fig. 74-81).

Dinophyceae ranged from 2.16 to 4.83 no.l⁻¹ x 10² and 1.5 to 3.0 no.l⁻¹ x 10² in 2006-07 and 2007-08 respectively. In 2006-07, highest density of Dinophyceae (4.83 no.l⁻¹ x 10²) was found in monsoon and lowest in winter (2.16 no.l⁻¹ x 10²) and totally absent in post-monsoon while in 2007-08, highest density of Dinophyceae was recorded in monsoon (3.0 no.l⁻¹ x 10²) and lowest in pre-monsoon (1.5 no.l⁻¹ x 10²). The density of Dinophyceae was found to be low throughout the study period (Fig. 74-81).

Station 7 (MB)

In this station, density of total phytoplankton ranged from 8.34 to 51.83 no.l⁻¹ x 10² and 18.0 to 39.83 no.l⁻¹ x 10² in 2006-07 and 2007-08 respectively. Highest was recorded in monsoon season and lowest in pre-monsoon season in 2006-07 (Fig. 90) while in 2007-08, it was recorded highest in pre-monsoon season and lowest in monsoon season (Fig. 92).

The density of Chlorophyceae ranged from 4.0 to 13.67 no.l⁻¹ x 10² and 10.34 to 18.0 no.l⁻¹ x 10² in 2006-07 and 2007-08, respectively. In 2006-07, highest density of Chlorophyceae (13.67 no.l⁻¹ x 10²) was recorded in monsoon and lowest in winter (4.0 no.l⁻¹ x 10²) while in 2007-08, it was found to be highest in pre-monsoon (18.0 no.l⁻¹ x 10²) and lowest in winter (10.34 no.l⁻¹ x 10²). Higher density of Chlorophyceae was found in all the seasons of 2007-08 than that of 2006-07 (Fig. 74-81).

Cyanophyceae density ranged from 1.5 to 10.34 no.l⁻¹ x 10² and 4.34 to 14.5 no.l⁻¹ x 10² in 2006-07 and 2007-08, respectively. In 2006-07, highest cyanophycean density (10.34 no.l⁻¹ x 10²) was recorded in monsoon and lowest in pre-monsoon (1.5 no.l⁻¹ x 10²) whereas in 2007-08, it was recorded highest in post-monsoon (14.5 no.l⁻¹ x 10²) and lowest in monsoon (4.34 no.l⁻¹ x 10²) (Fig. 74-81).

Bacillariophyceae density ranged from 1.67 to 26.5 no.l⁻¹ x 10² and 2.16 to 16.5 no.l⁻¹ x 10² in 2006-07 and 2007-08, respectively. In 2006-07, highest density of Bacillariophyceae (26.5 no.l⁻¹ x 10²) was found in monsoon and lowest in pre-monsoon (1.67 no.l⁻¹ x 10²) whereas in 2007-08, it was recorded highest in pre-monsoon (16.5 no.l⁻¹ x 10²) and lowest in monsoon (2.16 no.l⁻¹ x 10²) (Fig. 74-81).

The density of Euglenophyceae ranged from 0.83 to 3.5 no.l⁻¹ x 10² and 0.67 to 1.67 no.l⁻¹ x 10² in 2006-07 and 2007-08 respectively. In 2006-07, highest density of Euglenophyceae (3.5 no.l⁻¹ x 10²) was found in post-monsoon and lowest in pre-monsoon (0.83 no.l⁻¹ x 10²) while in 2007-08, it was found to be
present only in post-monsoon \((1.67 \text{ no.} l^{-1} \times 10^2)\) and winter \((0.67 \text{ no.} l^{-1} \times 10^2)\) and totally absent in rest of the seasons (Fig. 74-81).

Dinophyceae was found to be totally absent in all the seasons in both the years of study (Fig. 74-81).

**Station 8 (SAL)**

In this station, density of total phytoplankton ranged from 10.5 to 30.67 no.\(l^{-1} \times 10^2\) and 10.67 to 36.34 no.\(l^{-1} \times 10^2\) in 2006-07 and 2007-08 respectively. Highest was recorded in monsoon season and lowest in pre-monsoon season in 2006-07 (Fig. 90) while in 2007-08, it was recorded highest in winter season and lowest in monsoon season (Fig. 92).

The density of Chlorophyceae ranged from 4.0 to 11.0 no.\(l^{-1} \times 10^2\) and 7.0 to 23.16 no.\(l^{-1} \times 10^2\) in 2006-07 and 2007-08, respectively. In 2006-07, highest density of Chlorophyceae \((11.0 \text{ no.} l^{-1} \times 10^2)\) was recorded in monsoon and lowest in pre-monsoon \((4.0 \text{ no.} l^{-1} \times 10^2)\) while in 2007-08, it was found to be highest in winter \((23.16 \text{ no.} l^{-1} \times 10^2)\) and lowest in pre-monsoon \((7.0 \text{ no.} l^{-1} \times 10^2)\) (Fig. 74-81). Density of Chlorophyceae was found to be higher in almost all the seasons in 2007-08 than that of 2006-07 except monsoon.

The density of Cyanophyceae ranged from 3.0 to 7.16 no.\(l^{-1} \times 10^2\) and 0.34 to 10.16 no.\(l^{-1} \times 10^2\) in 2006-07 and 2007-08 respectively. In 2006-07, highest density of Cyanophyceae \((7.16 \text{ no.} l^{-1} \times 10^2)\) was recorded in monsoon and lowest in post-monsoon \((3.0 \text{ no.} l^{-1} \times 10^2)\) while in 2007-08, it was found to be highest in post-monsoon \((10.16 \text{ no.} l^{-1} \times 10^2)\) and lowest in monsoon \((0.34 \text{ no.} l^{-1} \times 10^2)\) (Fig. 74-81).

Bacillariophyceae ranged from 1.0 to 7.16 no.\(l^{-1} \times 10^2\) and 1.34 to 4.16 no.\(l^{-1} \times 10^2\) in 2006-07 and 2007-08 respectively. In 2006-07, highest density of Bacillariophyceae \((7.16 \text{ no.} l^{-1} \times 10^2)\) was found in monsoon and lowest in post-monsoon \((1.0 \text{ no.} l^{-1} \times 10^2)\) while in 2007-08 highest density of Bacillariophyceae was recorded in winter \((4.16 \text{ no.} l^{-1} \times 10^2)\) and lowest in monsoon \((1.34 \text{ no.} l^{-1} \times 10^2)\) and totally absent in post-monsoon (Fig. 74-81).

Euglenophyceae ranged from 0.5 to 2.16 no.\(l^{-1} \times 10^2\) and 2.67 to 3.16 no.\(l^{-1} \times 10^2\) in 2006-07 and 2007-08 respectively. In 2006-07, highest density of Euglenophyceae \((2.16 \text{ no.} l^{-1} \times 10^2)\) was found in monsoon and lowest in post-monsoon \((0.5 \text{ no.} l^{-1} \times 10^2)\) whereas in 2007-08 it was found to be present only in winter \((3.16 \text{ no.} l^{-1} \times 10^2)\) and pre-monsoon \((2.67 \text{ no.} l^{-1} \times 10^2)\) (Fig. 74-81).

Dinophytes were found to be present only in monsoon during 2006-07 \((3.16 \text{ no.} l^{-1} \times 10^2)\) while in 2007-08, it was found to be present in post-monsoon \((0.34 \text{ no.} l^{-1} \times 10^2)\) and winter \((0.67 \text{ no.} l^{-1} \times 10^2)\) and totally absent in rest of the seasons (Fig. 74-81).

**Station 9 (GR)**
In this station, density of total phytoplankton ranged from 5.16 to 17.83 \( \text{no.}^{-1} \times 10^2 \) and 9.67 to 34.34 \( \text{no.}^{-1} \times 10^2 \) in 2006-07 and 2007-08 respectively. Highest was recorded in winter season followed by monsoon season and lowest in post-monsoon season in 2006-07 (Fig. 90) while in 2007-08, it was recorded highest in winter season and lowest in monsoon season (Fig. 92).

In this site density of Chlorophyceae ranged from 2.34 to 9.83 \( \text{no.}^{-1} \times 10^2 \) and 5.0 to 22.67 \( \text{no.}^{-1} \times 10^2 \) in 2006-07 and 2007-08 respectively. In 2006-07, highest density of Chlorophyceae (9.83 \( \text{no.}^{-1} \times 10^2 \)) was recorded in post-monsoon and lowest in pre-monsoon (2.34 \( \text{no.}^{-1} \times 10^2 \)). Similarly in 2007-08 highest density was recorded in post-monsoon (22.67 \( \text{no.}^{-1} \times 10^2 \)) and lowest in pre-monsoon (5.0 \( \text{no.}^{-1} \times 10^2 \)) (Fig. 74-81). Density of Chlorophyceae was found to be higher in almost all the seasons of 2007-08 than that of 2006-07.

The density of Cyanophyceae ranged from 0.5 to 8.0 \( \text{no.}^{-1} \times 10^2 \) and 1.83 to 18.0 \( \text{no.}^{-1} \times 10^2 \) in 2006-07 and 2007-08 respectively. In 2006-07, highest density of Cyanophyceae (8.0 \( \text{no.}^{-1} \times 10^2 \)) was recorded in winter and lowest in post-monsoon (0.5 \( \text{no.}^{-1} \times 10^2 \)) whereas in 2007-08, it was also recorded highest in winter (18.0 \( \text{no.}^{-1} \times 10^2 \)) and lowest in post-monsoon (1.83 \( \text{no.}^{-1} \times 10^2 \)). However, it was found to be more than two times higher in winter season of 2007-08 than that of 2006-07 (Fig. 74-81).

Bacillariophycæae ranged from 2.0 to 3.34 \( \text{no.}^{-1} \times 10^2 \) and 1.16 to 3.34 \( \text{no.}^{-1} \times 10^2 \) in 2006-07 and 2007-08, respectively. In 2006-07, highest density of Bacillariophycæae (3.34 \( \text{no.}^{-1} \times 10^2 \)) was found in winter and lowest in pre-monsoon (2.0 \( \text{no.}^{-1} \times 10^2 \)) while in 2007-08 highest density was recorded in post-monsoon (3.34 \( \text{no.}^{-1} \times 10^2 \)) and lowest in monsoon (1.16 \( \text{no.}^{-1} \times 10^2 \)). In pre-monsoon it was totally absent (Fig. 74-81).

The density of Euglenophyceae ranged from 0.16 to 1.34 \( \text{no.}^{-1} \times 10^2 \) in 2006-07 and totally absent in all the season in 2007-08. In 2006-07, highest density of Euglenophyceae (1.34 \( \text{no.}^{-1} \times 10^2 \)) was found in winter and lowest density (0.16 \( \text{no.}^{-1} \times 10^2 \)) was found in post-monsoon and monsoon. In pre-monsoon it was totally absent (Fig. 74-81).

Dinophyceae was found to be totally absent in 2006-07 and ranged from 0.83 to 1.83 \( \text{no.}^{-1} \times 10^2 \) in 2007-08. Highest density of Dinophyceae (1.83 \( \text{no.}^{-1} \times 10^2 \)) was recorded in post-monsoon and lowest in pre-monsoon (0.83 \( \text{no.}^{-1} \times 10^2 \)). It was totally absent in monsoon but their population was found to be very less throughout the year (Fig. 74-81).

**Station 10 (BR)**

In this station, density of total phytoplankton ranged from 9.0 to 31.5 \( \text{no.}^{-1} \times 10^2 \) and 10.67 to 19.0 \( \text{no.}^{-1} \times 10^2 \) in 2006-07 and 2007-08 respectively. Highest was recorded in monsoon season and lowest in winter season in 2006-07 (Fig. 90) while in 2007-08, it was recorded highest in winter season and lowest in monsoon season (Fig. 92).
The density of Chlorophyceae ranged from 5.0 to 19.5 no.\,l\,-1 \times 10^2 and 2.83 to 9.16 no.\,l\,-1 \times 10^2 in 2006-07 and 2007-08 respectively. In 2006-07, highest density of Chlorophyceae (19.5 no.\,l\,-1 \times 10^2) was recorded in monsoon and lowest in winter (5.0 no.\,l\,-1 \times 10^2) whereas in 2007-08 it was recorded highest in monsoon (9.16 no.\,l\,-1 \times 10^2) and lowest in pre-monsoon (2.83 no.\,l\,-1 \times 10^2) (Fig. 74-81).

The density of Cyanophyceae ranged from 3.0 to 8.0 no.\,l\,-1 \times 10^2 and 1.5 to 9.67 no.\,l\,-1 \times 10^2 in 2006-07 and 2007-08 respectively. In 2006-07, highest Cyanophyceae density (8.0 no.\,l\,-1 \times 10^2) was recorded in monsoon and lowest in winter (3.0 no.\,l\,-1 \times 10^2) while in 2007-08 it was recorded highest in winter (9.67 no.\,l\,-1 \times 10^2) and lowest in monsoon (1.5 no.\,l\,-1 \times 10^2) (Fig. 74-81).

The density of Bacillariophyceae ranged from 1.0 to 2.5 no.\,l\,-1 \times 10^2 and 1.67 to 2.16 no.\,l\,-1 \times 10^2 in 2006-07 and 2007-08 respectively. In 2006-07, highest density of Bacillariophyceae (2.5 no.\,l\,-1 \times 10^2) was found in monsoon and lowest (1.0 no.\,l\,-1 \times 10^2) in post-monsoon and winter and totally absent in pre-monsoon while in 2007-08, it was found to be present only in winter (1.67 no.\,l\,-1 \times 10^2) and pre-monsoon (2.16 no.\,l\,-1 \times 10^2) (Fig. 74-81).

Euglenophyceae was found to be present only in post-monsoon 2006-07 (0.5 no.\,l\,-1 \times 10^2) in both the years (Fig. 74-81).

Dinophyceae was found to be present only in pre-monsoon (3.0 no.\,l\,-1 \times 10^2) and monsoon (1.5 no.\,l\,-1 \times 10^2) in 2006-07 and totally absent in rest of the seasons throughout the study period (Fig. 74-81).

**Density of different groups of phytoplankton in different sites**

**Chlorophyceae**

Density of Chlorophyceae in different sites ranged from 2.34 to 134.34 no.\,l\,-1 \times 10^2 and 1.16 to 55.83 no.\,l\,-1 \times 10^2 in 2006-07 and 2007-08 respectively.

In 2006-07 among all the sites, highest density of Chlorophyceae (134.34 no.\,l\,-1 \times 10^2) was found in monsoon at station 5 (UB) (Fig. 77) and lowest density was recorded in station 9 (GR) in post-monsoon (2.34 no.\,l\,-1 \times 10^2) (Fig. 74). In 2007-08 it was recorded highest in the station 6 (OW) in monsoon (55.83 no.\,l\,-1 \times 10^2) (Fig. 81) and lowest in the station 1 (JC) during winter (1.16 no.\,l\,-1 \times 10^2) (Fig. 79).

**Cyanophyceae**

Overall density of Cyanophyceae in different sites ranged from 0.5 to 42.34 no.\,l\,-1 \times 10^2 and 0.34 to 25.67 no.\,l\,-1 \times 10^2 in 2006-07 and 2007-08 respectively. In 2006-07, among all the sites highest cyanophycean density (42.34 no.\,l\,-1 \times 10^2) was recorded in winter (Fig. 75) at station 5 (UB) and lowest in station 9 (GR) during post-monsoon (0.5 no.\,l\,-1 \times 10^2) (Fig. 74). In 2007-08,
among all the sites it was recorded highest in the station 6 (OW) during winter (25.67 no.l\(^{-1}\) x 10\(^2\)) (Fig. 79) and lowest in the station 8 (SAL) during monsoon (0.34 no.l\(^{-1}\) x 10\(^2\)) (Fig. 81).

**Bacillariophyceae**

Overall density of Bacillariophyceae in different sites ranged from 1.0 to 69.0 no.l\(^{-1}\) x 10\(^2\) and 0.16 to 79.16 no.l\(^{-1}\) x 10\(^2\) in 2006-07 and 2007-08 respectively. Among all the sites in 2006-07, highest density of Bacillariophyceae (69.0 no.l\(^{-1}\) x 10\(^2\)) was found in station 5 (UB) during pre-monsoon (Fig. 76) and lowest (1.0 no.l\(^{-1}\) x 10\(^2\)) in station 8 and 10 (SAL and BR) during post-monsoon and winter (Fig. 74 and 75). In 2007-08, it was found to be highest in the station 4 (RB) during monsoon (79.16 no.l\(^{-1}\) x 10\(^2\)) and lowest in station 1 (JC) during monsoon (0.16 no.l\(^{-1}\) x 10\(^2\)) (Fig. 81).

**Euglenophyceae**

Overall density of Euglenophyceae in different sites ranged from 0.16 to 106.83 no.l\(^{-1}\) x 10\(^2\) and 0.67 to 22.5 no.l\(^{-1}\) x 10\(^2\) in 2006-07 and 2007-08 respectively. Among all the sites in 2006-07, highest density of Euglenophyceae (106.83 no.l\(^{-1}\) x 10\(^2\)) was recorded in station 5 (UB) during post-monsoon and lowest density was found in the station 9 (GR) during post-monsoon (0.16 no.l\(^{-1}\) x 10\(^2\)) (Fig. 74) while in 2007-08, it was recorded highest in the station 5 (UB) during winter (22.5 no.l\(^{-1}\) x 10\(^2\)) and lowest in the station 7 (MB) during winter (0.67 no.l\(^{-1}\) x 10\(^2\)) (Fig. 79).

**Dinophyceae**

Overall density of Dinophyceae in different sites ranged from 1.11 to 4.83 no.l\(^{-1}\) x 10\(^2\) and 0.16 to 3.0 no.l\(^{-1}\) x 10\(^2\) in 2006-07 and 2007-08 respectively. Among all the sites in 2006-07, highest density of dinoflagellates were recorded in the station 6 (OW) during monsoon (4.83 no.l\(^{-1}\) x 10\(^2\)) (Fig. 77) and lowest in the station 3 (DGK) during post-monsoon (1.11 no.l\(^{-1}\) x 10\(^2\)) (Fig. 74) whereas in 2007-08, highest density of Dinophyceae was recorded again in the station 6 (OW) during monsoon (3.0 no.l\(^{-1}\) x 10\(^2\)) (Fig. 81) and lowest in the station 1 (JC) during post-monsoon (0.16 no.l\(^{-1}\) x 10\(^2\)) (Fig. 78).

**Variation of phytoplankton density in different seasons**

**Fig.** 90 and 92: Spatial and temporal variation of density (no.l\(^{-1}\) x 10\(^2\)) of phyto and zooplankton in 10 different sampling station of Chatla Floodplain Lake during post-monsoon 2006-07 to monsoon 2007-08.

During 2006-07, overall highest (236.0 no.l\(^{-1}\) x 10\(^3\)) and lowest (5.16 no.l\(^{-1}\) x 10\(^2\)) density of total phytoplankton was recorded in post-monsoon in the station 5 (UB) and station 9 (GR) respectively (Fig. 90). During 2007-08, it was recorded highest (117.83 no.l\(^{-1}\) x 10\(^2\)) in the station 6 (OW) and lowest (4.34 no.l\(^{-1}\) x 10\(^2\)) in the station 2 (BC) in post-monsoon (Fig. 92).
During post-monsoon in 2006-07, highest density of total phytoplankton (236.0 no.l⁻¹ x 10²) was recorded in the station 5 (UB) and lowest density (5.16 no.l⁻¹ x 10²) was recorded in the station 9 (GR) (Fig. 90) whereas in 2007-08, it was recorded highest (69.83 no.l⁻¹ x 10²) in the station 6 (OW) and lowest (4.34 no.l⁻¹ x 10²) in the station 2 (BC) (Fig. 92).

During winter, in 2006-07, highest density of total phytoplankton (94.34 no.l⁻¹ x 10²) was recorded in the station 5 (UB) and lowest density (9.0 no.l⁻¹ x 10²) was recorded in the station 10 (BR) (Fig. 90). In 2007-08, it was found to be highest (70.34 no.l⁻¹ x 10²) again in the station 5 (UB). However, lowest density (5.0 no.l⁻¹ x 10²) was recorded in the station 1 (JC) (Fig. 92).

During pre-monsoon, in 2006-07, highest density of total phytoplankton (174.83 no.l⁻¹ x 10²) was recorded in the station 5 (UB) and lowest density (10.16 no.l⁻¹ x 10²) was found in the station 1 (JC) (Fig. 90). In 2007-08, it was found to be highest (70.16 no.l⁻¹ x 10²) again in the station 5 (UB) and lowest (4.5 no.l⁻¹ x 10²) in the station 1 (JC) (Fig. 92).

During monsoon in 2006-07, highest density of total phytoplankton (215.34 no.l⁻¹ x 10²) was recorded in the station 5 (UB) and lowest density (17.67 no.l⁻¹ x 10²) was found in the station 9 (GR) (Fig. 90) whereas in 2007-08, it was found to be highest (117.83 no.l⁻¹ x 10²) in the station 6 (OW) and lowest (6.0 no.l⁻¹ x 10²) was found in the station 3 (DGK) (Fig. 92).

Spatial variation of phytoplankton

Table 15 shows spatial variation of mean density (no.l⁻¹ x 10²) of phytoplankton taxonomic groups during September 2006 to August 2007.

Table 16 shows spatial variation of mean abundance (no.l⁻¹ x 10²) of phytoplankton taxonomic groups during September 2006 to August 2007.

A total of 60 taxa of phytoplankton were recorded in 2006-07 and 2007-08. 40 taxa were recorded in 2006-07 and 58 taxa in 2007-08. Phytoplankton community was represented by five major groups viz. Chlorophyceae (20), Cyanophyceae (10), Bacillariophyceae (6), Euglenophyceae (1) and Dinophyceae (3) (Table 15). During 2007-08, phytoplankton community represented by five major groups including one unidentified taxon viz. Chlorophyceae (32), Cyanophyceae (13), Bacillariophyceae (8), Euglenophyceae (1) and Dinophyceae (3) (Table 17).

During 2006-07, the major taxa of phytoplankton were recorded in terms of both density and abundance were Chlorella sp., Cladophora sp., Desmidium sp., Microspora sp., Maugeotia sp., Spirogyra sp., Ulothrix sp., Volvox sp., Zygnema sp. (Chlorophyceae), Anabaena sp., Nostoc sp., Oscillatoria sp. (Cyanophyceae), Cymbella sp., Fragillaria sp., Navicula sp., Nitzschia sp., Synedra sp. (Bacillariophyceae), Euglena sp. (Euglenophyceae), Amphidinium sp., and Glenodinium sp. (Dinophyceae) (Table 15 and 16). Whereas in 2007-08,
the major taxa of phytoplankton were recorded in terms of both density and abundance were *Chlorella* sp., *Closterium* sp., *Cylindrocapsa* sp., *Spirogyra* sp., *Volvox* sp. (Chlorophyceae), *Anabaena* sp., *Nostoc* sp., *Scytonema* sp. (Cyanophyceae), *Eunotia* sp., *Fragillaria* sp., *Nitzschia* sp., *Synedra* sp. (Bacillariophyceae), *Euglena* sp. (Euglenophyceae), *Ceratium* sp. (Dinophyceae) ([Table 17 and 18](#)).

Spatial variation of mean density and abundance of total phytoplankton community represented by five major groups comprising 40 taxa in 2006-07 (September 2006-August 2007) is shown in [Table 15 and 16](#).

During 2006-07, spatial variation of Chlorophyceae showed highest density (83.42 no.\(1^{-1}\) x \(10^2\)) and abundance (99.13 no.\(1^{-1}\) x \(10^2\)) in station 5 (UB) followed by Bacillariophyceae in terms of density (40.13 no.\(1^{-1}\) x \(10^2\)) and abundance (45.6 no.\(1^{-1}\) x \(10^2\)) ([Table 15 and 16](#)). Euglenophyceae attained the third position in terms of mean annual density (31.16 no.\(1^{-1}\) x \(10^2\)) and abundance (31.5 no.\(1^{-1}\) x \(10^2\)). Mean inter station variation of Cyanophyceae was also recorded highest in station 5 (UB) in terms of both density (25.42 no.\(1^{-1}\) x \(10^2\)) and abundance (27.13 no.\(1^{-1}\) x \(10^2\)) and least density and abundance of Dinophyceae were found in station 3, 4, 6, 8 and 10 (DGK, RB, OW, SAL and BR) throughout the year and totally absent in rest of the stations ([Table 15 and 16](#)).

Mean spatial variation of highest density (180.13 no.\(1^{-1}\) x \(10^2\)) and abundance (203.35 no.\(1^{-1}\) x \(10^2\)) of total phytoplankton was recorded from the station 5 (UB) followed by station 6 (OW) (density -53.96 no.\(1^{-1}\) x \(10^2\) and abundance-66.48 no.\(1^{-1}\) x \(10^2\)). Lowest density (14.04 no.\(1^{-1}\) x \(10^2\)) and abundance (19.63 no.\(1^{-1}\) x \(10^2\)) were recorded in the station 9 and 10 (GR and BR) respectively ([Table 15 and 16](#)). But station 4, 5 and 6 (RB, UB and OW) showed moderate density and abundance throughout the year (2006-07).

[Table 17](#) shows spatial variation of mean density (no.\(1^{-1}\) x \(10^2\)) of phytoplankton taxonomic groups during September 2007 to August 2008.

[Table 18](#) shows spatial variation of mean abundance (no.\(1^{-1}\) x \(10^2\)) of phytoplankton taxonomic groups during September 2007 to August 2008.

Spatial variation of mean density and abundance of phytoplankton community represented by five major groups comprising 58 taxa in 2007-08 (September 2007-August 2008) is shown in [Table 17 and 18](#).

During 2007-08, also Chlorophyceae showed highest mean inter station density (29.92 no.\(1^{-1}\) x \(10^2\)) and abundance (31.69 no.\(1^{-1}\) x \(10^2\)) in the station 6 (OW) followed by station 5 (UB) (density -24.04 no.\(1^{-1}\) x \(10^2\) and abundance-26.08 no.\(1^{-1}\) x \(10^2\)) ([Table 17 and 18](#)). Bacillariophyceae was also found to be the second dominant group in terms of density (22.21 no.\(1^{-1}\) x \(10^2\)) and abundance (22.7 no.\(1^{-1}\) x \(10^2\)) recorded from the station 4 (RB). This was followed by Cyanophyceae in terms of density (19.83 no.\(1^{-1}\) x \(10^2\)) and abundance (20.4 no.\(1^{-1}\) x \(10^2\)).
x 10^2) recorded from the station 6 (OW) (Table 17 and 18). Euglenophyceae showed highest density and abundance (7.58 no.l^-1 x 10^2) in station 5 (UB) followed by 6 (OW) (6.0 no.l^-1 x 10^2) and 4 (RB) (density - 5.83 no.l^-1 x 10^2 and abundance-6.08 no.l^-1 x 10^2). Dinophyceae was found to be the least dominant group in terms of density and abundance and totally absent in the station 3, 7 and 10 (DGK, MB and BR) (Table 17 and 18).

Mean spatial variation of highest density (71.96 no.l^-1 x 10^2) and abundance (75.31 no.l^-1 x 10^2) of total phytoplankton was recorded in the station 6 (OW) followed by station 5 (UB) (density -55.5 no.l^-1 x 10^2 and abundance-58.87 no.l^-1 x 10^2) and station 4 (RB) (density -54.58 no.l^-1 x 10^2 and abundance-58.17 no.l^-1 x 10^2). Lowest mean inter station density (7.75 no.l^-1 x 10^2) and abundance (10.17 no.l^-1 x 10^2) of total phytoplankton was found in the station 1 (JC) (Table 17 and 18).

Overall spatial variation of total phytoplankton density was recorded highest in the station 5 (UB) during 2006-07 and station 6 (OW) during 2007-08 respectively (Fig. 94 and 95). Lowest density of total phytoplankton was found in the station 8 (SAL) during 2006-07 and station 1 (JC) during 2007-08 respectively (Fig. 94 and 95).

**Temporal variation of Phytoplankton density and abundance**

Table 23 shows seasonal variation of mean density of phytoplankton community during 2006-07.

Table 24 shows seasonal variation of mean abundance of phytoplankton community during 2006-07.

In 2006-07, overall mean density of phytoplankton community tended to increase from winter (28.17 no.l^-1 x 10^2) to monsoon (59.31 no.l^-1 x 10^2) although a slight fluctuation was observed in post-monsoon (41.59 no.l^-1 x 10^2) (Table 23).

Chlorophyceae showed highest density in monsoon (33.45 no.l^-1 x 10^2) (Table 23). In post-monsoon (17.82 no.l^-1 x 10^2) and pre-monsoon (17.57 no.l^-1 x 10^2) there is not much difference in its density and found to be lowest in winter (9.98 no.l^-1 x 10^2). Cyanophyceae showed highest density in winter (10.4 no.l^-1 x 10^2) followed by monsoon (10.3 no.l^-1 x 10^2) (Table 23) and lowest in post-monsoon (5.75 no.l^-1 x 10^2). Density of Bacillariophyceae tended to increase from winter to monsoon but its density was found to be almost same in post-monsoon and winter (Table 23). Euglenophyceae showed highest density in post-monsoon (12.23 no.l^-1 x 10^2) and found to be progressively decreased in rest of the season and lowest density was recorded in monsoon (1.47 no.l^-1 x 10^2). Dinophytes showed less density in all the season with highest density in pre-monsoon (0.98 no.l^-1 x 10^2) and found to be progressively increase from post-monsoon to monsoon (Table 23).
In 2006-07, overall mean abundance of phytoplankton community followed the similar pattern of seasonal variation throughout the year and showed highest abundance in monsoon (74.32 no.1⁻¹ x 10²) (Table 24).

Mean seasonal abundance of Chlorophyceae was found to be progressively increased from winter (13.99 no.1⁻¹ x 10²) to monsoon (40.64 no.1⁻¹ x 10²) and decreased in post-monsoon (21.96 no.1⁻¹ x 10²) (Table 24). Cyanophyceae showed highest abundance in monsoon (14.74 no.1⁻¹ x 10²) followed by winter (13.51 no.1⁻¹ x 10²) and lowest abundance was recorded in post-monsoon (6.97) (Table 24) but a reverse trend was observed in case of Euglenophyceae. Abundance of Euglenophyceae was found to be highest in post-monsoon (12.58 no.1⁻¹ x 10²) and lowest in monsoon (1.98 no.1⁻¹ x 10²) but a slight difference in their abundance was noticed in winter (2.51 no.1⁻¹ x 10²) and pre-monsoon (2.24 no.1⁻¹ x 10²) (Table 24). Dinophyceae followed Bacillariophyceae and showed similar pattern of seasonal variation in terms of abundance and found to be highest in monsoon (1.68 no.1⁻¹ x 10²) and lowest in post-monsoon (0.28 no.1⁻¹ x 10²) (Table 24).

Euglena was found to be most abundant taxon in post-monsoon (12.58 no.1⁻¹ x 10²) followed by Maugeotia in monsoon (6.83 no.1⁻¹ x 10²). Navicula was found to be next abundant taxon in monsoon (5.88 no.1⁻¹ x 10²) and in winter Oscillatoria (3.67 no.1⁻¹ x 10²) was the most abundant taxon (Table 24).

Table 25: Seasonal variation of mean density of phytoplankton community during 2007-08.

In 2007-08, overall mean density of phytoplankton community was recorded highest in monsoon (33.4 no.1⁻¹ x 10²) followed by winter (32.32 no.1⁻¹ x 10²) and lowest in pre-monsoon (25.88 no.1⁻¹ x 10²) (Table 25).

Mean density of Chlorophyceae was recorded highest in post-monsoon (16.8 no.1⁻¹ x 10²) followed by monsoon (14.69 no.1⁻¹ x 10²) and did not show any noticeable change throughout the year. Highest density of Cyanophyceae was recorded in winter (9.8 no.1⁻¹ x 10²) followed by post-monsoon (8.43 no.1⁻¹ x 10²) and lowest in monsoon (4.98 no.1⁻¹ x 10²) (Table 25). Bacillariophyceae showed highest density in pre-monsoon (12.47 no.1⁻¹ x 10²) followed by pre-monsoon (6.02 no.1⁻¹ x 10²) and lowest in post-monsoon (2.4 no.1⁻¹ x 10²). Euglenophyceae showed highest density in winter (5.15 no.1⁻¹ x 10²) and their population was found to be relatively low in rest of the season throughout the year. Dinophyceae showed highest density in post-monsoon (0.73 no.1⁻¹ x 10²) and lowest in pre-monsoon (0.23 no.1⁻¹ x 10²) but their population was found to be very low in all the season throughout the year (Table 25).

Table 26: Overall mean seasonal variation of abundance of phytoplankton community during 2007-08.
In 2007-08, overall mean abundance of phytoplankton community did not show any clear seasonal variation with highest abundance in monsoon (36.31 no.l$^{-1}$ x 10$^2$) and lowest in pre-monsoon (29.06 no.l$^{-1}$ x 10$^2$) (Table 26).

Chlorophyceae attained the highest position in terms of abundance and recorded highest in post-monsoon (18.8 no.l$^{-1}$ x 10$^2$) followed by monsoon (17.14 no.l$^{-1}$ x 10$^2$) but a slight fluctuation was noticed in their abundance in winter (13.87 no.l$^{-1}$ x 10$^2$) and pre-monsoon (12.46 no.l$^{-1}$ x 10$^2$) (Table 26). Abundance of Cyanophyceae was recorded highest in winter (5.18 no.l$^{-1}$ x 10$^2$) followed by post-monsoon (9.11 no.l$^{-1}$ x 10$^2$), but a slight fluctuation was noticed in their abundance in winter (13.87 no.l$^{-1}$ x 10$^2$) and pre-monsoon (12.46 no.l$^{-1}$ x 10$^2$) (Table 26). Bacillariophyceae showed similar pattern of variation of abundance as density. Highest abundance was recorded in monsoon (12.33 no.l$^{-1}$ x 10$^2$) and lowest in post-monsoon (2.88 no.l$^{-1}$ x 10$^2$) (Table 26). Euglenophyceae showed highest abundance in winter (5.18 no.l$^{-1}$ x 10$^2$) and lowest in monsoon (0.83 no.l$^{-1}$ x 10$^2$) (Table 26). Abundance of Dinophyceae was recorded highest in post-monsoon (1.13 no.l$^{-1}$ x 10$^2$) and lowest in pre-monsoon (0.31 no.l$^{-1}$ x 10$^2$) (Table 26).

Eunotia sp. (6.45 no.l$^{-1}$ x 10$^2$) was found to be most abundant taxon in monsoon followed by Euglena sp. (5.18 no.l$^{-1}$ x 10$^2$) during winter among all the season. Volvox sp. (4.85 no.l$^{-1}$ x 10$^2$) was found to be the most abundant taxon followed by Nostoc sp. (3.05 no.l$^{-1}$ x 10$^2$) and Closterium sp. (2.29 no.l$^{-1}$ x 10$^2$) during post-monsoon. Chlorella was found to be next dominant taxon in monsoon and Nitzschia sp. (3.78 no.l$^{-1}$ x 10$^2$) was recorded the most abundant taxon during pre-monsoon (Table 26).

**Phytoplankton community structure**

The species diversity indices viz. Shannon-Wiener diversity index ($H'$), Margalef’s species richness Index (d), Evenness Index ($J'$) and Berger-Parker Index of dominance ($D_{BP}$) were presented as community composition parameters of phytoplankton community are presented in Fig. 98-101 and 102-105 during 2006-07 and 2007-08 respectively.

In station 1 (JC), Shannon-Wiener diversity index ($H'$) ranged from 1.92 to 2.44 and 1.18 to 2.0 in 2006-07 and 2007-08 respectively (Fig. 98 and 102). In 2006-07, highest $H'$-value was recorded in monsoon (2.44) and lowest in pre-monsoon (1.92) (Fig. 98) whereas in 2007-08, it was found to be highest in post-monsoon (2.0) and lowest in winter (1.18) (Fig. 102).

Margalef’s Index of species richness (d), ranged from 1.03 to 1.74 and 0.48 to 1.13 in 2006-07 and 2007-08 respectively (Fig. 99 and 103). In 2006-07, highest d-value was recorded in monsoon (1.74) and lowest in pre-monsoon (1.03) (Fig. 99) whereas in 2007-08, it was found to be highest in post-monsoon (1.13) and lowest in winter (0.48) (Fig. 103).

Evenness Index ($J'$) ranged from 0.91 to 0.93 and 0.86 to 0.95 in 2006-07 and 2007-08 respectively (Fig. 100 and 104). In 2006-07, highest $J'$-value (0.93)
was recorded in post-monsoon and pre-monsoon and lowest in monsoon (0.91) (Fig. 100) whereas in 2007-08, it was found to be highest in monsoon (0.95) and lowest in winter (0.86) (Fig. 104).

Berger-Parker Index of dominance (D<sub>BP</sub>) ranged from 0.13 to 016 and 0.19 to 0.39 in 2006-07 and 2007-08 respectively (Fig. 101 and 105). In 2006-07, highest value of D<sub>BP</sub> (0.16) was recorded in post-monsoon and monsoon and lowest in pre-monsoon (0.13) (Fig. 101) while in 2007-08, it was found to be highest in winter (0.39) and lowest in monsoon (0.19) (Fig. 105).

In station 2 (BC), Shannon-Wiener diversity index (H') ranged from 2.24 to 2.63 and 1.08 to 1.57 in 2006-07 and 2007-08 respectively (Fig. 98 and 102). In 2006-07, highest H'-value was recorded in monsoon (2.63) and lowest in post-monsoon (2.24) (Fig. 98) whereas in 2007-08, it was found to be highest (1.57) in pre-monsoon and monsoon and lowest in post-monsoon (1.08) (Fig. 102).

Margalef’s Index of species richness (d), ranged from 1.38 to 2.02 and 0.38 to 0.78 in 2006-07 and 2007-08 respectively (Fig. 99 and 103). In 2006-07, highest d-value was recorded in monsoon (2.02) and lowest in post-monsoon (1.38) (Fig. 99) whereas in 2007-08, it was found to be highest in winter (0.78) and lowest in post-monsoon (0.38) (Fig. 103).

Evenness Index (J') ranged from 0.92 to 0.94 and 0.78 to 0.96 in 2006-07 and 2007-08 respectively (Fig. 100 and 104). In 2006-07, highest J'-value (0.94) was recorded in winter and monsoon and lowest in post-monsoon (0.92) (Fig. 100) whereas in 2007-08, it was found to be highest in post-monsoon (0.96) and lowest in winter (0.78) (Fig. 104).

Berger-Parker Index of dominance (D<sub>BP</sub>) ranged from 0.09 to 0.13 and 0.15 to 0.48 in 2006-07 and 2007-08 respectively (Fig. 101 and 105). In 2006-07, highest value of D<sub>BP</sub> (0.13) was recorded in pre-monsoon and lowest in winter (0.09) (Fig. 101) while in 2007-08, it was recorded highest in winter (0.48) and lowest in pre-monsoon (0.15) (Fig. 105).

In station 3 (DGK), Shannon-Wiener diversity index (H') ranged from 2.6 to 2.68 and 1.15 to 1.77 in 2006-07 and 2007-08 respectively (Fig. 98 and 102). In 2006-07, highest H'-value was recorded in post-monsoon (2.68) followed by monsoon (2.67) and lowest in winter (2.6) (Fig. 98) whereas in 2007-08, it was found to be highest in pre-monsoon (1.77) and lowest in monsoon (1.15) (Fig. 102).

Margalef’s Index of species richness (d), ranged from 2.14 to 2.38 and 0.47 to 0.93 in 2006-07 and 2007-08 respectively (Fig. 99 and 103). In 2006-07, highest d-value was recorded in monsoon (2.38) and lowest in pre-monsoon (2.14) (Fig. 99) whereas in 2007-08, it was found to be highest in pre-monsoon (0.93) and lowest in monsoon (0.47) (Fig. 103).
Evenness Index ($J'$) ranged from 0.88 to 0.94 and 0.76 to 0.9 in 2006-07 and 2007-08 respectively (Fig. 100 and 104). In 2006-07, highest $J'$-value was recorded in post-monsoon (0.94) and lowest in monsoon (0.88) (Fig. 100) whereas in 2007-08, it was found to be highest in pre-monsoon (0.9) and lowest in post-monsoon (0.76) (Fig. 104).

Berger-Parker Index of dominance ($D_{BP}$) ranged from 0.08 to 0.22 and 0.28 to 0.54 in 2006-07 and 2007-08 respectively (Fig. 101 and 105). In 2006-07, highest value of $D_{BP}$ was recorded in monsoon (0.22) and lowest in post-monsoon (0.08) (Fig. 101) while in 2007-08, it was also recorded highest in monsoon (0.54) and lowest in pre-monsoon (0.28) (Fig. 105).

In station 4 (RB), Shannon-Wiener diversity index ($H'$) ranged from 2.4 to 2.57 and 1.6 to 2.76 in 2006-07 and 2007-08 respectively (Fig. 98 and 102). In 2006-07, highest $H'$-value was recorded in monsoon (2.58) followed by post-monsoon (2.56) and lowest in winter (2.4) (Fig. 98) whereas in 2007-08, it was found to be highest in post-monsoon (2.76) and lowest in monsoon (1.6) (Fig. 102).

Margalef’s Index of species richness (d), ranged from 1.62 to 2.18 and 0.74 to 1.6 in 2006-07 and 2007-08 respectively (Fig. 99 and 103). In 2006-07, highest d-value was recorded in post-monsoon (2.18) and lowest in winter (1.62) (Fig. 99) whereas in 2007-08, it was found to be highest in pre-monsoon (1.6) and lowest in post-monsoon (0.74) (Fig. 103).

Evenness Index ($J'$) ranged from 0.87 to 0.93 and 0.6 to 0.92 in 2006-07 and 2007-08 respectively (Fig. 100 and 104). In 2006-07, highest $J'$-value was recorded in winter (0.93) and lowest (0.87) in pre-monsoon and monsoon (Fig. 100) whereas in 2007-08, it was found to be highest in post-monsoon (0.92) and lowest in monsoon (0.6) (Fig. 104).

Berger-Parker Index of dominance ($D_{BP}$) ranged from 0.12 to 0.22 and 0.11 to 0.59 in 2006-07 and 2007-08 respectively (Fig. 101 and 105). In 2006-07, highest value of $D_{BP}$ was recorded in winter (0.22) followed by monsoon (0.21) and lowest in pre-monsoon (0.12) (Fig. 101) while in 2007-08, it was recorded highest in monsoon (0.59) and lowest in post-monsoon (0.11) (Fig. 105).

In station 5 (UB), Shannon-Wiener diversity index ($H'$) ranged from 2.09 to 2.66 and 1.85 to 2.82 in 2006-07 and 2007-08 respectively (Fig. 98 and 102). In 2006-07, highest $H'$-value was recorded in pre-monsoon (2.66) followed by winter (2.62) and lowest in post-monsoon (2.09) (Fig. 98) whereas in 2007-08, it was found to be highest in post-monsoon (2.82) and lowest in monsoon (1.85) (Fig. 102).

Margalef’s Index of species richness (d), ranged from 2.0 to 2.25 and 1.23 to 2.52 in 2006-07 and 2007-08 respectively (Fig. 99 and 103). In 2006-07, highest d-value was recorded in post-monsoon (2.25) and lowest in winter (2.0)
(Fig. 99) whereas in 2007-08, it was also recorded highest in post-monsoon (2.52) and lowest in monsoon (1.23) (Fig. 103).

Evenness Index ($J'$) ranged from 0.66 to 0.89 and 0.77 to 0.91 in 2006-07 and 2007-08 respectively (Fig. 100 and 104). In 2006-07, highest $J'$-value was recorded in winter (0.89) and lowest in post-monsoon (0.66) (Fig. 100) whereas in 2007-08, it was found to be highest in post-monsoon (0.91) and lowest in monsoon (0.77) and remain same (0.83) in rest of the two seasons (Fig. 104).

Berger-Parker Index of dominance ($D_{BP}$) ranged from 0.16 to 0.45 and 0.16 to 0.4 in 2006-07 and 2007-08 respectively (Fig. 101 and 105). In 2006-07, highest value of $D_{BP}$ was recorded in post-monsoon (0.45) and lowest in pre-monsoon (0.16) (Fig. 101) while in 2007-08, it was recorded highest in monsoon (0.4) and lowest in post-monsoon (0.16) and found to be almost steady in winter (0.32) and pre-monsoon (0.31) (Fig. 105).

In station 6 (OW), Shannon-Wiener diversity index ($H'$) ranged from 2.63 to 2.75 and 2.3 to 2.82 in 2006-07 and 2007-08 respectively (Fig. 98 and 102). In 2006-07, highest $H'$-value was recorded in post-monsoon (2.75) followed by post-monsoon (2.71) and monsoon (2.7) and lowest in winter (2.63) (Fig. 98) whereas in 2007-08, it was found to be highest in post-monsoon (2.82) and lowest in monsoon (2.3) and found very close in winter (2.63) and pre-monsoon (2.65) (Fig. 102).

Margalef’s Index of species richness ($d$), ranged from 2.18 to 2.62 and 1.67 to 2.52 in 2006-07 and 2007-08 respectively (Fig. 99 and 103). In 2006-07, highest $d$-value was recorded in pre-monsoon (2.62) and lowest in winter (2.18) (Fig. 99) whereas in 2007-08, it was also recorded highest in post-monsoon (2.52) and lowest in monsoon (1.67) (Fig. 103).

Evenness Index ($J'$) ranged from 0.87 to 0.89 and 0.81 to 0.9 in 2006-07 and 2007-08 respectively (Fig. 100 and 104). In 2006-07, $J'$-value was found to be remain steady (0.89) in all the season except post-monsoon (0.87) (Fig. 100) whereas in 2007-08, it was found to be highest (0.9) in post-monsoon and winter and lowest in monsoon (0.81) (Fig. 104).

Berger-Parker Index of dominance ($D_{BP}$) ranged from 0.16 to 0.2 and 0.15 to 0.23 in 2006-07 and 2007-08 respectively (Fig. 101 and 105). In 2006-07, highest value of $D_{BP}$ (0.2) was recorded in post-monsoon and winter and lowest in pre-monsoon (0.16) (Fig. 101) while in 2007-08, it was recorded highest (0.23) in pre-monsoon and monsoon and lowest in winter (0.15) (Fig. 105).

In station 7 (MB), Shannon-Wiener diversity index ($H'$) ranged from 1.83 to 2.34 and 2.3 to 2.6 in 2006-07 and 2007-08 respectively (Fig. 98 and 102). In 2006-07, highest $H'$-value was recorded in monsoon (2.34) and lowest in pre-monsoon (1.83) (Fig. 98) whereas in 2007-08, it was found to be highest in pre-monsoon (2.6) and lowest in monsoon (2.3) (Fig. 102).
Margalef’s Index of species richness (d), ranged from 0.94 to 1.95 and 1.34 to 1.81 in 2006-07 and 2007-08 respectively (Fig. 99 and 103). In 2006-07, highest d-value was recorded in monsoon (1.95) and lowest in pre-monsoon (0.94) (Fig. 99) whereas in 2007-08, it was recorded highest in pre-monsoon (1.81) and lowest in monsoon (1.34) (Fig. 103).

Evenness Index (J') ranged from 0.82 to 0.95 and 0.9 to 0.95 in 2006-07 and 2007-08 respectively (Fig. 100 and 104). In 2006-07, highest J'-value was recorded in pre-monsoon (0.95) and lowest in monsoon (0.82) (Fig. 100) whereas in 2007-08, it was found to be highest (0.95) in winter and monsoon and lowest in post-monsoon (0.9) (Fig. 104).

Berger-Parker Index of dominance (D_{BP}) ranged from 0.12 to 0.29 and 0.12 to 0.2 in 2006-07 and 2007-08 respectively (Fig. 101 and 105). In 2006-07, highest value of D_{BP} was recorded in monsoon (0.29) and winter and lowest in winter (0.12) (Fig. 101) while in 2007-08, it was recorded highest in post-monsoon (0.2) and lowest in winter (0.12) and remain steady (0.18) in rest of the seasons (Fig. 105).

In station 8 (SAL), Shannon-Wiener diversity index (H') ranged from 1.45 to 2.37 and 1.47 to 2.55 in 2006-07 and 2007-08 respectively (Fig. 98 and 102). In 2006-07, highest H'-value was recorded in monsoon (2.37) and lowest in pre-monsoon (1.45) (Fig. 98) whereas in 2007-08, it was found to be highest in winter (2.55) and lowest in monsoon (1.47) (Fig. 102).

Margalef’s Index of species richness (d), ranged from 0.86 to 1.6 and 0.62 to 2.07 in 2006-07 and 2007-08 respectively (Fig. 99 and 103). In 2006-07, highest d-value was recorded in monsoon (1.6) and lowest in pre-monsoon (0.86) (Fig. 99) whereas in 2007-08, it was recorded highest in winter (2.07) and lowest in monsoon (0.62) (Fig. 103).

Evenness Index (J') ranged from 0.75 to 0.93 and 0.9 to 0.93 in 2006-07 and 2007-08 respectively (Fig. 100 and 104). In 2006-07, highest J'-value was recorded in post-monsoon (0.93) and lowest in pre-monsoon (0.75) (Fig. 100) whereas in 2007-08, it was found to be highest in pre-monsoon (0.93) and remain steady (0.9) in rest of the seasons (Fig. 104).

Berger-Parker Index of dominance (D_{BP}) ranged from 0.14 to 0.42 and 0.18 to 0.3 in 2006-07 and 2007-08 respectively (Fig. 101 and 105). In 2006-07, highest value of D_{BP} was recorded in pre-monsoon (0.42) and lowest in post-monsoon (0.14) (Fig. 101) whereas in 2007-08, it was recorded highest in monsoon (0.3) and lowest in pre-monsoon (0.18) (Fig. 105).

In station 9 (GR), Shannon-Wiener diversity index (H') ranged from 1.77 to 2.42 and 1.66 to 2.53 in 2006-07 and 2007-08 respectively (Fig. 98 and 102). In 2006-07, highest H'-value was recorded in monsoon (2.42) and lowest in post-monsoon (1.77) (Fig. 98) whereas in 2007-08, it was found to be highest in winter (2.53) and lowest in pre-monsoon (1.66) (Fig. 102).
Margalef’s Index of species richness (d), ranged from 0.9 to 1.65 and 0.8 to 1.8 in 2006-07 and 2007-08 respectively (Fig. 99 and 103). In 2006-07, highest d-value was recorded in monsoon (1.65) and lowest in post-monsoon (0.9) (Fig. 99) whereas in 2007-08, it was recorded highest in winter (1.8) and lowest in pre-monsoon (0.8) (Fig. 103).

Evenness Index ($J'$) ranged from 0.92 to 0.96 and 0.88 to 0.92 in 2006-07 and 2007-08 respectively (Fig. 100 and 104). In 2006-07, highest $J'$-value was recorded in post-monsoon (0.96) and lowest (0.92) was recorded in winter and pre-monsoon (Fig. 100) whereas in 2007-08, it was found to be highest in winter (0.92) and lowest in pre-monsoon (0.88) (Fig. 104).

Berger-Parker Index of dominance ($D_{BP}$) ranged from 0.12 to 0.24 and 0.16 to 0.32 in 2006-07 and 2007-08 respectively (Fig. 101 and 105). In 2006-07, highest value of $D_{BP}$ was recorded in pre-monsoon (0.24) and lowest in winter (0.12) (Fig. 101) whereas in 2007-08, it was also recorded highest in pre-monsoon (0.32) and lowest in winter (0.16) (Fig. 105).

In station 10 (BR), Shannon-Wiener diversity index ($H'$) ranged from 1.83 to 2.4 and 1.72 to 2.13 in 2006-07 and 2007-08 respectively (Fig. 98 and 102). In 2006-07, highest $H'$-value was recorded in monsoon (2.4) and lowest in winter (1.83) (Fig. 98) whereas in 2007-08, it was found to be highest in winter (2.13) and lowest in monsoon (1.72) (Fig. 102).

Margalef’s Index of species richness (d), ranged from 0.98 to 1.7 and 0.72 to 1.24 in 2006-07 and 2007-08 respectively (Fig. 99 and 103). In 2006-07, highest d-value was recorded in monsoon (1.7) and lowest in pre-monsoon (0.98) (Fig. 99) whereas in 2007-08, it was recorded highest in winter (1.24) and lowest in monsoon (0.72) and remains steady (1.0) in rest of the two seasons (Fig. 103).

Evenness Index ($J'$) ranged from 0.88 to 0.95 and 0.91 to 0.96 in 2006-07 and 2007-08 respectively (Fig. 100 and 104). In 2006-07, highest $J'$-value was recorded in pre-monsoon (0.95) and lowest (0.88) in winter and monsoon (Fig. 100) whereas in 2007-08, it was found to be highest in monsoon (0.96) and lowest in winter (0.91) (Fig. 104).

Berger-Parker Index of dominance ($D_{BP}$) ranged from 0.17 to 0.33 and 0.2 to 0.25 in 2006-07 and 2007-08 respectively (Fig. 101 and 105). In 2006-07, highest value of $D_{BP}$ was recorded in winter (0.33) and lowest in post-monsoon (0.17) (Fig. 101) whereas in 2007-08, it was also recorded highest in winter (0.25) and lowest in post-monsoon (0.2) (Fig. 105).

Overall Shannon-Wiener diversity index ranged from 1.45 to 2.75 and 1.08 to 2.82 in 2006-07 and 2007-08 respectively (Fig. 98 and 102). In 2006-07, highest $H'$-value (2.75) was recorded in the station 6 (OW) and lowest (1.45) in the station 8 (SAL) in pre-monsoon (Fig. 98) whereas in 2007-08, it was recorded highest (2.82) in the station 5 and 6 (UB and OW) and lowest (1.08) in the station 2 (BC) in post-monsoon (Fig. 102).
Overall Margalef’s Index ranged from 0.86 to 2.62 and 0.38 to 2.52 in 2006-07 and 2007-08 respectively (Fig. 99 and 103). In 2006-07, highest d-value (2.62) was recorded in the station 6 (OW) in post-monsoon and lowest in pre-monsoon (0.86) in the station 8 (SAL) (Fig. 99) whereas in 2007-08, it was recorded highest (2.52) in the station 5 and 6 (UB and OW) and lowest (0.38) in the station 2 (BC) in post-monsoon (Fig. 99 and 103).

Overall evenness Index ($J'$) fluctuated between 0.66 to 0.96 and 0.6 to 0.96 in 2006-07 and 2007-08 respectively (Fig. 100 and 104). In 2006-07, highest $J'$-value (0.96) was recorded in the station 9 (GR) and lowest (0.66) in station 5 (UB) during post-monsoon (Fig. 100) whereas in 2007-08, it was recorded highest in station 2 and 10 (BC and BR) during post-monsoon and monsoon respectively and lowest (0.6) in station 4 (RB) in monsoon (Fig. 104).

Overall Berger-Parker Index of dominance ($D_{BP}$) ranged from 0.08 to 0.45 and 0.11 to 0.59 in 2006-07 and 2007-08 respectively (Fig. 101 and 105). In 2006-07, highest value of $D_{BP}$ (0.45) was recorded in the station 5 (UB) and lowest (0.08) in the station 3 (DGK) in post-monsoon (Fig. 101) whereas in 2007-08, highest (0.59) and lowest (0.11) value of $D_{BP}$ was found in the station 4 (RB) in monsoon and post-monsoon respectively (Fig. 105).

**Zooplankton**

Fig. 82-85 and 86-89 describe the spatial and temporal variation of zooplankton community in different stations during 2006-07 and 2007-08.

Zooplankton community was represented by Cladocera, Rotifera, Copepoda, Anostraca, Protozoa, Ostracoda, and Decapoda (Zoea larvae) during the investigation period.

Density of total zooplankton ranged from 4.0 to 133.83 no.1$^{-1}$ x 10$^2$ and 4.0 to 213.83 no.1$^{-1}$ x 10$^2$ in 2006-07 and 2007-08 respectively (Fig. 91 and 93).

**Station 1 (JC)**

In this station, density of total zooplankton ranged from 12.5 to 33.39 no.1$^{-1}$ x 10$^2$ and 4.0 to 8.67 no.1$^{-1}$ x 10$^2$ in 2006-07 and 2007-08 respectively (Fig. 91 and 93).

Density of Cladocera ranged from 3.5 to 17.61 no.1$^{-1}$ x 10$^2$ and 1.83 to 3.34 no.1$^{-1}$ x 10$^2$ in 2006-07 and 2007-08 respectively (Fig. 82-89). In 2006-07, highest cladoceran density (17.61 no.1$^{-1}$ x 10$^2$) was recorded in monsoon and lowest (3.5 no.1$^{-1}$ x 10$^2$) in post-monsoon (Fig. 82-85). Whereas in 2007-08, it was recorded highest pre-monsoon (3.34 no.1$^{-1}$ x 10$^2$) and lowest in winter (1.83 no.1$^{-1}$ x 10$^2$). Density of Cladocera was found to be higher in all the season in 2006-07 than that of 2007-08 (Fig. 86-89).
Density of Rotifers ranged from 1.89 to 3.83 no.l$^{-1} \times 10^2$ and 0.16 to 1.5 no.l$^{-1} \times 10^2$ in 2006-07 and 2007-08 respectively (Fig. 82-89). In 2006-07, highest density of rotifers (3.83 no.l$^{-1} \times 10^2$) was recorded in winter and lowest in pre-monsoon (1.89 no.l$^{-1} \times 10^2$) (Fig. 82-85). While in 2007-08, it was recorded highest in post-monsoon (1.5 no.l$^{-1} \times 10^2$) and monsoon (0.16 no.l$^{-1} \times 10^2$) although their population was found to be very less throughout the study period (Fig. 86-89).

Density of Copepoda ranged from 4.5 to 11.94 no.l$^{-1} \times 10^2$ and 0.67 to 4.5 no.l$^{-1} \times 10^2$ in 2006-07 and 2007-08 respectively (Fig. 82-89). In 2006-07, highest density of copepods (11.94 no.l$^{-1} \times 10^2$) was recorded in pre-monsoon and lowest in post-monsoon (4.5 no.l$^{-1} \times 10^2$) (Fig. 82-85). While in 2007-08, it was recorded highest in winter (4.5 no.l$^{-1} \times 10^2$) and lowest (0.67 no.l$^{-1} \times 10^2$) in pre-monsoon (Fig. 86-89). Density of Copepods was found to be higher in all the season in 2006-07 than that of 2007-08.

Density of Anostraca ranged from 2.23 to 3.28 no.l$^{-1} \times 10^2$ and 0.34 to 2.34 no.l$^{-1} \times 10^2$ in 2006-07 and 2007-08 respectively (Fig. 82-89). In 2006-07, highest density of Anostraca (3.28 no.l$^{-1} \times 10^2$) was recorded in winter and lowest in monsoon (2.23 no.l$^{-1} \times 10^2$) (Fig. 82-85). Whereas in 2007-08, it was found highest in post-monsoon (2.34 no.l$^{-1} \times 10^2$) and lowest in monsoon (0.34 no.l$^{-1} \times 10^2$) and totally absent in pre-monsoon (Fig. 86-89).

Protozoan was found to be present only in post-monsoon (1.5 no.l$^{-1} \times 10^2$) during 2006-07 whereas in 2007-08 it was found to be present in post-monsoon (1.34 no.l$^{-1} \times 10^2$) and monsoon (0.16 no.l$^{-1} \times 10^2$) and totally absent in winter and pre-monsoon (Fig. 82-89).

Ostracoda was found to be present only in winter during 2006-07 (0.67 no.l$^{-1} \times 10^2$) (Fig. 82-85) and totally absent in all the seasons throughout the investigation period.

Decapoda was found to be present only in pre-monsoon (0.34 no.l$^{-1} \times 10^2$) and monsoon (0.72 no.l$^{-1} \times 10^2$) season of 2006-07 (Fig. 82-85). No population of zoea larvae was encountered during 2007-08.

Station 2 (BC)

In this station, density of total zooplankton ranged from 14.11 to 40.3 no.l$^{-1} \times 10^2$ and 12.67 to 213.83 no.l$^{-1} \times 10^2$ in 2006-07 and 2007-08 respectively (Fig. 91 and 93).

Density of Cladocera ranged from 2.27 to 14.6 no.l$^{-1} \times 10^2$ and 6.34 to 141.83 no.l$^{-1} \times 10^2$ in 2006-07 and 2007-08 respectively (Fig. 82-89). In 2006-07, highest cladoceran density (14.86 no.l$^{-1} \times 10^2$) was recorded in monsoon and lowest in pre-monsoon (2.27 no.l$^{-1} \times 10^2$) (Fig. 82-85). While in 2007-08, it was recorded highest in post-monsoon (141.83 no.l$^{-1} \times 10^2$) and lowest in monsoon (6.34 no.l$^{-1} \times 10^2$) (Fig. 86-89).
Density of Rotifers ranged from 2.34 to 6.22 no.1^{-1} x 10^2 and 0.16 to 3.16 no.1^{-1} x 10^2 in 2006-07 and 2007-08 respectively (Fig. 82-89). In 2006-07, highest density of rotifers (6.22 no.1^{-1} x 10^2) was recorded in monsoon and lowest in winter (2.34 no.1^{-1} x 10^2) (Fig. 82-85). While in 2007-08, it was recorded highest in pre-monsoon (3.16 no.1^{-1} x 10^2) and lowest in winter (0.16 no.1^{-1} x 10^2) (Fig. 86-89).

Density of Copepoda ranged from 2.39 to 8.61 no.1^{-1} x 10^2 and 0.83 to 18.5 no.1^{-1} x 10^2 in 2006-07 and 2007-08 respectively (Fig. 82-89). In 2006-07, highest density of copepods (8.61 no.1^{-1} x 10^2) was recorded in monsoon and lowest in pre-monsoon (2.39 no.1^{-1} x 10^2) (Fig. 82-85) whereas in 2007-08, it was recorded highest in post-monsoon (18.5 no.1^{-1} x 10^2) and lowest in pre-monsoon (0.83 no.1^{-1} x 10^2) (Fig. 86-89).

Density of Anostraca ranged from 2.55 to 9.22 no.1^{-1} x 10^2 and 3.0 to 17.0 no.1^{-1} x 10^2 in 2006-07 and 2007-08 respectively (Fig. 82-89). In 2006-07, highest density of Anostraca (9.22 no.1^{-1} x 10^2) was recorded in monsoon 2007-08 and lowest in winter (2.55 no.1^{-1} x 10^2) (Fig. 82-85). While in 2007-08, it was found to be present only in post-monsoon (17.0 no.1^{-1} x 10^2) and monsoon (3.0 no.1^{-1} x 10^2) and totally absent in winter and pre-monsoon (Fig. 86-89).

Density of Protozoa ranged from 0.89 to 1.61 no.1^{-1} x 10^2 in 2006-07 and found to be present only in post-monsoon (0.89 no.1^{-1} x 10^2) and monsoon (1.61 no.1^{-1} x 10^2). But it was found to be present only in pre-monsoon (0.83 no.1^{-1} x 10^2) and totally absent in rest of the season in 2007-08 (Fig. 82-89).

Ostracoda was found to be present only in post-monsoon and pre-monsoon during 2006-07 (0.38 no.1^{-1} x 10^2) while in 2007-08 it was found to be present only in winter (1.83 no.1^{-1} x 10^2) and pre-monsoon (0.5 no.1^{-1} x 10^2) (Fig. 82-89).

Decapoda was found to be present only in winter (0.56 no.1^{-1} x 10^2) and pre-monsoon (0.44 no.1^{-1} x 10^2) season in 2006-07 and no population was found in 2007-08 throughout the year (Fig. 82-89).

Station 3 (DGK)

In this station, density of total zooplankton ranged from 13.83 to 52.44 no.1^{-1} x 10^2 and 5.0 to 56.34 no.1^{-1} x 10^2 in 2006-07 and 2007-08 respectively (Fig. 91 and 93).

Density of Cladocera ranged from 1.5 to 21.55 no.1^{-1} x 10^2 and 2.16 to 17.5 no.1^{-1} x 10^2 in 2006-07 and 2007-08 respectively (Fig. 82-89). In 2006-07, highest cladoceran density (21.55 no.1^{-1} x 10^2) was recorded in monsoon and lowest in post-monsoon (1.5 no.1^{-1} x 10^2) (Fig. 82-85). While in 2007-08, it was recorded highest in post-monsoon (17.5 no.1^{-1} x 10^2) and lowest in monsoon (2.16 no.1^{-1} x 10^2) (Fig. 86-89).
Density of Rotifers ranged from 0.94 to 2.61 no.\(L^{-1}\times 10^2\) in 2006-07 and found to be highest in pre-monsoon (2.61 no.\(L^{-1}\times 10^2\)) and lowest in monsoon (0.94 no.\(L^{-1}\times 10^2\)) (Fig. 82-85). Whereas in 2007-08 it was only found to be present in post-monsoon (3.34 no.\(L^{-1}\times 10^2\)) and totally absent in rest of the seasons (Fig. 86-89).

Density of Copepoda ranged from 7.34 to 16.34 no.\(L^{-1}\times 10^2\) and 2.0 to 11.34 no.\(L^{-1}\times 10^2\) in 2006-07 and 2007-08 respectively (Fig. 82-89). In 2006-07, highest density of copepods (16.34 no.\(L^{-1}\times 10^2\)) was recorded in monsoon and lowest in winter (7.34 no.\(L^{-1}\times 10^2\)) (Fig. 82-85). While in 2007-08, it was recorded highest in post-monsoon (11.34 no.\(L^{-1}\times 10^2\)) and lowest in pre-monsoon (2.0 no.\(L^{-1}\times 10^2\)) (Fig. 86-89).

Density of Anostraca ranged from 0.83 to 3.89 no.\(L^{-1}\times 10^2\) and 0.34 to 22.34 no.\(L^{-1}\times 10^2\) in 2006-07 and 2007-08 respectively (Fig. 82-89). In 2006-07, highest density of Anostraca (3.89 no.\(L^{-1}\times 10^2\)) was recorded in monsoon and lowest in post-monsoon (0.83 no.\(L^{-1}\times 10^2\)) (Fig. 82-85). Whereas in 2007-08, it was recorded highest in post-monsoon (22.34 no.\(L^{-1}\times 10^2\)) and lowest in pre-monsoon (0.34 no.\(L^{-1}\times 10^2\)) (Fig. 86-89).

Density of Protozoa ranged from 1.34 to 9.23 no.\(L^{-1}\times 10^2\) in 2006-07 and found to be totally absent in all the season during 2007-08 (Fig. 82-89). In 2006-07, highest density of Protozoa (9.23 no.\(L^{-1}\times 10^2\)) was recorded in monsoon and lowest in winter (1.34 no.\(L^{-1}\times 10^2\)) (Fig. 82-85).

Density of Ostracoda ranged from 0.5 to 1.11 no.\(L^{-1}\times 10^2\) in 2006-07 and recorded highest in pre-monsoon (1.11 no.\(L^{-1}\times 10^2\)) and lowest in monsoon (0.5 no.\(L^{-1}\times 10^2\)) (Fig. 82-85). While in 2007-08, it was found to be present only in post-monsoon (1.83 no.\(L^{-1}\times 10^2\)) and totally absent in rest of the season throughout the year (Fig. 86-89).

Decapoda was found to be present only in winter season of 2006-07 (1.78 no.\(L^{-1}\times 10^2\)) and totally absent in rest of the seasons (Fig. 82-89).

**Station 4 (RB)**

In this station, density of total zooplankton ranged from 20.16 to 105.67 no.\(L^{-1}\times 10^2\) and 19.34 to 83.5 no.\(L^{-1}\times 10^2\) in 2006-07 and 2007-08 respectively (Fig. 91 and 93).

Density of Cladocera ranged from 7.83 to 40.34 no.\(L^{-1}\times 10^2\) and 10.34 to 15.83 no.\(L^{-1}\times 10^2\) in 2006-07 and 2007-08 respectively (Fig. 82-89). In 2006-07, highest cladoceran density (40.34 no.\(L^{-1}\times 10^2\)) was recorded in monsoon and lowest in winter (7.83 no.\(L^{-1}\times 10^2\)) (Fig. 82-85). Whereas in 2007-08, it was recorded highest in pre-monsoon (15.83 no.\(L^{-1}\times 10^2\)) and lowest (10.34 no.\(L^{-1}\times 10^2\)) in winter and monsoon (Fig. 86-89).
Density of Rotifers ranged from 4.16 to 9.34 no.\(1^{-1}\) x 10\(^2\) and 1.5 to 4.16 no.\(1^{-1}\) x 10\(^2\) in 2006-07 and 2007-08 respectively (Fig. 82-89). In 2006-07, highest density of rotifers (9.34 no.\(1^{-1}\) x 10\(^2\)) was recorded in monsoon and lowest in pre-monsoon (4.16 no.\(1^{-1}\) x 10\(^2\)) (Fig. 82-85). While in 2007-08, it was found to be present only in post-monsoon (4.16 no.\(1^{-1}\) x 10\(^2\)) and pre-monsoon (1.5 no.\(1^{-1}\) x 10\(^2\)) and totally absent in winter and monsoon (Fig. 86-89).

Density of Copepoda ranged from 4.34 to 51.34 no.\(1^{-1}\) x 10\(^2\) and 3.16 to 53.16 no.\(1^{-1}\) x 10\(^2\) in 2006-07 and 2007-08 respectively (Fig. 82-89). In 2006-07, highest density of copepods (51.34 no.\(1^{-1}\) x 10\(^2\)) was recorded in monsoon and lowest in winter (4.34 no.\(1^{-1}\) x 10\(^2\)) (Fig. 82-85). Whereas in 2007-08, it was found to be highest in post-monsoon (51.34 no.\(1^{-1}\) x 10\(^2\)) and lowest in pre-monsoon (3.16 no.\(1^{-1}\) x 10\(^2\)) (Fig. 86-89).

Density of Anostraca ranged from 1.67 to 3.0 no.\(1^{-1}\) x 10\(^2\) and 0.16 to 13.5 no.\(1^{-1}\) x 10\(^2\) in 2006-07 and 2007-08 respectively (Fig. 82-89). In 2006-07, highest density of Anostraca (3.0 no.\(1^{-1}\) x 10\(^2\)) was recorded in pre-monsoon and lowest in winter (1.67 no.\(1^{-1}\) x 10\(^2\)) (Fig. 82-85). While in 2007-08, it was recorded highest in post-monsoon (13.5 no.\(1^{-1}\) x 10\(^2\)) and lowest in winter (0.16 no.\(1^{-1}\) x 10\(^2\)) (Fig. 86-89).

Density of Protozoa ranged from 0.34 to 2.16 no.\(1^{-1}\) x 10\(^2\) in 2006-07 and found to be present only in post-monsoon (0.83 no.\(1^{-1}\) x 10\(^2\)) during 2007-08 (Fig. 82-89). In 2006-07, highest density of Protozoan (2.16 no.\(1^{-1}\) x 10\(^2\)) was recorded in monsoon and lowest in winter (0.34 no.\(1^{-1}\) x 10\(^2\)) and totally absent in pre-monsoon (Fig. 82-85).

Ostracoda was found to be present only in post-monsoon (2.0 no.\(1^{-1}\) x 10\(^2\)) and pre-monsoon (1.5 no.\(1^{-1}\) x 10\(^2\)) and ranged from 0.34 to 3.83 no.\(1^{-1}\) x 10\(^2\) in 2007-08 (Fig. 82-85). In 2007-08, highest density of ostracods (3.83 no.\(1^{-1}\) x 10\(^2\)) was recorded in monsoon and lowest in post-monsoon (0.34 no.\(1^{-1}\) x 10\(^2\)) (Fig. 86-89).

Decapoda was found to be totally absent throughout the investigation period.

**Station 5 (UB)**

In this station, density of total zooplankton ranged from 33.16 to 133.83 no.\(1^{-1}\) x 10\(^2\) and 20.0 to 148.5 no.\(1^{-1}\) x 10\(^2\) in 2006-07 and 2007-08 respectively (Fig. 91 and 93).

Density of Cladocera ranged from 15.16 to 47.67 no.\(1^{-1}\) x 10\(^2\) and 11.0 to 63.16 no.\(1^{-1}\) x 10\(^2\) in 2006-07 and 2007-08 respectively (Fig. 82-89). In 2006-07, highest cladoceran density (47.67 no.\(1^{-1}\) x 10\(^2\)) was recorded in monsoon and lowest in winter (15.16 no.\(1^{-1}\) x 10\(^2\)) (Fig. 82-85). While in 2007-08, it was also recorded highest in monsoon (63.16 no.\(1^{-1}\) x 10\(^2\)) and lowest in pre-monsoon (11.0 no.\(1^{-1}\) x 10\(^2\)) (Fig. 86-89). Density of Cladocera showed high peaks in
monsoon season of both the year and found to be almost constant during monsoon of 2006-07 and post-monsoon of 2007-08.

Density of Rotifers ranged from 2.16 to 18.83 no.1⁻¹ x 10² and 1.83 to 5.83 no.1⁻¹ x 10² in 2006-07 and 2007-08 respectively (Fig. 82-89). In 2006-07, highest density of rotifers (18.83 no.1⁻¹ x 10²) was recorded in monsoon and lowest in winter (2.16 no.1⁻¹ x 10²) (Fig. 82-85). While in 2007-08, it was recorded highest in post-monsoon (5.83 no.1⁻¹ x 10²) and lowest in monsoon (1.83 no.1⁻¹ x 10²) (Fig. 86-89).

Density of Copepoda ranged from 9.67 to 42.16 no.1⁻¹ x 10² and 2.83 to 61.83 no.1⁻¹ x 10² in 2006-07 and 2007-08 respectively (Fig. 82-89). In 2006-07, highest density of copepods (42.16 no.1⁻¹ x 10²) was recorded in monsoon and lowest in winter (9.67 no.1⁻¹ x 10²) (Fig. 82-85). While in 2007-08, it was also recorded highest in monsoon (61.83 no.1⁻¹ x 10²) and lowest in pre-monsoon (2.83 no.1⁻¹ x 10²) (Fig. 86-89).

Density of Anostraca ranged from 0.83 to 40.34 no.1⁻¹ x 10² and 1.5 to 21.0 no.1⁻¹ x 10² in 2006-07 and 2007-08 respectively (Fig. 82-89). In 2006-07, highest density of Anostraca (40.34 no.1⁻¹ x 10²) was recorded in pre-monsoon and lowest in post-monsoon (0.83 no.1⁻¹ x 10²) (Fig. 82-85). While in 2007-08, it was also recorded highest in monsoon (21.0 no.1⁻¹ x 10²) and lowest in pre-monsoon (1.5 no.1⁻¹ x 10²) (Fig. 86-89).

Density of Protozoa ranged from 0.67 to 3.83 no.1⁻¹ x 10² in 2006-07 was found to be present only in post-monsoon (2.0 no.1⁻¹ x 10²) during 2007-08. (Fig. 82-89). In 2006-07, highest density of Protozoan (3.83 no.1⁻¹ x 10²) was recorded in pre-monsoon and lowest in monsoon (0.67 no.1⁻¹ x 10²) (Fig. 82-85).

Density of Ostracoda ranged from 1.16 to 3.0 no.1⁻¹ x 10² and 0.34 to 2.16 no.1⁻¹ x 10² in 2006-07 and 2007-08 respectively (Fig. 82-89). In 2006-07, highest density of ostracods (3.0 no.1⁻¹ x 10²) was recorded in monsoon and lowest in pre-monsoon (1.16 no.1⁻¹ x 10²) (Fig. 82-85). Whereas in 2007-08, it was recorded highest in post-monsoon (2.16 no.1⁻¹ x 10²) and lowest in pre-monsoon (0.34 no.1⁻¹ x 10²) and totally absent in winter (Fig. 86-89).

Decapoda was not recorded during the investigation period.

Station 6 (OW)

In this station, density of total zooplankton ranged from 15.0 to 72.93 no.1⁻¹ x 10² and 27.5 to 75.67 no.1⁻¹ x 10² in 2006-07 and 2007-08 respectively (Fig. 91 and 93).

Density of Cladocera ranged from 3.83 to 25.0 no.1⁻¹ x 10² and 11.5 to 39.34 no.1⁻¹ x 10² in 2006-07 and 2007-08 respectively (Fig. 82-89). In 2006-07, highest cladoceran density (25.0 no.1⁻¹ x 10²) was recorded in monsoon and lowest in winter (3.83 no.1⁻¹ x 10²) (Fig. 82-85). Whereas in 2007-08, it was also
recorded highest in monsoon (39.34 no. l^{-1} \times 10^2) and lowest in pre-monsoon (11.5 no. l^{-1} \times 10^2) (Fig. 86-89).

Density of Rotifers ranged from 2.34 to 9.34 no. l^{-1} \times 10^2 and 2.0 to 6.16 no. l^{-1} \times 10^2 in 2006-07 and 2007-08 respectively (Fig. 82-89). In 2006-07, highest density of rotifers (9.34 no. l^{-1} \times 10^2) was recorded in monsoon and lowest in winter (2.34 no. l^{-1} \times 10^2) (Fig. 82-85). While in 2007-08, it was also found to be highest monsoon (6.16 no. l^{-1} \times 10^2) and lowest in pre-monsoon (2.0 no. l^{-1} \times 10^2) (Fig. 86-89).

Density of Copepoda ranged from 6.67 to 28.16 no. l^{-1} \times 10^2 and 8.83 to 20.5 no. l^{-1} \times 10^2 in 2006-07 and 2007-08 respectively (Fig. 82-89). In 2006-07, highest density of copepods (28.16 no. l^{-1} \times 10^2) was recorded in monsoon and lowest in winter (6.67 no. l^{-1} \times 10^2) (Fig. 82-85). While in 2007-08, it was found to be highest in post-monsoon (20.5 no. l^{-1} \times 10^2) and lowest in monsoon (8.83 no. l^{-1} \times 10^2) (Fig. 86-89).

Density of Anostraca ranged from 1.34 to 4.5 no. l^{-1} \times 10^2 and 1.0 to 13.67 no. l^{-1} \times 10^2 in 2006-07 and 2007-08 respectively (Fig. 82-89). In 2006-07, highest density of Anostraca (4.5 no. l^{-1} \times 10^2) was recorded in monsoon and lowest in winter (1.34 no. l^{-1} \times 10^2) (Fig. 82-85). While in 2007-08, it was found to be highest in post-monsoon (13.67 no. l^{-1} \times 10^2) and lowest in monsoon (1.0 no. l^{-1} \times 10^2) (Fig. 86-89).

Density of Protozoa ranged from 0.83 to 2.67 no. l^{-1} \times 10^2 and 0.5 to 4.0 no. l^{-1} \times 10^2 in 2006-07 and 2007-08 respectively (Fig. 82-89). In 2006-07, highest density of Protozoa (2.67 no. l^{-1} \times 10^2) was recorded in monsoon and lowest in winter (0.83 no. l^{-1} \times 10^2) (Fig. 82-85). While in 2007-08, it was found to be highest in monsoon (4.0 no. l^{-1} \times 10^2) and lowest in winter (0.5 no. l^{-1} \times 10^2) and totally absent in pre-monsoon (Fig. 86-89).

Density of Ostracoda ranged from 0.5 to 3.16 no. l^{-1} \times 10^2 and 1.16 to 6.5 no. l^{-1} \times 10^2 in 2006-07 and 2007-08 respectively (Fig. 82-89). In 2006-07, highest density of ostracods (3.16 no. l^{-1} \times 10^2) was recorded in monsoon, lowest in pre-monsoon (0.5 no. l^{-1} \times 10^2) and totally absent in winter (Fig. 82-85). In 2007-08, it was found to be highest in monsoon (6.5 no. l^{-1} \times 10^2) and lowest in post-monsoon (1.16 no. l^{-1} \times 10^2) (Fig. 86-89).

Decapoda was not recorded throughout the investigation period.

Station 7 (MB)

In this station, density of total zooplankton ranged from 20.67 to 53.34 no. l^{-1} \times 10^2 and 32.34 to 45.0 no. l^{-1} \times 10^2 in 2006-07 and 2007-08 respectively (Fig. 91 and 93).

Density of Cladocera ranged from 5.34 to 19.67 no. l^{-1} \times 10^2 and 12.34 to 26.16 no. l^{-1} \times 10^2 in 2006-07 and 2007-08 respectively (Fig. 82-89). In 2006-07,
highest density of Cladocera (19.67 \text{nol}^{-1} \times 10^2) was recorded in monsoon and lowest density (5.34 \text{nol}^{-1} \times 10^2) was recorded in winter (Fig. 82-85). Whereas in 2007-08, it was recorded highest in pre-monsoon (26.16 \text{nol}^{-1} \times 10^2) and lowest in post-monsoon (12.34 \text{nol}^{-1} \times 10^2) (Fig. 86-89).

Density of Rotifers ranged from 1.5 to 14.0 \text{nol}^{-1} \times 10^2 and 1.16 to 4.5 \text{nol}^{-1} \times 10^2 in 2006-07 and 2007-08 respectively (Fig. 82-89). In 2006-07, highest density of rotifers (14.0 \text{nol}^{-1} \times 10^2) was recorded in monsoon and lowest in winter (1.5 \text{nol}^{-1} \times 10^2) (Fig. 82-85). Whereas in 2007-08, it was recorded highest in winter (4.5 \text{nol}^{-1} \times 10^2) and lowest in pre-monsoon (1.16 \text{nol}^{-1} \times 10^2) (Fig. 86-89).

Density of Copepoda ranged from 6.83 to 17.83 \text{nol}^{-1} \times 10^2 and 6.34 to 13.83 \text{nol}^{-1} \times 10^2 in 2006-07 and 2007-08 respectively (Fig. 82-89). In 2006-07, highest density of copepods (17.83 \text{nol}^{-1} \times 10^2) was recorded in monsoon and lowest in post-monsoon (6.83 \text{nol}^{-1} \times 10^2) (Fig. 82-85). Whereas in 2007-08, it was recorded highest in monsoon (13.83 \text{nol}^{-1} \times 10^2) and lowest in winter (6.34 \text{nol}^{-1} \times 10^2) (Fig. 86-89).

Density of Anostraca ranged from 1.16 to 4.16 \text{nol}^{-1} \times 10^2 and 4.34 to 5.83 \text{nol}^{-1} \times 10^2 in 2006-07 and 2007-08 respectively (Fig. 82-89). In 2006-07, highest density of Anostraca (4.16 \text{nol}^{-1} \times 10^2) was recorded in winter and lowest in monsoon (1.16 \text{nol}^{-1} \times 10^2) (Fig. 82-85). Whereas in 2007-08 it was found to be highest in monsoon (5.83 \text{nol}^{-1} \times 10^2) and lowest in winter (4.34 \text{nol}^{-1} \times 10^2) (Fig. 86-89). In 2007-08, density of branchiopods was found to be higher than that in 2006-2007 in all the season.

Density of Protozoa ranged from 0.5 to 0.83 \text{nol}^{-1} \times 10^2 in 2006-07 and totally absent in all the season in 2007-08 (Fig. 82-89). Highest density of Protozoan (0.83 \text{nol}^{-1} \times 10^2) was recorded in winter and lowest in post-monsoon (0.5 \text{nol}^{-1} \times 10^2) and totally absent in pre-monsoon and their population was found to be very less throughout the study period (Fig. 82-85).

Density of Ostracoda ranged from 0.5 to 2.34 \text{nol}^{-1} \times 10^2 and 0.67 to 2.16 \text{nol}^{-1} \times 10^2 in 2006-07 and 2007-08 respectively (Fig. 82-89). In 2006-07, highest density of Ostracods (2.34 \text{nol}^{-1} \times 10^2) was recorded in pre-monsoon and lowest in winter (0.5 \text{nol}^{-1} \times 10^2) (Fig. 82-85). Whereas in 2007-08, it was recorded highest (2.16 \text{nol}^{-1} \times 10^2) in winter and pre-monsoon and lowest in monsoon (0.67 \text{nol}^{-1} \times 10^2) (Fig. 86-89).

Decapoda was not encountered during the investigation period.

Station 8 (SAL)

In this station, density of total zooplankton ranged from 10.16 to 36.0 \text{nol}^{-1} \times 10^2 and 14.34 to 64.83 \text{nol}^{-1} \times 10^2 in 2006-07 and 2007-08 respectively (Fig. 91 and 93).
Density of Cladocera ranged from 2.16 to 17.67 no. l^{-1} \times 10^2 and 5.33 to 31.67 no. l^{-1} \times 10^2 in 2006-07 and 2007-08 respectively (Fig. 82-89). In 2006-07, highest density of Cladocera (17.67 no. l^{-1} \times 10^2) was recorded in monsoon and lowest in post-monsoon (2.16 no. l^{-1} \times 10^2) and found to be gradually increased throughout the year (Fig. 82-85). Whereas in 2007-08, it was found to be highest in pre-monsoon (31.67 no. l^{-1} \times 10^2) and lowest in post-monsoon (5.33 no. l^{-1} \times 10^2) (Fig. 86-89).

Density of Rotifers ranged from 2.34 to 8.34 no. l^{-1} \times 10^2 and 2.0 to 8.34 no. l^{-1} \times 10^2 in 2006-07 and 2007-08 respectively (Fig. 82-89). In 2006-07, highest density of rotifers (8.34 no. l^{-1} \times 10^2) was recorded in monsoon and lowest in pre-monsoon (2.34 no. l^{-1} \times 10^2) (Fig. 82-85). Whereas in 2007-08, it was recorded highest in winter (8.34 no. l^{-1} \times 10^2) and lowest in monsoon (2.0 no. l^{-1} \times 10^2) (Fig. 86-89).

Density of Copepoda ranged from 2.5 to 10.0 no. l^{-1} \times 10^2 and 6.83 to 10.0 no. l^{-1} \times 10^2 in 2006-07 and 2007-08 respectively (Fig. 82-89). In 2006-07, highest density of copepods (10.0 no. l^{-1} \times 10^2) was recorded in monsoon and lowest in winter (2.5 no. l^{-1} \times 10^2) (Fig. 82-85). Whereas in 2007-08, it was recorded highest in winter (10.0 no. l^{-1} \times 10^2) and lowest in monsoon (6.83 no. l^{-1} \times 10^2) (Fig. 86-89).

Density of Anostraca ranged from 0.67 to 2.34 no. l^{-1} \times 10^2 and 0.67 to 5.34 no. l^{-1} \times 10^2 in 2006-07 and 2007-08 respectively (Fig. 82-89). In 2006-07, highest density of Anostraca (2.34 no. l^{-1} \times 10^2) was recorded in winter and lowest in pre-monsoon (0.67 no. l^{-1} \times 10^2) (Fig. 82-85). Whereas in 2007-08, it was recorded highest in pre-monsoon (5.37 no. l^{-1} \times 10^2) and lowest in post-monsoon (0.67 no. l^{-1} \times 10^2) (Fig. 86-89).

Density of Protozoa ranged from 0.5 to 1.16 no. l^{-1} \times 10^2 and 0.83 to 1.16 no. l^{-1} \times 10^2 in 2006-07 and 2007-08 respectively (Fig. 82-89). In 2006-07, highest density of Protozoa (1.16 no. l^{-1} \times 10^2) was recorded in monsoon, lowest in post-monsoon (0.5 no. l^{-1} \times 10^2) and totally absent in pre-monsoon (Fig. 82-85). Whereas in 2007-08, it was found to be present only in winter (1.16 no. l^{-1} \times 10^2) and pre-monsoon (0.83 no. l^{-1} \times 10^2) and totally absent in rest of the seasons (Fig. 86-89).

Density of Ostracoda was found to be present only in monsoon in 2007-08 (0.83 no. l^{-1} \times 10^2) throughout the investigation period (Fig. 82-89).

Ostracoda was not recorded throughout the investigation period

Station 9 (GR)

In this station, density of total zooplankton ranged from 8.83 to 27.16 no. l^{-1} \times 10^2 and 5.16 to 34.83 no. l^{-1} \times 10^2 in 2006-07 and 2007-08 respectively (Fig. 91 and 93).
Density of Cladocera ranged from 1.34 to 12.34 no.1\textsuperscript{-1} x 10\textsuperscript{2} and 2.0 to 18.0 no.1\textsuperscript{-1} x 10\textsuperscript{2} in 2006-07 and 2007-08 respectively (Fig. 82-89). In 2006-07, highest cladoceran density (12.34 no.1\textsuperscript{-1} x 10\textsuperscript{2}) was recorded in monsoon and lowest in winter (1.34 no.1\textsuperscript{-1} x 10\textsuperscript{2}) (Fig. 82-85). Whereas in 2007-08, it was recorded highest in winter (18.0 no.1\textsuperscript{-1} x 10\textsuperscript{2}) and lowest in pre-monsoon (2.0 no.1\textsuperscript{-1} x 10\textsuperscript{2}) (Fig. 86-89).

Density of Rotifers ranged from 2.34 to 3.16 no.1\textsuperscript{-1} x 10\textsuperscript{2} and 1.0 to 3.67 no.1\textsuperscript{-1} x 10\textsuperscript{2} in 2006-07 and 2007-08 respectively (Fig. 82-89). In 2006-07, highest density of rotifers (3.16 no.1\textsuperscript{-1} x 10\textsuperscript{2}) was recorded in post-monsoon and lowest in winter (2.34 no.1\textsuperscript{-1} x 10\textsuperscript{2}) (Fig. 82-85). In 2007-08, it was recorded highest in post-monsoon (3.67 no.1\textsuperscript{-1} x 10\textsuperscript{2}) and lowest in monsoon (1.0 no.1\textsuperscript{-1} x 10\textsuperscript{2}) (Fig. 86-89).

Density of Copepoda ranged from 2.16 to 12.0 no.1\textsuperscript{-1} x 10\textsuperscript{2} and 1.5 to 11.67 no.1\textsuperscript{-1} x 10\textsuperscript{2} in 2006-07 and 2007-08 respectively (Fig. 82-89). In 2006-07, highest density of copepods (12.0 no.1\textsuperscript{-1} x 10\textsuperscript{2}) was recorded in pre-monsoon and lowest in post-monsoon (2.16 no.1\textsuperscript{-1} x 10\textsuperscript{2}) (Fig. 82-85). Whereas in 2007-08, it was recorded highest in post-monsoon (11.67 no.1\textsuperscript{-1} x 10\textsuperscript{2}) and lowest in pre-monsoon (1.5 no.1\textsuperscript{-1} x 10\textsuperscript{2}) (Fig. 86-89).

Density of Anostraca ranged from 0.5 to 2.0 no.1\textsuperscript{-1} x 10\textsuperscript{2} in 2006-07 and found to be present only in post-monsoon (2.83 no.1\textsuperscript{-1} x 10\textsuperscript{2}) in 2007-08 (Fig. 82-89). In 2006-07, highest density of Anostraca (2.0 no.1\textsuperscript{-1} x 10\textsuperscript{2}) was recorded in post-monsoon and lowest in monsoon (0.5 no.1\textsuperscript{-1} x 10\textsuperscript{2}) (Fig. 82-85).

Density of Protozoa was found to be present only in winter (0.34 no.1\textsuperscript{-1} x 10\textsuperscript{2}) in 2006-07 (Fig. 82-85). In 2007-08 it was not recorded at all.

Density of Ostracoda ranged from 0.5 to 1.5 no.1\textsuperscript{-1} x 10\textsuperscript{2} and 0.5 to 1.67 no.1\textsuperscript{-1} x 10\textsuperscript{2} in 2006-07 and 2007-08 respectively (Fig. 82-89). In 2006-07, highest density of ostracods (1.5 no.1\textsuperscript{-1} x 10\textsuperscript{2}) was recorded in monsoon and lowest in pre-monsoon (0.5 no.1\textsuperscript{-1} x 10\textsuperscript{2}) (Fig. 82-85). Whereas in 2007-08, it was recorded highest (1.67 no.1\textsuperscript{-1} x 10\textsuperscript{2}) in post-monsoon and pre-monsoon, and lowest in winter (0.5 no.1\textsuperscript{-1} x 10\textsuperscript{2}) (Fig. 86-89).

Decapoda was not recorded throughout the investigation period

**Station 10 (BR)**

In this station, density of total zooplankton ranged from 4.0 to 32.5 no.1\textsuperscript{-1} x 10\textsuperscript{2} and 6.67 to 9.83 no.1\textsuperscript{-1} x 10\textsuperscript{2} in 2006-07 and 2007-08 respectively (Fig. 91 and 93).

Density of Cladocera ranged from 1.5 to 12.5 no.1\textsuperscript{-1} x 10\textsuperscript{2} and 2.16 to 4.5 no.1\textsuperscript{-1} x 10\textsuperscript{2} in 2006-07 and 2007-08 respectively (Fig. 82-89). In 2006-07, highest cladoceran density (12.5 no.1\textsuperscript{-1} x 10\textsuperscript{2}) was recorded in pre-monsoon and lowest in post-monsoon (1.5 no.1\textsuperscript{-1} x 10\textsuperscript{2}) (Fig. 82-85). Whereas in 2007-08, it
was also recorded highest in pre-monsoon \(4.5 \text{ no.} \cdot 1 \cdot 10^2\) and lowest \(2.16 \text{ no.} \cdot 1 \cdot 10^2\) in post-monsoon and winter (Fig. 86-89).

Density of Rotifers ranged from 0.5 to 2.0 \text{ no.} \cdot 1 \cdot 10^2 and 0.67 to 2.16 \text{ no.} \cdot 1 \cdot 10^2 in 2006-07 and 2007-08 respectively (Fig. 82-89). In 2006-07, highest density of rotifers \(2.0 \text{ no.} \cdot 1 \cdot 10^2\) was recorded in pre-monsoon and lowest \(0.5 \text{ no.} \cdot 1 \cdot 10^2\) in post-monsoon and winter (Fig. 82-85). Whereas in 2007-08, it was found to be highest in winter \(2.16 \text{ no.} \cdot 1 \cdot 10^2\) and lowest in monsoon \(0.67 \text{ no.} \cdot 1 \cdot 10^2\) (Fig. 86-89).

Density of Copepoda ranged from 1.0 to 15.0 \text{ no.} \cdot 1 \cdot 10^2 and 1.67 to 3.16 \text{ no.} \cdot 1 \cdot 10^2 in 2006-07 and 2007-08 respectively (Fig. 82-89). In 2006-07, highest density of copepods \(15.0 \text{ no.} \cdot 1 \cdot 10^2\) was recorded in pre-monsoon and monsoon and lowest in post-monsoon \(1.0 \text{ no.} \cdot 1 \cdot 10^2\) (Fig. 82-85). Whereas in 2007-08, it was found to be highest in post-monsoon \(3.16 \text{ no.} \cdot 1 \cdot 10^2\) and lowest in monsoon \(1.67 \text{ no.} \cdot 1 \cdot 10^2\) (Fig. 86-89).

Density of Anostraca ranged from 0.5 to 1.5 \text{ no.} \cdot 1 \cdot 10^2 and 0.67 to 1.16 \text{ no.} \cdot 1 \cdot 10^2 in 2006-07 and 2007-08 respectively. (Fig. 82-89). In 2006-07, highest density of anostraca \(1.5 \text{ no.} \cdot 1 \cdot 10^2\) was recorded in winter and pre-monsoon and lowest in monsoon \(0.5 \text{ no.} \cdot 1 \cdot 10^2\) (Fig. 82-85). Whereas in 2007-08, it was recorded highest \(1.16 \text{ no.} \cdot 1 \cdot 10^2\) in pre-monsoon and monsoon and lowest in post-monsoon \(0.67 \text{ no.} \cdot 1 \cdot 10^2\) and totally absent in winter (Fig. 86-89).

Protozoan was found to be totally absent in all the season throughout the investigation period.

Ostracoda was found to be present only in pre-monsoon \(1.5 \text{ no.} \cdot 1 \cdot 10^2\) and monsoon \(1.0 \text{ no.} \cdot 1 \cdot 10^2\) in 2006-07 and totally absent in rest of the seasons throughout the investigation period (Fig. 82-89).

Decapoda was not encountered during the investigation period.

**Density of different groups of zooplankton in different sites**

**Cladocera**

The density of Cladocera in different stations ranged from 1.34 to 47.67 \text{ no.} \cdot 1 \cdot 10^2 and 1.83 to 141.83 \text{ no.} \cdot 1 \cdot 10^2 in 2006-07 and 2007-08 respectively (Fig. 82-89).

In 2006-07 among all the stations, highest density of Cladocera was recorded in monsoon \(47.67 \text{ no.} \cdot 1 \cdot 10^2\) in the station 5 (UB) and lowest in winter \(1.34 \text{ no.} \cdot 1 \cdot 10^2\) in the station 9 (GR) (Fig. 82-85). In 2007-08, it was recorded highest \(141.83 \text{ no.} \cdot 1 \cdot 10^2\) in the station 2 (BC) in post-monsoon followed by station 5 (UB) in monsoon \(63.16 \text{ no.} \cdot 1 \cdot 10^2\) and lowest in station 1 (JC) in winter \(1.83 \text{ no.} \cdot 1 \cdot 10^2\) (Fig. 86-89).
**Rotifera**

The density of Rotifera in different stations ranged from 0.5 to 18.83 no.\(1^{-1}\) \(x\) 10\(^2\) and 0.16 to 6.16 no.\(1^{-1}\) \(x\) 10\(^2\) in 2006-07 and 2007-08 respectively (Fig. 82-89).

In 2006-07, among all the stations highest density of Rotifers (18.83 no.\(1^{-1}\) \(x\) 10\(^2\)) was recorded in monsoon in the station 5 (UB) and lowest in post-monsoon (0.5 no.\(1^{-1}\) \(x\) 10\(^2\)) in the station 10 (BR) (Fig. 82-85). In 2007-08, it was highest in monsoon (6.16 no.\(1^{-1}\) \(x\) 10\(^2\)) in the station 6 (OW) and lowest (0.16 no.\(1^{-1}\) \(x\) 10\(^2\)) in winter and monsoon in the station 1 and 2 (JC and BC) (Fig. 86-89).

**Copepoda**

The density of Copepoda in different stations ranged from 1.0 to 51.34 no.\(1^{-1}\) \(x\) 10\(^2\) and 0.67 to 61.83 no.\(1^{-1}\) \(x\) 10\(^2\) in 2006-07 and 2007-08 respectively (Fig. 82-89).

In 2006-07, among all the stations highest density of Copepoda (51.34 no.\(1^{-1}\) \(x\) 10\(^2\)) was recorded in the station 4 (RB) followed by station 5 (UB) (42.16 no.\(1^{-1}\) \(x\) 10\(^2\)) in monsoon and lowest in post-monsoon (1.0 no.\(1^{-1}\) \(x\) 10\(^2\)) in the station 10 (BR) (Fig. 82-85). In 2007-08, it was recorded highest in monsoon (61.83 no.\(1^{-1}\) \(x\) 10\(^2\)) in the station 5 (UB) followed by station 4 (RB) in post-monsoon (53.16 no.\(1^{-1}\) \(x\) 10\(^2\)) and lowest in pre-monsoon (0.67 no.\(1^{-1}\) \(x\) 10\(^2\)) in the station 1 (JC) (Fig. 86-89).

**Anostraca**

The density of Anostraca in different stations ranged from 0.5 to 40.34 no.\(1^{-1}\) \(x\) 10\(^2\) and 0.16 to 22.34 no.\(1^{-1}\) \(x\) 10\(^2\) in 2006-07 and 2007-08 respectively (Fig. 82-89).

In 2006-07, among all the stations highest density of Anostraca (40.34 no.\(1^{-1}\) \(x\) 10\(^2\)) was recorded in the station 5 (UB) in pre-monsoon and lowest in monsoon (0.5 no.\(1^{-1}\) \(x\) 10\(^2\)), in the station 9 (GR) (Fig. 82-85). In 2007-08, it was recorded highest in post-monsoon (22.34 no.\(1^{-1}\) \(x\) 10\(^2\)) in the station 3 (DGK) followed by station 5 (UB) in monsoon (21.0 no.\(1^{-1}\) \(x\) 10\(^2\)) and lowest in station 4 (RB) during winter (0.16 no.\(1^{-1}\) \(x\) 10\(^2\)) (Fig. 86-89).

**Protozoa**

The density of Protozoa in different stations ranged from 0.34 to 9.23 no.\(1^{-1}\) \(x\) 10\(^2\) and 0.16 to 4.0 no.\(1^{-1}\) \(x\) 10\(^2\) in 2006-07 and 2007-08 respectively (Fig. 82-89).

In 2006-07, among all the stations highest density of Protozoan (9.23 no.\(1^{-1}\) \(x\) 10\(^2\)) was recorded in the station 3 (DGK) in monsoon and lowest (0.34 no.\(1^{-1}\) \(x\) 10\(^2\))
in station 4 and 9 (RB and GR) in winter (Fig. 82-85). In 2007-08, it was recorded highest (4.0 no.l^{-1} x 10^2) in the station 6 (OW) and lowest in the station 1 (JC) during monsoon (0.16 no.l^{-1} x 10^2) (Fig. 86-89).

**Ostracoda**

The density of Ostracoda in different stations ranged from 0.38 to 3.16 no.l^{-1} x 10^2 and 0.34 to 6.5 no.l^{-1} x 10^2 in 2006-07 and 2007-08 respectively (Fig. 82-89).

In 2006-07, among all the stations highest density of Ostracoda (3.16 no.l^{-1} x 10^2) was recorded in the station 6 (OW) in monsoon and lowest (0.38 no.l^{-1} x 10^2) in the station 2 (BC) during post-monsoon and pre-monsoon (Fig. 82-85). In 2007-08, it was also recorded highest (6.5 no.l^{-1} x 10^2) in the station 6 (OW) in monsoon. Lowest density (0.34 no.l^{-1} x 10^2) was recorded in the station 4 (RB) in post-monsoon and pre-monsoon (Fig. 86-89).

**Decapoda**

Decapoda was represented by a single taxon *Zoea larva* recorded in station 1, 2 and 3 (JC, BC and DGK) in winter, pre-monsoon and monsoon during 2006-07 and totally absent in all the stations in all the seasons in 2007-08 (Fig. 82-89).

**Variation of zooplankton density in different seasons**

During post-monsoon, in 2006-07, highest density of total zooplankton (54.5 no.l^{-1} x 10^2) was recorded in the station 5 (UB) and lowest density (4.0 no.l^{-1} x 10^2) was recorded in the station 10 (BR) (Fig. 91). In 2007-08, it was recorded highest (213.83 no.l^{-1} x 10^2) in the station 2 (BC) and lowest density (7.83 no.l^{-1} x 10^2) was recorded again in the station 10 (BR) (Fig. 93).

During winter in 2006-07, highest density of total zooplankton (33.16 no.l^{-1} x 10^2) was recorded in the station 5 (UB) and lowest (6.5 no.l^{-1} x 10^2) in the station 10 (BR) (Fig. 91). In 2007-08, it was recorded highest (48.16 no.l^{-1} x 10^2) in the station 6 (OW) and lowest (6.67 no.l^{-1} x 10^2) in the station 10 (BR) (Fig. 93).

During pre-monsoon, in 2006-07, highest density of total zooplankton (124.5 no.l^{-1} x 10^2) was recorded in the station 5 (UB) and lowest (14.11 no.l^{-1} x 10^2) in the station 2 (BC) (Fig. 91) whereas in 2007-08, it was found to be highest (45.0 no.l^{-1} x 10^2) in the station 7 (MB) and lowest (4.0 no.l^{-1} x 10^2) in the station 1 (JC) (Fig. 93).
During monsoon, in 2006-07, highest density of total zooplankton (133.83 no.1\(^{-1}\) x 10\(^2\)) was recorded in the station 5 (UB) and lowest (26.5 no.1\(^{-1}\) x 10\(^2\)) in the station 10 (BR) (Fig. 91). In 2007-08, it was also recorded highest (148.5 no.1\(^{-1}\) x 10\(^2\)) in the station 5 (UB) and lowest (4.67 no.1\(^{-1}\) x 10\(^2\)) in the station 1 (JC) (Fig. 93).

**Spatial variation of zooplankton**

Table 19: shows spatial variation of mean density (no.1\(^{-1}\) x 10\(^2\)) of zooplankton taxonomic groups during post-monsoon 2006 to monsoon 2007.

Table 20: shows spatial variation of mean abundance (no.1\(^{-1}\) x 10\(^2\)) of zooplankton taxonomic groups during post-monsoon 2006 to monsoon 2007.

A total of 36 taxa of zooplankton were recorded in 2006-07 and 2007-08 of which 24 taxa were recorded 2006-07 and 34 taxa in 2007-08. Zooplankton community was represented by Cladocera (6), Rotifera (6), Copepoda (6), Anostraca (2), Protozoa (1), Ostracoda (2), and Decapoda (1) (Table 19). While in 2007-08, zooplankton community was represented by Cladocera (11), Rotifera (8), Copepoda (8), Anostraca (3), Protozoa (1), Ostracoda (2) and one unidentified taxon (Table 21).

Spatial variation of mean density and abundance of zooplankton community represented by six major groups comprising 24 taxa in different stations in 2006-07 (September 2006-August 2007) (Table 19 and 20) and 34 taxa in different stations in 2007-08 (September 2007-August 2008) are depicted in the Table 21 and 22.

Spatial variation of mean density and abundance of zooplankton community represented by six major groups comprising 24 taxa in different stations in 2006-07 (September 2006-August 2007) (Table 19 and 20) and 34 taxa in different stations in 2007-08 (September 2007-August 2008) are depicted in the Table 21 and 22.

During 2006-07, mean spatial variation of Cladocera showed highest density (29.34 no.1\(^{-1}\) x 10\(^2\)) and abundance (29.71 no.1\(^{-1}\) x 10\(^2\)) in station 5 (UB) by Copepoda in terms of density (29.25 no.1\(^{-1}\) x 10\(^2\)) and abundance (29.58 no.1\(^{-1}\) x 10\(^2\)) (Table 19 and 20). This was followed by Anostraca in the station 5 (UB) (density -16.08 no.1\(^{-1}\) x 10\(^2\) and abundance -16.3 no.1\(^{-1}\) x 10\(^2\)). Next group was found to be Rotifers in the same station 5 (UB) (density - 7.8 no.1\(^{-1}\) x 10\(^2\) and abundance - 8.55 no.1\(^{-1}\) x 10\(^2\)) (Table 19 and 20). Protozoa showed highest
density \((3.43 \text{ no.l}^{-1} \times 10^2)\) and abundance \((3.47 \text{ no.l}^{-1} \times 10^2)\) in the station 3 (DGK) and lowest density \((0.08 \text{ no.l}^{-1} \times 10^2)\) and abundance \((0.25 \text{ no.l}^{-1} \times 10^2)\) was recorded in the station (GR). Ostracoda showed highest density \((2.0 \text{ no.l}^{-1} \times 10^2)\) and abundance \((2.23 \text{ no.l}^{-1} \times 10^2)\) in the station 5 (UB) and lowest density \((0.17 \text{ no.l}^{-1} \times 10^2)\) and abundance \((0.21 \text{ no.l}^{-1} \times 10^2)\) was recorded in the station 1 (JC) and totally absent in the station 8 (SAL). Decapoda showed highest density \((2.0 \text{ no.l}^{-1} \times 10^2)\) and abundance \((2.23 \text{ no.l}^{-1} \times 10^2)\) in the station 5 (UB) and lowest density \((0.17 \text{ no.l}^{-1} \times 10^2)\) and abundance \((0.21 \text{ no.l}^{-1} \times 10^2)\) was recorded in the station 1 (JC) and totally absent in rest of the stations (Table 19 and 20).

During 2006-07, spatial variation of mean density and abundance of total zooplankton revealed that highest density \((86.5 \text{ no.l}^{-1} \times 10^2)\) and abundance \((88.85 \text{ no.l}^{-1} \times 10^2)\) was recorded in the station 5 (UB) followed by station 4 (RB) (density \(-47.79 \text{ no.l}^{-1} \times 10^2\) and abundance-\(-51.88 \text{ no.l}^{-1} \times 10^2\) ) and lowest density \((17.17 \text{ no.l}^{-1} \times 10^2)\) was found in the station 9 (GR) and lowest abundance \((19.19 \text{ no.l}^{-1} \times 10^2)\) was found in the station 10 (BR) (Table 19 and 20).

Table 21: shows spatial variation of mean density \((\text{no.l}^{-1} \times 10^2)\) of zooplankton taxonomic groups during post-monsoon 2007 to monsoon 2008.

Table 22: shows spatial variation of mean abundance \((\text{no.l}^{-1} \times 10^2)\) of zooplankton taxonomic groups during post-monsoon 2007 to monsoon 2008.

During 2007-08, mean spatial variation of different groups of zooplankton revealed that Cladocera was the most dominant group in terms of mean density \((35.17 \text{ no.l}^{-1} \times 10^2)\) and mean abundance \((35.29 \text{ no.l}^{-1} \times 10^2)\) in the station 5 (UB). Copepods was found to be the second dominant group in terms of mean density \((28.21 \text{ no.l}^{-1} \times 10^2)\) and mean abundance \((28.35 \text{ no.l}^{-1} \times 10^2)\) in the station 5 (UB). Anostraca showed moderate variation of mean density \((9.25 \text{ no.l}^{-1} \times 10^2)\) and abundance \((9.44 \text{ no.l}^{-1} \times 10^2)\) recorded in the station 5 (UB). Next group was found to be the Rotifera in terms of density \((3.83 \text{ no.l}^{-1} \times 10^2)\) and abundance \((4.71 \text{ no.l}^{-1} \times 10^2)\) recorded in the station 6 (OW). This is followed by Ostracoda in terms of density \((2.71 \text{ no.l}^{-1} \times 10^2)\) and abundance \((3.5 \text{ no.l}^{-1} \times 10^2)\) recorded in the station 6 (OW) and totally absent in the station 1 and 10 (JC and BR). Protozoa showed lowest mean inter station variation of density \((0.21 \text{ no.l}^{-1} \times 10^2)\) and abundance \((0.31 \text{ no.l}^{-1} \times 10^2)\) recorded in the station 2 and 4 (BC and RB) and totally absent in the station 3, 7, 9 and 10 (DGK, MB, GR and BR) (Table 21 and 22).

During 2007-08, spatial variation of mean density and abundance of total zooplankton revealed that highest density and abundance was recorded (density-\(-77.42 \text{ no.l}^{-1} \times 10^2\) and abundance -\(-78.89 \text{ no.l}^{-1} \times 10^2\) ) in the station 5 (UB) followed by station 2 (BC) (density -\(-63.83 \text{ no.l}^{-1} \times 10^2\) and abundance -\(-64.56 \text{ no.l}^{-1} \times 10^2\) ) and station 6 (OW) (density -\(-54.29 \text{ no.l}^{-1} \times 10^2\) and abundance -\(-57.21 \text{ no.l}^{-1} \times 10^2\) ). Lowest density \((6.29 \text{ no.l}^{-1} \times 10^2)\) and abundance \((9.02 \text{ no.l}^{-1} \times 10^2)\) of total zooplankton was recorded in the station 1 (JC) (Table 21 and 22).

Temporal variation of mean density and abundance of zooplankton
Table 27 shows seasonal variation of mean density of zooplankton community during 2006-07.

Table 28 shows seasonal variation of mean abundance of zooplankton community during 2006-07.

In 2006-07, seasonal variation of mean density of zooplankton was recorded highest in monsoon (58.14 no.1⁻¹ x 10²) followed by pre-monsoon (36.14 no.1⁻¹ x 10²) and post-monsoon (20.74 no.1⁻¹ x 10²) and lowest in winter (17.64 no.1⁻¹ x 10²) (Table 27).

Cladoceran density was found to be highest in monsoon (22.34 no.1⁻¹ x 10²) and lowest in winter (5.72 no.1⁻¹ x 10²). Highest density of rotifers was recorded in monsoon (19.57 no.1⁻¹ x 10²) followed by pre-monsoon (13.22 no.1⁻¹ x 10²) and lowest in winter (5.67 no.1⁻¹ x 10²). Density of Anostraca was found to be progressively increases from post-monsoon (1.81 no.1⁻¹ x 10²) to pre-monsoon (6.24 no.1⁻¹ x 10²) season but a slight decrease in their density was noticed in monsoon (4.73 no.1⁻¹ x 10²). Protozoa was recorded highest in monsoon (1.82 no.1⁻¹ x 10²) and lowest in pre-monsoon (0.65 no.1⁻¹ x 10²). Ostracods were recorded highest in monsoon (0.92 no.1⁻¹ x 10²) and lowest in winter (0.54 no.1⁻¹ x 10²). Decapoda was found to be highest in winter (0.23 no.1⁻¹ x 10²) and totally absent in post-monsoon although very population was found throughout the year (Table 27).

In 2006-07, seasonal variation of mean abundance of total zooplankton community showed highest abundance in monsoon (65.62 no.1⁻¹ x 10²) followed by pre-monsoon (40.81 no.1⁻¹ x 10²) and found to be very close in post-monsoon (24.67 no.1⁻¹ x 10²) and winter (23.08 no.1⁻¹ x 10²) (Table 28).

Cladocera showed highest abundance in monsoon (23.91 no.1⁻¹ x 10²) followed by pre-monsoon (12.48 no.1⁻¹ x 10²) and found to be very close in post-monsoon (7.66 no.1⁻¹ x 10²) and winter (6.95 no.1⁻¹ x 10²) (Table 28). Rotifera showed highest abundance in monsoon (9.14 no.1⁻¹ x 10²), followed by pre-monsoon (4.28 no.1⁻¹ x 10²) and lowest in winter (3.52 no.1⁻¹ x 10²). Copepoda showed highest abundance in monsoon (23.7 no.1⁻¹ x 10²) and lowest in winter (7.72 no.1⁻¹ x 10²) (Table 28). Abundance of Anostraca was recorded highest in pre-monsoon (6.77 no.1⁻¹ x 10²) followed by monsoon (5.29 no.1⁻¹ x 10²) and lowest in post-monsoon (2.34 no.1⁻¹ x 10²). Protozoa showed highest abundance in monsoon (2.0 no.1⁻¹ x 10²) and lowest in pre-monsoon (0.65 no.1⁻¹ x 10²). Ostracods showed the highest abundance in pre-monsoon (1.36 no.1⁻¹ x 10²) and lowest in monsoon (0.76 no.1⁻¹ x 10²). Abundance of Decapoda was found to be highest in winter (0.33 no.1⁻¹ x 10²) and lowest in monsoon (0.16 no.1⁻¹ x 10²) and totally absent in post-monsoon (Table 28).

During 2006-07, Daphnia sp. was found to be most abundant taxon (12.42 no.1⁻¹ x 10²) followed by Cyclops sp. (10.32 no.1⁻¹ x 10²) recorded in
monsoon. *Streptocephalus* sp. (6.46 no.1⁻¹ x 10²) was found to be the next abundant taxon recorded in pre-monsoon followed by *Diaptomus* sp. (5.94 no.1⁻¹ x 10²) and *Bosmina* sp. (5.89 no.1⁻¹ x 10²) during monsoon. *Daphnia* sp. (5.18 no.1⁻¹ x 10²) and *Cyclops* sp. (4.5 no.1⁻¹ x 10²) were again found to be the major taxa recorded during winter (*Table 28*).

*Table 29* shows seasonal variation of mean density of zooplankton community during 2007-08.

In 2007-08, seasonal variation of mean density of total zooplankton was recorded highest in post-monsoon (67.0 no.1⁻¹ x 10²) followed by monsoon (38.87 no.1⁻¹ x 10²) and winter (23.28 no.1⁻¹ x 10²) and lowest in pre-monsoon (16.72 no.1⁻¹ x 10²) (*Table 29*).

Mean density of Cladocera was found highest in post-monsoon (31.57 no.1⁻¹ x 10²) followed by monsoon (17.6 no.1⁻¹ x 10²) and lowest in pre-monsoon (9.2 no.1⁻¹ x 10²) (*Table 29*). Mean density of rotifers was found to be very low in all the season except post-monsoon (3.03 no.1⁻¹ x 10²). Density of Copepoda was recorded highest in post-monsoon (17.82 no.1⁻¹ x 10²) followed by monsoon (13.68 no.1⁻¹ x 10²) and lowest in pre-monsoon (3.65 no.1⁻¹ x 10²) (*Table 29*). Density of Anostraca was also found to be highest in post-monsoon (9.34 no.1⁻¹ x 10²) followed by monsoon (4.13 no.1⁻¹ x 10²) and lowest in winter (1.63 no.1⁻¹ x 10²) and pre-monsoon (1.64 no.1⁻¹ x 10²) respectively (*Table 29*). Mean density of Protozoa was found to be very less in all the seasons throughout the year and recorded highest in post-monsoon (0.68 no.1⁻¹ x 10²) and almost absent in winter (0.05 no.1⁻¹ x 10²) and pre-monsoon (0.08 no.1⁻¹ x 10²). Ostracoda showed highest mean density in monsoon (1.27 no.1⁻¹ x 10²) followed by post-monsoon (0.92 no.1⁻¹ x 10²) and lowest in pre-monsoon (0.73 no.1⁻¹ x 10²). Decapoda was not encountered throughout the year (*Table 29*).

In 2007-08, seasonal variation of mean abundance of total zooplankton showed highest abundance in post-monsoon (69.24 no.1⁻¹ x 10²) followed by monsoon (40.21 no.1⁻¹ x 10²) and winter (25.68 no.1⁻¹ x 10²) and lowest in pre-monsoon (18.78 no.1⁻¹ x 10²) (*Table 30*).

Mean abundance of Cladocera was recorded highest in post-monsoon (32.19 no.1⁻¹ x 10²) and lowest in pre-monsoon (9.45 no.1⁻¹ x 10²). Highest abundance of Rotifera was recorded in post-monsoon (4.0 no.1⁻¹ x 10²) and lowest in pre-monsoon (1.86 no.1⁻¹ x 10²) (*Table 30*). Copepods showed highest abundance in post-monsoon (18.1 no.1⁻¹ x 10²) followed by monsoon (13.72 no.1⁻¹ x 10²) and lowest in pre-monsoon (4.32 no.1⁻¹ x 10²) (*Table 30*). Abundance of Anostraca was recorded highest in post-monsoon (9.4 no.1⁻¹ x 10²) and lowest in pre-monsoon (1.9 no.1⁻¹ x 10²) (*Table 30*). Protozoan followed same pattern of variation like Branchiopods and showed highest mean abundance in post-monsoon (0.73 no.1⁻¹ x 10²) and lowest in pre-monsoon (0.13 no.1⁻¹ x 10²).
Ostracods showed highest mean abundance in monsoon (1.43 no.\(1^{-1}\) x \(10^2\)) and lowest in winter (1.06 no.\(1^{-1}\) x \(10^2\)) (Table 30).

During 2007-08, *Daphnia* sp. was the most abundant taxon recorded during post-monsoon (12.82 no.\(1^{-1}\) x \(10^2\)) followed by *Cyclops* sp. (9.45 no.\(1^{-1}\) x \(10^2\)) recorded in monsoon among all the seasons. *Diaptomus* sp. was the next abundant taxon recorded in post-monsoon (7.28 no.\(1^{-1}\) x \(10^2\)) which was followed by *Chydorus* sp. (7.01 no.\(1^{-1}\) x \(10^2\)), *Streptocephalus* sp. (6.65 no.\(1^{-1}\) x \(10^2\)) and *Bosmina* sp. (5.45 no.\(1^{-1}\) x \(10^2\)). The major taxa recorded in terms of abundance were *Daphnia* sp. (5.22 no.\(1^{-1}\) x \(10^2\)) and *Cyclops* sp. (4.5 no.\(1^{-1}\) x \(10^2\)) during winter. During pre-monsoon, *Daphnia* sp. (3.66 no.\(1^{-1}\) x \(10^2\)) and *Chydorus* sp. (3.18 no.\(1^{-1}\) x \(10^2\)) were the major taxa recorded in terms of abundance (Table 30).

**Zooplankton community structure**

The species diversity indices viz. Shannon-Wiener diversity index (\(H'\)), Margalef’s species richness Index (d), Evenness Index (\(J'\)) and Berger-Parker Index of dominance (\(D_{BP}\)) of zooplankton community were presented in Fig. 106-109 and 110-113).

In station 1 (JC), Shannon-Wiener diversity index (\(H'\)) of zooplankton community ranged from 1.48 to 1.92 and 1.0 to 1.55 in 2006-07 and 2007-08 respectively (Fig. 106 and 110). In 2006-07, highest \(H'\)-value was recorded in winter (1.92) and lowest in post-monsoon (1.48) (Fig. 106). Whereas in 2007-08, it was found to be highest in post-monsoon (1.55) and lowest in pre-monsoon (1.0) (Fig. 110).

Margalef’s Index of species richness (d) of zooplankton community ranged from 0.56 to 1.03 and 0.4 to 0.69 in 2006-07 and 2007-08 respectively (Fig. 107 and 111). In 2006-07, highest d-value was recorded in winter (1.03) and lowest in post-monsoon (0.56) (Fig. 107). Whereas in 2007-08, it was found to be highest in post-monsoon (0.69) and lowest in pre-monsoon (0.4) (Fig. 111).

Evenness Index (\(J'\)) of zooplankton community ranged from 0.85 to 0.92 and 0.81 to 0.91 in 2006-07 and 2007-08 respectively (Fig. 108 and 112). In 2006-07, highest \(J'\)-value (0.92) was recorded in post-monsoon and lowest in pre-monsoon (0.85) (Fig. 108). Whereas in 2007-08, it was found to be highest in monsoon (0.91) and lowest in winter (0.81) (Fig. 112).

Berger-Parker Index of dominance (\(D_{BP}\)) of zooplankton community ranged from 0.18 to 0.34 and 0.29 to 0.43 in 2006-07 and 2007-08 respectively (Fig. 109 and 113). In 2006-07, highest value of \(D_{BP}\) (0.34) was recorded in monsoon and lowest in winter (0.18) (Fig. 109). While in 2007-08, it was recorded highest in monsoon (0.43) and lowest in post-monsoon (0.29) (Fig. 113).
In station 2 (BC), Shannon-Wiener diversity index ($H'$) of zooplankton community ranged from 1.62 to 2.08 and 1.4 to 2.13 in 2006-07 and 2007-08 respectively (Fig. 106 and 110). In 2006-07, highest $H'$-value was recorded in monsoon (2.08) and lowest in pre-monsoon (1.62) (Fig. 106). Whereas in 2007-08, it was found to be highest in post-monsoon (2.13) and lowest in pre-monsoon (1.4) (Fig. 110).

Margalef’s Index of species richness ($d$) of zooplankton community ranged from 0.85 to 1.2 and 0.61 to 1.0 in 2006-07 and 2007-08 respectively (Fig. 107 and 111). In 2006-07, highest $d$-value was recorded in monsoon (1.2) and lowest in post-monsoon (0.85) (Fig. 107). Whereas in 2007-08, it was found to be highest in post-monsoon (1.0) and lowest in monsoon (0.61) (Fig. 111).

Evenness Index ($J'$) of zooplankton community ranged from 0.81 to 0.92 and 0.8 to 0.91 in 2006-07 and 2007-08 respectively (Fig. 108 and 112). In 2006-07, highest $J'$-value (0.92) was recorded in winter and lowest in pre-monsoon (0.81) (Fig. 108). Whereas in 2007-08, it was found to be highest in monsoon (0.91) and lowest in pre-monsoon (0.8) (Fig. 112).

Berger-Parker Index of dominance ($D_{BP}$) of zooplankton community ranged from 0.18 to 0.43 and 0.22 to 0.47 in 2006-07 and 2007-08 respectively (Fig. 109 and 113). In 2006-07, highest $D_{BP}$ (0.43) was recorded in pre-monsoon and lowest in winter (0.18) (Fig. 109). While in 2007-08, it was found to be highest in pre-monsoon (0.47) and lowest in post-monsoon (0.22) (Fig. 113).

In station 3 (DGK), Shannon-Wiener diversity index ($H'$) of zooplankton community ranged from 1.67 to 2.15 and 1.28 to 1.94 in 2006-07 and 2007-08 respectively (Fig. 106 and 110). In 2006-07, highest $H'$-value was recorded in winter (2.15) and lowest in post-monsoon (1.67) (Fig. 106). Whereas in 2007-08, it was also found to be highest in winter (1.94) and lowest in monsoon (1.28) (Fig. 110).

Margalef’s Index of species richness ($d$) of zooplankton community ranged from 0.93 to 1.3 and 0.51 to 0.92 in 2006-07 and 2007-08 respectively (Fig. 107 and 111). In 2006-07, highest $d$-value was recorded in winter (1.3) and lowest in post-monsoon (0.93) (Fig. 107). Whereas in 2007-08, it was also found to be highest in winter (0.92) and lowest in monsoon (0.51) (Fig. 111).

Evenness Index ($J'$) of zooplankton community ranged from 0.82 to 0.9 and 0.81 to 0.94 in 2006-07 and 2007-08 respectively (Fig. 108 and 112). In 2006-07, highest $J'$-value (0.9) was recorded in winter and lowest (0.82) in post-monsoon and monsoon (Fig. 108). Whereas in 2007-08, it was also found to be highest in winter (0.94) and lowest in post-monsoon (0.81) and remain steady (0.87) in rest of the seasons (Fig. 112).

Berger-Parker Index of dominance ($D_{BP}$) of zooplankton community ranged from 0.23 to 0.37 and 0.27 to 0.36 in 2006-07 and 2007-08 respectively
In 2006-07, highest value of $D_{BP}$ (0.37) was recorded in post-monsoon and lowest in winter (0.23) (Fig. 109). While in 2007-08, it was found to be highest (0.36) in pre-monsoon and monsoon and lowest in winter (0.27) (Fig. 113).

In station 4 (RB), Shannon-Wiener diversity index ($H'$) of zooplankton community ranged from 1.9 to 2.23 and 1.61 to 2.0 in 2006-07 and 2007-08 respectively (Fig. 106 and 110). In 2006-07, highest $H'$-value was recorded in post-monsoon (2.23) and lowest in monsoon (1.9) (Fig. 106). Whereas in 2007-08, it was found to be highest in monsoon (2.0) and lowest in winter (1.61) (Fig. 110).

Margalef’s Index of species richness (d) of zooplankton community ranged from 1.16 to 1.4 and 0.75 to 1.33 in 2006-07 and 2007-08 respectively (Fig. 107 and 111). In 2006-07, highest d-value was recorded in post-monsoon (1.4) and lowest in monsoon (1.16) (Fig. 107). Whereas in 2007-08, it was also found to be highest in post-monsoon (1.33) and lowest in winter (0.75) (Fig. 111).

Evenness Index ($J'$) of zooplankton community ranged from 0.77 to 0.9 and 0.74 to 0.91 in 2006-07 and 2007-08 respectively (Fig. 108 and 112). In 2006-07, highest $J'$-value (0.9) was recorded in post-monsoon and winter and lowest (0.77) in monsoon (Fig. 108). Whereas in 2007-08, it was found to be highest in monsoon (0.91) and lowest in post-monsoon (0.74) (Fig. 112).

Berger-Parker Index of dominance ($D_{BP}$) of zooplankton community ranged from 0.16 to 0.3 and 0.23 to 0.37 in 2006-07 and 2007-08 respectively (Fig. 109 and 113). In 2006-07, highest $D_{BP}$ (0.3) was recorded in monsoon and lowest in post-monsoon (0.16) (Fig. 109). While in 2007-08, it was found to be highest (0.37) in post-monsoon and lowest in monsoon (0.23) (Fig. 113).

In station 5 (UB), Shannon-Wiener diversity index ($H'$) of zooplankton community ranged from 2.11 to 2.42 and 1.8 to 2.32 in 2006-07 and 2007-08 respectively (Fig. 106 and 110). In 2006-07, highest $H'$-value was recorded in monsoon (2.42) and lowest in pre-monsoon (2.11) (Fig. 106). Whereas in 2007-08, it was found to be highest in post-monsoon (2.32) and lowest in pre-monsoon (1.61) (Fig. 110).

Margalef’s Index of species richness (d) of zooplankton community ranged from 1.4 to 1.86 and 1.01 to 1.94 in 2006-07 and 2007-08 respectively (Fig. 107 and 111). In 2006-07, highest d-value was recorded in monsoon (1.86) and lowest in pre-monsoon (1.4) (Fig. 107). Whereas in 2007-08, it was found to be highest in post-monsoon (1.94) and lowest in pre-monsoon (1.01) (Fig. 111).

Evenness Index ($J'$) of zooplankton community ranged from 0.8 to 0.91 and 0.8 to 0.9 in 2006-07 and 2007-08 respectively (Fig. 108 and 112). In 2006-07, highest $J'$-value (0.91) was recorded in winter and lowest (0.8) in pre-
monsoon (Fig. 108). Whereas in 2007-08, it was also found to be highest in winter (0.9) and lowest in post-monsoon (0.8) (Fig. 112).

Berger-Parker Index of dominance (D<sub>BP</sub>) of zooplankton community ranged from 0.17 to 0.33 and 0.24 to 0.4 in 2006-07 and 2007-08 respectively (Fig. 109 and 113). In 2006-07, highest value of D<sub>BP</sub> (0.33) was recorded in post-monsoon and lowest (0.17) in winter and monsoon (Fig. 109). While in 2007-08, it was found to be highest (0.4) in pre-monsoon and lowest in winter (0.23) (Fig. 113).

In station 6 (OW), Shannon-Wiener diversity index (H') of zooplankton community ranged from 1.88 to 2.33 and 2.01 to 2.4 in 2006-07 and 2007-08 respectively (Fig. 106 and 110). In 2006-07, highest H'-value was recorded in monsoon (2.33) and lowest in winter (1.88) (Fig. 106). Whereas in 2007-08, it was found to be highest in post-monsoon (2.4) and lowest in winter (2.01) (Fig. 110).

Margalef’s Index of species richness (d) of zooplankton community ranged from 1.0 to 1.47 and 1.3 to 1.94 in 2006-07 and 2007-08 respectively (Fig. 107 and 111). In 2006-07, highest d-value was recorded in post-monsoon (1.47) and lowest in winter (1.0) (Fig. 107). Whereas in 2007-08, it was also found to be highest in post-monsoon (1.94) and lowest (1.3) in winter and monsoon (Fig. 111).

Evenness Index (J') of zooplankton community ranged from 0.83 to 0.92 and 0.81 to 0.92 in 2006-07 and 2007-08 respectively (Fig. 108 and 112). In 2006-07, highest J'-value (0.92) was recorded in pre-monsoon and lowest (0.83) in post-monsoon (Fig. 108). Whereas in 2007-08, it was also found to be highest in pre-monsoon (0.92) and lowest in winter (0.81) and remain steady (0.82) in rest of the seasons (Fig. 112).

Berger-Parker Index of dominance (D<sub>BP</sub>) of zooplankton community ranged from 0.14 to 26 and 0.2 to 0.37 in 2006-07 and 2007-08 respectively. (Fig. 109 and 113). In 2006-07, highest value of D<sub>BP</sub> (0.26) was recorded in post-monsoon and lowest (0.14) in monsoon and gradually decreases throughout the year (Fig. 109). While in 2007-08, it was found to be highest (0.37) in monsoon and lowest in pre-monsoon (0.2) (Fig. 113).

In station 7 (MB), Shannon-Wiener diversity index (H') of zooplankton community ranged from 1.86 to 2.1 and 2.16 to 2.35 in 2006-07 and 2007-08 respectively (Fig. 106 and 110). In 2006-07, highest H'-value was recorded in pre-monsoon (2.1) and lowest in monsoon (1.86) (Fig. 106). Whereas in 2007-08, it was also found to be highest in pre-monsoon (2.35) and lowest in winter (2.16) (Fig. 110).

Margalef’s Index of species richness (d) of zooplankton community ranged from 0.9 to 1.3 and 1.28 to 1.55 in 2006-07 and 2007-08 respectively (Fig. 107 and 111). In 2006-07, highest d-value was recorded in post-monsoon
(1.3) and lowest in monsoon (0.9) (Fig. 107). Whereas in 2007-08, it was also found to be highest (1.55) in pre-monsoon and monsoon and lowest (1.28) in winter (Fig. 111).

Evenness Index ($J'$) of zooplankton community ranged from 0.86 to 0.91 and 0.84 to 0.91 in 2006-07 and 2007-08 respectively (Fig. 108 and 112). In 2006-07, highest $J'$-value (0.91) was recorded in winter and pre-monsoon and lowest (0.86) in monsoon (Fig. 108). Whereas in 2007-08, it was also found to be highest in winter (0.91) and lowest in monsoon (0.84) (Fig. 112).

Berger-Parker Index of dominance ($D_{BP}$) of zooplankton community ranged from 0.16 to 0.22 and 0.2 to 0.3 in 2006-07 and 2007-08 respectively (Fig. 109 and 113). In 2006-07, highest value of $D_{BP}$ (0.22) was recorded in monsoon and lowest (0.16) in winter (Fig. 109). While in 2007-08, it was found to be highest (0.3) in post-monsoon and monsoon and lowest in pre-monsoon (0.2) (Fig. 113).

In station 8 (SAL), Shannon-Wiener diversity index ($H'$) of zooplankton community ranged from 1.7 to 2.04 and 1.74 to 2.2 in 2006-07 and 2007-08 respectively (Fig. 106 and 110). In 2006-07, highest $H'$-value was recorded in monsoon (2.04) and lowest in post-monsoon (1.7) and progressively increased throughout the year (Fig. 106). Whereas in 2007-08, it was also found to be highest in winter (2.2) and lowest in pre-monsoon (1.74) (Fig. 110).

Margalef's Index of species richness (d) of zooplankton community ranged from 0.85 to 1.2 and 0.78 to 1.33 in 2006-07 and 2007-08 respectively (Fig. 107 and 111). In 2006-07, highest d-value was recorded in winter (1.2) and lowest in winter (0.85) (Fig. 107). Whereas in 2007-08, it was also found to be highest (1.33) in post-monsoon and lowest (0.78) in pre-monsoon (Fig. 111).

Evenness Index ($J'$) of zooplankton community ranged from 0.8 to 0.92 and 0.8 to 0.92 in 2006-07 and 2007-08 respectively (Fig. 108 and 112). In 2006-07, highest $J'$-value (0.92) was recorded in winter and lowest (0.8) in post-monsoon and remain steady (0.86) in rest of the two seasons (Fig. 108). Whereas in 2007-08, it was found to be highest in pre-monsoon (0.92) and lowest (0.8) in post-monsoon and monsoon (Fig. 112).

Berger-Parker Index of dominance ($D_{BP}$) of zooplankton community ranged from 0.16 to 0.26 and 0.17 to 0.36 in 2006-07 and 2007-08 respectively (Fig. 109 and 113). In 2006-07, highest value of $D_{BP}$ (0.26) was recorded in pre-monsoon and lowest (0.16) in post-monsoon and monsoon (Fig. 109). While in 2007-08, it was found to be highest (0.36) in monsoon and lowest in winter (0.17) (Fig. 113).

In station 9 (GR), Shannon-Wiener diversity index ($H'$) of zooplankton community ranged from 1.8 to 1.96 and 1.31 to 2.17 in 2006-07 and 2007-08 respectively (Fig. 106 and 110). In 2006-07, highest $H'$-value was recorded in pre-monsoon (1.96) and lowest in post-monsoon (1.8) (Fig. 106). Whereas in
2007-08, it was found to be highest in post-monsoon (2.17) and lowest in pre-monsoon (1.31) (Fig. 110).

Margalef’s Index of species richness (d) of zooplankton community ranged from 0.84 to 1.18 and 0.48 to 1.43 in 2006-07 and 2007-08 respectively (Fig. 107 and 111). In 2006-07, highest d-value was recorded in monsoon (1.18) and lowest in post-monsoon (0.84) (Fig. 107). Whereas in 2007-08, it was also recorded highest (1.43) in post-monsoon and lowest (0.48) in pre-monsoon (Fig. 111).

Evenness Index \( J' \) of zooplankton community ranged from 0.84 to 1.18 and 0.48 to 1.43 in 2006-07 and 2007-08 respectively (Fig. 107 and 111). In 2006-07, highest \( J' \)-value (0.95) was recorded in post-monsoon and lowest (0.84) in monsoon (Fig. 107). Whereas in 2007-08, it was found to be highest in pre-monsoon (0.95) and lowest (0.85) in post-monsoon (Fig. 111).

Berger-Parker Index of dominance (\(D_{BP} \)) of zooplankton community ranged from 0.16 to 0.27 and 0.25 to 0.37 in 2006-07 and 2007-08 respectively (Fig. 109 and 113). In 2006-07, highest \( D_{BP} \) (0.27) was recorded in monsoon and lowest in winter (0.16) (Fig. 109). While in 2007-08, it was also found to be highest (0.37) in monsoon and lowest in winter (0.25) (Fig. 113).

In station 10 (BR), Shannon-Wiener diversity index (\(H' \)) of zooplankton community ranged from 1.5 to 1.84 and 1.37 to 1.81 in 2006-07 and 2007-08 respectively (Fig. 106 and 110). In 2006-07, highest \( H' \)-value was recorded in pre-monsoon (1.84) and lowest (1.5) in post-monsoon and winter (Fig. 106). Whereas in 2007-08, it was found to be highest in pre-monsoon (1.81) and lowest in monsoon (1.37) (Fig. 110).

Margalef’s Index of species richness (d) of zooplankton community ranged from 0.67 to 0.93 and 0.51 to 0.87 in 2006-07 and 2007-08 respectively (Fig. 107 and 111). In 2006-07, highest d-value was recorded in monsoon (0.93) and lowest (0.67) in post-monsoon and winter (Fig. 107). Whereas in 2007-08, it was also found to be highest (0.87) in pre-monsoon and lowest (0.51) in monsoon (Fig. 111).

Evenness Index \( J' \) of zooplankton community ranged from 0.83 to 0.95 and 0.91 to 0.95 in 2006-07 and 2007-08 respectively (Fig. 108 and 112). In 2006-07, highest \( J' \)-value (0.95) was recorded in post-monsoon and lowest (0.83) in monsoon (Fig. 108). Whereas in 2007-08, it was found to be highest in winter (0.95) and lowest in post-monsoon (0.91) (Fig. 112).

Berger-Parker Index of dominance (\(D_{BP} \)) of zooplankton community ranged from 0.25 to 0.36 and 0.23 to 0.3 in 2006-07 and 2007-08 respectively (Fig. 109 and 113). In 2006-07, highest value of \( D_{BP} \) (0.36) was recorded in monsoon and lowest in post-monsoon (0.16) (Fig. 109). While in 2007-08, it was also found to be highest (0.3) in post-monsoon and lowest (0.23) in winter and monsoon (Fig. 113).
Overall Shannon-Wiener diversity Index ($H'$) of zooplankton community ranged from 1.48 to 2.42 and 1.0 to 2.4 during 2006-07 and 2007-08 respectively (Fig. 106 and 110). In 2006-07, among all the stations highest value of $H'$ (2.42) was recorded in monsoon in the station 5 (UB) and lowest in post-monsoon (1.48) in the station 1 (JC) (Fig. 106). While in 2007-08, it was found to be highest in post-monsoon (2.4) in the station 6 (OW) and lowest in pre-monsoon (1.0) in the station 1 (JC) (Fig. 110).

Overall Margalef’s Index ($d'$) of zooplankton community ranged from 0.56 to 1.86 and 0.4 to 1.94 in 2006-07 and 2007-08 respectively (Fig. 107 and 111). Among all the stations, in 2006-07, highest $d$-value (1.86) was recorded in monsoon in the station 5 (UB) and lowest in post-monsoon (0.56) in the station 1 (JC) (Fig. 107). Whereas in 2007-08, it was recorded highest in post-monsoon (1.94) in the station 5 and 6 (UB and OW) and lowest in pre-monsoon (0.4) in the station 1 (JC) (Fig. 111).

Overall Evenness Index ($J'$) of zooplankton community ranged between 0.77 to 0.95 and 0.74 to 0.95 in 2006-07 and 2007-08 respectively (Fig. 108 and 112). Among all the stations, in 2006-07, highest value of $J'$ was found in post-monsoon (0.95) in the station 9 and 10 (GR and BR) and lowest in monsoon (0.77) in the station 4 (RB) (Fig. 108). Whereas in 2007-08, it was recorded highest both in winter and pre-monsoon (0.95) in the station 9 and 10 (GR and BR) respectively and lowest value was found in post-monsoon (0.74) in the station 4 (RB) (Fig. 112).

Overall Berger-Parker Index of dominance ($D_{BP}$) of zooplankton community ranged from 0.14 to 0.43 and 0.17 to 0.47 in 2006-07 and 2007-08 respectively (Fig. 109 and 113). Among all the stations, in 2006-07, highest value of $D_{BP}$ (0.43) was recorded in pre-monsoon in the station 2 (BC) and lowest in monsoon (0.14) in the station 6 (OW). (Fig. 109). In 2007-08, it was also recorded highest in pre-monsoon (0.47) in station 2 (BC). Lowest $D_{BP}$ (0.17) was recorded in winter in the station 8 (SAL) (Fig. 113).

Fig. 96 and 97 depicted the seasonal variation of overall mean density of phyto and zooplankton in relation to rainfall during 2006-07 and 2007-08 respectively. During 2006-07, highest mean density of phyto and zooplankton was recorded in monsoon and lowest in winter (Fig. 96). During 2007-08, overall mean density of phytoplankton was recorded in monsoon followed by winter and lowest in pre-monsoon. Highest mean density of zooplankton was recorded in post-monsoon and lowest in pre-monsoon (Fig. 97).

Correlation analysis among physico-chemical properties and total phyto and zooplankton and their diversity indices

During 2006-07, total phytoplankton density showed significant positive correlation with TA, pH, turbidity, $SO_4^{2-}$, RF and species diversity ($S$) while significant negative correlation was found with TSS, $NO_3^-$ and $NH_4^+$ (Table 2). Species diversity ($S$) and Margalef’s species richness Index ($d$) showed
significant positive correlationship with turbidity, $SO_4^{2-}$ and RF while significant negative correlation was found with TH, $Ca^{2+}$, $Mg^{2+}$, $NO_3^-$ and $NH_4^+$. Again d showed significant positive correlationship with total phytoplankton density, S and $H'$. Shannon-Wiener Index ($H'$) showed significant positive correlationship with $SO_4^{2-}$, RF, total phytoplankton density and S while significant negative correlation was found with TA and $NH_4^+$. Evenness index ($J'$) showed significant positive correlation with $NH_4^+$ and $H'$ while significant negative correlationship was found with TA, total phytoplankton density, S and d'. Berger-Parker Index of dominance ($D_{BP}$) showed significant positive correlation with TA, transparency and total phytoplankton density while significant negative correlationship was found with $J'$ and $H'$ (Table 2).

In the second year of study (2007-08) total phytoplankton density showed only significant positive correlationship with transparency while significant negative correlationship was found with pH, TSS, TH, $Ca^{2+}$, $Mg^{2+}$ and turbidity. Species diversity (S) showed significant positive correlationship with transparency, BOD, $NO_3^-$ and total phytoplankton density while significant negative correlationship was found with EC, TH, $Mg^{2+}$ and turbidity (Table 3). $H'$ showed significant positive correlationship with TA, BOD, $NO_3^-$, total phytoplankton density and S but no significant negative correlationship was found. Significant positive correlation of d was found with transparency, $NO_3^-$, total phytoplankton density, S and $H'$ while significant negative correlationship was found with TH, $Mg^{2+}$ and turbidity. $J'$ showed significant positive correlation with TA, pH, TSS, TH, $Ca^{2+}$, $Mg^{2+}$ and $H'$ while significant negative correlationship was found with $KH^+$ and total phytoplankton density. $D_{BP}$ showed significant negative correlation with total alkalinity, $NO_3^-$, diversity, $H'$ and $J'$ but it did not show any significant positive correlationship with water quality parameters (Table 3).

During 2006-07, total zooplankton density showed significant positive correlationship with WT, turbidity, $SO_4^{2-}$ and RF whereas significant negative correlation was found with DO, TSS, $Ca^{2+}$, $NO_3^-$ and $NH_4^+$(Table 3). Zooplankton species diversity (S) showed significant positive correlationship with turbidity, $SO_4^{2-}$ and RF while significant negative correlation was found with transparency, TH, $Ca^{2+}$, $NO_3^-$ and $NH_4^+$. Shannon-Wiener Index ($H'$) showed significant positive correlationship with turbidity, $SO_4^{2-}$, total zooplankton density, S and $H'$ while significant negative correlationship was found with transparency, TH, $Ca^{2+}$, $Mg^{2+}$, $NO_3^-$ and $NH_4^+$ Evenness ($J'$) showed significant positive correlationship with $Cl^-$ and $NO_3^-$ while significant negative correlation was found with WT, turbidity, RF, total zooplankton density and S. $D_{BP}$ did not show any significant positive correlationship with physico-chemical properties of water while significant negative correlationship was observed with S, $H'$, d and $J'$ (Table 3).
In the second year of study (2007-08), total zooplankton density showed significant positive correlation with WT, BOD, K⁺, PO₄³⁻ and RF while significant negative correlation was found with DO, TA, EC, TH and Mg²⁺ (Table 32). Zooplankton species diversity (ZS) showed significant positive correlation with BOD, K⁺ and total zooplankton density while significant negative correlation was found with DO, EC, TH, Mg²⁺ and turbidity. H' showed significant positive correlation with BOD, K⁺, NO₃⁻, total zooplankton density and S while significant negative correlation was found with DO and EC. Margalef’s species richness Index (d) showed significant positive correlation with BOD, NO₃⁻, total zooplankton density and S, and H' while significant negative correlation was found with DO, EC, TH, Mg²⁺ and turbidity. J' showed only significant positive correlation with TH while significant negative correlation was found with BOD, Na⁺, total zooplankton density, S and d. DP showed only significant positive correlation with DO whereas significant negative correlation was found with S, H', d and J' (Table 32).

**Analysis of Variance (ANOVA)**

One-way analysis of variance (ANOVA) was performed to test the level of significance for both phyto and zooplankton density and diversity indices among different sampling station and different season during the investigation period (2006-07 and 2007-08) as depicted in the Table 33 and 34. Phytoplankton density, species diversity and diversity indices showed significant station-wise variation in both the years of study except DP. DP did not show any significant station-wise variation during 2006-07 whereas during 2007-08, significant variation was found. Similarly, zooplankton density, species diversity and diversity indices also showed significant station-wise variation in both the years of study except DP and there is no significant station-wise variation was found for DP in both the years of study (Table 33).

ANOVA revealed that phytoplankton density, evenness index (J') and DP did not show any significant seasonal variation during 2006-07 and 2007-08. But phytoplankton species diversity, Shannon-Wiener Index (H') and Margalef’s species richness Index (d) showed significant seasonal variations in both the years of study (Table 34). Zooplankton density and species diversity showed significant seasonal variations in both the years of study (Table 34). Shannon-Wiener Index (H') and Margalef’s species richness Index (d) did not show any significant seasonal variation during 2006-07 while significant seasonal variations was found during 2007-08 (Table 34). Evenness index (J') showed significant seasonal variations during 2006-07 while it did not show any significant seasonal variation during 2007-08 (Table 34). DP did not show any significant seasonal variation during both the years of study (Table 34).

**Canonical Correspondence Analysis (CCA)**

Fig. 82-83 and 84-85 depicted the CCA among different physico-chemical variables and plankton community to determine the responses of
planktonic community along the major ecological gradients. CCA with non-linear rescaling of axes for both phyto and zooplankton community line transect data were classified into three clusters clearly shown the responses of phyto and zooplankton towards the major environmental variables.

**Discussion**

**Phytoplankton**

The density and abundance of phytoplankton are presented in Table 15-16 and 17-18.

During 2006-07, the phytoplankton was represented by 40 taxa (55.85%) and zooplankton by 24 taxa (44.15%) while in 2007-08 phytoplankton was represented by 58 taxa (45.38%) and zooplankton by 34 taxa (54.62%). Phytoplankton community was dominated by members of Chlorophyceae in terms of density, abundance and species diversity in all the seasons except winter during both the years of study (Table 23-24 and 25-26).

Temporal and spatial variation of density of total phytoplankton community

One-way analysis of variance (ANOVA) showed significant spatial variation of phytoplankton density during 2006-07 and 2007-08 (Table 33) but it did not show any significant seasonal variation during both the years of study (Table 34).

**2006-07**

Highest density and abundance of total phytoplankton was recorded in the station 5 (UB) followed by station 6 (OW) and lowest in the station 9 and 10 (GR and BR) respectively (Table 15 and 16). Total phytoplankton showed highest density and abundance during monsoon followed by post-monsoon and lowest in winter (Table 23 and 24).

During 2006-07, in all the stations phytoplankton density was found highest in monsoon, station 5 being exception (Fig. 90). This could be due to seasonal flooding induced by heavy rainfall during monsoon and alteration of nutrient dynamics of the floodplain lake. Enhanced nutrient levels are characteristics of floodplain habitats, as changes in water level followed by an expansion of the water sheet causes a direct release of nutrients accumulated in the terrestrial zone over the dry period (Payne, 1997; Neiff, 2001; Gopal and Chauhan, 2001; Carvalho et al., 2003; Zalocar de Domitrovic, 2003; Muzaffar and Ahmed, 2008). A study on the south Pantanal floodplain, Brazil, recorded highest phytoplankton density at the rising water period (de Oliveira and Calheiros, 2000). A study made in the Oyun reservoir showed that phytoplankton were highly abundant during the rains which corresponded to the period when the ions were highly concentrated (Mustapha, 2009). This is further confirmed by the increase of phytoplankton density with an increase of rainfall in monsoon (Fig.
Thomas et al. (2000) has reported that high primary productivity in tropical reservoir is usually rain induced. Higher density of phytoplankton during monsoon recorded in the present study agrees with the above findings. Phytoplankton density was found much higher in station 5 in all the seasons than that of other stations where highest density was recorded in post-monsoon (236.0 no.1⁻¹ x 10²) closely followed by monsoon (215.0 no.1⁻¹ x 10²) (Fig. 90). Station 5 (UB) being a managed site of Chatla basin is rich in nutrient due to external application of fertilizers for fish culture which gets concentrated in post monsoon due to evaporation. Laskar and Gupta (2009) also reported highest phytoplankton density in the same sampling station in post-monsoon. In the floodplain lakes of Bug River, eastern Poland, both diversity and abundance of phytoplankton were highest in summer (Wojciechowska et al., 2007). Similar high density in summer was also observed in the floodplain lakes of Argentina (Garcia de Emiliani, 1993).

Lowest density of total phytoplankton (5.16 no.l⁻¹ x 10²) recorded in the same season in the station 9 (GR) could be attributed to the turbulence in water and presence of high suspended matter which caused lower penetration of light creating unfavourable condition for the growth of phytoplankton (Fig. 90). Akoma (2008) reported that the peak of nutrients did not coincide with the phytoplankton density and diversity in the Imo River Estuary, Nigeria.

Highest species diversity of phytoplankton was recorded in monsoon (40) followed by winter (38) and lowest in both post-monsoon and pre-monsoon (37) (Table 23). Chowdhury et al. (2007) reported highest phytoplankton density and species diversity during September to November and lowest in January in the Borobila beel in Rangpur district, Bangladesh when the temperature and NO₃-N was found to be highest and they suggested that the favourable period for primary production is from August to November, when nutrient accumulation from freshwater run-off due to monsoon rainfall is higher. Present study coincided with their findings although NO₃-N was found moderate and water temperature was lower.

2007-08

During 2007-08, unlike 2006-07 in most of the stations phytoplankton density was found lowest in monsoon although among all the stations highest phytoplankton density (117.83 no.1⁻¹ x 10²) was recorded in the station 6 (OW) followed by station 4 (RB) (110.67 no.1⁻¹ x 10²) in monsoon (Fig. 92). Lowest density recorded in most of the stations in monsoon might be due to dilution of nutrient by too high water level caused by flood as rainfall in monsoon ranged from 330 mm to 678 mm (June to August 2008). However several studies throughout the world recorded high density of phytoplankton in monsoon and attributed it to high water level coupled with nutrient (Muzaffar and Ahmed, 2006; Neiff, 2001; Davies et al., 2009a).

Highest density of total phytoplankton recorded in the station 6 could be attributed to the fact that heavy rainfall introduced nutrient rich water through
run-off. Similar view was given by Mukhopadhyay et al. (2004) in two tropical ponds, West Bengal and Prabhakar et al. (2008) in Khadakwasla Reservoir, Pune, Maharashtra. Highest DO concentration in monsoon recorded in this station is an indication of healthy system and sufficient to maintain aquatic life forms (Bilgrami and Dutta Munshi, 1979; George, 1969; Basu et al., 2010).

**Spatial variation of mean density and abundance of total phytoplankton**

Highest mean density and abundance of total phytoplankton was recorded in the station 5 (UB) and lowest density was recorded in the station 9 (GR) and abundance in station 10 (BR) in 2006-07 (Table 15 and 16). During 2007-08, highest density and abundance of total phytoplankton was recorded in the station 6 (OW) followed by station 5 (UB) and station 4 (RB) and lowest in the station 1 (JC) (Table 17 and 18). The highest phytoplanktonic density in the lentic portion of Chatla Floodplain Lake could be due to favorable environment unlike the riverine zones where fast current and higher turbidity affect growth. Similar study was made by Ayoade et al. (2009) in Tehri Dam, reservoir Garhwal Himalaya. Water currents can affect distribution of phytoplankton, since phytoplankton are largely restricted to lentic waters and phytoplankton of rivers are reduced because of abrasive action of turbulence and of the substrata (Wetzel, 1975; Chandler, 1937).

**Temporal variation of mean density and abundance of total phytoplankton**

**2006-07**

Periodic fluctuations in quantity and species composition are the characteristic features of phytoplankton in freshwater, brackish water and marine environments (Nwankwo, 1998) and it occurs due to physico-chemical conditions of the lake (Caplancq, 1995). Mean density and abundance of total phytoplankton community followed similar pattern of seasonal variation and was highest in monsoon (Table 23 and 24). This might be due to high temperature and high nutrient availability (particularly PO₄ and NH₃) by surface runoff which increases photosynthetic activities of phytoplankton and in turn increase their population (Davies et al., 2008). Davies et al. (2009) in their study in Minichinda Stream, Niger Delta, Nigeria also recorded higher phytoplankton density in wet season. Mean seasonal abundance and density of all the different phytoplankton groups except Euglenophyceae were found highest in monsoon. Schultze et al. (1995) has highlighted that each phytoplankton group has its own optimum condition for growth. Branes et al. (2007) showed that the lake Oubeira was favourable for the proliferation of Chlorophyceae and Cyanophyceae in all the seasons.

Highest Chlorophycean density followed by Bacillariophyceae and then Cyanophyceae as found in the present study in 2006-07 was also observed by Akoma (2008) in tropical estuarine system, Imo River Estuary, Nigeria.

During winter and pre-monsoon the density of phytoplankton was found to be low which could be attributed to the low depth of the lake (low transparency
was found in all the stations except station 10). Huovinen et al. (1999) reported that low depth of the lake and strong light intensity in the pre-monsoon would inhibit the phytoplankton development on the surface water. Arrignon (1991) also opined that temperature variations can have direct effects on the development of certain species.

**2007-08**

During 2007-08, highest mean density and abundance of total phytoplankton was recorded during monsoon followed by winter and lowest in pre-monsoon (Table 25 and 26). This could be attributed to the recruitment of majority of the taxa in the open water and fisheries of lake during inundation period coupled with long resident time of floodwater over a month in which phytoplankton get sufficient nutrient for their growth and proliferation. Paul and Mazid (1997) in their study showed that the receding waters corresponded with declines in total phytoplankton abundance. Present study also more or less revealed the same fact. A few studies referred that water bodies in the Indian subcontinent are known to sometimes go through one or more peaks in the phytoplankton densities (Zafar, 1986; Gopal and Zutshi, 1998). In this study highest density was recorded in monsoon closely followed by winter.

Mean density and abundance of total phytoplankton community as well as different phytoplankton groups did not show much seasonal fluctuation or any definite pattern (Table 25 and 26). According to Çetin, (2000), Calijuri et al. (2002) freshwater ecosystems are subject to temporal changes that cause uncertainty in phytoplankton composition and assemblage. Melack (1979) opined that phytoplankton seasonality in shallow tropical freshwater bodies corresponded with rainfall pattern. Chattopadhyay and Banerjee (2007) made a study on a lake in Burdwan, W.B. and showed that rainfall affect the physico-chemical variables thus causing variation in abundance and diversity of plankton (Davies et al., 2009).

Highest species diversity of phytoplankton was recorded in winter (42) followed by pre-monsoon (41). Both post-monsoon and monsoon share equal number of taxa (40) during 2007-08 (Table 25).

**Correlation**

**2006-07**

Significant positive correlation of phytoplankton density with TA, pH, turbidity, $SO_4^{2-}$ and RF (Table 2) indicated that nutrient rich alkaline environment favoured the growth of phytoplankton community as reported by several researchers (Boney, 1983; Reynolds, 2006). According to Moyle (1949), water bodies having total alkalinity above 50 mg l$^{-1}$ can be considered productive. Present study also showed lentic portion of Chatla Floodplain Lake as being productive in all the seasons which is confirmed by significant positive correlation of TA and pH with phytoplankton density. Gasse et al. (1983)
correlated phytoplankton species composition of lakes with a number of water quality parameters including temperature, alkalinity and pH. In Oubeira Lake (North-East Algeria) the range of pH was found to correspond to the optimal zone for phytoplankton production (Arrignon, 1991; Branes et al., 2007). Bharadwaja (1940) and Hujare (2005) has pointed out that temperature, light and pH are the factors responsible for the higher phytoplankton density.

Increased phytoplankton diversity with the onset of rainfall is due to the fact that most of the taxa were recruited from the riverine systems during inundation period. This is confirmed by the significant positive correlation of phytoplankton diversity with RF, turbidity and SO$_4^{2-}$. Significant negative correlation of phytoplankton density with TSS, NO$_3^-$ and NH$_4^+$ might be attributed to their utilization by phytoplankton. Montein et al. (1999) also reported that phytoplankton biomass positively correlated with pH and negatively correlated with NO$_3^-$, NH$_4^+$ nitrogen and TSS.

2007-08

A significant positive correlation of total phytoplankton density with transparency and DO (Table 3) have been found in the present study. Mishra (2005) recorded maximum DO (>8.0 mgl$^{-1}$) in rainy season in the water bodies in and around Rourkela, Odissa, India and opined that higher phytoplankton activity during the period liberated more oxygen. Onyema (2007) reported strong positive correlation of Bacillariophyceae with transparency. Significant negative relationship of phytoplankton density was found with pH, TSS, TH, Ca$^{2+}$, Mg$^{2+}$ and turbidity which could be due to higher phytoplanktonic uptake of nutrients (Table 3). In the present study, phytoplankton species diversity (S) showed significant positive relationship with transparency, BOD, NO$_3^-$ and total phytoplankton density but significant negative relationship was found with EC, TH, Mg$^{2+}$ and turbidity (Table 3). Onyema and Ojo (2008) reported positive correlation of phytoplankton species diversity with transparency, RF, Cl$^-$, EC, TH, DO, Ca$^{2+}$ and Mg$^{2+}$ and significant negative relationship with BOD, NO$_3^-$ and SO$_4^{2-}$. Significant positive correlation of Margalef’s species richness Index (d) was found with transparency, NO$_3^-$, total phytoplankton density, species diversity (S), and Shannon H$^\prime$ while significant negative relationship was found with TH, Mg$^{2+}$ and turbidity. J$^\prime$ showed significant positive correlation with TA, pH, TSS, TH, Ca$^{2+}$, Mg$^{2+}$ and H$^\prime$ while significant negative correlation was found with K$^+$ and total phytoplankton density. D$_{BP}$ showed significant negative correlation with total alkalinity, NO$_3^-$, diversity, Shannon H$^\prime$ and Shannon J$^\prime$ but it did not show any significant positive relationship with water quality parameters (Table 3). The study revealed that the governing factors of phytoplankton proliferation are TA, pH, TSS, transparency, BOD and NO$_3^-$. 

Density and abundance of different groups of phytoplankton in different stations

Chlorophyceae
Phytoplankton community was dominated by members of Chlorophyceae (represented by 34 taxa) in terms of density, abundance and species diversity in all the stations during both the years of study except station 4 (RB) in 2007-08 (Table 15-16 and 17-18). Number of taxa increased gradually at the onset of rainfall during monsoon.

2006-07

In 2006-07, highest density of Chlorophyceae was recorded in the station 5 (UB) in monsoon (134.34 no.l⁻¹ x 10²) (Fig. 77) which could be due to the fact that station 5 (UB) is a lentic system as well as managed site of Chatla floodplain. Several studies reported dominance of Chlorophyceae in terms of cell density and species diversity and their increase with the increase in loadings of TIN and TP (Johansson et al., 1992; Abd El-Karim, 2009). Fathi et al. (2009) reported that Chlorophyceae dominated the phytoplankton groups with highest density, species diversity and abundance in summer in Al-Asfar Lake, Saudi Arabia. Lowest density of Chlorophyceae was recorded in station 9 (GR) in post-monsoon (2.34 no.l⁻¹ x 10²) (Fig. 74) which could be attributed to the unfavourable ecological condition due to high turbidity in lotic system and high rate of decomposition of organic material in post-flood situation.

The mean density and abundance of Chlorophyceae was recorded highest during monsoon and lowest during winter (Table 23 and 24). Boom of Chlorophyceae in monsoon could be attributed to high water temperature, high rainfall and resultant dilution of water (Valecha and Bhatnagar, 1988) while low water temperature and low depth during winter limits the proliferation of Chlorophytes.

2007-08

Density and abundance of Chlorophyceae was recorded highest in the station 6 (OW) in monsoon (55.83 no.l⁻¹ x 10²) and lowest in the station 1 (JC) in winter (1.16 no.l⁻¹ x 10²) (Fig. 79 and 81).

Both the years recorded highest density in lentic systems. Chlorophyceae associated with open water is the characteristic of floodplain lakes with long annual flood duration (Van den Brink et al., 1994) as high rainfall inundated the whole system in monsoon and plankton were recruited from all the inlets. Ayoade et al. (2009) reported that the higher plankton population and diversity in lentic portion of Tehri dam reservoir area is due to favourable environment unlike the riverine zones where current and higher turbidity affect their growth. Although species diversity of Chlorophyceae was recorded higher in 2007-08, their density and abundance was found more than two fold higher in 2006-07. Lowest Chlorophycean density (1.16 no.l⁻¹ x 10²) in winter in the station 1 (JC) (Fig. 79) could be attributed to the anthropogenic disturbances in the river water beside water current. According to Uttah et al. (2008), the predominance of Chlorophyceae is a common feature of lotic flowing water whereas Cyanophyceae bloom in eutrophic and polluted water.
Mean density and abundance of Chlorophyceae was recorded highest during post-monsoon followed by monsoon and lowest during pre-monsoon (Table 25 and 26). Vermaat (2005) reported that green algae become abundant when nitrogen and phosphorus concentrations are high and there is wide light availability. These algae have short life cycles and are opportunistic, reaching fast growth rates when nutrient availability is adjusted (Happey-Wood, 1988).

**Bacillariophyceae**

Bacillariophyceae attained second position in terms of density in 2006-07 and third position in 2007-08 represented by 8 taxa throughout the study period.

**2006-07**

Among all the stations it was found to be highest in number in station 5 (UB) in all the seasons (Fig. 74-77). Station 5 being a managed site of Chatla basin is rich in nutrient due to external application of fertilizers for fish culture which might be the reason for highest population of Bacillariophyceae as diatoms prefer nutrient rich conditions with increased turbulence in the water column (Gaedke et al., 1998). The diatoms are very good competitors for nutrients, especially phosphorus (Sommer, 1988) and, frequently, dominate the periphytic algae community (Vermaat, 2005). Several studies revealed that diatoms thrive well in widely changing hydrographical conditions (Mani, 1992; Tiwari and Nair, 1998; Rajasegar et al., 2000; Gopinathan et al., 2001; Gowda et al., 2001; Senthilkumar et al., 2002; Perumal et al., 2009). Bacillariophyceae was totally absent in station 10 (BR) in pre-monsoon (Fig. 76).

Temporal variation of diatoms showed highest density and abundance in monsoon followed by pre-monsoon and lowest in winter and did not show much differences with post-monsoon (Table 23 and 24). Highest density during monsoon could be attributed to the high water level and dilution of water. Low density during post-monsoon and winter could be due to low transparency and high turbidity caused by receding flood water. Muzaffar and Ahmed (2006) in a study made in Tanguar Haor, Bangladesh reported that Bacillariophyceae were in abundance during the high water period but declined dramatically with the progress of the season.

**2007-08**

Among all the stations and all the seasons highest density of Bacillariophyceae was recorded in the station 4 (RB) followed by station 6 during monsoon and station 5 (UB) during pre-monsoon (Fig. 78-81). This could be due to increase of water temperature, allochthonous input of nutrient during high water period. They were found to be very less in almost all the lentic systems and absent in most of the lotic systems during post-monsoon. High densities of Bacillariophyceae indicate relatively unpolluted condition of a system (Islam 1991; Gopal and Zutshi, 1998).
One of the reasons of highest density and abundance of Bacillariophyceae in monsoon (Table 25 and 26) might be due to the fact that diatoms are considered efficient and fast colonizers, because many species have specialized structures to attach to substratum, such as mucilaginous stalks, production of mucilaginous matrices and formation of base fixed colonies (Round, 1991). Lowest density and abundance of diatom during post-monsoon (Table 25 and 26) could be possibly due to very low concentration of DO and high turbidity caused by humus and decomposition of sewage, organic matter during large flood of 2007.

**Cyanophyceae**

Cyanophyceae ranked third in terms of density in 2006-07 and second position in 2007-08 represented by 13 taxa throughout the study period.

**2006-07**

In 2006-07, among all the stations, highest cyanophycean density (42.34 no.1⁻¹ x 10²) was recorded in winter (Fig. 75) in station 5 (UB) followed by station 6 (OW) in pre-monsoon (Fig. 76). This could be attributed to the highest NO₃⁻ and PO₄³⁻ concentration coupled with low water temperature at low water period during winter. El-Sheekh et al. (2010) showed that the predominance of Cyanophyta was due to the high N and P content of Hadous Drain water of river Nile, Egypt. Cyanophyceae are found to be favoured in nitrogen enriched environments in a shallow eutrophic reservoir (Garças Pond), São Paulo, southeast Brazil, (Crossetti and Bicudo, 2005). According to Azim and Asaeda, (2005) they occur in high density in low flow environments. Deyab et al. (2002) reported that the vigorous growth of Cyanophyta is correlated with the increased phosphorus in surface water.

Lowest density of cyanophytes in the station 9 (GR) (0.5 no.1⁻¹ x 10²) in post-monsoon could be attributed to the low level of transparency and reduced light penetration (Fig. 74). Filamentous cyanobacteria can more or less tolerate lower light levels and also create higher turbidity (Scheffer, 1998).

Temporal variation of Cyanophyceae showed highest density and abundance during winter and monsoon (Table 23 and 24) which could be due to higher concentration of N and P.

**2007-08**

While in 2006-07, among all the stations highest density of Cyanophyceae was recorded in station 5 in winter (Fig. 75), in 2007-08 it was recorded highest in the station 6 (OW) during winter (25.67 no.1⁻¹ x 10²) (Fig. 79). Both the systems are adjacent and followed similar pattern of phytoplankton density and abundance. High concentration of NO₃⁻-N and moderate DO concentration with high transparency in station 6 lead to sufficient light penetration increasing the proliferation of photosynthetic blue-green algae. Oh et
al. (2007) reported that the water temperature, TPN, daily irradiance, and TN all played an important role in the proliferation of Cyanophyceae in the Daechung Reservoir (Korea). Lowest density recorded in the station 8 (SAL) (0.34 no.1⁻¹ x 10²) in monsoon (Fig. 81) could be due to dilution.

Higher density and abundance of cyanophytes in the station 5, 6 and 7 (UB, OW and MB) (Table 17 and 18) could be linked with the presence of macrophytic vegetations also as Macrophytes provide refuge to cyanophytic algae against predation by planktonic copepods. Since the growth of cyanobacteria is P-limited principally due to the ability of several species to fix nitrogen (Blomqvist et al., 1994), high nutrient concentrations (especially phosphate) in these systems were favourable for filamentous cyanobacterial development (Mihaljevic´ and Stevic, 2011).

Highest mean density and abundance of cyanophytes was recorded in winter followed by post-monsoon and lowest in pre-monsoon (Table 25 and 26). The dominance of cyanobacteria resulting from high nutrient loading and low N: P ratio was observed in shallow South African lakes (Thornton, 1987). Moreover, fluctuation of water temperature is one important factor controlling the composition of Cyanobacteria (Imai et al., 2009; Sipaúba-Tavares et al., 2010). According to Hyenstrand et al. (1998) high concentrations of ammonia–nitrogen encourage the growth of non nitrogen fixing phytoplankton.

**Euglenophyceae**

Euglenophyceae ranked fourth in terms of density and abundance and was represented by a single taxa *Euglena* sp. in Chatla Floodplain Lake.

**2006-07**

The highest density and abundance of Euglenophyceae during post-monsoon and lowest in monsoon could be due to the enrichment of nutrients from various sources into the systems at low water period during post-monsoon and later could be due to dilution by rain in monsoon.

The study revealed absence of Euglenophyceae in the lotic systems in the pre-monsoon and monsoon. In the lentic systems although present their density was low (Fig. 74). This is due to the fact that due to rainfall there was dilution of nutrient and as a result environment was not conducive for their growth. In lotic systems situation was worse due to high flow of water. Hence their density increased in the dry season. The higher density of Euglenophyceae during post-monsoon and winter in 2006-07 (Fig. 74 and 75) could be attributed to the decomposition of macrophytes which releases nutrient into the system. Laskar and Gupta (2009) in the same study area recorded dominance of Euglenophyceae in post-monsoon and attributed it to the influx of domestic sewage in monsoon and their increased concentration in post-monsoon. According to Zafar, (1986) and Shamsudin and Shazali, (1991) the conditions that predispose bloom include warm summer temperature and high organic load derived from domestic sewage.
A previous study made in the Chatla floodplain showed that Euglenophyceae bloom was induced by high concentrations of NH$_3$-N, NO$_3$, Fe, Ca, Mg, and to some extent, PO$_4$, Cu and Zn in their water (Duttagupta et al., 2004).

Highest density and abundance of Euglenophyceae (Table 15 and 16) recorded in the station 5 (UB) in post-monsoon could be due to the input of various fertilizers. Drastic reduction in the population of Euglenophyceae in winter in the same station could be attributed to the utilization of essential nutrients during their boom and bust period in post-monsoon as shown by Duttagupta et al. (2004) in their study on the Euglenophyceae of Chatla wetland. Station 4, 6 and 7 (RB, OW and MB) being lentic systems also supported higher density and abundance of Euglenophytes which could be due to favourable nutrient rich condition of these systems. Lowest density and abundance of Euglenophytes in the station 10 (BR) might be due to high water current, flow rate and depth.

**2007-08**

In 2007-08, compared to 2006-07 density of Euglenophyceae was found to be low and in most of the systems in monsoon it was totally absent (Fig. 81). In post-monsoon due to evaporation nutrients concentrated and Euglenophyceae developed in 5 stations (station 3, 4, 5, 6 and 7) and in winter it was recorded in seven stations. In station 9 and 10 it was absent in all the seasons (Fig. 78-81). All these factors conform to the fact that dry season is favourable for their proliferation. Euglenophytes showed highest density and abundance during winter followed by pre-monsoon and lowest in monsoon (Table 25 and 26). This could be due to enrichment of nutrient levels from various sources into the systems during low water period. However, unlike 2006-07, Euglenophyceae was recorded in the systems in pre-monsoon. This may be due to relatively less rainfall during that season which was 129.4 mm.

Highest density of Euglenophytes were recorded in the station 5 (UB) followed by station 4 (RB) and station 6 (OW) and lowest in the station 7 (MB) during winter (Fig. 79). The highest density in the station 5 could be due to nutrient rich environment as the waste from the surrounding agricultural fields and tea gardens provide sufficient nutrient for the proliferation of euglenoid blooms in the water bodies and the lowest in the station 5 could possibly be due to competition for nutrients among the macrophytes and dominance of cyanophycean bloom over the Euglenophytes. A study made on the Egbe reservoir, Nigeria revealed that the relatively alkaline environment coupled with the presence of high nutrient levels probably account for prolific euglenoid growth (Ugwumba and Ugwumba, 1993; Edward and Ugwumba, 2010). Since *Euglena* species are known to tolerate various levels of organically polluted waters and used as indicators of organic pollution (Nwankwo, 1996; Krishnan, 2008; Alam et al., 1996) it can be said that in the present study, presence of *Euglena* in Chatla floodplain in dry season indicated the stressed condition of the lake.
**Dinophyceae**

Dinophyceae was represented by 3 taxa and their population was found to be very less in almost all the stations in all the seasons throughout the study period.

**2006-07**

Dinophytes showed highest density in the station 6 (OW) during monsoon followed by station 4 and 6 (RB and OW) during pre-monsoon and lowest in post-monsoon in the station 3 (DGK) (Fig. 74-77). The former could be attributed to the presence of higher concentration of ions (Ca$^{2+}$, PO$_4^{3-}$, NH$_4^+$ and SO$_4^{2-}$) in both the seasons. They were totally absent in the station 1, 2, 5, 7 and 9 (JC, BC, UB, MB and GR) (Table 15). Ogato (2007) reported that Dinophyceae (minor groups of phytoplankton) were frequently seen during wet periods and had very low representation with less than 1% contribution throughout the study period in the lake Bishoftu, Ethiopia. Present study also recorded very low population of Dinophytes. According to Wood and Talling (1988) insignificant contribution of dinoflagelates is associated with high conductivity of the lake. Muzaffar and Ahmed (2006) reported that the Dinophyceae occurred in low densities in Tanguar Haor, Bangladesh.

**2007-08**

Like 2006-07 during 2007-08 also highest density of Dinophyceae was recorded in the station 6 (OW) during monsoon (Fig. 81). This could be attributed to the changes in physico-chemical properties of water with monsoon rain providing opportunity to exploit nutrients. Lowest density was recorded during post-monsoon in the station 1 (JC) (Fig. 78) and they were totally absent in the station 3, 8 and 10 (DGK, SAL and BR) (Table 17 and 18). Low density and abundance and their total absence in the lotic systems could be possibly due to their less swimming capability against strong water current.

The dinophytes were found to be totally absent in all the stations during pre-monsoon and monsoon in 2007-08 except station 4, 6, and 9 (RB, OW and GR) (Fig. 80 and 81).

**Variation of mean density and abundance of different groups of phytoplankton and total phytoplankton (irrespective of station and season) in Chatla floodplain**

**2006-07**

Density of different groups of phytoplankton in terms of percentage composition are as follows:

Chlorophyceae>Bacillariophyceae>Cyanophyceae>Euglenophyceae>Dinophyceae (2006-07) 46%>21%>20%>11%>2% (density)
Percentage composition of different groups of phytoplankton community revealed that among all the groups Chlorophyceae was found to be dominant in terms of density (46%). Chlorophycean density followed by Bacillariophyceae and then Cyanophyceae was also observed by Akoma (2008) in tropical estuarine system, Imo River Estuary, Nigeria. Laskar and Gupta (2009, 2010 and 2011) reported similar trends of phytoplankton community composition in terms of density and abundance. Sharma (2009) reported Chlorophyta as the sole dominant quantitative component of phytoplankton in Loktak Lake, Manipur, India. Other studies reported from different parts of India also revealed the same (Yadava et al., 1987; Choudhary and Singh, 2001; Goswami and Goswami, 2001).

Cyanophyceae (21%) also showed highest abundance in monsoon followed by winter and lowest abundance was recorded in post-monsoon (Table 24). Branes et al. (2007) found that in the lake Oubeira Chlorophyceae and Cyanophyceae were present in all the season. Schultze et al. (1995) has highlighted that each of the phytoplankton group has its own optimum condition for growth. Euglenophyceae ranked fourth in terms of density (11%) and Dinophyceae (2%) was found to be the least abundant group.

**Seasonal variation of total phytoplankton (2006-07)**

Density: Monsoon>post-monsoon>pre-monsoon>winter

\[ 35.34\% > 24.8\% > 23.15\% > 16.8\% \]

Seasonal variation of mean density of total phytoplankton showed highest percentage composition in monsoon (35.34%) followed by post-monsoon (24.8%) and pre-monsoon (23.15%) and lowest in winter (16.8%) (Table 23).

**Spatial variation of total phytoplankton (2006-07)**

Spatial variation of mean density of total phytoplankton (Table 15) in terms of percentage composition are as follows:

Density:

\[ 42.93\% > 12.86\% > 9.87\% > 7.95\% > 5.79\% > 4.7\% > 4.23\% > 4.19\% > 4.13\% > 3.34\% \]

UB>OW>RB>DGK>MB>BC>BR>JC>SAL>GR

Spatial variation of total phytoplankton density was recorded highest in the station 5 (42.93%) and lowest in the station 9 (3.34%) (Table 15).

**2007-08**
Mean density and abundance of different groups of phytoplankton in terms of percentage composition were as follows:

Chlorophyceae>Cyanophyceae>Bacillariophyceae>Euglenophyceae>Dinophyceae (2007-08) 45.48%>24.05%>20.5%>8.41%>1.52% (density)

During 2007-08, Chlorophyceae was again found to be the dominant group in terms of density (45.48%) like previous year of study. It was followed by Cyanophyceae, Bacillariophyceae, Euglenophyceae and Dinophyceae. Percentage composition of both density and abundance of different groups followed same sequence. Chellappa et al. (2008) also found highest percentage composition of Chlorophyceae (79%) followed by Cyanophyceae (12%) and Bacillariophyceae (4%) in terms of relative abundance in the month of March in surface waters of Cruzeta, RN reservoir Brazil.

**Seasonal variation of total phytoplankton (2007-08)**

Seasonal variation of mean density of total phytoplankton showed highest percentage composition in monsoon (27.56%) followed by winter (26.67%) and post-monsoon (24.42%) and lowest in pre-monsoon (21.4%) (Table 25).

Density: Monsoon> winter> post-monsoon> pre-monsoon
27.56%>26.67%>24.42%>21.4%

Mustapha (2009) suggested that the phytoplankton were highly abundant during the rains which corresponded to the period when the ions were highly concentrated in the small, shallow tropical reservoir Oyun, Nigeria. Thomas et al. (2000) has also reported high primary productivity in tropical reservoir is usually rain induced. In the present study, highest density and abundance of total phytoplankton in Chatla Floodplain Lake during 2006-07 and 2007-08 is in agreement with the above findings. Verma et al. (2001) have reported phytoplankton density in different seasons in order of summer> winter> monsoon, did not match with the present study.

**Spatial variation of total phytoplankton (2007-08)**

Spatial variation of mean density of total phytoplankton (Table 17) in terms of percentage composition are as follows:

Density:
23.75%>18.32%>18.01%>10.14%>7.32%>7.07%>5.2%>4.33%>3.31%>2.56%

OW>UB>RB>MB>SAL>GR>DGK>BR>BC>JC

Spatial variation of total phytoplankton density was recorded highest in the station 6 (23.75%) and lowest in the station 1 (2.56%) (Table 17).
Mustapha (2009) reported the dominance of different groups of phytoplankton (Chlorophyceae, Cyanobacteria and Desmidiaeae) in the station 2 (transition zone) of Oyun reservoir, Nigeria was due to the station’s high nutrients; transparency and water residence time. In the present study, highest density and abundance of phytoplankton in the open water of Chatla Floodplain Lake (station 6) is in agreement with the above findings.

The presence of *Microcystis* spp. in most of the stations of Chatla Floodplain Lake might be one of the possible causes of lower density and abundance of other genera and it also poses a major threat to the fish population. Brunberg and Blomqvist (2002) reported that *Microcystis* is a widely distributed organism, which dominates the phytoplankton community in nutrient rich lakes. *Microcystis aeruginosa* is one of the main microcystin producers of lakes (Lindholm *et al.*, 2003). Other investigations also stressed cyanobacterial dominance associated with different factors such as shallow mixing (Reynolds, 1987; Oliver and Ganf, 2000), low light (Smith, 1986). The dominance of *Microcystis* may suppress other genera (Zohary *et al.*, 1996). High levels of temperature favour optimal growth of cyanobacteria, especially *Microcystis* in lakes and reservoirs of the temperate and tropical regions (Robarts and Zohary, 1987; NSW, 2000).

**Species diversity**

A total of 60 taxa of phytoplankton were recorded in Chatla Floodplain Lake during the study period. Razzaque *et al.* (1995) and Ehshan *et al.* (2000) observed 87 genera of phytoplankton in Halti beel and 44 genera in Chanda beel, respectively which was higher than the genus recorded in Chatla Floodplain Lake. Saha and Hossain (2002) found 46 genera in Saldu beel which was found lower than the present study.

**2006-07**

A wide array of phytoplankton (40 taxa) were recorded with highest species diversity (40) during monsoon followed by winter (38) but it remain same during post-monsoon and pre-monsoon (37) (Table 23).

Station 6 (OW) harbours highest number of taxa (39) followed by station 4 (RB) (38). Station 3 and 5 (DGK and UB) shared equal number of taxa (34) followed by station 7 (MB) (33), station 2 (32), station 9 (31), station 1 (30) and station 8 (29). Lowest number of taxa was recorded in the station 10 (26) (Table 15).

Among the phytoplankton taxa recorded during 2006-07 in Chatla Floodplain Lake, *Euglena* was found to be most abundant taxon in post-monsoon followed by *Madogotia* in monsoon (Table 24). Jafari and Alavi (2010) reported that Euglenophyceae was represented by genera *Euglena* and *Phacus* in Talar River, Iran with peak population during summer and minimum in winter. Euglenophyceae are generally found in waters enriched with organic substances.
The dominance of *Euglena* in Chatla floodplain indicated that the lake is rich in nutrient during post-monsoon after it received surface runoff in monsoon. *Navicula* was found to be the second abundant taxon followed by *Spirogyra* and *Chlorella* in monsoon. *Oscillatoria* and *Navicula* was the most abundant taxon in winter and pre-monsoon respectively (Table 24). During monsoon, *Navicula* and *Nitzschia* was also found to be the dominant taxa in Vellar Estuary (Chandran, 1985). Perumal *et al.* (2009) recorded several freshwater algal forms like *Anabaena* sp., *Oscillatoria* sp., *Chlorella* sp., *Nostoc* sp., *Lyngbya* sp., *Spirogyra* sp., *Volvox* sp., *Spirulina* sp. and *Microcystis* sp. during monsoon in Kaduviyar estuary, Nagapattinam, Southeast coast of India which were also found to be present in Chatla floodplain lake. Occurrence of Cyanophyceae members, like *Oscillatoria* indicates that the water body is polluted (Mahajan and Mahajan, 1988). Dominance of *Oscillatoria* during winter season (isolation period) indicated that Chatla Floodplain Lake is under pollution stress during the isolation period.

**2007-08**

A total of 58 taxa of phytoplankton were recorded in 2007-08. Station 4 and 6 (RB and OW) harbour highest number of taxa (38) followed by station 5 (UB) (37), station 8 (31), station 7 (MB) (28), station 9 (26), station 10 (24), station 2 (22), station 1 (21) and least number of taxa was recorded in the station 3 (17) (Table 17). In Chatla Floodplain Lake, the species diversity was found higher (58 taxa) in 2007-08 than that of 2006-07 (40 taxa).

Highest species diversity of phytoplankton was recorded in winter (42) followed by pre-monsoon (41). Lowest species diversity was found in both post-monsoon and monsoon which share equal number of taxa (40) during 2007-08 (Table 25). Not much seasonal difference in the species diversity was recorded. This could be attributed to the stable hydrological condition and optimum level of nutrients during the period. The dominance of phytoplankton species in the water bodies is determined by complex interaction between biological, physical and chemical variables (Melack, 1979). Different factors such as nutrient availability, grazing pressure competition and light availability govern the response of phytoplankton toward the environmental changes. Different species composition indirectly affects the pelagic primary productivity, since they have different capabilities of utilization of amount of light and nutrient availability (Berman and Chava 1999; Kufel, 2001; Calijuri and Santos, 2001). Tavernini *et al.* (2009) showed that phytoplankton distribution was influenced by the different water column stability in two Italian sand-pit lakes (Viner 1985; Salmaso, 1996).

During 2007-08, *Eunotia* was the most dominant taxon of phytoplankton in monsoon followed by *Euglena* in winter, *Volvox* in post-monsoon and *Nitzschia* in pre-monsoon in terms of density and abundance (Table 25 and 26). Rouf *et al.* (2008) showed that the diatom species composition such as *Eunotia* spp., *Frustulia* spp. and *Stenopterobia* spp. in Lake Kenyir, Malaysia are representative of oligotrophic or mesotrophic flora. Similar observation was made by Kilroy *et al.* (2006) in the benthic diatom communities in subalpine
pools of New Zealand, in which electrical conductivity was one of the most important defining variables, ranging from 5.7 and 22.2 μS cm$^{-1}$. In the present study, in Chatla Floodplain Lake dominance of *Eunotia* sp. indicated that the lake is in either oligotrophic or mesotrophic state. Conductivity (29.34 to 5233.34 μS cm$^{-1}$) was found to be the determining variable in their population growth.

Melo and Huszar (2000) reported that during low water level, the lake becomes shallow with euphotic zone throughout the water column which results in a uniform vertical distribution of the algae in Amazonian flood-plain lake. Similar result was described by García de Emiliani, (1990) in a shallow flood-plain lake of the Paraná River (Brasil). According to Reynolds, (1997), during low water period the phytoplankton is dominated by filamentous and elongated species (R-strategists) with high surface/volume ratio such as *Mougeotia*, and *Mesotaenium* which can survive in mixed-water environments (Happey-Wood, 1988). However in the present study *Mougeotia* was found dominant during monsoon (2006-07).

Highest number of phytoplankton taxa was recorded in Station 6 (OW) followed by station 4 (RB) during both the years (Table 15 and 17). This may be due to the fact that station 6 is the open water zone of lake and beside the native lentic species it also receives riverine taxa of phytoplankton through the inlets. Association of *Calamus tennis*-Baringtonia acutangula in station 4 (RB) provide microhabitat to various phytoplankton taxa. Further in lentic systems species diversity was found higher than that of lotic systems. Lowest species diversity (17) was recorded in the station 3 (DGK) during 2007-08 and station 10 (26) during 2006-07 (Table 15 and 17). The former could be due to the release of various inorganic substances used for construction of RCC Bridge over the inlet. Low species diversity in the later could be attributed to the inability of most of the phytoplankton taxa to survive against high flow rate and strong water current of the river Barak.

**Correlation coefficients**

During 2006-07, species diversity (S) showed significant positive relationship with turbidity, SO$_4^{2-}$ and RF while significant negative correlation was found with TH, Ca$^{2+}$, Mg$^{2+}$, NO$_3^-$ and NH$_4^+$ (Table 2). This could be explained by the fact that rapid runoff brought suspended materials (acts as a substratum), nutrients and phytoplanktonic algae from the inlets thereby increasing species richness. Thomaz *et al.* (2007) suggested that intensive floods are important for exchange of propagules, nutrients and organisms in river floodplain systems.

During 2007-08, species diversity (S) showed significant positive correlation with transparency, BOD, NO$_3^-$ and total phytoplankton density while significant negative correlation was found with EC, TH, Mg$^{2+}$ and turbidity (Table 3). Some authors believed that physical environment such as light availability and temperature (Carpenter and Kitchell, 1993; Bormans and Condie, 1998), nutrients (Mortensen *et al.*, 1992) and carbon dioxide (Shapiro,
1997), influences the phytoplankton assemblages and distribution in lakes and rivers. In the present study in Chatla Floodplain Lake, neither water temperature nor free CO\textsubscript{2} showed any significant relationship with species diversity. The distribution of species is found to be influenced by a group of factors such as turbidity, SO\textsubscript{4}\textsuperscript{2-} and RF during 2006-07 and transparency, BOD, NO\textsubscript{3}\textsuperscript{-} during 2007-08.

**Phytoplankton community structure**

**Shannon-Wiener diversity index (H\textsuperscript{′})**

Analysis of phytoplankton community structure revealed that Shannon-Wiener diversity index was recorded highest in the station 6 (2.75) in pre-monsoon during 2006-07 and station 5 and 6 (2.82) in post-monsoon during 2007-08. Lowest H\textsuperscript{′} value was recorded in the station 8 (1.45) in pre-monsoon during 2006-07 and station 2 (1.08) in post-monsoon during 2007-08 (**Fig.** 98 and 102).

Station 6 (OW) attained the highest rank followed by station 5 (UB) in both the years of study indicating the suitability of growth and development of phytoplankton in stagnant water bodies. Lowest Shannon-Wiener diversity index in station 2 (BC) during post-monsoon in 2007-08 (**Fig.** 102) could be attributed to the anthropogenic activities like bathing, washing and fishing in the lotic systems. Singh (1960) in his study on the phytoplankton of inland water of Uttar Pradesh in India recorded primary peak of phytoplankton in the months of September and suggested that phytoplankton abundance and taxonomic diversity depend upon the supply of nutrients in natural waters. In the present study, the highest Shannon-Wiener diversity index was found in post-monsoon during 2007-08 when the temperature, and concentration of N-NO\textsubscript{3} were found to be optimum and PO\textsubscript{4}\textsuperscript{3-}-P was found to be very high.

Shannon–Wiener Index value was found (>2) in almost all stations and followed similar patterns of seasonal variation in both the years except monsoon 2007-08 where H\textsuperscript{′} were low and found (>2) only in station 6 and 7 (OW and MB). This could be due to predation by zooplankton (*Diaptomus* and *Cyclops*) because zooplankton play an important role in shaping the phytoplankton community (**Fig.** 99 and 103).

**Margalef’s Index (d)**

Highest value of Margalef’s Index (d\textsuperscript{′}) recorded during post-monsoon in the station 6 (OW) (2.62) among all the stations in 2006-07 and station 5 and 6 (2.52) in 2007-08 indicated that nutrient inputs through runoff and by inlets during monsoon was utilized by phytoplankton during isolation period in both the years of study (**Fig.** 99 and 103). Similar observations was made by López-Archilla *et al.* (2004) in a hypereutrophic shallow lake (Southern Spain). Higher concentration of nutrients influences the growth and reproduction of plankton which in turn gives higher values of Margalef’s Index (d).
Lowest value recorded in the station 8 (SAL) during pre-monsoon (0.86) in 2006-07 and in the station 2 (BC) in post-monsoon (0.38) in 2007-08 (Fig. 99 and 103) could be due to influx of domestic sewage, reduction of water level, bathing and washing in the river made the environment unhealthy for phytoplankton development.

**Evenness Index (J')**

High value of Evenness Index (J') indicate a relatively balanced community composition (Battes, 2005). In the present study, highest J'-value (0.96) was recorded in the station 9 (GR) during post-monsoon in 2006-07 (Fig. 100) indicated even distribution of species during this season (Karuppasamy and Perumal, 2000). Melo and Huszar (2000) also found the high specific diversities and evenness in an Amazonian flood-plain lake (Lago Batata, Brasil) which imply that there is no sustained period of dominance by specific algae.

Lowest J'-value (0.66) recorded in the station 5 (UB) in post-monsoon during 2006-07 could be due to the fact that by external input of nutrient and by their concentration in post monsoon the environment of the station became conducive for one or two species only and thus all the taxa were not evenly distributed.

During 07-08, evenness Index (J') was recorded highest in station 2 and 10 (BC and BR) during post-monsoon and lowest (0.6) in station 4 (RB) in monsoon (Fig. 104). The former could be attributed to the stable hydrological condition of the lotic systems at low water periods and lowest value in lentic system indicated that the input of floodwater changed the nutrient content of water which was conducive only for a few phytoplankton groups.

**Berger-Parker Index of dominance (D_{BP})**

Berger-Parker Index of dominance (D_{BP}) of phytoplankton community represents the single taxon having high density. Highest values of D_{BP} (0.45) was recorded in the station 5 (UB) during post-monsoon (2006-07) and station 4 (RB) in monsoon (0.59) (2007-08) (Fig. 101 and 105). Dominance of particular species in these two stations is confirmed by their lowest value of evenness index (J'). Lowest values of D_{BP} (0.08) recorded in post-monsoon in the station 3 (DGK) (2006-07) and station 4 (RB) (0.11) (2007-08) (Fig. 101 and 105) indicated even distribution of species in those stations.

**Correlation coefficient**

During 2006-07, Shannon-Wiener Index (H') and Margalef’s species richness Index (d) showed significant positive correlation with turbidity, SO_{4}^{2-}, RF, total phytoplankton density while significant negative correlation with H' was found with TA and NH_{4}^{+} and d with TH, Ca^{2+}, Mg^{2+}, NO_{3}^{-} and NH_{4}^{+} (Table 2). This could be attributed to the fact that heavy rainfall creates turbid and nutrient rich environment which favored the phytoplankton development and high growth of phytoplankton also make the water turbid. Train and Rodrigues
(1997) reported that the low transparency and consequent decrease in photosynthetically active radiation (PAR), together with the stress produced in the phytoplanktonic cells by the high current velocities and by mechanical shock to the particles are factors that contribute to diversity reduction. Sharma (2009) reported significant negative correlation of species richness with NO$_3$ in Loktak Lake, Manipur, India is in agreement with the results of the present study.

During 2006-07, Evenness index ($J'$) showed significant positive correlation with NH$_4^+$ and $H'$ while significant negative correlation was found with TA, total phytoplankton density, and $d$ (Table 2). Berger-Parker Index of dominance ($D_{BP}$) showed significant positive correlation with TA, transparency and total phytoplankton density while significant negative correlation was found with $J'$ and $H'$ (Table 2). This could be attributed to the fact that growth of some dominant taxa of phytoplankton (Euglena, Spirogyra, Oscillatoria, Chlorella and Navicula) was favoured by high alkalinity and high transparency.

During 2007-08, $H'$ showed significant positive correlation with TA, BOD, NO$_3^-$, total phytoplankton density and $S$ but no significant negative correlation was found (Table 3). Significant positive correlation of Margalef’s Index species richness ($d$) was found with transparency, NO$_3^-$, total phytoplankton density, $S$ and $H'$ while significant negative correlation was found with TH, Mg$^{2+}$ and turbidity. $J'$ showed significant positive correlation with TA, pH, TSS, TH, Ca$^{2+}$, Mg$^{2+}$ and $H'$ while significant negative correlation was found with K$^+$ and total phytoplankton density (Table 3). Karikal (1995) noted that occurrence and growth of various species of algae in the water bodies are controlled by a single factor or group of factors, and these factors vary from one water body to another. $D_{BP}$ showed significant negative correlation with total alkalinity, NO$_3^-$, species diversity, $H'$, $d$ and $J'$ but it did not show any significant positive correlation with water quality parameters (Table 3). Sharma (2009) reported significant negative correlation of dominance with species diversity and richness in Loktak Lake, Manipur, India is in agreement with the present study.

**Canonical correspondence analysis (CCA)**

Canonical correspondence analysis (CCA) is a direct ordination technique that selects the combinations of environmental variables which maximize the dispersion of the scores of the species (Jongman *et al.*, 1995) as well as population. The lines of the matrixes of environmental data were allocated randomly, and the CCA was calculated. The derived CCA scores applied to the phyto and zooplankton community and environmental variables of the year 2006-07 and 2007-08 indicated that Chatla Floodplain Lake showed limnological and biological differences.

During 2006-07, for phytoplankton community, on the first axis total alkalinity, pH, turbidity and SO$_4$ were placed adjacent to the second axis and thereby promoted the growth of phytoplankton community but rainfall has a
direct effect on the density, species diversity, dominance etc. as it was positioned on the top of the axis 2 which was the driving factor for all the physico-chemical and biological characteristics of the Chatla basin (Fig. 114). In the present study, the correlation between density and diversity indices of phytoplankton community and environmental variables was expressed by the positioning of the variables such as total alkalinity, pH, turbidity and SO$_4$ pointed in the same direction. The opposite direction of different environmental variables like TSS, NO$_3^-$ and NH$_4^+$ indicated their negative correlation with phytoplankton density. Danilov and Ekelund (2001) reported that, the presence of humic substances in water do affect the availability of light consequently influencing distribution of phytoplankton and photosynthetic bacteria. During 2007-08, CCA revealed that transparency, NO$_3^-$ and NH$_4^+$ were very closely located at the intercept of the second axis and their was no effect of rainfall on phytoplankton (Fig. 115). But TSS in both the years showed negative impact on phytoplankton community. Decomposition of sewage, decomposed aquatic vegetation might have blocked the photosynthetic activity of phytoplankton community and thereby decreased their population density, diversity and dominance.

**Zooplankton**

In Chatla floodplain lake zooplankton community was represented by 24 taxa (44.15%) during 2006-07 (Table 19) and 34 taxa (54.62%) during 2007-08 (Table 21).

**Temporal and spatial variation of density of total zooplankton community**

One-way analysis of variance showed significant spatial and temporal variation of zooplankton density during 2006-07 and 2007-08 (Table 33 and 34).

**2006-07**

During 2006-07, highest density of total zooplankton was recorded in the station 5 (UB) in monsoon (133.83 no.l$^{-1}$ x 10$^2$) and lowest in the station 10 (BR) in post-monsoon (4.0 no.l$^{-1}$ x 10$^2$) (Fig. 91). Seasonal succession of zooplankton communities in the tropics has been attributed to a number of factors such as the environmental characteristics of the water, predation, quality and quantity of edible algae and competition (Onwudinjo and Egboroge, 1994, Ovie and Adeniji, 1994). In the present study highest density of zooplankton in monsoon could be attributed to the heavy rainfall which carried nutrients into the floodplain allowing the growth of phytoplankton which correspondingly increased zooplankton. Further availability of macrophytes in the lentic systems provide shelter and varied niches (Ganesan and Khan, 2008) which created optimum environmental condition in the lentic portion of Chatla floodplain. Station 5 particularly being a managed system was most productive with high phytoplankton and high zooplankton. Highest zooplankton population in monsoon could be attributed to the influence of flood water on the homogenization of the water column, which in turn led to the distribution of species amongst different water columns (Okogwu et al., 2009). Peak
zooplankton population in rainy season have also been reported by Saint-Jean (1983), Masundire (1994) and Okogwu and Ugwumba (2006). Further, zooplankton recruitment in floodplain lakes during monsoon could be attributed to the constant input of individuals transported from river (Walz and Welker, 1998) and restings eggs in the sediments or isolated patches inside the lake (Obertegger et al., 2007).

Lowest density during post-monsoon in station 10, Barak River (Fig. 91) could be possibly due to inability of zooplankton to swim against strong water current. Maar et al. (2003) reported that juveniles of zooplankton have reduced swimming capacities compared to adults. Similar observations were made by Dodson and Ramcharan (1991) for Daphnia pulex.

The low level of food in water as a result of the low primary productivity can be responsible for the low population of zooplankton (Thadeus and Lekinson, 2010). Oxygen is known to have a negative impact on zooplankton at levels below 2.5 mg/l (Aka et al., 2000). In the present study zooplankton showed significant negative correlation with DO. The significant positive correlation of DO with WT have been recorded in the present study. Water temperature and oxygen are also known to influence zooplankton abundance (Allan, 1976; Wetzel, 1983). Significant positive correlation of zooplankton density, H' and species diversity with turbidity and SO$_4^{2-}$ could be attributed to the runoff which brought nutrient rich water into the floodplain increasing density and diversity of zooplankton and in turn turbidity (Table 31). In the present study, total zooplankton density showed significant negative correlation with DO, TSS, Ca$^{2+}$, NO$_3^-$ and NH$_4^+$ (Table 31). Maria-Heleni et al. (2000) also reported inverse relationship of different zooplankton groups with nitrite, ammonia and phosphate, in the Aliakmon River, Greece.

2007-08

During 2007-08, highest density of total zooplankton was recorded in the station 2 (BC) in post-monsoon ($213.83 \text{no.}^1 \times 10^5$) (Fig. 93) followed by station 5 (UB) in monsoon ($148.5 \text{no.}^1 \times 10^5$) and post-monsoon ($105.16 \text{no.}^1 \times 10^5$). Highest density in lotic system in post monsoon is in contrast to the 2006-2007 highest phyto and zoo plankton population in lentic system in monsoon. This can be explained by the fact that in 2007-2008 onset of monsoon was late accompanied by high floodwater which retained for quite some time. So food and temperature in post flood situation were conducive for zooplankton proliferation contributing highest density. This is further confirmed by the significant positive correlation of zooplankton density with BOD, WT, K$^+$, PO$_4^{3-}$ and RF (Table 32). Özbay and Altındag (2009) reported that increasing nutrient levels by the input of waste into the river from rural, urban and industrial sites increased zooplankton abundance in River Kars, Northeast Turkey. Abdel-Aziz and Aboul-Ezz (2004) reported that low DO concentration harboured highest density of zooplankton in the Lake Maryout, Alexandria, Egypt. This is in agreement with the results of present study which showed significant negative correlation between zooplankton density and dissolved oxygen (Table 32). Maximum density of zooplankton in
low oxygen concentration was also recorded in Narmada River (India) (Sharma et al., 2010).

The community structure of zooplankton depends not only on the seasons but on the trophic status of the lake and individual species may reflect the level of eutrophication (Rogozin, 2000). Lowest zooplankton density recorded in the station 1 (JC) in pre-monsoon \(4.0 \times 10^2\) (Fig. 93) could be probably due to predation pressure from planktivorous fishes (Carpenter et al., 1985; Stemberger and Lazorchak, 1994), low water level as well as their less tolerance against the flow.

**Spatial variation of mean density and abundance of total zooplankton**

During 2006-07, highest mean density and abundance of total zooplankton was recorded in the station 5 (UB) followed by station 4 (RB) and station 6 (OW) (Table 19 and 20). During 2007-08, highest mean density and abundance of total zooplankton was recorded in the station 5 (UB) followed by station 2 (BC) and station 6 (OW) (Table 21 and 22). This could be attributed to the greater food availability due to continuous input of various organic and inorganic fertilizers for fish growth as well as resting of eggs emerging from the sediments. In addition, seasonal inundation brought large amount of nutrient rich water into the station 6 (open water) and station 5 (UB) which provided enough food for zooplankton and contributed higher density and abundance. Zooplankton community in the three sampling stations 4, 6 and 7 (RB, OW and MB) had higher density and abundance as during flood they were interconnected and thus have homogeneous distribution of zooplankton community. Lowest density and abundance recorded in the station 9 and 10 (GR and BR) during 2006-07 (Table 19 and 20) could be attributed to the hydrographically washable environmental condition (Damutharan et al., 2010) due to strong water current. During 2007-08, lowest density and abundance recorded in the station 1 (JC) (Table 21 and 22) could be attributed to the less availability of phytoplankton due to construction of RCC bridge adjacent to the sampling station. Variation of phytoplankton biomass has been linked to light, macronutrient availability, temperature and zooplankton grazing (Perissinotto et al., 2000; Froneman, 2001). Due to tropical location of this lake, meteorological factors can affect the physical conditions of the lake throughout the year (Papa and Zafaralla, 2011) and thereby influences spatial variability of zooplankton density and abundance.

**Temporal variation of mean density and abundance of total zooplankton**

During 2006-07, highest density and abundance of total zooplankton was recorded in monsoon followed by pre-monsoon and post-monsoon and lowest in winter (Table 27 and 28). Froneman (2002, 2004) suggested that the elevated zooplankton abundance and biomass can be related to greater food availability during the wet seasons which is in consistent with the results of present study. Lowest density and abundance of total zooplankton was found in winter (Table 27 and 28) could be attributed to the lower availability of phytoplanktonic algae due to low temperature. Sellami et al. (2012) observed low density of
zooplankton in winter in Sidi Saâd reservoir in Centre of Tunisia and related it with less phytoplankton density (Sommer et al., 1986). The impact of fish predation on zooplankton abundance is indicated by Whittaker et al. (2001), where significantly lower plankton density was associated with the presence of the planktivore fish.

During 2007-08, highest density and abundance of total zooplankton recorded in post-monsoon followed by monsoon could be attributed to higher availability of nutrient (Table 29 and 30). This is indicated by the direct relationship of BOD, K⁺ and PO₄³⁻ with their species diversity (S), H' and d (Table 32). During monsoon, nutrients carried with the rain enrich water favouring phytoplankton and consequently zooplankton (Mala-Barbosa and Bozelli, 2006). Tasevska et al. (2010) reported that productivity gradient of a lake ranged according to the TP level and revealed an increasing density and biomass of all zooplankton groups in Lake Dojran, Macedonia. Based on zooplankton densities, rotifers showed the strongest response to increased phosphorus levels (Lauridsen and Hansson, 2002). In the present study, higher availability of PO₄³⁻-P corresponded to higher density and diversity of rotifers. This is confirmed by the significant positive correlation of PO₄³⁻ with total zooplankton density (Table 32). Lowest density and abundance of total zooplankton during pre-monsoon (Table 29 and 30) could be attributed to the predatory effect of larger crustaceans and zooplanktivorous fishes. Vijverberg et al. (2008) reported that an intermediate season (October to November) characterized by low rainfall and low temperatures influences zooplankton distribution.

**Density and abundance of different zooplankton community in different stations**

Zooplankton community was represented by Cladocera (11), Rotifera (8), Copepoda (9), Anostraca (3), Protozoa (1), Ostracoda (2) and Decapoda (Zoea larva) (1) (Table 27-28 and 29-30). The species composition and richness of zooplankton in floodplain lakes vary remarkably among seasons in response to changes in their environmental variables (Okogwu, 2009).

**Cladocera**

Zooplankton community was dominated by Cladocerans in terms of species diversity where 11 taxa were identified during the both the years of study (Table 19 and 21).

**2006-07**

During 2006-07, highest density of Cladocera was recorded in the station 5 (UB) in monsoon followed by station 4 and 6 (RB and OW) in monsoon (Fig. 82-85). Station 5 (UB) being a managed fishery is rich in nutrient due to the application of various fertilizers. Further due to changes in the water level and connectivity with the fisheries of Chatla floodplain cladocerans had taken the opportunity for rapid multiplication under favourable nutritional condition and
resting eggs emerging from the sediments contributed highest cladoceran density. Okogwu (2009) reported that cladocerans accounted for over 58% of zooplankton population and attained the peak values during the rainy season while it declined rapidly during the post-rainy season to the lowest level during the dry season. A succession pattern where cladocerans dominate during the rainy season is typical of Nigerian inland waters such as Asejire Lake (Egborge, 1981) and Lamingo dam (Khan and Ejike, 1984). Higgins et al. (2007) also found that zooplankton community was dominated by cladocerans in an artificial lake created on Irish cutaway peat lands, Ireland. Dejen et al. (2004) attributed the dominance of cladocerans in Lake Tana to the rapid hatching of resting egg under optimum environmental conditions, (Gilbert, 1988). Lowest density recorded in the station 9 (GR) during winter (Fig. 83) could be attributed to the deterioration of water quality by human activities coupled with the cyanobacterial dominance which are low-quality food for zooplankton, due to their filamentous or colonial structure (Abrantes et al., 2006) and low level of food in the water as a result of the low primary productivity (Thadeus and Lekinson, 2010). Predation by larger copepods (Cyclops sp. and Diaptomus sp.) might be another reason which is confirmed by the high densities of both the taxa of copepods. Several studies have also shown that fish predation could be the major factor structuring zooplankton assemblages (El-Bassat and Taylor, 2007; Jeppesen et al., 2001; Havens, 2002; Hobaek et al. 2002).

2007-08

During 2007-08, highest density of Cladocera was recorded in the station 2 (BC) in post-monsoon followed by station 5 (UB) in monsoon and lowest in station 1 (JC) in winter (Fig. 86-89). The observed high density of Cladocera in Station 2 (BC) could be attributed to the low water level, dumping of organic and inorganic waste in the system which accelerated phytoplankton growth that support zooplankton community. Similar study was made by Davies and Otene (2009) Minichinda Stream, Port Harcourt, Rivers State, Nigeria which reported that high density of zooplankton could be due to the accumulated wastes like cow dung and poultry droppings which enhanced phytoplankton growth that supported the zooplankton community. The settling of rain water return of favourable conditions contributed highest density of zooplankton community in Narmada River (India) in post-monsoon (Sharma et al., 2010). Lowest density in the station 1 (JC) during winter (Fig. 87) could be attributed to the increase of domestic activities at low level of water. Further, water flow in lotic systems may act as an important source of disturbance for zooplankton communities (De Bie et al., 2008) which reflects the lowest density and abundance of cladoceran in this stream ecosystem. Several authors reported that many species of phytoplankton, zooplankton, and fish are sublethally, negatively affected by the pH of lake water (Hesthagen et al. 2001; Frost et al., 2006; Wærvågen and Nilssen, 2011). Low population of cladoceran in this station might be due to acidic pH recorded during winter.

Rotifera
Rotifera was represented by 8 taxa and showed comparatively low population density in all the seasons during both the years of study (Table 19 and 21).

2006-07

During 2006-07, rotifers showed marked seasonal variation of population with highest density during monsoon recorded in the station 5 (UB) followed by station 7 (MB) (Fig. 85) and lowest during winter in station 10 (Fig. 83). This could be attributed to the availability of allochthonous food material during monsoon and presence of macrophytic vegetation which provide shelter against predation by large crustaceans and planktivorous fishes. Ferrara et al. (2002) also observed highest abundance of rotifers in monsoon in Lake Bracciano, Latium, Italy. Abundance of rotifers in summer was noticed by several authors (Yadava et al., 1987; Bahura et al., 1993; Sanjer and Sharma, 1995). Allan (1976) reported that the zooplankton community of the Aliakmon River was dominated by rotifers due to their short generation time and their high reproductive rate (Klimowicz, 1981; Pourriot et al., 1982; Saunders and Lewis, 1988; Van Dijk and Van Zanten, 1995). Okogwu (2009) reported abundance of rotifers during post-rainy seasons in Ehoma floodplain Lake, Nigeria which he attributed to the low population of cladocerans and hence less competition. Lowest density of rotifers recorded in the station 10 (BR) in both post-monsoon or winter (Fig. 82 and 83) might be due to their inability to swim against strong current (Marzolf, 1990) in River Barak. According to Kebede et al. (1992) and Tadesse et al. (2010) absence or low attendance of rotifers during their survey in Lake Hayq in the Ethiopian Highlands could be due to food limitation and predation. The seasonality of rotifers in tropical lakes has been ascribed to a number of climatological factors and rotifers are highest in number during the warm, dry months and lowest during the cold period or during periods of high water transparency (Egborge, 1981; Burgis, 1974). In the present study not much differences were recorded in their mean density and abundance during post-monsoon, winter and pre-monsoon (Table 29 and 30) which could be due to relatively stable limnological condition of the lake.

2007-08

During 2007-08, highest density of Rotifer was recorded in the station 6 (OW) in monsoon followed by station 5 (UB) and lowest in the station 1 (JC) in monsoon and station 2 (BC) in winter (Fig. 86-89). The former could be attributed to the presence of macrophytes in the lentic systems and also possibility of transport of rotifers with aquatic macrophytes from other areas during flood as reported by Green (1963, 1975) in the lagoon Mato Grosso, Central Brazil. High concentration of DO and high phytoplankton density in station 6 might have increased Rotifera density. A study made in Loktak Lake, Manipur, North eastern India reported that density of Rotifera is significantly positively correlated with DO (Sharma, 2010). The population size of Rotifera is relatively low in Chatla Floodplain Lake and totally absent in the station 1, 2, 3 and 4 (JC, BC, DGK and RB) in different seasons throughout the year. Lowest
density recorded in the lotic portion of Chatla floodplain could be due to lower availability of phytoplankton.

**Copepoda**

Copepoda was represented by 9 taxa dominated by *Cyclops* sp and *Diaptomus* sp. in all the seasons during both the years of study (Table 19 and 21).

**2006-07**

During 2006-07, highest density of Copepoda was recorded in the station 4 (RB) in monsoon followed by station 5 (UB) in monsoon and pre-monsoon (Fig. 85 and 84). This could be due to higher abundance of phytoplankton and increased concentration of PO$_4^{3-}$ which provided sufficient food for copepods in all the three lentic systems. Higher number of nauplii in the monsoon collection confirms the availability of food resources, proper mixing of water column during inundation and emergence of resting eggs from the sediments. This conformed to the study made by Paulose and Maheshwari (2008) who opined that high density of copepods in the Ramgarh Lake could be related to the fertilization of the leftover eggs of the previous breeding seasons in monsoon. Wood *et al.* (1976) also reported that maximum density of copepods in Lake Babogaya, Ethiopia may be associated with seasonal mixing of the water column. Present study found presence of Copepods in all the stations throughout the year in varying environmental condition which is in agreement with the findings of Barnes *et al.* (1988) who said that Copepods dominate most aquatic ecosystems because of their resilience and adaptability to changing environmental conditions and ability to withstand varying environmental stresses. Presence of Copepods through out the year was also recorded by several workers (Aquino and Nielsen, 1983; Perez *et al*., 2008; Zafaralla, 1992). According to several authors rotifers and small copepods are known to be more tolerant of adverse environmental conditions than the cladocerans (Auclair *et al*., 1993, Hannson *et al*., 2007). Contrary to all these views, Das *et al*., (1996) reported that copepods are high in stable environmental conditions and they disappear at increased pollution level. Temperature appears to be one of the major factors in the seasonal fluctuation of copepods (Chen, 1986).

Lowest density of Copepoda was recorded in the station 10 (BR) during post-monsoon (Fig. 82). Maria-Heleni *et al.* (2000) reported that abundance of different zooplankton groups were inversely related to nitrite, ammonia and phosphate, in the Aliakmon River, Greece. Okogwu (2009) reported lowest abundance of all the zooplankton groups (including copepods) in post-rainy season which they attributed to predation by juvenile fish. The low population of Copepoda in this station also could be due to the effects of fish predation as reported by several studies (Jeppesen *et al.* 2001; Havens, 2002; Hobaek *et al.* 2002).

**2007-08**
During 2007-08, highest density of copepods were recorded in monsoon in the station 5 (UB) followed by station 4 (RB) in post-monsoon and lowest in the station 1 (JC) in pre-monsoon (Fig. 86-89). Highest density in monsoon could be attributed to the transport of large amounts of organic matter (both particulate and dissolved) from inlets along with zooplankton by heavy rainfalls into the lake (Wærvågen and Nilssen, 2011). Station 5 being a managed fishery is rich in phytoplankton. Hence with higher food availability density of major group (Copepoda) increased. Station 4 (RB) located nearer to the fisheries and being an area of Baringtonia Rattan association is itself a nutrient rich environment supporting phytoplankton growth directly required for development of copepods and providing shelter against fish predation. Decline of copepod density in the station 1 (JC) could be attributed to the domestic use of the stream at low water period resulting very low pH. Mustafa (2009) reported that alkaline pH favoured zooplankton growth and abundance in the Oyun Reservoir, Nigeria. Similar view was opined by Byars (1960).

**Anostraca**

Anostraca was represented by 3 taxa, most dominant species being *Streptocephalus* sp. It was recorded in all sampling stations in almost all the seasons of both the years of study (Table 19 and 21).

**2006-07**

During 2006-07, highest density of Anostraca was recorded in the station 5 (UB) in pre-monsoon and lowest in the station 9 and 10 (GR and BR) in monsoon (Fig. 84 and 85). This could be linked with high turbidity and nutrient rich environment at low water level during isolation period. Several authors have reported that Anostraca were seen abundantly in seasonal ponds and pools in different parts of India. *Streptocephalus* spp. the fairy shrimp are widely distributed in Tamilnadu, (Sars, 1901; Bond, 1934), Madurai (Bernice, 1972a and b; Palaniyappan, 1989), Servareyan Hills and Yearcard in Selam District (Munusamy, 1982) in Tiruchirappalli area. Lowest density in monsoon in station 9 and 10 could be possibly due to the increased level of EC and their less adaptability against strong water current. It can be said that input of various fertilizers into the floodplain fisheries during pre-monsoon promoted the growth of Anostraca. Amutha *et al.* (2007) reported that the known distribution of *Streptocephalus dichotomus* is mainly in the river side. In the present study also *Streptocephalus* sp. was frequently found in all the lotic and lentic systems of Chatla floodplain throughout the year.

**2007-08**

During 2007-08, highest density of Anostraca was recorded in the station 3 (DGK) in post-monsoon followed by station 5 (UB) in monsoon and lowest in station 4 (RB) in winter (Fig. 86-89) could be linked with level of nutrients. The occurrence of *Streptocephalus vitreus* reported in the temporary pond of Kenya (Hildrew, 1985) and *Holopedium gibberum* Windgfallweifer in the Schwarzwald
(Lampert and Krauss, 1976) is in agreement with the present study. Lowest density of Anostraca was recorded in station 4 (RB) in winter (Fig. 87) could be attributed to the low density of phytoplankton at low temperature and low concentration of DO.

Protozoa

Protozoan was represented by a single taxa Actinophyrs sp. and their density was found to be relatively low in all the stations throughout the study periods (Table 19 and 21).

2006-07

During 2006-07, highest density of protozoa was recorded in the station 3 (DGK) in monsoon, lowest in station 4 and 9 (RB and GR) in winter and their total absence in most of the station during pre-monsoon (Fig. 82-85). Introduction of species during connectivity along with the increased level of nutrients particularly increased concentration of NO$_3^-$ and PO$_4^{3-}$ in the system might have promoted growth of protozoa particularly Actinophyrs sp. Several authors have reported that the degree of connectivity of floodplain lakes to the main rivers has gained attention as an important controlling factor in structuring aquatic communities in floodplain systems (Tockner et al., 1998; Ward et al., 1999; Bini et al., 2003; Velho et al., 2003; Alves et al., 2005; Thomaz et al., 2007; José de Paggi and Paggi, 2008; Bonecker et al., 2009). Further, highest density of protozoa in the station 3 could be attributed to the presence of highest level of BOD, Na$^+$ and K$^+$ which promotes the growth of anaerobic bacteria and thereby increases Protozoan density. Lowest density during winter could be due the increased level of EC in the station 4 (RB) and higher concentration of TH in the station 10 (BR) which might has negative impact of their population.

Protozoans are known to be bio-indicators of organic pollution (Ghazy and El-Senousy, 2008). In the present study, high population of Actinophyrs sp. was recorded in the station 5 in most of the season. This might be due to presence of floating macrophyte as they prefer to stay attached with macrophytes (Battish, 1992).

2007-08

During 2007-08, highest density of protozoa was recorded in the station 6 (OW) in monsoon and lowest in the station 1 (JC) during monsoon and found to be totally absent in most of stations during winter and pre-monsoon (Fig. 86-89). This might be due to entry of protozoa into the open water of Chatla floodplain from its inlets and adjoining fisheries during monsoon. Fulone et al. (2005 and 2008) found higher densities of protozoa in the rainy season due to entrainment from the sediment. Protozoa was found to be totally absent during winter and pre-monsoon might be due to the effect of temperature and turbidity. de Oliveira and Hardoim (2010) reported that different taxa of protozoa (Arcella spp., Centropyxis spp. etc.) were found more abundant in the presence of higher
concentrations of total solids, temperature, turbidity and color, a situation typical of the rainy period in a touristic waterfall regions of Chapada dos Guimarães National Park, Mato Grosso State, Brazil which is in agreement with the results of present study. Lowest density recorded in the station 1 (JC) during monsoon could be due to hydrological washout by strong water currents because development of high densities of protozoa in environments with fast-flowing currents seems to be unfavorable (Velho et al., 2003).

Ostracoda

Ostracods were represented by 2 taxa and were found to be absent in most of the stations in different seasons during both the years of study. They were in the sixth position in terms of density and abundance of zooplankton community (Table 19 and 21).

2006-07

During 2006-07, highest density of Ostracoda recorded in the station 6 (OW) in monsoon followed by station 5 (UB) in monsoon and 7 (MB) in pre-monsoon (Fig. 82-85) could be linked with the constant input of zooplankton taxa from nearby catchment into the open water (station 6) and presence of macrophytic vegetation in the station 5 and 7 which provided shelter against predation. Shayestehfar and Seyfoddin (2010) observed highest density of ostracods in the month of July in Yassbolagh Dam, Markazi, Iran. This study recorded very low population of Ostracods. Rajashekhar et al. (2010) reported that Ostracoda occupied fourth position and represented very low population and diversity compared to other groups in a freshwater reservoir Gulbarga District, Karnataka. Harshey et al. (1987) reported high abundance and diversity of ostracods in hard water. Lowest density in the station 2 (BC) during both post-monsoon and pre-monsoon could be due to the increased level of Cl\textsuperscript{−} and turbidity.

2007-08

During 2007-08, highest density of ostracods was recorded in the station 6 (OW) in monsoon (Fig. 89). Highest density in monsoon could be directly linked to the highest density and abundance of phytoplankton recorded in the station 6 (OW). Lowest density of ostracods recorded in the station 4 (RB) in post-monsoon and station 5 (UB) in pre-monsoon respectively (Fig. 86 and 88) could be due to the very low concentration of DO during post-monsoon and acidic pH during pre-monsoon.

Decapoda

Decapoda was represented by a single taxa Zoea larva and found to be present in the station 1, 2 and 3 (JC, BC and DGK) in winter, pre-monsoon and monsoon during 2006-07 (Fig. 82-85). Their presence only in the station 1, 2 and 3 (JC, BC and DGK) might be due to the lotic nature of all the three systems
which are inlets of Chatla floodplain (Table 19 and 20). According to Fernandes et al. (2002) the depth and season influence the density of total decapod crustaceans. Occurrence of decapods during winter, pre-monsoon and monsoon in very low density and abundance might be due to varying environmental condition, competition for nutrients with other groups as well as predation by fishes. Chattopadhyay and Barik (2009) observed high density of Decapoda in the month of October in a tropical freshwater lake, Krishnasayer, Burdwan, West Bengal, India.

They were found to be totally absent in all the stations in all seasons during 2007-08. Dhembare (2011) also reported low density of Decapoda and their monthly average varied from 0.73 to 2.98 Ind.L$^{-1}$ in Mula Dam, Rahuri, MS, India. Imoobe and Egborge, (1997) reported that Ostracods and decapods were generally of very low importance and absent in more than 50% of the sampling period, and never up to 20% of the total crustaceans.

### Variation of density and abundance of different groups of zooplankton and total zooplankton in Chatla floodplain

#### 2006-07

Density of different groups of zooplankton in terms of percentage composition are as follows:

Cladocera > Copepoda > Rotifera > Anostraca > Protozoa > Ostracoda > Decapoda

(2006-07): 35.4% > 35.31% > 12.1% > 11.44% > 3.13% > 2.36% > 0.29% (Density)

Cladocerans are considered to provide information on various environmental events and disturbances affecting lake status such as climate and trophic state changes (Goulden, 1969; Jeppesen et al., 1996; Rautio, 1998), acidification (Korhola, 1999) and water level fluctuations (Alhonen, 1970; Sarmaja-Korjonenen and Hyvärinen, 1999). In the present study, percentage composition of different groups of zooplankton community revealed that cladocerans dominated among the zooplankton community in terms of density (35.4%) while Copepoda dominated in terms of abundance and contributed 36.1% of the total zooplankton. Lima et al. (2003) recorded greatest mean abundance of cladocerans in the Ivinheima and Baía systems mainly in the lagoons and the connection channels of Upper Paraná River. Kumar and Perumal (2011) recorded the descending order of abundance of various group of zooplankton in Ayyampattinam coast (southeast coast of India) and they found that Copepoda formed the major fraction (44%), followed by metazoans (25%), Ciliates (8%), Decapoda (2%), etc. Copepods dominate most aquatic ecosystems because of their resilience and adaptability to changing environmental stresses (Barnes et al., 1988). Presence of Cyclops, Mesocyclops and Diaptomus in all the stations in almost all the seasons in the present study are indicative of their high adaptability in different ecosystems. Rotifers constituted third position in terms of both density and abundance. The low rotifer density and abundance may be
related to their competition for food with calanoids and predation pressure of cyclopoids (José de Paggi 1993, 1995). Anostraca attained fourth position in terms of percentage composition in their density and abundance which could be attributed to their large size and active behavior (Jocque et al., 2010) as they are highly vulnerable to predation. Several authors argued that Anostraca are particularly vulnerable to predation, mostly by insect predators (Brendonck et al., 2002), but also by some amphibians (Wissinger et al. 1999). Protozoa, Ostracoda and Decapoda were the least contributors of total zooplankton in terms of density and abundance respectively. Sampaio and López (1999) reported that protozoans might have been underestimated due to the relatively large mesh size of 68 µm used in sampling. But in the present study, mesh size of 40 µm plankton net was used in the sampling, other factors such as low food availability might be responsible for lower density and abundance of protozoans. Pandit et al. (2007) stated that poor number of Ostracods in Pravara river in Ahmedsagar, Maharashtra was due to alkaline nature of water which is in agreement with the findings of the present study. Manzer et al. (2005) reported seasonal fluctuation of Ostracoda abundance in a freshwater lentic ecosystem of north Bihar. Chattopadhyay and Barik (2009) also reported least abundance of zooplankton group in Lake Krishnasayer, Burdwan, West Bengal, India.

**Seasonal variation of total zooplankton (2006-07)**

Density: Monsoon>pre-monsoon>post-monsoon>winter

43.83%> 27.24%> 15.63%> 13.3%

Seasonal variation of mean density of total zooplankton showed highest percentage composition in monsoon (43.83%) followed by pre-monsoon (27.24%) and post-monsoon (15.63%) and lowest in winter (13.3%) (Table 27). Okogwu (2009) reported peak in total zooplankton abundance during rainy season in Ehoma floodplain Lake, Nigeria. During monsoon ponds, pools, fisheries, depression, paddy fields, small streams, rivers (including inlets and outlet) etc. of Chatla floodplain lakes were interconnected where inlets transported large amount of organic matter and biota into the lake, associated with heavy rainfall (Waervågen and Nilssen, 2003) which could be the reason for highest percentage composition of density and abundance of total zooplankton during monsoon. Ferrara et al. (2002) reported that zooplankton population is generally low in winter in Lake Bracciano, Latium, Italy.

**Spatial variation of total zooplankton (2006-07)**

Spatial variation of mean density of total zooplankton (Table 19) in terms of percentage composition are as follows:

Density:

26.08%>14.41%>11.96%>9.6%>8.82%>6.72%>6.52%>5.48%>5.24%>5.18%
Spatial variation of mean zooplankton density and abundance was found highest in the station 5 (UB) and lowest in the station 10 (BR) (Table 19 and 20). The mean density and abundance of total zooplankton tended to decrease from lentic systems to lotic systems which could be attributed to the degree of permanence or the size of the habitat (Bilton et al., 2001). Most of the taxa recorded in lentic systems were not available in the lotic systems which might be due to their inability to survive in strong currents. Lakes consequently had the highest local richness (Fryer 1985; Collinson et al., 1995) because of stagnant nature and biota (including zooplankton), availability of sufficient space and time for their growth than that of rivers and streams. Water flow in lotic systems may act as disturbance for zooplankton communities (De Bie et al., 2008).

2007-08

Mean density of different zooplankton community in terms of percentage composition were as follows:

Cladocera > Copepoda > Anostraca > Rotifera > Ostracoda > Protozoa

(2007-08): 48.26% > 29.08% > 11.48% > 5.26% > 2.5% > 0.88% (Density)

Percentage composition of zooplankton community revealed that Cladocera dominated in terms of density (48.26%). Mohammad et al. (2012) reported that Cladocera was predominant group in Lar Reservoir, Iran followed by Rotatoria (37.71%) and Copepoda (6.45%) which is in agreement with the present study. They also found a positive relationship of zooplankton abundance with water temperature which is in accordance with the results of the present study. Jappesen (2002) mentioned that the abundance and concentration of zooplankton, particularly Cladocera depend on the limnologic condition and eutrophic level of the lake. Copepoda was the second dominant group of zooplankton in terms of density (29.08%) and abundance (28.41%). Perumal et al. (2009) reported that the percentage compositions of zooplankton were dominantly occupied by copepods followed by other groups at both the stations of Kaduviyar estuary, Nagapattinam, southeast coast of India which is similar to the results of the present study. In the present study Anostraca was the third dominant group of zooplankton followed by Rotifera in terms of density and abundance which could be due to predation by fishes (Gulatti, 1990). Protozoa, Ostracoda and Decapoda were the least contributors of zooplankton density and abundance like 2006-07.

Seasonal variation of total zooplankton (2007-08)

Density: Post-monsoon > monsoon > winter > pre-monsoon

45.93% > 26.64% > 15.95% > 11.46%
Seasonal variation of mean density of total zooplankton showed highest percentage composition in post-monsoon (45.93%), followed by monsoon (26.64%) and winter (15.95%) and lowest in pre-monsoon (11.46%) (Table 29). Zooplankton density showed significant negative correlation with DO and phosphate (Table 32). Decline of DO concentration could be due to increased respiratory rate of zooplankton (Sharma et al., 2010). Allochthonous input of organic matter during monsoon and their subsequent decomposition increased PO₄³⁻ concentration thus increasing phytoplankton density. This in turn increased zooplankton density in post-monsoon and monsoon. Lowest density and abundance in pre-monsoon could be due to the predation pressure by fishes as well as interspecific/ conspecific competition for exploitation of nutrients and phytoplankton (Nogrady et al., 1993).

**Spatial variation of total zooplankton (2007-08)**

Spatial variation of mean density of total zooplankton (Table 21) in terms of percentage composition are as follows:

Density:

\[
21.23\% > 17.5\% > 14.9\% > 10.61\% > 10.33\% > 10.25\% > 6.07\% > 5.25\% > 2.15\% > 1.72\%
\]

\[
UB > BC > OW > MB > RB > SAL > DGK > GR > BR > JC
\]

The percentage composition of spatial variation of density and abundance of total zooplankton was recorded highest in the lentic system like 2006-07 (Table 21 and 22). However, station 2 (lotic system- stream) occupied second position in terms of density and abundance which could be due to the fact that during monsoon stream area increases as flood water spread into several kilometers and nature of the lotic system changes to lentic system temporarily. Lima et al. (1998) observed highest abundance of *Bosmina hagmanni* in the low water period in low pH. In the present study, highest density and abundance of *Bosmina* sp. followed by *Daphnia* sp. was recorded in the station 2 (BC) with lowest pH in post-monsoon.

**Species Diversity**

**Species diversity of zooplankton in different seasons**

Species diversity of zooplankton community was recorded highest in monsoon (23) followed by pre-monsoon (19) and lowest in post-monsoon (18) and winter (18) during 2006-07 (Table 28). During 2007-08, highest species diversity of zooplankton community was recorded in post-monsoon (29) and monsoon (29) followed by winter (28) and lowest in pre-monsoon (24) (Table 30). Highest number of taxa in monsoon in both the years could be due to recruitment of more taxa from the inlets as well as fisheries during seasonal inundation. Sarkkula et al. (2005) pointed out that almost all the annual
biological production takes place in the high-water season due to the immense volume of the flood waters, although the peak of the biomass appeared in the low-water season. In the present study, both the density and abundance of total zooplankton showed highest peak in monsoon during 2006-07 and in post-monsoon during 2007-08. Sharma (2000) found higher species diversity of rotifers in several floodplain lakes of Assam such as Dhekiya and Balak beels.

Species diversity of zooplankton in different stations

During 2006-07, spatial variation of zooplankton community showed that out of 24 taxa, station 5 (UB) harboured maximum species diversity (21) followed by station 7 and 6 (MB and OW) (i.e., 18 and 17) (Table 19) which could be due to the higher abundance of phytoplankton in the lentic systems which are rich in nutrient. This is further confirmed by their significant positive correlation of species diversity with total phytoplankton density. Equal number of taxa (16) was recorded in the station 3, 4 and 8 (DGK, RB and SAL) could be due to the fact that during inundation period, all the three stations were interconnected with the open water of Chatla floodplain forming a lake without any differentiation and biota were more evenly distributed. Lowest species diversity (12) was recorded in the station 10 (BR) (Table 19) which could be due to the inability of most of the taxa to swim against strong water currents.

During 2007-08, zooplankton community was represented by 36 taxa, Highest numbers of taxa (25) was recorded in the station 5 (UB) followed by station 6 (OW) (23). Both the stations are located just opposite to each other and during monsoon both are connected and have same zooplankton community. Further, presence of vegetation in the lentic systems provided shelter to zooplankton against fish predation and sufficient nutrients for their growth and reproduction. Equal numbers of taxa (21) for the station 4 and 7 (RB and MB) and also for station 2 and 9 (BC and GR) (18) were recorded (Table 21). Lowest number of taxa (13) was recorded in the station 1 and 10 (JC and BR).

Among the zooplankton taxa recorded in Chatla Floodplain Lake Daphnia sp. was found to be the most dominant taxon in terms of both density and abundance among cladocerans followed by Chydorus sp. and Bosmina sp. during both the years of study (Table 27-30). Antunes et al. (2003) concluded that some Daphnia species attain high population growth rates at high food levels and are recommended for use in biomonitoring of eutrophic lakes. Saunders et al. (1999) concluded that Cladoceran abundance is a balancing act in Lake Oglethorpe, Georgia, USA where temperature appears to limit population growth. Cladocerans showed high species diversity and abundance during the rainy season is in agreement with the study made by Okogwu et al. (2009). Egborge et al. (1994) reported that Bosmina longirostris is known to be acidophilic and thrive well in waters with pH range of 4.0-6.5 in a coastal river of western Nigeria. In the present study also Bosmina sp. was recorded at low pH (5.42) in station 2 (BC) of Chatla Floodplain Lake. Among the Rotifera, the recorded major taxa were Brachionus sp., Keratella sp. and Lecane sp. and found to be present in all the seasons in both the year of study (Table 27-30). Kaushik and
Saxena (1995) have also reported abundance of genus Brachionus in various water bodies of Central India. Rotifers and small copepods are known to be more tolerant of adverse environmental conditions than the cladocerans (Auclair et al., 1993, Hannson et al., 2007). Okogwu (2009) suggested that rotifers (Brachionus sp. and Keratella sp.) were resistant to suppression by the cladocerans and able to maintain high population in wet season. Occurrence of Moina sp. and Bosmina sp. in Chatla Floodplain Lake along with several genera of rotifers support the above findings. Mengistou (1989) reported that dominant taxa of rotifers Brachionus and Keratella were replaced by Filinia and Trichocerca in most months may be due to predation pressure on Keratella and Brachionus by planktivorous fish and/or cyclopoids in Lake Awasa, Ethiopia. But in the present study, Filinia sp., Monostyla sp. and Taphrocampa sp. coexisted with Brachionus spp., Keratella sp. and Lecane sp. during monsoon and totally absent in rest of the seasons during 2006-07 (Table 27 and 28). This indicated that they were recruited during connectivity. But in 2007-08, all the above mentioned taxa were found to be present throughout the year. Conochilus sp. was found to occur only during winter and Monostyla sp. was absent during monsoon which could be due to predation by Diaptomus sp. Cyclops sp. Diaptomus sp. and Mesocyclops sp. were the major taxa among the copepods in terms of density and abundance in both the years of study (Table 29 and 30). Helicyclops sp. was found to occur only in post-monsoon while Eucyclops sp. was found to occur only in monsoon during 2007-08. Eucyclops sp. was found to occur throughout the year except winter (2007-08). Nauplii larvae and Neodiaptomus sp. were found in both the years of study. Kedar et al. (2008) reported that presence of Cyclops sp., Diaptomus sp., Eucyclops sp., Nauplii sp., and Senecel sp. in Rishi Lake indicated that the lake is rich in organic matter. Pawar and Pulle (2005) also observed presence of Cyclops and Diaptomus in Pethwadaj dam, Nanded District (Maharashtra) India. Similar observation was also made by Somani and Pejaver (2004) in Lake Masunda. Among Anostraca, Streptocephalus sp. dominated over Chirocephalus sp. and found to be present throughout study periods (Table 27-30) which might be due to the fact that they were more resistant in variable environmental conditions and have differential feeding habits (Selvarani, 2009). Munuswamy et al. (2009) reported that Anostraca inhabit unpredictable environs, which dry up often or undergo wide physico-chemical variations. To overcome these unpredictable environmental conditions, many anostracans have evolved through interesting mechanisms viz, production of resistant-shelled and dormant embryo (resting eggs or cysts). The resting eggs of freshwater anostracans usually lie at the bottom of the water body and hatch in response to suitable environmental conditions. Chirocephalus sp. was found to be totally absent in post-monsoon during 2006-07 (Table 27) which could be due to predation by ornamental fishes (Selvarani, 2009) as they are the biggest individuals of zooplankton that have more pigments in the body and are more easily seen by predators in tropical environments (Zaret, 1975). Artemia sp. was found to be present in all the seasons during 2007-08 but it was totally absent during 2006-07. Their presence throughout in 2007-08 could be due to the recruitment during seasonal inundation and prolonged inundation might have helped them to grow. Actinophrys sp. was the only representative of protozoa and found in all the seasons during both the years of study (Table 27-30). Slight increase of their
population during monsoon and post-monsoon coincided with the increased level of BOD along with the increased concentration of NO$_3^-$ and PO$_4^{3-}$. Ghazy and El-Senousy (2008) also reported that ciliated protozoans are bio-indicators of organic pollution. Among Ostracods, *Cypris* sp. dominated over *Stenocypris* sp. and maximum density was recorded during pre-monsoon (2006-07) and monsoon (2007-08) (Table 27-30) which might be due to the increase of temperature and turbidity coupled with the increase of domestic activities providing favourable condition for their proliferation. *Stenocypris* was found to be absent during winter in 2006-07. Padmanabha and Belagali (2008) reported presence of several genera of ostracods (including *Cypris* sp. and *Stenocypris* sp) in the lakes of Mysore with highest density in summer and lowest in winter. In the present study *Zoea larvae* was the only representative of Decapoda high in number during winter during 2006-07 and totally absent in all the seasons during 2007-08 (Table 27-30). Fernandes et al. (2002) reported that brachyuran *Zoea* contributed 90% of total density of Decapods during winter which is in agreement with the present study.

**Zooplankton community Structure**

Fig. 106-109 and 110-113 depicted the seasonal variation of zooplankton species diversity indices in 10 different sampling stations of Chatla Floodplain Lake during the investigation period.

**Shannon-Wiener diversity Index ($H'$)**

**2006-07**

During 2006-07, Shannon-Wiener diversity Index ($H'$) was recorded highest in the station 5 (UB) in monsoon (2.42) followed by winter (2.35) (Fig. 106). Increased phytoplankton density and influx of nutrients from nearby catchments during monsoon corresponded to increased zooplankton density and diversity which is further confirmed by significant positive correlation of $H'$ with RF (Table 31). Battes, (2005) reported that high $H'$ of a system indicate favourable ecological condition. The Shannon-Wiener index of species diversity for the whole zooplankton community tends to decrease as water body becomes more eutrophic (Andronikova, 1996). In Chatla floodplain lake, $H'$ was found (>2) in all the lentic habitats and (<2) in lotic habitats which indicated that lentic water bodies provided specialized niches for zooplankton due to stable environmental conditions compared to the fast flowing lotic systems. Lowest value recorded in the station 1 (JC) during post-monsoon (Fig. 106) could be attributed to increased domestic activities deteriorating water quality.

**2007-08**

During 2007-08, highest value of Shannon-Wiener diversity Index ($H'$) was recorded in the station 6 (OW) during post-monsoon followed by station 7 (MB) during pre-monsoon (Fig. 110). Increased concentration of nutrients promoted the growth of phytoplankton and in turn zooplankton density and
diversity. This is confirmed by the significant positive correlationship of $H'$ with TA, BOD, NO$_3^-$, total phytoplankton density and $S$ (Table 32). Highest $H'$ - value in post monsoon conform to the findings of McClintock and Wilhm (1977) who suggested that zooplankton community maintaining high values of Shannon diversity Index ($H'$) from June to October generally reflect stable physicochemical environments. Similar view was also given by Ferrara (2002) from a study made on the Lake Bracciano, Latium, Italy. In the present study, the range of Shannon-Wiener diversity Index varied between 1.48-2.42 and 1.0-2.4 during 2006-07 and 2007-08 respectively. From all these facts it can be said that Chatla Floodplain Lake is a good habitat for zooplankton community due to the greater availability of foods and niche. Lowest Shannon-Wiener diversity Index (1.0) recorded in the station 1 (JC) could be due to the increased anthropogenic activities during pre-monsoon.

**Margalef’s Index (d)**

2006-07

Margalef’s Index (d) of species richness of zooplankton community showed highest value recorded in the station 5 (UB) during monsoon and lowest in the station 1 (JC) during post-monsoon (0.56) in 2006-07 (Fig. 107) which could be attributed to the permanently stable water body as well as the largest size of the managed fishery among all the stations. De Bie et al. (2008) reported that average local species richness in lentic systems tended to increase from small and temporary systems to larger and permanent systems. Increase in species richness during the high water phase (monsoon), by allochthonous contribution or habitat expansion and availability of food have been reported by several authors (Bozelli, 1994; Campos et al., 1996). Mala-Barbosa and Bozelli (2006) concluded that the inundation pulse, associated with characteristics of high turbidity determine the structuring of the zooplankton community at Lake Batata. In the present study also significant positive relationship of Margalef’s Index (d) with turbidity, SO$_4^{2-}$ and total zooplankton density could be recorded. Lowest species richness in the station 1 (JC) could be due to the fact that water flow in lotic systems may act as disturbance for zooplankton communities (De Bie et al., 2008).

2007-08

During 2007-08, highest value of Margalef’s Index (d) of species richness was recorded in post-monsoon (1.94) in the station 5 and 6 (UB and OW) and lowest in pre-monsoon (0.4) in the station 1 (JC) (Fig. 111). This may be due to the fact that large volume of flood water in the lentic systems during post-monsoon supported the zooplankton taxa by providing food and shelter. Ganesan and Khan (2008) reported that the high value of species richness reflects the suitability of the habitat for the organisms.

During seasonal inundation in monsoon water spread area of the Chatla floodplain increases to 1750 ha when zooplankton community get sufficient
space, food and sunlight for colonization which might be the reason for increase of zooplankton species diversity and richness. According to species area curve model several authors believed that species richness often increases with ecosystem size (Gaston, 2000) or lake area (Browne, 1981; Fryer, 1985; Dodson, O’Brien et al., 2004). Dodson et al. (2000) attributed higher species richness to larger mesotrophic lakes, which contain more distinct habitats and more resources than smaller lakes. However, Roozen (2005) suggested that zooplankton SW-diversity and taxonomic richness were not related to lake size or depth in a floodplain of Rhine.

**Evenness Index (J′)**

Evenness Index (J′) indicates on the evenness with which the individuals are apportioned among the species (Uttah et al., 2008). Evenness Index (J′) of zooplankton community showed almost similar pattern of seasonal variation in both the years of study (Fig. 108 and 112). Battes (2005) observed that Evenness or Equitability Index values ranged from 0.537 to 0.857, showing a relatively balanced community in Lake Știucii, Plain of Transylvania. In the present study, Evenness Index (J′) ranged from 0.77 to 0.95 and 0.74 to 0.95 in 2006-07 and 2007-08 respectively which was slightly higher than the above observations. Sharma (2009) reported that Evenness Index (J′) of microcrustacea ranged from 0.746 to 0.983 and 0.832 to 0.999 during 2002-03 and 2003-04, respectively in Loktak Lake (Ramsar Site), Manipur, North-East India which was very close to the results of present study observed in Chatla Floodplain Lake.

**2006-07**

During 2006-07, Evenness Index (J′) of zooplankton community showed highest value in post-monsoon (0.95) in the station 9 and 10 (GR and BR) and lowest in monsoon (0.77) in the station 4 (RB) (Fig. 108). Sharma (2009) reported that higher evenness reflects equitable abundance of various species and found peaks in the month of September (0.983) and November (0.999) i.e., post-monsoon. This coincided with the findings of the present study.

**2007-08**

During 2007-08, evenness Index (J′) was recorded highest both in winter and pre-monsoon (0.95) in the station 9 and 10 (GR and BR) respectively and lowest value was found in post-monsoon (0.74) in the station 4 (RB) (Fig. 112).

Lawal-Are et al. (2010) reported that equitability (evenness) Index of zooplankton community showed maximum value in the month of April in a Tropical Tidal Creek, Lagos, Nigeria and according to them high values of the diversity index indicate that the species are more evenly dispersed within the system. Our study also revealed highest evenness index in pre-monsoon in the station 9 (GR). However, Nwankwo et al. (2008) reported that the Equitability index of zooplankton community was found higher in wet months in Kuramo lagoon, Nigeria. Sharma (2009) found positive correlation of evenness with the
species diversity and abundance of microcrustacea in Loktak Lake (Ramsar Site), Manipur, North-East India. In Chatla Floodplain Lake, evenness Index (J') showed significant negative correlation with total zooplankton density and species diversity and Margalef’s Index (d) (Table 32).

**Berger-Parker Index of dominance (D_{BP})**

Berger-Parker Index of dominance (D_{BP}) of zooplankton community indicate highest density of single taxon dominating over the whole zooplankton community.

**2006-07**

During 2006-07, highest value of D_{BP} was recorded in pre-monsoon in the station 2 (BC) (Fig. 109). The zooplankton community was dominated by *Streptocephalus* sp. Lowest value of D_{BP} in monsoon (0.14) in the station 6 (OW) could be attributed to the high diversity index value in that season. This is confirmed further by the significant negative correlationship of D_{BP} with S, H', d and J' (Table 31). Sharma (2009) also revealed similar result in a study made on Loktak Lake (Ramsar Site), Manipur, North-East India.

**2007-08**

During 2007-08, it was also recorded highest in pre-monsoon in station 2 (BC) due to the dominance of *Chydorus* sp during pre-monsoon. Lowest D_{BP} was recorded in winter in the station 8 (SAL) (Fig. 113) which indicated lack of distinct qualitative importance of any individual species (Sharma, 2009).

**Canonical Correspondence Analysis**

CCA for zooplankton community revealed that during 2006-07. Water temperature, turbidity, K, BOD, SO_4 and rainfall were placed on the axis 2 and lied in the same direction which indicated that these parameters favoured increase of density, but EC, TDS positioned in the opposite direction of zooplankton density indicated that they have negative impact on the zooplankton density. Yildiz et al. (2007) reported that the total dissolved salt and electrical conductivity (EC) are important factors affecting zooplankton distribution is in agreement with the present study (Fig. 116). During 2007-08, again water temperature, BOD, PO_4 and rainfall have a direct effect on the growth and development of zooplankton community (Fig. 117).

The impressive species diversity observed for both phytoplankton and zooplankton agree with the aphorism that the status of phytoplankton species diversity influences the status of species diversity of organisms of higher trophic levels such as zooplankton, macro-invertebrates and vertebrates (Yakub, 2004).