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Monthly changes in the abundance and biomass of zooplankton and water quality parameters in Kukkarahalli Lake of Mysore, India

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Abstract

Zooplankton abundance and distribution are of ecological importance, as they are very sensitive to change, therefore zooplankton make ideal indicators of aquatic ecosystem. This study carried out on the abundance of rotifer, cladoceran, cyclopoid-copepod and ostracod zooplankton groups and biomass of total zooplankton were studied every month for one year. It is interesting and noteworthy to note that Calanoid and Harpacticoid zooplankton groups and free carbon dioxide were completely absent in all the four sampling sites throughout the study year. About 53% of the variation in the abundance of Cladoceran, 55% of variation in the Cyclopoid -copepod, 39% of variation in the ostracod and 53% of variation in the abundance of total zooplankton were mainly due to pH. Interestingly, negative relationship was found between the total zooplankton and concentration of phosphate as in this lake 67% decrease in wet biomass was mainly because of phosphate, where as 47% of dry biomass of total zooplankton was positively correlated with conductivity.

Key words

Plankton, Zooplankton, Biomass, Abundance, Water quality parameters

Introduction

The inland water bodies can be classified as either lotic (running water) or lentic (standing water). Lotic habitats include rivers, streams and brooks. Lentic habitats include lakes, ponds and marshes. Lakes are extremely variable in their physical, chemical and biological characteristics. Physically, they vary in terms of the level of light, temperature and water current. Chemically they vary in nutrients, major ions and contaminants and biologically in terms of biomass, population numbers and growth. Human intervention, different microbial abundance, water quality, nutrient supply, climatic variations are the main factors that determine the trophic status of the lake. Zooplankton community is highly sensitive to environmental variation. As a result, change in their abundance and species diversity or community composition can provide important indications of environmental change or disturbance, hence, they are of ecological importance. Zooplankton communities are typically diverse and occur in almost all lakes and ponds. Zooplankton communities respond to a wide variety of disturbances including nutrient loading (Pace, 1986; Dodson, 1992) acidification (Sprules, 1977) and fish densities (Canfield and Jones, 1996).

Internationally, several investigative studies have examined and reported about zooplankton in different regions of world. Rezai *et al.* (2003) studied on zooplankton biomass in the Straits of Malacca in Malaysia, and they have reported that the zooplankton biomass might be slightly overestimated in their study due to contamination of materials. Magalhaes *et al.* (2006) studied the spatial and temporal density and biomass distribution of the copepods in Caste river in Brazil and they determined copepod biomass using regression parameters based on the relation of dry weight and body length. Adel and Mahmoud (2006) studied on the factors affecting seasonal patterns in epilimnion zooplankton community in Africa. The main objective of their study was to determine which factors regulate zooplankton organisms along the lake; the lowest standing stock of zooplankton was noticed during spring due to highest fish predation associated with lowest turbidity and also temperature was considered as a controlling factor related to a range of tolerance of species. Chowdhury and Mamum (2006) studied on physico-chemical conditions and zooplankton population of two fish ponds in Khulna in Bangladesh and have reported maximum diversity and abundance of zooplankton in the months of August and September.

In India, many studies on physico-chemical and biological water quality parameters and abundance of zooplankton have been carried out. Sabu and Azis (1998) made some observations about plankton abundance in Peppara reservoir in Kerala, and reported that there are zonal differentiations in the abundance of zooplankton. Das *et al.* (2005) studied on zooplankton diversity of two fresh water and two brackish water wetlands of Goa and a total of 42 species of zooplankton have been recorded. Patil and Auti (2005) observed seasonal variations of zooplankton from Salim Ali lake of Aurangabad and reported the seasonal diversity of different zooplankton which indicates a characteristic pattern peculiar to water bodies in urban environment. In the study on the zooplankton diversity and physico–chemical conditions in the three perennial ponds of Virudhunagar district of Tamilnadu state, Rajagopal *et al.* (2010) have reported that the presence of certain species like, *Monostyla,*, *Keratella*, *Leydigia*, *Moinodaphnia*, *Diaptomus*, *Diaphanosoma* , *Cypris* and *Brachionus* are considered to be biological indicator for eutrophication.

In Karnataka state, Mridula *et al.* (2002) who studied on the distribution and abundance of copepods and copepodites in the Arabian sea off Mangalore receiving treated industrial effluents, and have reported more population density of copepods and copepodites in Chitrapur area when compared with the Panambur area, which is away from the effluent discharge point. In the study on the diversity and seasonal fluctuations of zooplankton in fish pond of Bhadra fish farm in Karnataka state, Kiran *et al.* (2007) have reported, the diversity of zooplankton showed distinct seasonal variations and their own maximal and minimal peaks. Kudari and Kanamadi (2008) studied impact of changed trophic status on the zooplankton composition in six water bodies of Dharward district of Karnataka state. In the study on zooplankton diversity of three fresh water lakes with relation to trophic status, in Gulbarga district, Karnataka state, Rajashekhar *et al.* (2009) have reported occurrence of 39 species of different groups of zooplankton. Locally, there are only few studies available on zooplankton diversity and seasonal variations in zooplankton population correlated with physico-chemical properties of water of lakes of Mysore. Padmanabha and Belagali (2007) studied the diversity indices of rotifers for the assessment of pollution in four lakes of Mysore city and reported that the rotifers in the Dalvoi lake were under more stress than the other three lakes. Koorosh *et al.* (2009) carried out investigative studies on the abundance of copepods on three contrasting lakes (Lingabudhi, Hebbal and Bannur) in Mysore and reported that the abundance of copepods were less than that of rotifers.

The main objectives are to study monthly variations in the abundance of rotifer, cladoceran, cyclopoid-copepod and ostracod zooplankton groups, wet and dry biomass of total zooplankton and water quality parameters, and to establish the relationship, if any, in Kukkarahalli Lake, Mysore city, India.

Materials and Methods

Counting of zooplankton: Water samples were collected every month between 6-8 am, from October 2008 to September 2009. One hundred liters of water sample was passed through 60 µm mesh size plankton net. 50 ml of the concentrated zooplankton sample was collected from the bottle attached at the end of plankton net. Identification and counting of organisms (Org l^{-1}) was carried out as given in Edmondson (1959) and Battish (1992). For the estimation of the zooplankton abundance, the modified Sedgwick-Rafter method as given in (APHA, 1992; Kamaladasa and Jayatunga , 2007) were followed. 5 ml from the concentrated sample from each sampling site *i.e.* S1 to S4 (Fig. 1) was transferred into Sedgwick- Rafter counting chamber (1 ml at time) and observed under Olympus binocular microscope.

Biomass estimation: Biomass of total zooplankton was measured using standard gravimetric method (Altaff,2004; Adel and Mageed, 2006). The 50 ml biomass sample was placed in a watch glass and adherent water, debris and phytoplankton were removed with the help of fine blotting paper as far as possible and noted the fresh wet weight of the zooplankton. Next, this pre-weighed sample was kept in an oven at 60°C for 48 hr. After cooling in a dessicator and it was weighed again and the dry weight was noted.

Determination of water quality parameters: The surface water samples were collected in 5 lit. plastic cans, early in the morning (6-8 am) from each site, every month from October 2008 to September 2009. Temperature and pH were recorded on the sampling sites itself and other water quality parameters were determined separately for all the samples in the laboratory by following standard methods (APHA, 1992; Trivedi and Goel 1986).

Statistical analysis: Relationships were examined using Pearson's correlation coefficient. This is calculated after $\log_{10}$ transformation of all the calculated data. The multiple regressions were used as per SPSS-11.5 version.

Results and Discussion

Zooplankton variables: The mean (data collected at 4 different sites for 1 year, *i.e.*, 12 months) of 48 samples of rotifer, cladoceran, cyclopoid-copepod and ostracod zooplankton groups recorded from the Kukkarahalli Lake, is shown in the Table.1.

The mean abundance of rotifers recorded was 81 Org l^{-1}. More monthly variation of abundance of rotifers (CV=111%) were noticed. However, maximum abundance of rotifers (283 Org l^{-1}) were noticed in the month of January 2009 and minimum (16 Org l^{-1}) in June 2009. However, the abundance of rotifers did not show any correlation with any of the water quality parameters (Table 3,5). This may be due to their special characteristic, *i.e.*, less specialized feeding and frequent parthenogenetic reproduction which is favoured in unstable and eutrophic environments. The results obtained in this study are similar to the study of Rocha and Sendacz Matsumura- Tundisi (1995) who made limnological studies of two

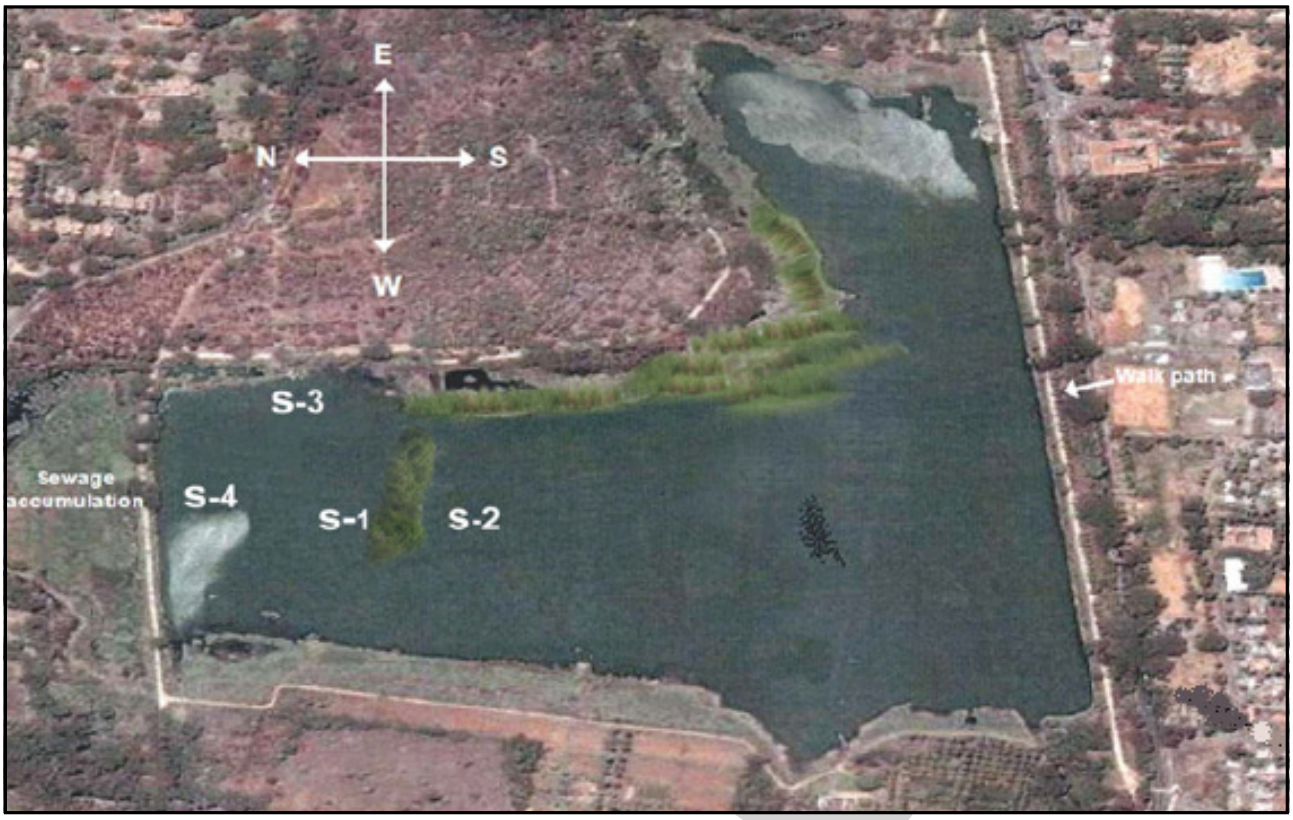

Fig. 1: Map showing sampling sites (S1-S4) on Kukkarahalli Lake, Mysore, India

Table - 1: Summary of the abundance of zooplankton groups determined in Kukkarahalli Lake, October-2008 to September 2009

Zooplankton groups (Org l^{-1})	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Mean± SD	CV%
		2008						2009						
Rotifers	20.0	156	21	283	38	157	184	27	16	28	19	22	81 ± 90	111
Cladocerans	53.0	91	697	204	275	356	147	16	8	9	8	24	157 ± 206	131
Cyclopoid – Copepods	15.0	16	163	223	120	51	403	71	258	30	15	55	117 ± 123	104
Ostracods	8.0	7	37	11	9	28	19	0	0	6	8	6	12 ± 11	95
Abundance of total Zooplankton	96	265	909	727	443	513	756	116	282	73	52	109	362 ± 303	84
Wet biomass (mg m^{-3})	11.7	10.17	33.8	17.9	9.9	19.9	22.5	35.8	8.4	6.9	7.2	3.9	16 ± 11	67
Dry biomass (mg m^{-3})	0.58	0.038	2.64	1.05	0.40	0.79	1.09	3.7	0.31	0.28	0.36	1	1 ±1	108

Values are Mean±SD, SD = Standard deviation, CV = Coefficient of variation, n = 48

ponds and reported that the abundance of rotifer were more in winter season and less abundant during rainy season.

The mean abundance of cladocerans recorded was 157 Org l^{-1} (Table.1). More monthly variation of abundance of cladocerans (CV=131%) were noticed during study period. However, maximum abundance of cladocerans (697 Org l^{-1}) were noticed in the month of December 2008 and minimum (8 Org l^{-1}) in June 2009. The cladocerans showed significant positive correlation only with pH and negative correlation with turbidity, phosphate and nitrate. In the present investigation, the regression analysis revealed that 53% of the variation in the abundance of cladocerans was due to pH in Kukkarahalli Lake. Moreover, other water quality parameters such as turbidity, nitrate, and phosphate also entered the regression equation and thus participated in deciding the abundance of cladocerans (Table 3,5). Yousuf and Quadri (1985) studied the seasonal fluctuation of zooplankton in lake Manasbal, Kashmir, State of India and reported that the abundance of Cladocerans were more during rainy season, and lowest during summer seasons. Similarly, Jindal and Ghezta (1991) studied limnology of Sukhana lake, Chandigarh and reported maximum abundance during rainy season and minimum abundance during summer season and Kiran *et al.* (2007) have studied diversity and seasonal fluctuations of zooplankton in a fish pond of Bhadra, Shankaraghatta, Karnataka and reported that the highest abundance of cladocerans were during rainy season, but the lowest abundance of cladocerans were during summer season.

Table - 2: Summary of water quality parameters in Kukkarahalli Lake, October-2008 to September-2009

Water quality parameters	Oct	Nov	Dec	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Mean± SD	CV%
		2008					2009							
Air temperature(°C)	23.75	23.75	15.5	24	26.3	24.5	22.3	24	22.8	22.7	23.7	20.5	22.8±2.7	11.8
Water temperature(°C)	24.75	23.25	19.75	25.75	27.7	25	25	25.7	24	24.7	20.5	20	23.8±2.5	10.5
pH (F) 9.22	9.22	9.90	9.75	9.80	9.88	9.85	9.30	9.60	9.17	9.35	9.20	9.5±0.3	3 . 16	
pH (L) 9.24	9.22	9.77	9.70	9.25	9.78	9.50	9.50	9.57	9.02	9.25	9.30	9.4±0.2	2 . 1	
Conductivity (μS^{-1})	1433	848	1633	2225	1718	1525	1695	1980	1757	1962	1695	2048	1709±354	20.7
Turbidity (NTU)	80	74	39	36	26	68	72	71	68	74	82	66	62.7±18.6	29.7
DO (mg l^{-1})	3.8	1.56	10.7	13.68	9.30	5.13	3.10	2.9	3.5	9.2	3.8	7.72	6.2±3.8	61.3
BOD (mg l^{-1})	8.5	3.56	2.7	3.61	2.90	4.08	5.1	6.3	5.9	1.2	1.07	5.10	4.2±2.2	52.4
COD (mg l^{-1})	2.6	4	2.8	4.4	18.8	2.8	18	8.8	4	6	4	5.7	6.9±5.6	81.2
CO_2 (mg l^{-1})	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hardness (mg l^{-1})	200	215	198	249	247	243	240	284	296	252	221	234	239.7±29.7	12.4
Calcium (mg l^{-1})	38	39	48	41	45	42	44	47	59	45	49	45	44.9±5.7	12.7
Alkalinity (mg l^{-1})	274	338	427	420	403	376.4	374	357	483	433	279	383	378.8±61.5	16.2
Chloride (mg l^{-1})	101	104	106	114	111	118	125	117	119	114	83	84	107.8±13.2	12.2
Phosphate (mg l^{-1})	0.95	0.73	0.79	0.77	0.67	0.60	0.77	0.64	1.01	2.90	2.97	2.9	1.3±0.98	75.4
Nitrate (mg l^{-1})	0.18	0.35	0.2	0.45	1.4	0.25	1.5	1.4	1.3	2.6	1.3	2	1.07±0.79	73.8
Sulphate (mg l^{-1})	13	33	40	26	30	39	78	49	45	179	185	173	73.9±65	87.9
TASA (mg l^{-1})	101	104	146	140	143	156	204	167	164	286	269	257	20.2±9.8	48.5
TSS (mg l^{-1})	22.5	45	22.5	27.5	40	32.5	65	52.5	47.5	60	50	32.5	41.5±14.2	34.2
POM (mg l^{-1})	1.8	1.75	2.25	4	3.75	4	4	3.25	3	3.5	2.8	3.5	3.1±0.8	25.8
Chlorophyll-*a* (µg l^{-1})	10.49	7.49	17.68	6.3	8.4	33.3	29	20.09	26.67	27.80	26.90	28.60	178±62.3	35.0

Values are mean±SD, SD = Standard deviation, CV = Coefficient of variation, n = 48

Table - 3: Interrelationships between zooplankton groups and water quality parameters in Kukkarahalli Lake, October-2008 to September-2009

Zooplankton groups	Water quality parameters
Rotifers	No significant correlation found
Cladocerans	pH(F)(+) **, Turbidity(-)*,PO_4 (-)*,NO_3(-)*
Cyclopoid-copepods	pH(F)(+)**, Turbidity(-)*,PO_4 (-)*, NO_3(-)*
Ostracods	pH(F) (+)*, Hardness(-)*
Abundance of total zooplankton	pH(F)(+) **, Turbidity(-)*,PO_4 (-)*, NO_3(-)*
Wet biomass	PO_4 (-) *
Dry biomass	Conductivity (+)*

Values are Pearson correlation coefficient, a 2-tailed test was applied and calculated after $\log_{10}$ transformation of all variables after scaling so that all values were >1, *p<0.05, **p <0.005 and NS= Non significant, Signs within parenthesis indicate positive (+) or negative (-) correlations

Table - 4: Interrelationships between water quality parameters in Kukkarahalli Lake, October-2008 to September-2009

Water quality parameters	Water quality parameters
Air temperature	Water temprrature (+)**
Water temprrature	Cl_2 (+) **
pH(F)	PO_4(-) *,Turbidity (-) *, pH(L) (+)*
pH(L)	PO_4(-)*
Conductivity	POM(+)** , DO(+)*
Turbidity	DO(-)*
BOD	SO_4(-)*
Hardness	NO_3(+)*
PO_4	Cl_2(-) *
NO_3	SO_4(+) **, COD(+)*
SO_4	PO_4 (+) **
Chlorophyll-*a*	TASA (+) **, SO_4 (+)*
TSS	COD(+)*
POM	NO_3 (+)** , Hardness (+)*
TASA	PO_3(+)** ,SO_4(+)**,NO_3(+)

Only those water quality parameters which showed correlation with other water quality parameters are shown in the table. Values are Pearson correlation coefficient, a 2-tailed test was applied and calculated after $\log_{10}$ transformation of all variables after scaling so that all values were >1, *p<0.05, **p<0.005. •Signs within parenthesis indicate positive (+) or negative (-) correlations

The copepods constitute dominant planktonic group of both freshwater and marine habitats. It includes three groups *viz*., Calanoid, Cyclopoid and Harpacticoid. It is interesting and noteworthy to record that Calanoid and Harpacticoid zooplankton groups were completely absent in all the 4 sites during the entire study period in Kukkarahalli Lake. In the present study it is observed that the pH value of surface water varies between 8.9 and 10.2. Many surface water supports extensive algal blooms particularly when the pH exceeds 10. This lake harbours an abundant growth of phytoplankton mainly *Microcystis aerugenosa* which occurred as a bloom during the entire study period. Algae use carbon dioxide in their photosynthetic activity, and its removal is responsible for such a high pH as reported by Purandara *et al*. (2003). Thus, this algae makes very little provision for the abundance of sensitive zooplankton groups and it is probably toxic to Calanoid and Harpacticoid, hence, in this study only Cyclopoid-copepods were noticed. The copepods described here include only the abundance of Cyclopoid-copepods. The mean abundance of Cyclopoid-copepods recorded was 117 Org l^{-1} (Table 1). More monthly variation (CV=104%) of abundance of cyclopoid-copepods were noticed. Maximum abundance of Cyclopoids (403 Org l^{-1}) were noticed in the month of April 2009 and minimum (15 Org l^{-1}) in August 2009. The abundance of Cyclopoid – copepods showed significant positive correlation with pH and they also showed significant negative correlation with turbidity, phosphate and nitrate. The regression analysis revealed that 55% of the cyclopoids were positively controlled by pH. Moreover, other water quality parameters such as nitrate, turbidity and phosphate also affected, but negatively, in deciding the abundance of Cyclopoids. Thus, it is notworthy that, when concentration of nitrate, phosphate and turbidity was more, the abundance of Cyclopoid were less (Table 3,5).

Ostracods are found in a wide variety of aquatic habitats where weeds and algae are abundant. Ostracods are very common in the most inland waters. The mean abundance of Ostracods recorded was 12 Org l^{-1}. More monthly variation (CV=95%) of abundance of Ostracods were noticed, as the abundance of Ostracods were completely absent in few months (May and June). The maximum abundance of Ostracods (37 Org l^{-1}) were noticed in the month of December 2009 (Table 1). The abundance of Ostracods showed significant positive correlation with pH and significant negative correlation only with hardness. The regression analysis revealed that the 39% of Ostracods were positively controlled by pH. Other water quality parameters like hardness also entered the regression equation (Table 3,5). These results agree with observation of Sampaio *et al.* (2002) who studied the composition and abundance of zooplankton in the limnetic zone of seven reservoirs in Brazil and reported that the abundance of Ostracods were maximum during the winter months and minimum during the rainy months. Choudhary and Singh (1999) studied zooplankton population of Boosra lake at Muzaffarpur, Bihar State of India, and reported that the abundance of zooplankton were more during winter months and less during rainy months. Kumar (2001) studied the fresh water zooplankton of some lake in Dharmapuri District, Tamil Nadu state of India and reported that the abundance of Ostracods were maximum during winter months and minimum during rainy months. Reet *et al.* (2007) noted significant changes in phytoplankton and zooplankton in lake Piepsi, Tortu, Estonia, and they have reported that the abundance of ostracods were highest during the summer months and lowest during the rainy months, which was mainly due to the seasonal changes and eutrophic condition of the lake.

Table - 5: Results of stepwise multiple regression analysis between various Zooplankton groups and water quality parameters in Kukkarahalli Lake, October – 2008 to September -2009

Zooplankton groups	Water quality parameters
Rotifers	No water quality parameters entered in the regression equation
Cladocerans	pH (F) (+), (R^2= 0.53, F= 11.56, P< 0.005), Turbidity (-), Nitrate (-), Phosphate (-) .
Cyclopoid-copepods	pH (F) (+), (R^2= 0.55, F= 11.97, P< 0.005), Turbidity(-), Nitrate (-), Phosphate (-).
Ostracods	pH(F) (+), (R^2 =0.39, F =6.62, P<0.05), Hardness (-).
Abundance of total zooplankton	pH(F) (+), Nitrate (-) , (R^2 =0.53 , F =11.56 , P<0.005) , Turbidity(-), Phosphate (-).
Wet biomass	Phosphate (-) , (R^2 =0.67, F = 5.34 , P<0.05) .
Dry biomass	Conductivity (+), (R^2 =0.47, F =8.9 , P<0.05).

Water quality parameters(independent) in the final regression equation (P in= 0.05, P out= 0.1) are shown multiple coefficients of determinations (R^2) and overall F and P values for each equation are given in the parenthesis. Water quality parameters which were not in the final equation but which are co-related ($p<0.05$) with the relevant zooplankton group variables are then listed in order of decreasing magnitude of correlation coefficient, the sign of the correlation is also indicated in the parenthesis.

The mean abundance of total zooplankton (which is the sum total of rotifer, cladoceran, Cyclopoid-copepod and ostracod groups) was 362 Org l^{-1} (Table 1). More monthly variation (CV=84%) in the abundance total zooplankton were noticed during the study period. However, maximum abundance of total zooplankton (909 Org l^{-1}) were noticed in the month of December 2008 and minimum (52 Org l^{-1}) in August 2009. This finding is in agreement with (Rocha *et al.*, 1995; Islam *et al.*, 1998; Islam, 2007; Choudhary and Singh 1999). The abundance of total zooplankton showed significant positive correlation only with pH and negative correlation with turbidity, phosphate and nitrate. In the present investigation, the regression analysis revealed that 53% of the variation in the abundance of total zooplankton was due to pH (+) and Nitrate (-) in Kukkarahalli Lake. Moreover, other water quality parameters such as turbidity and phosphate also entered the regression equation and thus participated in deciding the abundance of total zooplankton (Table 3,5).

Wet and dry biomass: Biomass is the total weight of all living material present in a unit area at a given time and gives and idea of the productivity of the ecosystem. The mean wet biomass of zooplankton recorded was 16 mg m^{-3}. More monthly variation (CV=67%) of wet biomass of zooplankton was noticed during the study period. However, maximum wet biomass (35.8 mg m^{-3}) of zooplankton was recorded in the month of May 2009 and minimum (0.038 mg m^{-3}) in September 2009. The mean dry biomass of zooplankton recorded was 1.0 mg m^{-3}. More monthly variation (CV=108 %) of dry biomass of zooplankton was noticed during the study period. However, maximum dry biomass (3.7 mg m^{-3}) of zooplankton were noticed in the month of May 2009 and minimum (0.04 mg m^{-3}) in November 2008 (Table.1). Thus, we recorded highest wet biomass during summer months and lowest during rainy months. Interestingly, the wet biomass of total zooplankton showed negative correlation with phosphate, where as the dry biomass of total zooplankton was positively correlated with conductivity. The regression analysis revealed that 67% of wet biomass was negatively controlled by phosphate concentration, where as 47% of dry biomass was affected by conductivity (Table 3,5). High values of wet and dry biomass in Kukkarahalli Lake may be due to entry of sewage that affects the zooplankton biomass indirectly by increasing the nutrients availability in water, which leads to an increase in the plankton biomass in these areas as recorded in the study of Adel Ali Mageed (2007) on biomass, production, and turnover rate of zooplankton in lake Manzala in South Mediterranean sea, Egypt.

Water quality changes: The mean (data collected at 4 different sites for 1 yr, *i.e.*, 12 months) of 48 samples of 21 water quality parameters recorded from the Kukkarahalli Lake (Table 2). Very high monthly variations (CV%= 20.7 to 87.9) was noticed in conductivity, turbidity, DO, BOD, COD, phosphate, nitrate, sulphate, TASA, TSS, POM and chlorophyll-*a* . However, little monthly variations (CV%=2.1 to 16.2) noticed in air temperature, water temperature, pH (F), pH (L), hardness, calcium, alkalinity and chloride (Table 2). The interrelationship between water quality parameters showed 23 significant correlations, out of which, 17 were positive and 6 were negative correlations in Kukkarahalli Lake (Table 4). Interestingly, free CO_2 was completely absent in this lake, throughout the study period. This is probably because the lake harbours an abundant growth of phytoplankton mainly *Microcystis aerugenosa* which occurs as a blooms throughout the study year. Algae and other aquatic plants mainly use CO_2 for their photosynthetic activity which naturally depletes CO_2, if it is not replenished by the aquaticanimal or zooplankton respiratory activities, during which O_2 is utilized and CO_2 is released. Even though there is abundance of zooplankton and other aquatic animals, still the CO_2 is completely absent, which is probably because of more utilization of CO_2 by phytoplanktons, than the amount of CO_2 released by zooplankton and other aquatic animals.

It is found that accelerated eutrophication has led to the deterioration of the water quality of Kukkarahalli Lake because of anthropogenic activities such as fishing, domestic waste disposal in the form of sewage *etc.*, If such activities continue, then the Kukkarahalli Lake will become completely a dead lake in course of time.

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