



Phytoplankton species diversity indices in Anjanapura reservoir, Western Ghat region, India

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Publication Info

Paper received:
04 November 2011

Revised received:
07 June 2012

Accepted:
28 July 2012

Abstract

A qualitative study on species composition and diversity of phytoplankton flora was carried out in the Anjanapura reservoir. Water samples were collected monthly at four sites from November 2005 to October 2007 for plankton analysis. A total of 152 phytoplankton species belonging to 59 genera were recorded. The species belonging to genera *Crucigenia*, *Pediastrum*, *Scenedesmus*, *Tetraedron*, *Cyclotella*, *Gyrosigma*, *Melosira*, *Navicula*, *Fragillaria*, *pinnularia*, *Synedra*, *Closterium*, *Cosmarium*, *Euastrum*, *Staurastrum*, *Gleocapsa*, *Merismopedia*, *Microcystis*, *Oscillatoria*, *Euglena* and *Phacus* were found dominant. Phytoplankton density was recorded in the range of 222-1467 Org l⁻¹ for chlorococcales, 267-1467 Org l⁻¹ for diatoms, 44-889 Org l⁻¹ for desmids, 44-889 Org l⁻¹ for blue-greens and 22-1667 Org l⁻¹ for euglenoids. Seasonal density Shannon-Weiner diversity index (1.60-1.88) indicate that reservoir exhibited rich phytoplankton and Nygaard tropic status indices for myxophycean(1.0-1.50), chlorophycean(1.62-2.16), diatoms(0.10-0.14), euglenophycean(0.18-0.19) and compound quotient(3.25-4.66) showed that reservoir was moderately polluted. From the observed data, it could be concluded that the presence of more diverse group of phytoplankton indicate the productivity of the reservoir.

Key words

Phytoplankton diversity, Western ghats, Anjanapura reservoir.

Introduction

Phytoplankton are free floating unicellular, filamentous and colonial autotrophic organisms that grow in aquatic environments whose movement is more or less dependent upon water currents (Millman *et al.*, 2005). These micro flora act as primary producers as well as the basis of the food chain, source of protein, biopurifier and bioindicators of the aquatic ecosystems of which diverse array of life depends (Monika and Patralekh, 2004; Ariyadej *et al.*, 2004). They are considered as an important component of aquatic flora, play a key role in maintaining equilibrium between abiotic and biotic components of the aquatic ecosystem (Pandey *et al.*, 2004). However, their species composition, abundance and diversity are regulated by environmental factors like physico-chemical properties of water, meteorological characteristics of the region and morphometric and hydrographic features of the water body

(Dahl and Wilson, 2000). In general, different planktonic species can tolerate different ranges of temperature as well as light and nutrient limitation. These tolerant levels determine the dominance of different species within different seasons (Akbar *et al.*, 1999). The members of cyanobacteria are dominated in summer and autumn, whereas, bacillariophytes shows dominance in late winter and spring, and chlorophytes abundance in spring and autumn (Dao-Gui Deng *et al.*, 2007). Further, these entities can tolerate wide range of pollution in the aquatic environment. Therefore, in the study of the science of reservoirs, phytoplankton ecology is of special importance because they play a dynamic role in trapping solar energy and also reflects the average ecological condition (Kotut *et al.*, 1998). Keeping these in view, the present study was undertaken to evaluate phytoplankton species diversity indices which indicates the quality of water in Anjanapura reservoir of Western Ghat region.

Materials and Methods

Study area : The Anjanapura reservoir was constructed across the River Kumudvathi in 1936. Reservoir has catchment area of 520 sq.km with storage capacity of 39.77 million cubic meter. For study purpose, four sampling sites were selected to collect water sample. The geographic coordinates of each site was determined by Global Positioning System (GPS). The location of the sampling sites are indicated in the map (Fig. 1) : Site 1, Near Mahasathipura village at 14° 06.969'N, 75° 22.056' E (inlet of reservoir, River zone); Site 2, Near left bank channel, Koppadakere village at 14° 09.046' N, 75° 22.555' E; Site 3, Near Anjanapura village at 14° 09.462'N, 75° 23.168' E (outlet of reservoir, near dam wall); and Site 4, Beyond Anjanapura village, Shikaripur road at 14° 09.249' N, 75° 23.856' E.

Sample collection and identification : Surface water samples were collected monthly at four sampling sites in 1 l capacity polythene can from November 2005 to October 2007. Sample were scanned and identified for phytoplankton with the help of text books of Cox (1996), Desikachary (1959) and Prescott (1978). The density was enumerated using Sedgwick Rafter cell and calculated using standard methods (APHA, 2005). Seasonal (winter, summer and rainy) variation in phytoplankton density was calculated. Shannon-Wiener diversity index was calculated to know the diversity of phytoplankton (Shannon and Wiener, 1949). It was calculated from the proportional abundances (pi) of each species (abundance of the species

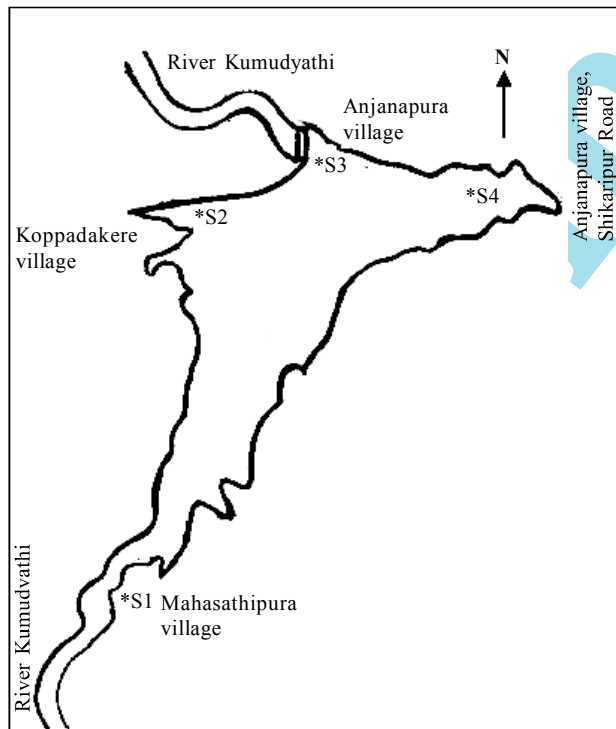


Fig. 1 : Sampling sites in Anjanapura reservoir, Western ghats, India

(n.) /total abundances (N) as

$$H' = - \sum p_i \ln p_i$$

Results and Discussion

In the present study, a total of 152 phytoplankton species belonging to 59 genera were identified from four sampling sites of the reservoir.

A total of 36 species of chlorococcales belonging to 15 genera were recorded and constituted 23.68% of total phytoplankton diversity (Table 1). The reservoir was predominantly occupied by *Chlorella vulgaris*, *Coelastrum microporum*, *Crucigenia rectangularis*, *Kirchneriella lunaris*, *Pediastrum duplex*, *P. simplex*, *Scenedesmus bijugatus*, *S. platydiscus*, *S. quadricauda*, *Schroederia setigera* and *Tetraedron trigonum*, whereas *Dictyosphaerium pulchellum*, *Hydrodictyon* sp, *Oocystis macropora* displayed scarce representation. As per diversity is concerned, more number of species were encountered at Sites 1 and 4 compared to the Sites 2 and 3. The genus such as *Chlorella*, *Coelastrum*, *Pediastrum* and *Scenedesmus* were found high in numbers during rainy season. Falco and Calijuri (2002) recorded a greater contribution of chlorophyceae during the rainy season in the American reservoir. On the other hand, *Chlorella vulgaris*, *Coelastrum microporum*, *Pediastrum duplex*, *P. simplex*, *Scenedesmus acuminatus*, *S. quadricauda* and *Tetraedron trigonum* showed repeated occurrence. Further, *Chlorella vulgaris*, *Coelastrum microporum*, *Scenedesmus quadricauda*, *Pediastrum duplex* and *Tetraedron muticum* were observed as pollution tolerant species in the reservoir. The chlorococcales density was recorded in range of 222 Org l⁻¹ at Site 1 (August 2007) to 1467 Org l⁻¹ at Site 4 (March 2007). Seasonal mean minimum density of 472 Org l⁻¹ at Site 3 during rainy season (2006-07) and maximum density of 1189 Org l⁻¹ at Site 4 during summer (2005-06) was recorded. This shows that their density was high in summer season

Table 1 : Phytoplankton composition in Anjanapura reservoir, Western ghat region

Family		Sites				Total	
		S-1	S-2	S-3	S-4	Genus	Species
Chlorococcales	Genus	13	13	12	14	15	36(23.68)
	Species	29	24	21	31		
Diatoms	Genus	19	21	16	18	22	45(30.26)
	Species	31	37	28	34		
Desmids	Genus	6	8	6	7	28	33(21.71)
	Species	19	28	24	26		
Blue-greens	Genus	9	8	7	8	10	20(13.16)
	Species	16	15	11	13		
Euglenoids	Genus	4	3	3	4	4	18(11.54)
	Species	15	9	7	12		

Values in parentheses are % diversity

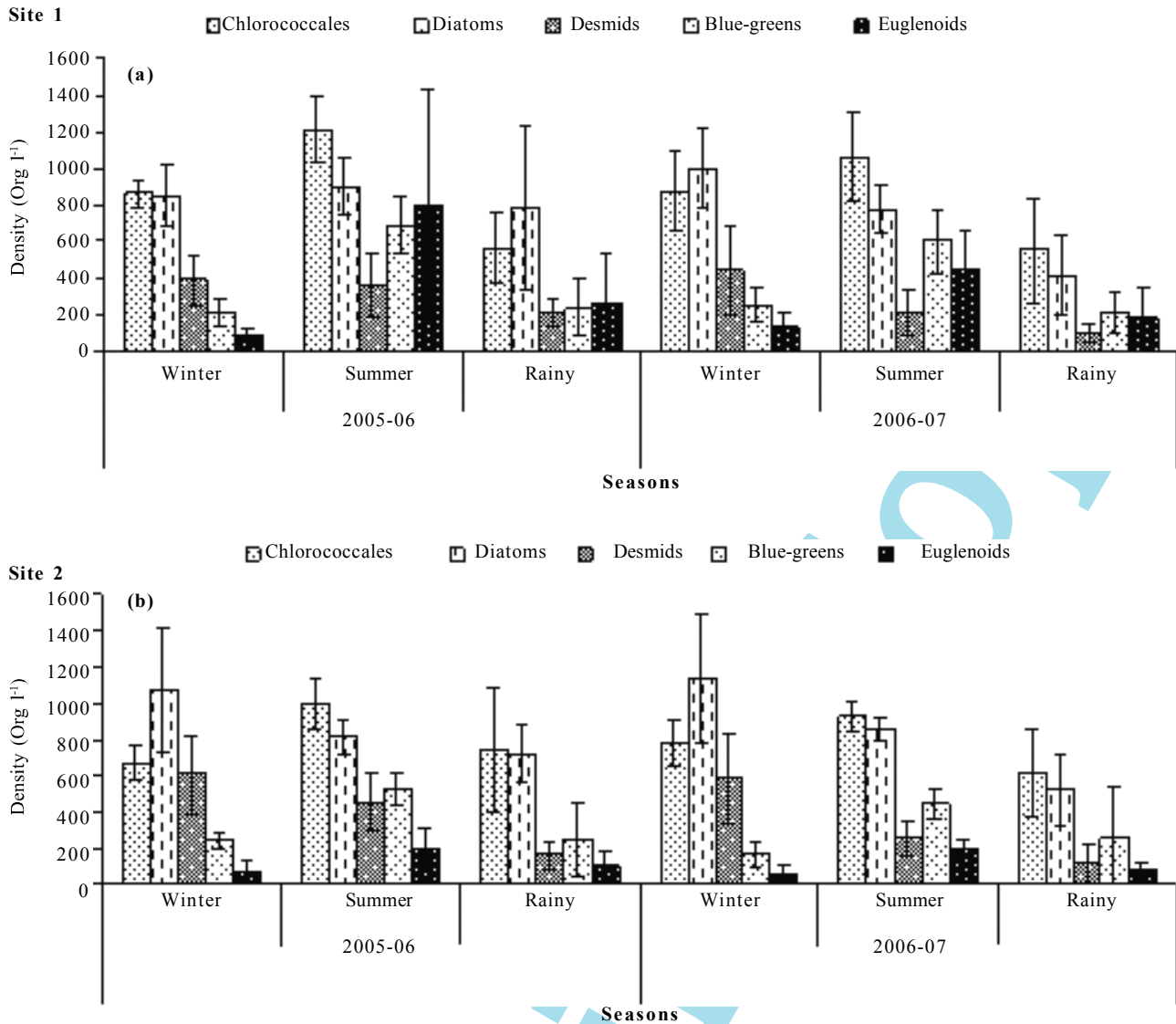


Fig. 2 : Seasonal variation of phytoplankton density in (a) Site 1 and (b) Site 2 in Anjanapura reservoir

followed by winter and rainy season (Fig. 2 a-d). The chlorococcales showed a significant positive correlation with the blue greens and euglenoids (at 0.05 level).

Among aquatic communities, diatoms are of great ecological significance because they comprise a major component of primary producers in aquatic ecosystems (Zalewski *et al.*, 1997). The reservoir harbors a total of 22 genera and 45 species of diatoms. This group contributes 30.26% of the total phytoplankton and occupies dominating position (Table 1). The species such as *Cyclotella meneghiniana*, *Cymbella turgida*, *Fragilaria capucina*, *Gomphonema tenellum*, *Melosira granulata*, *Navicula hustedtii* *krasske*, *Navicula mutica*, *Rhopalodia gibba* and *Synedra ulna* were recorded as dominant taxa in the reservoir. The rare species includes *Cocconeis placentula*,

Diatoma elongatum and *Nitzschia obtusa*. Their population was found high at Site 2 and 4. Ezra and Nwankwo (2001) recorded highest diatoms in Gubi reservoir. Cetin and Sen (1998) and Tahir *et al.* (2005) witnessed the species of *Melosira* and *Synedra* to occur throughout the year. The frequently reported forms were *Achnanthes minutissima*, *Cyclotella meneghiniana*, *Fragilaria capucina*, *Gyrosigma acuminatum*, *Melosira granulata*, *Navicula dicephala*, *N. mutica*, *Rhopalodia gibba* and *Synedra ulna*. The pollutant tolerant diatoms included *Cyclotella meneghiniana*, *Cymbella ventricosa*, *Navicula radiosa*, *Nitzschia obtusa*, *Pinnularia major* and *Synedra ulna*. However, the abundance of pennate diatoms compared to centric diatoms was recorded in the reservoir because the pennales, or pennate diatoms, occupy and dominate the freshwater environments (Hunter, 2007). With respect to

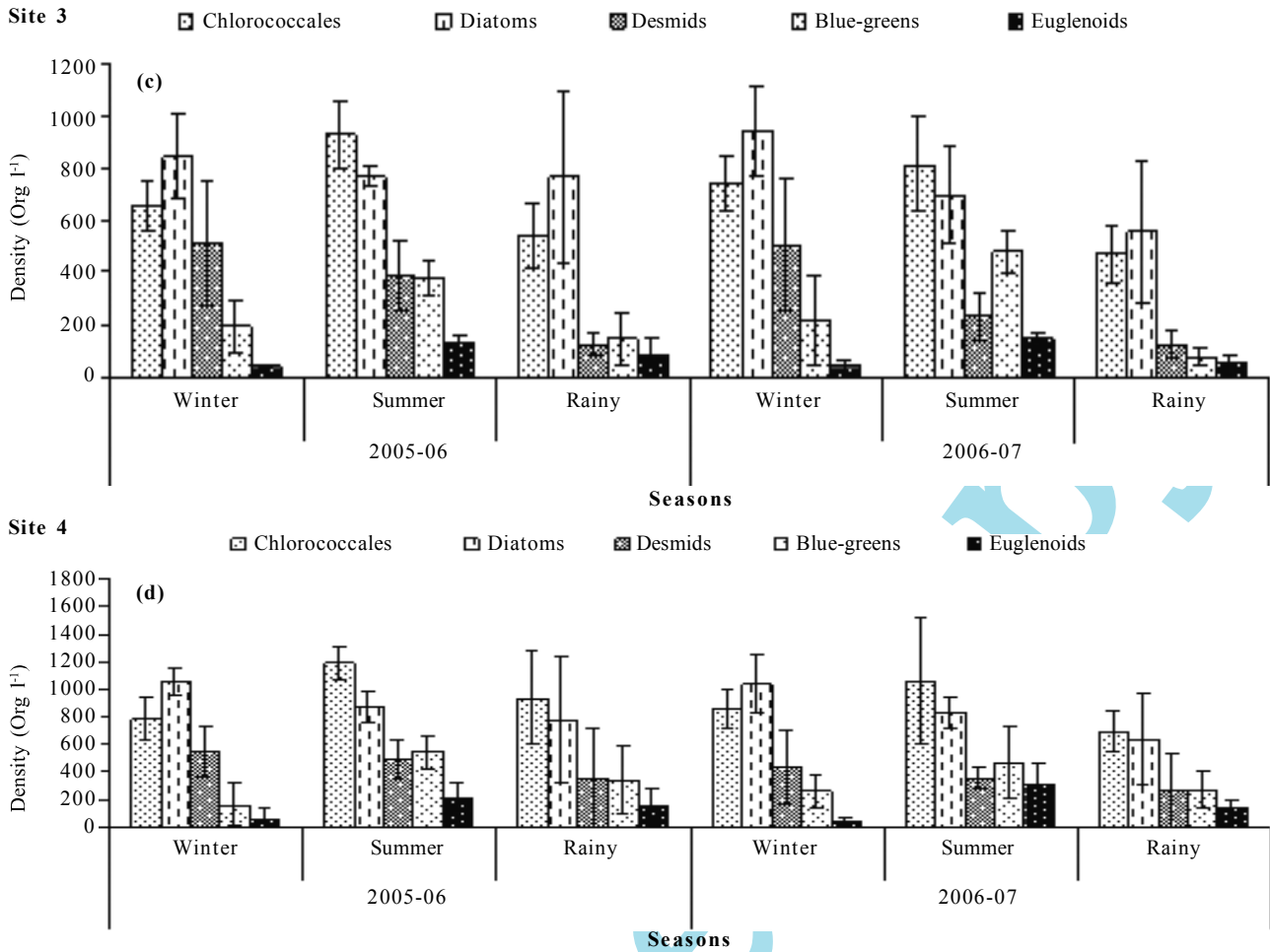


Fig. 2 : Seasonal variation of phytoplankton density in (c) Site 3 and (d) Site 4 in Anjanapura reservoir

density, they fall in the following range: 267 Org l⁻¹ at Site 1 (September 2007), Site 2 and 3 (June 2007) and 1467 Org l⁻¹ at Site 2 (November 2005). Mean seasonal density shows that a minimum average of 417 Org l⁻¹ at Site 1 during rainy season (2006-07) to maximum of 1133 Org l⁻¹ at Site 2 in winter season (2006-07). Seasonal fluctuation indicated that higher density existed in winter season followed by summer and rainy season (Fig. 2 a - d). Similar observation was also made by Bomchul *et al.* (2001) and Kuang *et al.* (2004). Samiha and Ahmed (2006) opined that diatoms preferred low temperature and nutrients. Further, Sabir and Fakhrudin (2007) opined that high density of bacillariophyceae indicated relatively unpolluted conditions. In the present study, diatoms exhibited significant positive relationship with desmids (at 0.05 level).

Desmids group consist of 28 genera and 33 species at all sites and represents 21.71% of the total phytoplankton diversity (Table 1). As per diversity is concerned, species such as *Closterium acerosum*, *C. arcuatum*, *Cosmarium arnelli*, *C. contractum*, *C. magneticum*, *C. pseudoconnatum*,

Euastrum flommeum and *Staurastrum gracile* were found predominant in the reservoir. The rare species included *Cosmarium cyclearis*, *C. subtumudum*, *Micrasterias incisor* and *Staurastrum longibrachiatum*. Besides, the species such as *Cosmarium contractum*, *C. depressum*, *C. pseudoconnatum*, *Euastrum flommeum* and *Staurastrum gracile* have shown repeated occurrence. According to Sabir and Fakhrudin (2007) the abundance of desmids clearly indicated unpolluted conditions. In the present study, Site 2, 3 and 4 indicated unpolluted zones of the reservoir due to presence of high desmid population. However, *Cosmarium retusifforme* and *Penium cucurbitinum* were identified as pollution tolerant species in the reservoir. Their density was recorded in the range of 44 Org l⁻¹ at Site 2 (September 2007) to 889 Org l⁻¹ at Site 4 (July 2006) and seasonal mean density varied between 100 Org l⁻¹ at Site 1 during rainy season (2006-07) to 606 Org l⁻¹ at Site 2 in winter season (2005-06) (Fig. 2 a - d). Their maximum number was attained in winter season. Which is in agreement with the study of Hulyal and Kaliwal (2009) who observed that desmids reached peak in winter and low in monsoon season of Almatti reservoir.

Table 2 : Shannon-Weiner diversity index for phytoplankton

Sampling Site	Shannon-Weiner diversity index(H')
S-1	1.88
S-2	1.72
S-3	1.60
S-4	1.77

Blue-greens are cosmopolitan microorganisms, which play significant roles in diverse ecosystems. In the present investigation, a total of 10 genera and 20 species (13.16%) were registered at all stations (Table 1). The dominant forms included *Chroococcus minor*, *Gloeocapsa minuta*, *Merismopedia glauca*, *M. tenuissima*, *Microcystis aeruginosa*, *Oscillatoria acuta* and *Phormidium jenkilianum* and rare forms such as *Anabaena spiroides*, *Gloeocapsa crepidinum*, *Nostoc microscopicum* and *Spirulina major*. However, some species such as *Anabaena*, *Chroococcus minor*, *Merismopedia glauca* and *Microcystis aeruginosa* occurred throughout the study period. Few pollutant tolerant species were also noticed in the reservoir which included: *Gloeocapsa crepidinum*, *Microcystis aeruginosa*, *Oscillatoria acuta*, *O. tenuis* and *Spirulina major*. Paramasivam and Srinivasan (1981) have reported that the polluted water bodies exhibited heavy growth of blue-green algae which also dominate over chlorophyceae and bacillariophyceae. In the present study, blue-green population was found to be lower than chlorophyceae and bacillariophyceae and it is witnessed the oligotrophic condition of the reservoir. Their population density was recorded in the range of 44 Org l⁻¹ at Site 1 (August 2006) and Site 3 (June & September 2007) to 889 Org l⁻¹ at Site 1 (March 2006). Whereas, an average seasonal density fluctuated between 72 Org l⁻¹ at Site 3 during rainy season (2006-07) and 689 Org l⁻¹ at Site 1 in summer season (2005-06). Further, mean seasonal fluctuation confirmed that density increased towards summer and falls in winter followed by rainy season (Fig. 2 a-d). In summer season bright sunshine and high temperature favours maximum growth of blue-greens. It was supported by Bomchul *et al.* (2001) and Aleksandar *et al.* (2007) who also observed the dominance of cyanobacteria population in summer season. The members of blue-greens showed significant positive correlation with euglenoids (at 0.05 level).

Euglenoids population consisted of 18 species belonging to 4 genera and contributed 11.54 %, a minor fraction of the phytoplankton group (Table 1). The dominant species included *Euglena acus*, *Euglena elastica*, *Euglena gracilis*, *Phacus curvicauda*, *Phacus tortus*, *Trachelomonas bulla* and *T. robusta*. The species such as *Euglena limnophila*, *Euglena spirogyra* and *Phacus helicoides* occurred rarely. They were represented by the genera *Euglena*, *Lepocinclis*, *Phacus* and *Trachelomonas*. The species like *Euglena acus*, *E. elastica*, *E. gracilis*, *Trachelomonas bulla* and *T. robusta* showed repeated occurrence. On the other hand, *Euglena limnophila*, *E. minuta*, *Phacus helicoides* and *Trachelomonas bulla* were observed to be pollutant tolerant species in the reservoir. On the other hand, euglenoids density varied from 22 Org l⁻¹ at Site 2 (December 2005 and November 2006), Site 3 (December 2005, August and November 2006, September and October 2007) and Site 4 (December 2005 and January 2007) to 1667 Org l⁻¹ at Site 1 (June 2006). This group exhibits least with respect to diversity as well as density. According to Nweze (2006), the low population of euglenophyceae is an indication of low organic pollution. Their mean seasonal values were observed in the range of 39 Org l⁻¹ at Site 3 during winter season (2005-06 and 2006-07) to 800 Org l⁻¹ at Site 1 in summer season (2005-06). Seasonal variation of euglenoids showed that their density was high during summer followed by rainy and winter season (Fig. 2 a-d). Similar observation were witnessed by Ashesh and Chauhan (2006) in the Kitham Lake, Agra.

Shannon-Weiner diversity index is most widely used index for measuring biological diversity. The higher value of H, the greater is the diversity and however, the maximum value of H can be more than 1. The decrease in the value of H is considered as an evidence of pollution. In the present study, diversity index (H) value was higher than 1 (1.60-1.88) at all the sites (Table 2). Hence, it indicates the more diversity of phytoplankton in the reservoir with moderate pollution. On the other hand, Nygaards index have been developed on the basis of the fact that various algal groups have different tolerance to organic pollution and nutrient enrichment. The Nygaard's trophic state indices for four sites of Anjanapura reservoir is represented in Table 3. The trophic state indices for myxophycean (1.0-1.50) and chlorophycean (1.62-2.16) at all sites indicated eutrophic condition. While the trophic state indices of diatoms (0.10-0.14) and euglenoids (0.15-

Table 3 : Nygaard's Status indices for phytoplankton in Anjanapura reservoir

Index	Trophic Status Indices	Site 1	Site 2	Site 3	Site 4	Range
Myxophycean	0.0-0.40.1-3.0	1.50	1.0	1.16	1.14	1.0-1.50
Chlorophycean	0.0-0.70.2-9.0	2.16	1.62	1.66	2.00	1.62-2.16
Diatoms	0.0-0.30.0-1.75	0.12	0.10	0.14	0.12	0.10-0.14
Euglenophycean	0.0-0.70.0-1.0	0.18	0.15	0.17	0.19	0.15-0.19
Compound Quotient(CQ)	0.0-1.01.2-2.5	4.66	3.25	3.66	4.00	3.25-4.66

0.19) indicate oligotrophic nature of reservoir at all sites. However, the compound index, which had wide range showed eutrophic nature of reservoir. The similar observation was also encountered by Jafari and Gunale (2006).

Phytoplanktons play a very important role as primary producers upon which the ecological dynamics of an aquatic water bodies depends. The Shannon-Wiener diversity index and Nygaards tropic status indices confirmed that reservoir is moderately polluted. Based on the observation, it can be concluded that Anjanapura reservoir is rich in diverse group of phytoplankton species and if this reservoir is protected, it will support fisheries production.

Acknowledgments

The authors are grateful to the authorities of Kuvempu University, Jnana Sahyadri, Shankaraghatta, Shimoga district, Karnataka, India for providing facilities to carryout the research work. We are also thankful to R&D division Scientist, Journal of Environmental Biology for their help.

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