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STUDY OF ZOOPLANKTON OF CHILIYA BUND, SINDH WITH REFERENCE TO POPULATION DYNAMICS

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ABSTRACT

The main objective of the present work was to study the physico-chemical parameters and abundance of zooplanktons at Chiliya Bund. For this purpose regular trips were made on monthly basis during the whole study period. Physical factors and chemistry of lake water was analyzed with regular intervals. The color of water showed variation from light green to dark green, air temperature ranged between 21 ℃ to 35 ℃, water temperature between 19 ℃ to 33 ℃ , pH 6 to 7,dissolved oxygen 4.5 mg/L to 9.2 mg/L, salinity 0.18 mg/L to 0.766 mg/L, alkalinity from 30 mg/L to 155 mg/L, acidity 11 to 80 mg/L, sulphate 01 ppm to 380 ppm, phosphate from 4.6 ppm to 46 ppm, nitrates 14 ppm to 135 ppm during 2006, 2007 and 2008. Four groups of zooplankton were observed in decreasing order of abundance: Ostracoda, followed by other taxa, Cladocera, and Copepoda.

Key words: Zooplankton, Chiliya bund, population, Sindh.

INTRODUCTION

Chiliya bund is the outlet of Keenjhar Lake. It is located at latitude 24° 50′ 23.51" N and longitude 67° 59′ 36.16" E. In West Keerthar range, in North Makli hills, in East Indus River and agricultural fields and in extreme South Indus Delta are found. The area is mixture of rocks and sand. From this outlet water is supplied to nearby areas and to Karachi.

Freshwater lakes are an important source of drinking water and fisheries. It is estimated that freshwater lakes in Sindh account for 65% of the total freshwater fisheries in Pakistan, and more than 120 species of freshwater fish are found in the region. These lakes also provide a protein-rich food source in the form of fish and crustaceans. The relationship between biotic and abiotic components is clearly evident, as a change in a single factor can disturb the entire ecosystem. Singh *et al*. (1990) described seasonal and diurnal variations in the physico-chemical parameters of water and plankton.

The examination of water bodies and aquatic reservoirs in the past has been carried out for many different reasons. Baqai and Rehana (1973), Baqai, Siddiqui and Iqbal (1974 a), Baqai, Zuberi and Iqbal (1974b) worked on limnological studies of Kinjher Lake. Further work is of Najam-un-Nisa *et al*. (1987) and Azmi and Rao (2011).

MATERIAL AND METHODS

To study the physico-chemical parameters of Chiliya Bund, regular monthly sampling was conducted from January 2006 to December 2008. Water samples were collected from both sides of the bund and average values were calculated. Glass stoppered bottles and necessary reagents were taken in carriers and samples were examined and fixed on site. The color was observed visually. Water temperature was recorded by dipping a mercury thermometer directly into the lake while in air by holding in hand through a thread. pH was determined through "Merck Rollen Form Art.9564". Chemical analysis of sample water was carried out in the laboratory. Dissolved oxygen was estimated with the help of modified Winkler's method. Salinity was estimated by Mohar's method. Total alkalinity was analyzed according to APHA (1971). Acidity of the sample was estimated by using a HI.3820 Hanna Kit. Sulphate was analyzed by using Hi-38000 Hanna kit for sulphate test. To improve the method a Schimadzu – UV-120-02 spectrophotometer was used and reading was noted at wave length of 420 λ. Phosphate was analysed in the sample by using Hanna kit Hi-3833. The method was improved by using Schimadzu – UV-120-02 spectrophotometer at wave length of 880 λ (EPA method). To measure nitrate in water samples a Hanna kit Hi-3874

was used. Then reading was taken into Schimadzu – UV-120-02 spectrophotometer at wave length of 410 λ to improve the method. A dilution graph was made to convert the values of sulphate, phosphate and nitrate into ppm.

For the sampling of biomass, horizontal hauls were made for about 20 minutes from a boat at a slow speed 0.1 meter/sec. by using silk bolting cloth plankton net No.20 (335 µ mesh size), with 0.25 meter in diameter from Chiliya Bund, at regular monthly intervals. The plankton samples were preserved immediately in 4% formalin (in lake water) and were carried to the laboratory for further studies. The plankton catch was stirred and homogenous sample was taken in a measuring cylinder of 10 ml and then transferred into the counting tray and under a light compound microscope (LABOVAL 4) zooplanktons were identified upto genus level with the help of keys by Ward and Whipple (1959), Battish (1992), Najm-un-Nisa (1987) and Saleem (1988) and counting was made.

The statistical analysis was done by using MINITAB Release 14. Mean and Standard Deviations were taken out for physico-chemical factors and population of zooplankton. ANOVA and Regression analysis were also performed to find out relationship among ecological parameters and zooplankton abundance.

RESULTS AND DISCUSSION

(Table 1a,1b,1c) (January, 2006 to December, 2008)**:**

The color of water showed variation from light green to dark green due to suspended particles which are mostly microscopic algae (Schmitt, 2005). Air temperature ranged between 21 °C to 35 °C and water temperature varied between 19 °C to 33 °C during all the three years. The observed temperature is strictly attributed to weather conditions and suitable for production of plankton in tropical ponds (Jhingran, 1991, Begum *et al*,., 2003). Singh, *et al*., (1990) explained their influence upon the limnological phenomenon such as stratification, pH, dissolved gas and planktons. pH of surface layer varied from 6 to 7, means slightly acidic to neutral. Das and Srivastava (1956) explained biotic factor, like photosynthetic activity due to increased population of phytoplankton may support an increase in pH.

Dissolved oxygen contents of surface water were estimated lowest in June (2006, 2007 and 2008) when the temperature was noted highest while maxima was noted in January (2006, 2007 and 2008) when the temperature was lowest. Dissolved oxygen contents were declined with rising temperature at Chiliya Bund. This phenomenon was also noted by Welch (1952). He described that at low temperature water holds more gases than at high temperature, if no other factor is working. Salinity was recorded 0.18 mg/L to 0.766 mg/L**.** Maximum salinity was noted in September (summer) in all the studied years while least values were noted in (colder months) January (2006) and November (2007, 2008). Kumar *et al.*, (2002) also reported increase of salinity during summer and decrease in winter. In summer, water loss occurred due to evaporation that ultimately increased the salinity in lake (Hammer, 1990).

At Chiliya Bund maximum value of alkalinity was in September (2006, 2007 and 2008) while minimum quantity was in February and June (2006), July (2007) and in February (2008). The high range may be due to fall in water level as it was noted in pre- and post-monsoon season. Bicarbonates increase with fall in water level has also been reported by Singhal *et al*. (1986). In Haleji Lake, at higher temperature (24 – 32 °C) respiratory activities over succeeded the photosynthesis. That ultimately reduced the oxygen contents and water became slightly alkaline (Baqai, *et al*., 1974).

Acidity at Chiliya Bund was estimated from lowest 13mg/L (July, 2006), 11mg/L (July, 2007), 14 mg/L (January, 2008) to highest in May, 80 mg/L (2006), 70 mg/L (2007) and 60 mg/L (2008). The density and species of zooplankton are related to pH such as in acidic pH fewer species can survive. It was evident in Swedish lake where *Daphnia* sp. did not found at low pH (Almer *et al*, 1974, Hanson, 1974). In some lakes industrial wastes, organic acids may also contribute to acidity (Abbasi, 1998).

At Chiliya Bund highest value of sulphate was noted in April (2006), March (2007) and March and April (2008), while lowest quantity was noted in September (2006, 2007 and 2008). In Ramsagar reservoir sulphate concentration was high during summer season due to evaporation (Garg, *et al.*, 2010). Sulphate values were found between 244 to 325 mg/L in 3 different lakes of Chennai. Highest values were during summer and pre-monsoon period. It may also indicate enrichment due to insufficient inflow of rainwater.

In the present study the highest quantity of phosphate at Chiliya Bund was noted during September (2006 and 2008) and May (2007), while lowest values were noted in January in all years. Phosphates are liberated by zooplankton in Cayuga Lake during summer. Fluctuation in total phosphorus quantity shows fluctuated trophic status of the lake (Baloch and Suzuki, 2009).

At Chiliya Bund the maximum value of nitrate was noted in August (2006, 2007 and 2008) while minimum quantity was noticed in October (2006 and 2007) and January (2008). The nitrate concentration was high during summer season due to evaporation (Garg *et al*., 2010).

Table 1a. Physico-Chemical parameters of Chiliya Bund during January to December 2006.

Parameters	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec
Colour	Light Green	Light Green	Green	Dark green	Light Green	Green	Green	Green	Green	Green	Green	Green
Temperature(C°)Air	22	28	30	29	34	35	34	33	34	31	28	25
Temperature(C°)H_2O	19	26	28	27	32	33	32	30	32	28	25	23
pH	6	6.5	7	7	7	7	7	6.5	6.5	6.5	6.5	6.5
Diss.Oxygen(mg/L)	9.2	6.4	5.5	5.2	4.7	4.5	4.9	5.1	5.7	6.2	6.6	7.8
Salinity(mg/L)	0.18	0.433	0.41	0.4	0.433	0.366	0.4	0.4	0.766	0.53	0.2	0.28
Alkalinity(mg/L)	50	30	35	140	95	30	40	45	155	35	40	60
Acidity(mg/L)	14	16	20	24	80	28	13	32	30	60	34	20
Sulphates(mg/L)	13	260	310	380	5.1	70	285	11.1	1	80	22	21
Phosphates(mg/L)	4.6	6.2	8	10	43	13.4	26	13.4	46	29	17	12.7
Nitrates(mg/L)	18	23	32	26	39	58	36	135	39	17	28	21

Table 1b. Physico-Chemical parameters of Chiliya Bund during January to December, 2007.

Parameters	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
Colour	Light Green	Light Green	Green	Green	Light Green	Green	Green	Green	Green	Green	Green	Green
Air Temp.(C°)	21	27	30	31	35	35	34	33	34	32	28	25
Water Temp.(C°)	19	25	27	29	32	33	31	31	31	30	25	22
pH	6	6.5	7	7	7	7	7	6.5	6.5	7	6.5	6.5
Diss.Oxygen(mg/L)	8.1	6.2	5.9	5.5	5.3	4.8	5.1	4.9	5.4	5.1	6.5	6.8
Salinity(mg/L)	0.2	0.42	0.41	0.42	0.433	0.354	0.4	0.41	0.723	0.55	0.19	0.25
Alkalinity(mg/L)	45	35	40	130	100	40	30	40	135	45	55	50
Acidity(mg/L)	13	15	18	22	70	32	11	35	27	55	36	23
Sulphate (mg/L)	12	210	270	240	6	58	267	13	2	75	23	23
Phosphate (mg/L)	5	7	10	14	45	15	24	14	42	25	21	13
Nitrate (mg/L)	16	21	30	24	41	55	32	120	33	14	24	19

Table 1c. Physico-Chemical parameters of Chiliya Bund during January to December 2008.

Parameters	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec
Colour	Light Green	Light Green	Green	Dark green	Light Green	Green	Green	Green	Green	Green	Green	Green
Temperature(C°) Air	21	28	30	30	34	35	34	33	34	32	29	25
Temperature(C°) H_2O	18	25	27	28	32	33	32	30	32	29	26	23
pH	6	6.5	7	7	7	7	7	6.5	6.5	6.5	6.5	6.5
Diss.Oxygen(mg/L)	8.6	6.3	5.9	5.6	5.2	4.6	5.1	5.2	5.6	5.7	6.7	6.5
Salinity(mg/L)	0.19	0.433	0.42	0.4	0.42	0.35	0.4	0.41	0.73	0.51	0.18	0.26
Alkalinity(mg/L)	50	30	40	135	90	35	35	45	145	45	45	50
Acidity(mg/L)	14	16	19	23	60	30	12	34	29	37	37	21
Sulphates(mg/L)	13	230	290	290	5.6	62	274	12.1	2	21	21	21
Phosphates(mg/L)	4.8	6.6	9	12	40	14.2	25	13.8	43	18	18	14
Nitrates(mg/L)	17	22	31	25	40	56	34	125	35	25	25	18

Table 2. Standard Deviation and Mean of Air and Water Temperature and pH of Chiliya Bund from January, 2006-December, 2008.

	Air Temp. (C°)	Water Temp. (C°)	pH
Months	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**
January	21.33 ± 0.58	18.67 ± 0.58	6.00 ± 0.00
February	27.67 ± 0.58	25.33 ± 0.58	6.50 ± 0.00
March	30.00 ± 0.00	27.33 ± 0.58	7.00 ± 0.00
April	30.00 ± 1.00	28.00 ± 1.00	7.00 ± 0.00
May	34.33 ± 0.58	32.00 ± 0.00	7.00 ± 0.00
June	35.00 ± 0.00	33.00 ± 0.00	7.00 ± 0.00
July	34.00 ± 0.00	31.67 ± 0.58	7.00 ± 0.00
August	33.00 ± 0.00	30.33 ± 0.58	6.50 ± 0.00
September	34.00 ± 0.00	31.67 ± 0.58	6.50 ± 0.00
October	31.67 ± 0.58	29.00 ± 1.00	6.67 ± 0.29
November	28.33 ± 0.58	25.33 ± 0.58	6.50 ± 0.00
December	25.00 ± 0.00	22.67 ± 0.58	6.50 ± 0.00

Table 3 Standard Deviation and Mean of Dissolved Oxygen, Salinity, Alkalinity and Acidity of Chiliya Bund from January, 2006- December, 2008.

	Diss. Oxygen (mg/L)	Salinity (mg/L)	Alkalinity (mg/L)	Acidity (mg/L)
Months	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**
January	8.63 ± 0.55	0.19 ± 0.01	48.33 ± 02.89	13.67 ± 0.58
February	6.30 ± 0.10	0.43 ± 0.01	31.67 ± 02.89	15.67 ± 0.58
March	5.77 ± 0.23	0.41 ± 0.01	38.33 ± 02.89	19.00 ± 1.00
April	5.43 ± 0.21	0.41 ± 0.01	135.00 ± 05.00	23.00 ± 1.00
May	5.07 ± 0.32	0.43 ± 0.01	95.00 ± 05.00	70.00 ± 10.00
June	4.63 ± 0.15	0.36 ± 0.01	35.00 ± 05.00	30.00 ± 2.00
July	5.03 ± 0.12	0.40 ± 6.81	35.00 ± 05.00	12.00 ± 1.00
August	5.07 ± 0.15	0.41 ± 0.01	43.33 ± 02.89	33.67 ± 1.53
September	5.57 ± 0.15	0.74 ± 0.02	145.0 ± 10.00	28.67 ± 1.53
October	5.67 ± 0.55	0.53 ± 0.02	41.67 ± 05.78	50.67 ± 12.09
November	6.60 ± 0.10	0.19 ± 0.01	46.67 ± 07.64	35.67 ± 1.53
December	7.03 ± 0.68	0.26 ± 0.02	53.33 ± 5.77	21.33 ± 1.53

Table 4. Standard Deviation and Mean of Sulphate, Phosphate and Nitrate at Chiliya Bund from January, 2006-December, 2008.

	Sulphate (ppm)	Phosphate (ppm)	Nitrate (ppm)
Months	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**
January	12.67 ± 0.58	04.80 ± 0.20	17.00 ± 1.00
February	233.33 ± 25.17	06.60 ± 0.40	22.00 ± 1.00
March	290.00 ± 20.00	09.00 ± 1.00	31.00 ± 1.00
April	303.33 ± 70.95	12.00 ± 2.00	25.00 ± 1.00
May	05.57 ± 0.45	42.67 ± 2.52	40.00 ± 1.00
June	63.33 ± 6.11	14.2 ± 0.80	56.33 ± 1.53
July	275.33 ± 9.074	25.00 ± 1.00	34.00 ± 2.00
August	12.07 ± 0.95	13.73 ± 0.31	126.67 ± 7.64
September	01.67 ± 0.58	43.67 ± 2.08	35.67 ± 3.05
October	58.67 ± 32.72	24.00 ± 5.57	18.67 ± 5.69
November	22.00 ± 1.00	18.67 ± 2.08	25.67 ± 2.08
December	21.67 ± 1.15	13.23 ± 0.68	19.33 ± 1.53

Table 5. One-Way ANOVA of all Physico-Chemical Parameters of Chiliya Bund from January, 2006- December, 2008.

Parameter	F-Value	P-Value	Remarks
Air Temperature(C°)	1.27	0.295	Non Significant
Water Temperature(C°)	0.00	1.00	Non Significant
pH	0.06	0.938	Non Significant
Diss.Oxygen (mg/L)	0.08	0.922	Non Significant
Salinity (mg/L)	0.01	0.991	Non Significant
Alkalinity(mg/L)	0.00	0.998	Non Significant
Acidity (mg/L)	0.11	0.897	Non Significant
Sulphate (ppm)	0.10	0.906	Non Significant
Phosphate (ppm)	0.04	0.965	Non Significant
Nitrate (ppm)	0.04	0.959	Non Significant

Zooplankton

Quantitative analysis indicated that zooplankton comprised crustaceans, insect larvae, nematode worms and tardigrades. Amongst crustacean group, cladocera, copepoda and ostracoda were recorded. A total of 33 types of zooplankton were studied. The most abundant group was Ostracoda, and least abundant group was Copepoda. Among all genera Nematode worms were the only zooplankton type that was found continously in all study years.

1.Cladocera: (Fig.1)

A total of 10 genera belonged to this group out of 33 genera of all zooplankton recorded. This was the third abundant group. None of the genera was found throughout the all 3 years.

This group constituted 13.27% of the total zooplankton population in 2006 (Fig.5a), 14.03% in 2007 (Fig.5b) and 13.84% in 2008 (Fig.5c). In all the study years maximum population was noted in September (72.73%, 67.35% and 64.58%) respectively and minimum was in April (05.68%, 05.64% and 05.58%) respectively. Only *Chydorus* sp. was showed maximum population in all the three years. The least abundant genera were *Moina* sp. and *Daphnia* sp. (0.10%) in 2006. A rhythmic up and down in population was evident. The genus found were *Chydorus*>*Ceriodaphnia*>*Bosmina*>*Alona*>*Bosminopsis*>*Macrothrix*>*Diaphanosoma*>*Moinodaphnia*>*Daphnia* and *Moina*.

In 2007, none of the genus was found continuous throughout the study year. The least frequently found genus was *Moina* sp. The genus found were *Chydorus*> *Bosmina*>*Alona*> *Ceriodaphnia*>*Bosminopsis*>*Macrothrix*> *Diaphanosoma*>*Moinodaphnia*>*Daphnia* and *Moina*.

The least frequently found genus was *Daphnia* sp. (0.23%) in 2008. The genus found were *Chydorus*> *Bosmina*>*Alona*> *Ceriodaphnia*>*Bosminopsis*>*Macrothrix*>*Diaphanosoma*>*Moina* and *Moinodaphnia*>*Daphnia*. The seasonality of plankton shows that the favorable time for primary production is from August to November due to monsoon rainfall that brings nutrient (Chowdhury *et al*., 2007). The lowest numbers of species of zooplanktons were noted in cold and dry season, while onset of wet season they increased quantitatively (Lopez *et al*., 1999). At Chiliya Bund the continously found genus was *Chydorus* (2006). *Chydorus* is found in shallow water while *Bosmina* and *Bosminopsis* are found near the edges (Baloch *et al*, 1998). At Chiliya Bund the continuously found genera were *Moina* (2006, 2007) and *Daphnia* (2006, 2008). *Macrothrix* and *Sida* appeared for a short time period with low density throughout the study period (Iqbal *et al*., 1990).

2.Copepoda : (Fig. 2)

A total of six genera were recorded from this group. It was the least abundant group among all the samples collected during the study period. No single genus was consistently present in all samples.

It constituted 05.24% of the total zooplankton population in 2006 (Fig.5a), 06.05% in 2007 (Fig.5b) and 6.04% in 2008 (Fig.5c). The maximum population was observed in August 33.33%, 25.93% and 25.00% in 2006,2007 and 2008 respectively. While minima were noted in June (01.14%) 2006 , April (01.10%) and June (01.10%) 2007 and 0.84% in 2008. In 2006, the maximum popultion of *Mesocyclops* (1.73%) was evident while *Diaptomus* was only 0.31% (least). The sequence of abundance was *Mesocyclops*>*Cyclops*>*Eucyclops*> *Heliodiaptomus*>*Attheyella*> *Diaptomus.*

In 2007, the most abundant genus was *Mesocyclops* while *Attheyella* was scarcely found (0.42%). The sequence of abundance was *Mesocyclops*>*Cyclops*>*Eucyclops*>*Heliodiaptomus*> *Diaptomus* >*Attheyella.* In 2008, no one genus was continuously found. Maximum population of *Mesocyclops* sp. (02.07%) and minimum population of

Attheyella sp. (0.36%) was observed. This might be due to fish predation that maintain the size of zooplankton communities (Brooks and Dodson, 1965; Rodriguez *et al*., 1993). Planktivorous fish affects the density of zooplankton (Iqbal, 1989). At Chiliya Bund no one genus was perennial from this group.Cyclopoid copepoda were captured in high density from Hub lake during June, August and January, (Iqbal, 1989). Copepods were maximum in August in lake water (Manca, *et al*., 1999). *Attheyella* and *Diaptomus* were the only copepods that were least found at all study years. The sequence of abundance was *Mesocyclops>Cyclops>Eucyclops>Diaptomus >Heliodiaptomus> Attheyella.*

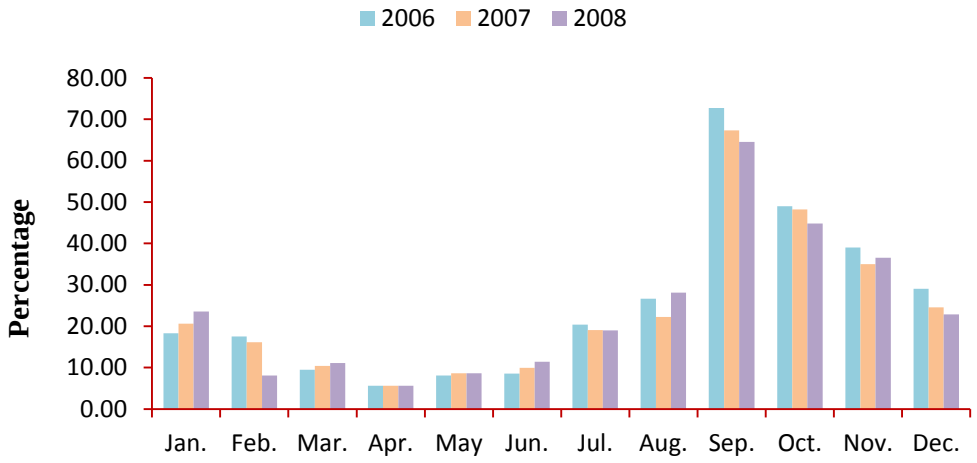


Fig.1. Monthly variation of total Cladocera at Chiliya Bund during 2006, 2007 and 2008.

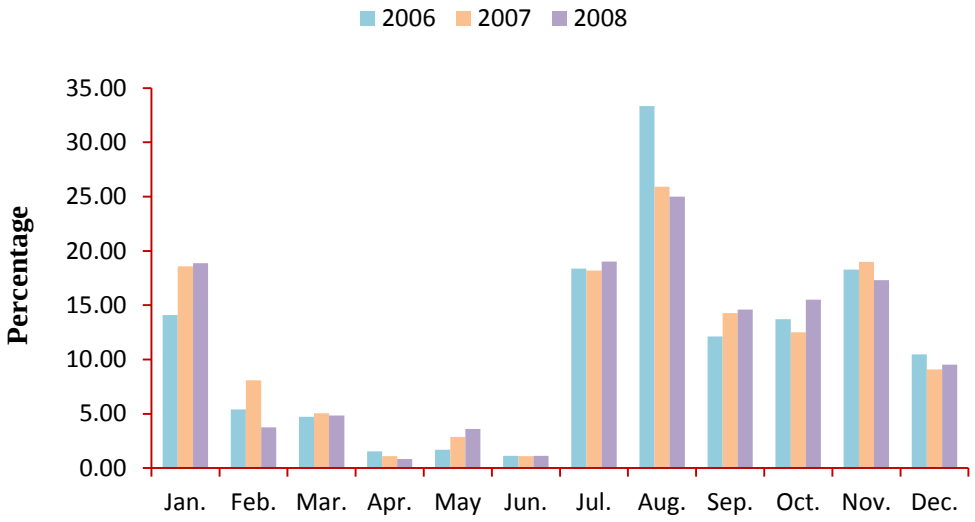


Fig. 2. Monthly variation of total Copepoda at Chiliya Bund during 2006, 2007 and 2008.

3. Ostracoda: (Fig.3)

A total of 10 genera out of 33 were recorded from this group. This was the most abundant group among all zooplankton found at Chiliya Bund. No one genus was continously found.

This was the most frequently occurring group among crustacean zooplankton at Chiliya Bund, constituting 58.72% in 2006 (Fig.5a), 57.48% in 2007 (Fig.5b), and 58.61% in 2008 (Fig.5c). The maximum population was observed in June (88.07%) in 2006, (86.19%) in 2007 and 84.00% in 2008, might be due to nutrient rich water inflow (Paulose and Maheshwari, 2008). While the minimum population was in September (06.06%) in 2006, (10.20%) in 2007 and (12.50%) in 2008 .The most abundant genus was *Cyprinotus* sp. (30.10%) in 2006, (28.16%) in 2007 and (26.78%) in 2008, not only from this group but in all zooplanktons, might be in egg stage (Ferguson, 1944). They showed their maxima in summer while minima in monsoon season (Kedar, *et al*., 2008). The least abundant genera were *Stenocypris* sp. (0.10%) in 2006, (26.78%) in 2008 and *Candona* sp. With 0.38% in 2007. Predation plays an important role in structuring zooplankton community size (Masson, *et al*., 2004). During 2006, the genus were found in sequence of *Cyprinotus*>*Cypria*>*Cyclocypris*>*Eucypris*>*Cypridopsis*>*Darwinula*> *Heterocypris*>*Cndona*> *Herpetocypris*>*Stenocypris*.

In 2007, the genus were found in sequence of *Cyprinotus*> *Cyclocypris*>*Cypria*> *Eucypris*> *Heterocypris*> *Herpetocypris*> *Cypridopsis*>*Darwinula*>*Stenocypris*> *Candona*. In 2008, the genus were found in sequence of *Cyprinotus*>*Cypria*>*Cyclocypris*>*Eucypris*>*Heterocypris*>*Cypridopsis*>*Darwinula*>*Candona*>*Herpetocypris*>*Ste nocypris*.

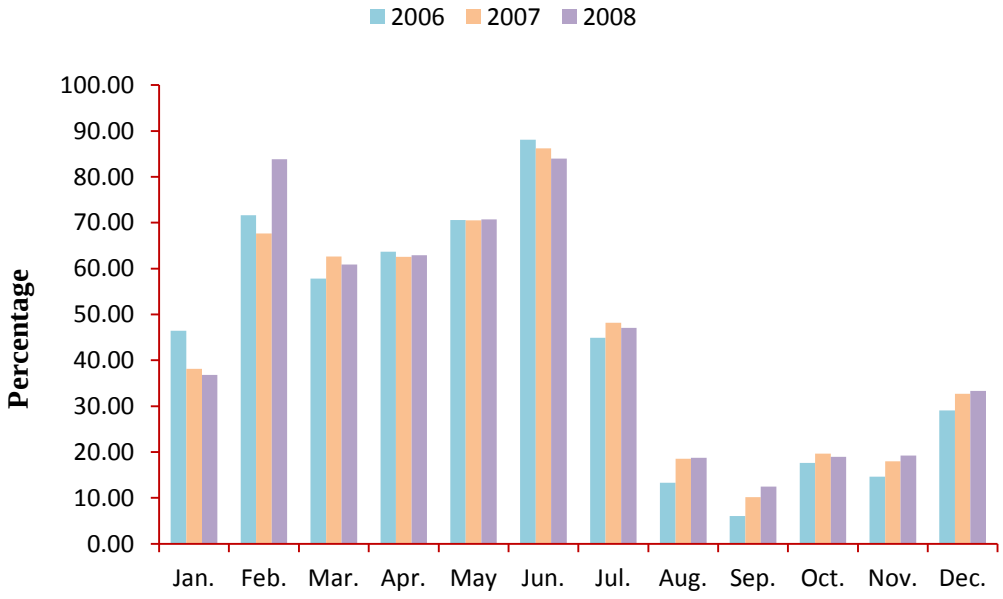


Fig.3. Monthly variation of total Ostracoda at Chiliya Bund during 2006, 2007 and 2008.

4.Other Taxa:- (Fig.4)

Out of the 33 genera recorded, seven belonged to this group. Only nematodes were present throughout the entire study period. This was the second most abundant group among all zooplankton collected from Chiliya Bund. Nematodes were the only zooplankton group that showed a continuous presence over all three years.

This group shared 22.78% in 2006 (Fig.5a), (22.43%) in 2007 (Fig.5b) and 21.51% in 2008, among all zooplankton groups (Fig.5c). The maximum population was recorded in December (31.40%) in 2006, (33.64%) in 2007 and (34.29%) in 2008. The minimum population was observed in June (02.27%) in 2006, (02.76%) in 2007 and (03.43%) in 2008. The most abundant zooplankton of this group was Nematode worms (18.81%, 18.25% and 17.54%) in 2006,2007 and 2008, respectively and least abundant was *Corethera* larva (0.25%) in 2006, (0.38%) in 2007 and 0.14% in 2008 with Back swimmer (0.14%). *Chaoborus* larvae are limited due to the rate of deficiency of oxygen and stratification. They are common in oxygen depleted waters (Sæther, 1997; Liljendahl-Nurminen *et al*., 2002).

The sequence of abundance of organisms was Nematode worms> Mayfly nymph>Water mites> Tardigrades> Back swimmer>*Corethera* larva in 2006.

In 2007 The abundance of organisms was Nematode worms> Tardigrades> Mayfly nymph>Water mites> Back swimmer>*Corethera* larva. In 2008, the abundance of organisms was Nematode worms> Mayfly nymph>Water mites> Tardigrades>Back swimmer and *Corethera* larva.

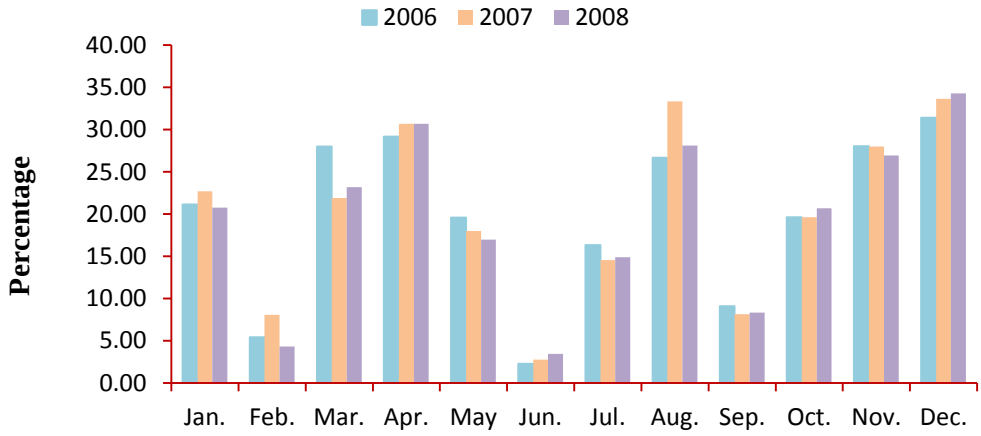
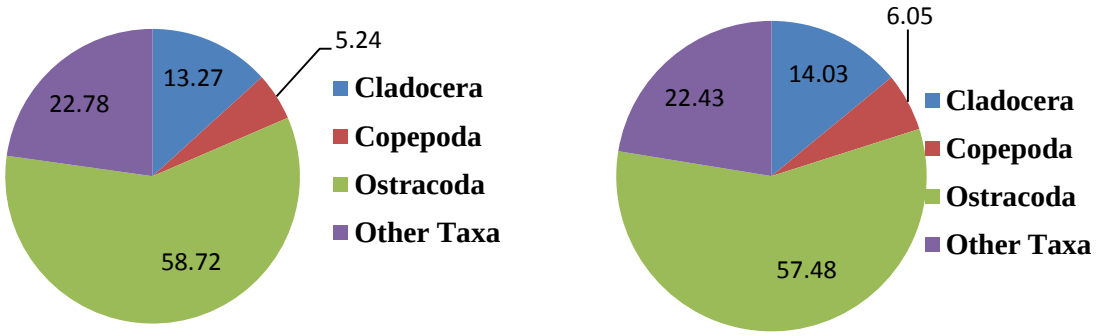
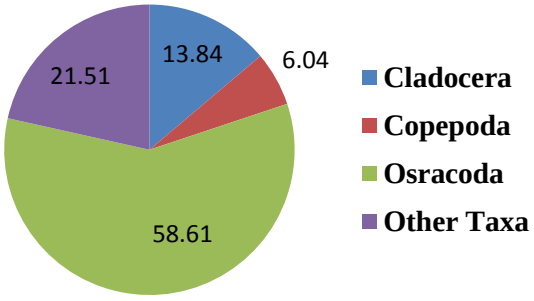


Fig.4. Monthly variation of Other Taxa at Chiliya bund during 2006, 2007 and 2008.



(a)

(b)



(c)

Fig. 5. Total abundance of all zooplankton groups at Chiliya Bund from Jan. to Dec. 2006 (a), 2007 (b) and 2008 (c).

Statistical Analysis:

Analysis of Variance: (ANOVA)

The ANOVA of population of zooplanktons of all three studied years showed that was non-significant (Table 7). On the other contrary, the ANOVA of zooplankton with physico-chemical parameters was significant (Table 8).

Table 6. Standard deviation and Mean of zooplankton of Three years of Chiliya Bund.

Months		**Mean and SD**
January		91.34 ± 18.18
February		119.67 ± 58.79
March		287.0 ± 11.14
April		718.0 ± 8.54
May		283.67 ± 10.69
June		177.34 ± 3.21
July		109.67 ± 11.50
August		24.67 ± 8.74
September		43.34 ± 8.96
October		55.00 ± 3.61
November		95.34 ± 11.72
December		100.34 ± 12.66

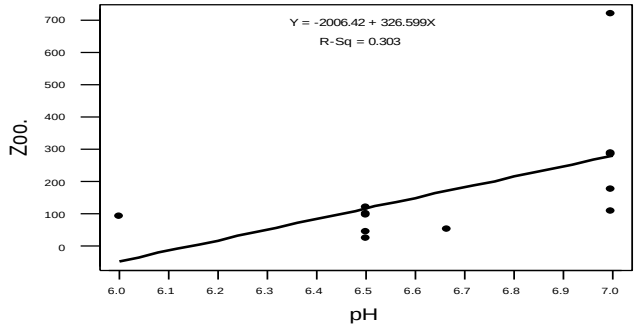
Table 7. One-Way Analysis of Variance of Population of Zooplankton from 2006-2008.

Location	**F- Value**	**P-value**	**Remarks**
Chiliya Bund	0.04	0.964	Non Significant

Table 8. One-Way ANOVA of Physico-Chemical Parameters with Zooplankton of Chiliya Bund from 2006-2008.

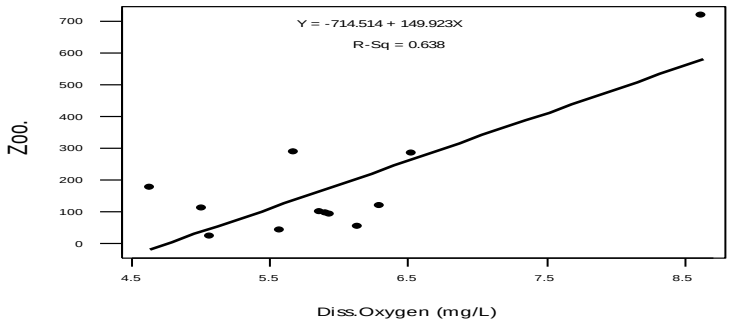
Parameter	**F-Value**	**P-Value**	**Remarks**
Air Temp.(C°)+ Zooplankton	6.30	0.020	Significant
Water Temp.(C°)+ Zooplankton	7.18	0.014	Significant
pH+ Zooplankton	9.40	0.006	Significant
Diss.Oxygen (mg/L) +Zooplankton	9.49	0.005	Significant
Salinity (mg/L) + Zooplankton	10.12	0.004	Significant
Alkalinity(mg/L) + Zooplankton	4.05	0.057	Significant
Acidity (mg/L) + Zooplankton	6.98	0.015	Significant
Sulphate (ppm) + Zooplankton	1.04	0.320	Significant
Phosphate (ppm) + Zooplankton	8.05	0.010	Significant
Nitrate (ppm) + Zooplankton	6.12	0.022	Significant

Regression:



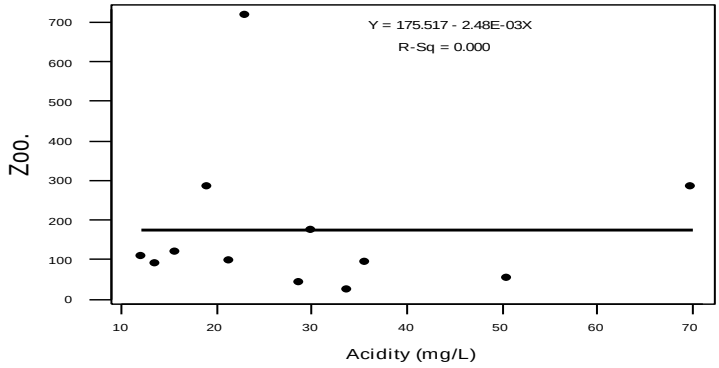
(P=0.084)

Fig.6. Fitted line plot of Zooplankton and pH at Chiliya Bund**.**



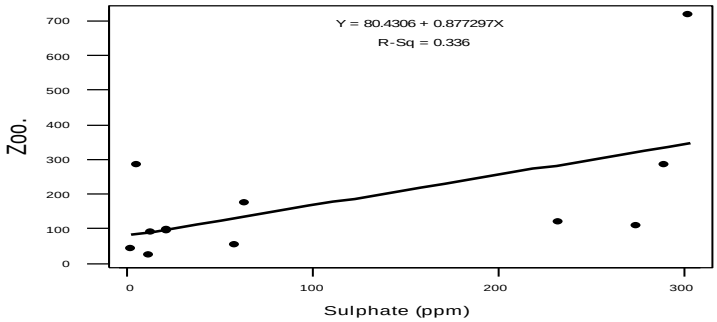
(P=0.008)

Fig. 7. Fitted line plot of Zooplankton and Diss.Oxygen (mg/L) at Chiliya Bund.



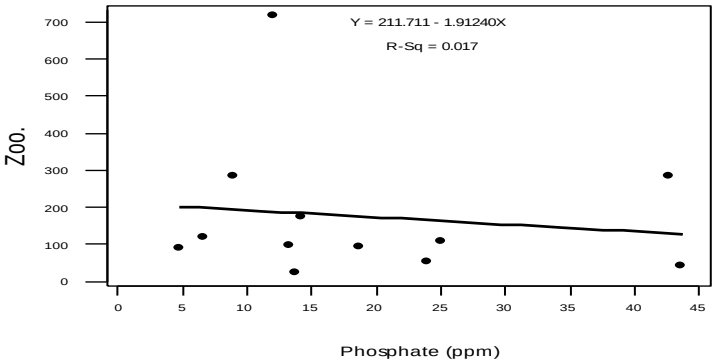
(P=0.175)

Fig. 8. Fitted line plot of Zooplankton and Acidity (mg/L) at Chiliya Bund.



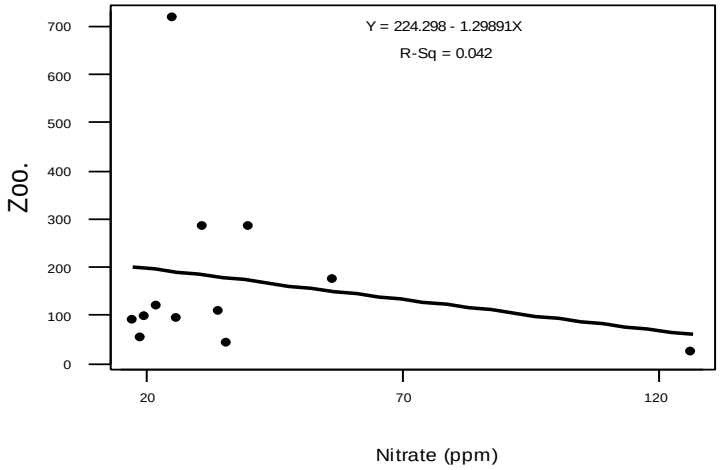
(P=0.232)

Fig. 9. Fitted line plot of Zooplankton and Sulphate (ppm) at Chiliya Bund.



(P=0.072)

Fig. 10. Fitted line plot of Zooplankton and Phosphate (ppm) at Chiliya Bund**.**



(P=0.036)

Fig. 11. Fitted line plot of Zooplankton and Nitrate (ppm) at Chiliya Bund.

Correlation between Zooplankton and Physico-Chemical parameters:

Relationship between pH and Zooplankton: (Fig.6)

At Chiliya Bund the regression analysis showed r^2 = 30.3% among pH and zooplankton that is a poor relation. At a low pH fewer species are present (Almer *et al*. 1974, Hanson, 1974).

Relationship between Dissolved Oxygen and Zooplankton: (Fig.7)

A strong relation was noted between dissolved oxygen and zooplankton at Chiliya Bund as r^2 = 63.8%. In Lake Ojofu, amount of dissolved oxygen exhibited positive effect on abundance of zooplankton (Stephen, *et al*., 2011).

Relationship between Zooplankton and Acidity: (Fig. 8)

The relationship between these variables at Chiliya Bund was zero may be due to rapid flow of water.

*The relation between zooplankton and other abiotic factors (Temperature, Salinity and Alkalinity) was poor or negligible.

Relationship between Phosphate and Zooplankton: (Fig.10)

It was noted in our work that Cladocera showed positive relation towards the high phosphate concentration. Masson *et al*. (2004) observed strong variations at low total phosphorus level in the relationship between TP and zooplankton biomass. On the other hand, in present study phosphate showed poor relation with zooplankton at all sites. The relation between Sulphate and Nitrate was also poor or negligible (Fig.9 - 11).

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