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Monthly Variations of Physico-Chemical Factors of Keenjhar Lake, Sindh, Pakistan

Shahina Rao, Muhammad Arshad Azmi, Solaha Rahman

Department of Zoology, University of Karachi-75270, Pakistan

*****Email: shahina.ku@gmail.com

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Abstract: The present study was carried out with the aim to assess water quality using physico-chemical factors of Keenjhar lake. For this purpose, lake water was analyzed with regular intervals. The air temperature ranged between 21 °C to 38 °C, water temperature between 19 °C to 36 °C , pH 5.5 to 8, dissolved oxygen 2.26 mg/L to 6.81 mg/L, salinity 0.16 mg/L to 1.13 mg/L, alkalinity from 30 mg/L to 165 mg/L, acidity 8 to 110 mg/L, sulphate 2.6 mg/L to 310 mg/L, phosphate from 1 mg/L to 31 mg/L and nitrates 16 mg/L to 180 mg/L during 2006, 2007 and 2008. It was concluded that various parameters lie within the permissible range except in a few months and suitable for drinking, irrigation and fish culture purposes.

Keywords: Physico-chemical, factors, fluctuated, water quality.

Introduction

Lakes and surface water reservoirs are the planet's most important freshwater resources and provide innumerable benefits. They are used for domestic and irrigation purposes. The physico-chemical parameters are very essential and important to test the water, before it is used for drinking, domestic, agricultural or industrial purpose. Water quality analysis is important to protect the natural ecosystem (Patil et al., 2012).

The quality of water generally refers to the component of water present at the optimum level for suitable growth of plants and animals. Aquatic organisms need a healthy environment to live and adequate nutrients for their growth and the productivity depends on the physico-chemical characteristics of the water body (Agbaire and OBI, 2009 and Verma *et al.*, 2012). The maximum productivity can be obtained only when the physical and chemical parameters are present at optimum level. Water for human consumption must be free from organisms and chemical substances and such large concentrations may affect health (Uduma, 2014).

Many researchers have worked on Keenjhar lake in this respect in past like Baqai *et al* (1974b) and Lashari *et al* (2009). The physico-chemical factors and nutrient status of water play important role in governing the production of planktonic biomass. The main purpose of present work is to study current status of physico-chemical factors of Keenjhar lake.

Study Area

Keenjhar lake is situated at a distance of 113 km from Karachi and about 20 km North and North-East of Thatta town between the longitude of 68 and 69° N and latitude 24 and 25° E. It is 24 km long, 6 km wide, and has a depth of 8 meters, spread over 13,468 hectares.

Materials and Methods

To study the physico-chemical parameters of Keenjhar lake, regular trips were made on a monthly basis. Sample collection was made during 5 am to 10 am. Samples were examined and fixed at the spot. Temperature of air and water and pH were recorded on the spot. For dissolved oxygen Winkler's method was used (Welch 1948). Salinity of the water was estimated by Mohar's method. Total alkalinity was analyzed according to APHA (1998) method. Acidity, sulphate, phosphate, and nitrate were estimated by using Hanna Kit HI.3820, Hi-38000, Hi-3833 and Hi-3874 respectively. Mean and Standard Deviations were taken out for physico-chemical factors. ANOVA was performed to find out the significance of these parameters.

Results and Discussion

Air temperature ranged between 23°C (January) to 34°C (October) in 2006. It was decreasing from May (33°C) to July (28°C) and increasing from August (30°C) to October (34°C). While in 2007, the air temperature fluctuated between 21°C in January to 38°C in September. It was observed that air temperature increased gradually from 25°C to 36°C from March to June while decreased from 38°C to 23°C during September to November. In 2008 the air temperature ranged between 22°C (January) to 36°C (September). Increasing trend from January to June while decreasing values from September to December were noted (Fig.1). The mean values ranged between 22-35°C (Table 1).

In 2006, the water temperature fluctuated between 20°C (January) to 31°C (May, September, and October, 2006). It was decreasing gradually from May (31°C) to July (27°C). The minimum water temperature in 2007 was noted in January (19°C) while maximum temperature (36°C) was observed in

September. A gradual decrease in temperature from September to December (36°C to 21°C) and increase from March to June (22°C to 34°C) was evident. It ranged between 20°C (January) to 33°C (June and September) in 2008. Decreasing trend was noted from September to December while gradual increasing values were noted from January to June (Fig.2). The mean values ranged between 19.67 - 33.34°C (Table: 1).

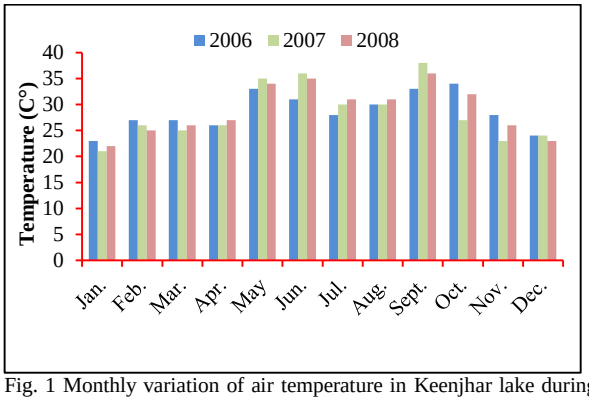

Fig. 1 Monthly variation of air temperature in Keenjhar lake during 2006, 2007 and 2008.

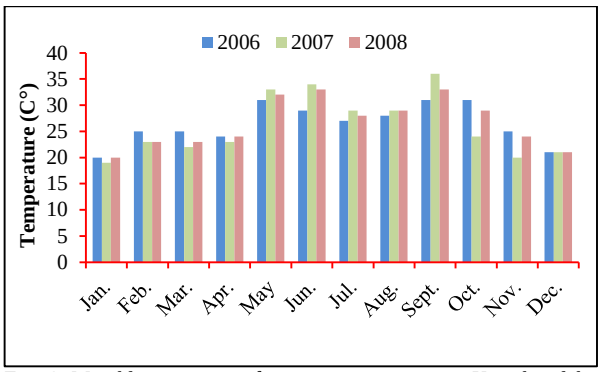

Fig. 2 Monthly variation of water temperature in Keenjhar lake during 2006,2007 and 2008.

Table 1.Standard Deviation and Mean of Air and Water Temperature (°C), pH and Diss.Oxygen of Keenjhar lake (2006-2008).

	Air Temp. (°C)	Water Temp. (°C)	pH	Diss.Oxygen (mg/L)
Months	**Mean ±SD**	**Mean± SD**	**Mean ±SD**	**Mean± SD**
January	22.00±1.00	19.67±0.58	5.84±0.29	6.53±0.29
February	26.00±1.00	23.67±1.15	5.67±0.29	5.26±0.05
March	26.00±1.00	23.34±1.53	6.00±0.00	4.33±0.06
April	26.34±0.58	23.67±0.58	6.17±0.29	3.46±0.33
May	34.00±1.00	32.00±1.00	7.17±0.76	2.73±0.18
June	34.00±2.65	32.00±2.65	7.00±0.50	3.12±0.74
July	29.67±1.53	28.00±1.00	6.83±0.29	2.70±0.19
August	30.34±0.58	28.67±0.58	7.00±0.00	2.54±0.33
September	35.67±2.52	33.34±2.52	7.50±0.50	3.60±0.01
October	31.00±3.61	28.00±3.61	7.17±0.76	3.65±1.14
November	25.67±2.52	23.00±2.65	6.50±0.50	4.71±0.59
December	23.67±0.58	21.00±0.00	6.00±0.00	5.69±0.14

During 2006, pH fluctuated between 5.5 (February) to 8 (May, September and October). In 2007, the results of pH were similar to the results of 2006 in few months such as in January, February, March, July, August, and December. Minimum value was noted in February (5.5) whereas maximum value was in June (7.5). It was also observed that from February to June pH was increasing from 5.5 to 7.5 gradually while decreasing during September to December (7 to 6). The result revealed that from July to September, the pH remained same (7). It ranged from 5.5 (January) to 7.5 (September) in 2008. Decreasing values were noted from September to December. A gradual increase started from January (5.5) that became 6 in February and persisted during March and April then increased up to 7 in May to June (Fig.3). The mean values ranged between 5.67 – 7.5 (Table 1).

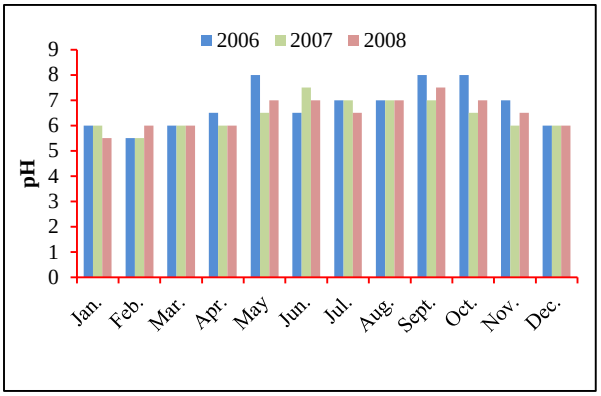

Fig. 3 Monthly variation in pH in Keenjhar lake during 2006, 2007 and 2008.

The minimum value of dissolved oxygen was recorded in May (2.55 mg/L) and July, while maximum value was noted in January (6.24 mg/L). The gradual decreasing values were observed from January to May whereas an increasing trend was noted from July to October. During 2007, the minimum contents were recorded in August (2.26 mg/L) while maximum were noted in January (6.55 mg/L). During this year, an increasing trend was noted from October to December. During 2008, a maxima was noted in same month as was in 2006 and 2007 but with different values while a minima was recorded in August (2.45 mg/L). A gradual decreasing value was evident from January to May and increasing from August to December (Fig.4). The mean values ranged between 2.54-6.53 mg/L (Table: 1).

Salinity ranged between 0.16 mg/L in September to 0.76 mg/L in July during 2006 (Fig. 5). The salinity value was noted to decrease from February to May (0.56 to 0.36 mg/L) and increase from May to July (0.36 to 0.76 mg/L). During 2007, maximum value was observed in August (01.13 mg/L) while minimum was in November (0.31 mg/L). No increasing or decreasing trends were distinct. In 2008, a minima (0.34 mg/L) was in November while maxima were noted in March (0.7 mg/L). A gradual decrease in values was evident from March (0.7 mg/L) to May (0.41 mg/L). The mean values ranged between 0.34-0.68 mg/L (Table 2).

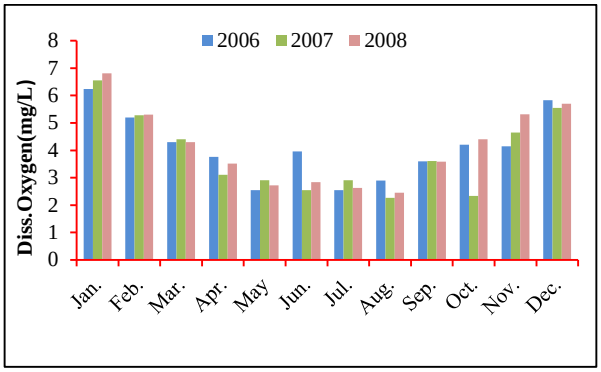

Fig. 4 Monthly variation in Dissolved Oxygen (mg/L) in Keenjhar lake during 2006-8.

Table 2. Standard deviation and mean of salinity, alkalinity and acidity of Keenjhar lake (2006-2008).

	Salinity(mg/L)	Alkalinity(mg/L)	Acidity (mg/L)
Months	**Mean ± SD**	**Mean ±SD**	**Mean ±SD**
January	0.60±0.07	40.00±5.00	37.67±11.15
February	0.55±0.02	48.34±7.64	106.34±3.51
March	0.65±0.17	60.00±5.00	24.00±9.17
April	0.52±0.09	150±13.23	10.00±2.00
May	0.47±0.14	101.67±5.77	39.34±35.23
June	0.68±0.02	46.67±5.77	17.00±5.57
July	0.53±0.20	31.67±2.89	46.67±18.15
August	0.68±0.39	68.34±10.41	19.67±11.59
September	0.35±0.16	141.67±7.64	47.34±32.47
October	0.50±0.04	58.34±2.89	50.34±28.92
November	0.34±0.04	73.34±7.64	52.00±2.00
December	0.62±0.01	58.34±7.64	62.00±0.00

Table 3. Standard deviation and mean of sulphate, phosphate and nitrate of Keenjhar lake (2006-2008).

	Sulphate (mg/L)	Phosphate (mg/L)	Nitrate (mg/L)
Months	**Mean ±SD**	**Mean ±SD**	**Mean ±SD**
January	37.67±11.15	203.34±66.58	26.34±3.21
February	106.34±3.51	10.50±2.63	45.00±13.23
March	24.00±9.17	7.77±2.48	23.00±6.24
April	10.00±2.00	76.67±11.55	16.67±0.58
May	39.34±35.23	29.00±17.06	33.34±5.13
June	17.00±5.57	4.97±2.45	53.34±2.89
July	46.67±18.15	295.00±15.00	29.34±1.15
August	19.67±11.59	7.17±1.04	146.67±30.55
September	47.34±32.47	175.03±152.51	135.00±5.00
October	50.34±28.92	20.00±2.00	60.67±1.53
November	52.00±2.00	5.83±1.89	33.34±2.52
December	62.00±0.00	32.34±11.55	18.34±0.58

In 2006, the highest value of alkalinity was recorded in April (165 mg/L) that gradually decreased up to 30 mg/L during July, 2006. The values were relatively higher in summer months. In 2007, two minima of alkalinity during January and July (35 mg/L) were noted. A maxima was observed in September (150 mg/L) that gradually decreased till December up to 50 mg/L. The data revealed that alkalinity was increasing from January (35 mg/L) to April (140 mg/L) and showed seasonality, that in relatively colder months it showed less quantity while in warmer months it exhibited relatively higher quantity. During 2008, maxima (145 mg/L) was noted in April while minima (30 mg/L) was in July. A gradual increase from January (45 mg/L) to April (145 mg/L) was noticed and a decrease from April to July (Fig.6). The mean values ranged between 31.67 - 150 mg/L (Table 2).

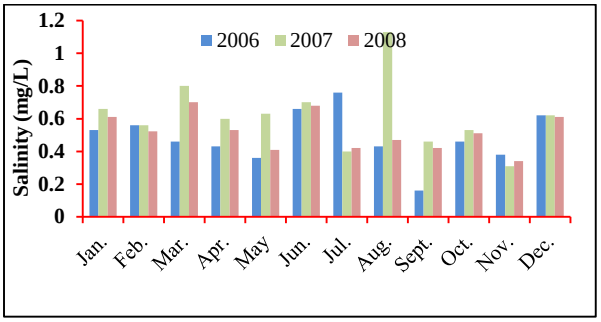

Fig. 5 Monthly variation of salinity (mg/L) in Keenjhar lake during 2006, 2007 and 2008.

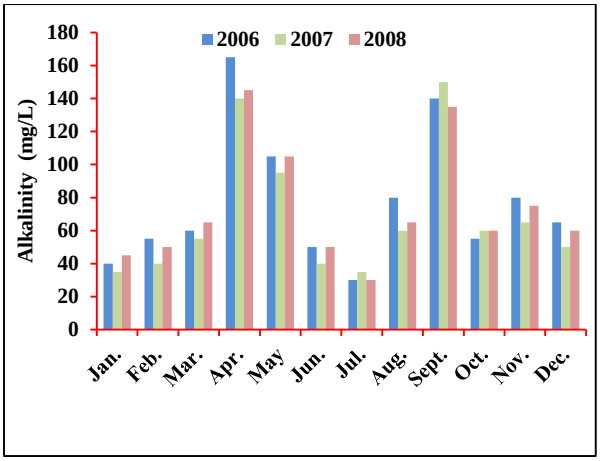

Fig. 6 Monthly variation of Alkalinity (mg/L) in Keenjhar lake during 2006-8.

Table 4. One-way ANOVA of all physico-chemical parameters of Keenjhar lake from 2006-2008.

Parameter	F-Value	P-Value	Remarks
Air Temperature(C°)	0.05	0.954	Non Significant
Water Temperature(C°)	0.03	0.967	Non Significant
pH	0.95	0.397	Significant
Diss.Oxygen (mg/L)	0.18	0.836	Non Significant
Salinity (mg/L)	2.09	0.140	Significant
Alkalinity(mg/L)	0.14	0.869	Non Significant
Acidity (mg/L)	0.57	0.569	Non Significant
Sulphate (mg/L)	0.39	0.681	Non Significant
Phosphate (mg/L)	1.21	0.310	Significant
Nitrate (mg/L)	0.03	0.974	Non Significant

In 2006, the highest value of acidity was 110 mg/L, which was found during February and it gradually decreased to 08 mg/L in April. The value of acidity showed increasing trend from 10 to 62 mg/L during September to December because of the less entry of fresh water. Highest and lowest values were recorded in the same months in 2007, as were in 2006 but with different values (103 and 10 mg/L respectively). Acidity fluctuated throughout the year and no distinct increasing or decreasing trend was noted. In 2008 one maxima (106 mg/L) and two minima (12 mg/L) were

noted in February, April, and August respectively (Fig.7). The mean values ranged between 10-106 mg/L (Table 2).

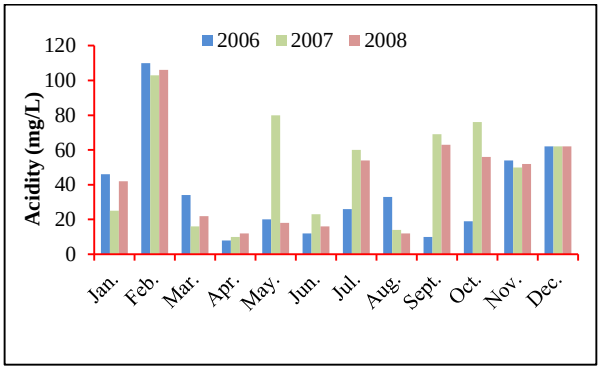

Fig.7 Monthly variation of acidity (mg/L) in Keenjhar lake during 2006-8.

Sulphate fluctuated between 02.6 mg/L to 310 mg/L during 2006. Higher values of 280 mg/L, 300 mg/L, and 310 mg/L were recorded in January, September, and July respectively. Minimum quantity was recorded in June (02.6 mg/L). The values were decreasing during January to March from 280 mg/L -10 mg/L gradually and during September to November it decreased from 300 mg/L to 4.5 mg/L. The complete analysis of sulphate during 2007 revealed that maximum value was 295 mg/L (July) and minimum was 05 mg/L (November). In 2008 a minima (4.8 mg/L) in June while maxima (280 mg/L) was noted in July (Fig. 8). The mean values ranged between 10-106.34 mg/L (Table 3).

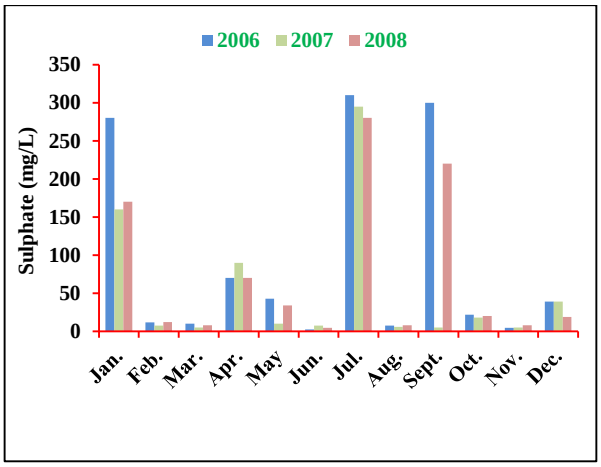

Fig. 8 Monthly variation of Sulphate (mg/L) in Keenjhar lake during 2006-8.

Fig.9 shows minimum value of phosphate in April (01 mg/L) that gradually increased in later months up to 28 mg/L in July (maximum) and same value was noted in September as well. Phosphate showed fluctuation throughout 2006. Minimum and maximum values in 2007 were noted to be 2.6 mg/L in April and 31 mg/L in May. During 2008 a maximum value (27 mg/L) in September, while a minimum value (01.3 mg/L) in April were noted. Gradually decreasing values were noted from January (11 mg/L) to April (1.3 mg/L). A gradual increase was evident from May (12 mg/L) to July (21 mg/L). The mean values ranged between 4.97 - 295 mg/L (Table 3).

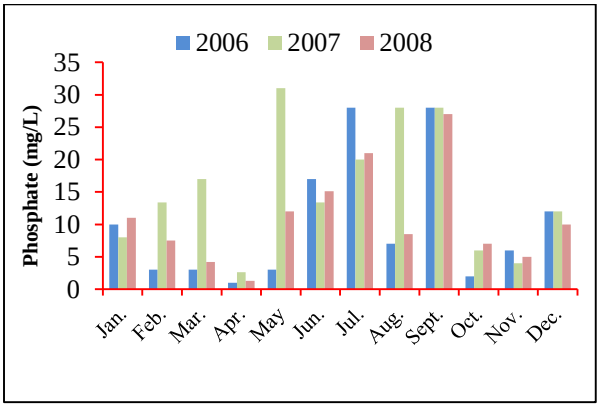

Fig. 9 Monthly variation of phosphate (mg/L) in Keenjhar lake during 2006-8.

In 2006, nitrate contents fluctuated between 17 mg/L (minima) to 180 mg/L (maxima) in April and August respectively. Its value increased from April to June (17-55 mg/L), but decreased from August to December (180-18 mg/L). The results of 2007 revealed an increasing value trend of nitrate from April to June (17-55 mg/L) and July to September (30-140 mg/L). Its value showed decreasing trend from September to December (140-18 mg/L). Highest value was in September and least was in April. During 2008, maxima (140 mg/L) was noted in August while minima (16 mg/L) in April. A gradual increase from April (16 mg/L) to June (50 mg/L) and a gradual decrease from August (140 mg/L) to December (19 mg/L) were noted (Fig.10). The mean values ranged between 16.67 - 135 mg/L (Table 3).

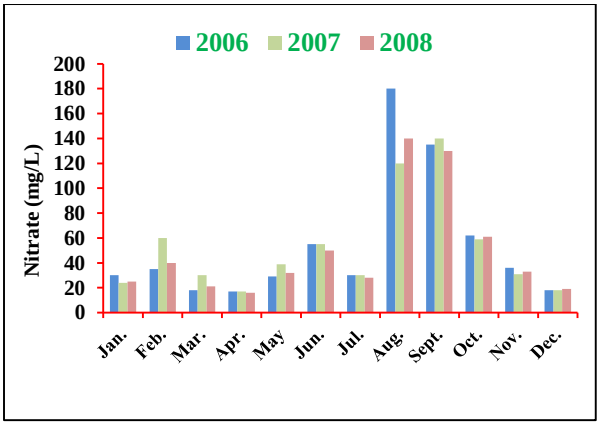

Fig. 10 Monthly variation of nitrate (mg/L) in Keenjhar lake during 2006, 2007 and 2008.

Analysis of variance of all physico-chemical factors showed that only three factors namely pH, salinity, and phosphate exhibited significance (Table 4).

The air temperature ranged between 21°C–38°C while in water it was recorded between 19°C–36°C. High temperature was due to low depths and increased solar

radiation in longer days in both air and water. Similarly, gradual reduction in solar radiation may explain fall in temperature in colder months. A direct relationship of water temperature with bright sunshine and its duration has also been suggested by Munawar (1970) and Harshley *et al.*, (1982).

pH was between 5.5 to 8. The minimum value was only noted once during February (2006, 2007) and January (2008) which might be because of low inflow of water in winter that turned the water acidic. Maxima was noted in May (2006), June (2007) and September (2008). Das and Srivastava (1956) explained biotic factor, like photosynthetic activity due to increased population of phytoplankton may support an increase in pH. The alkaline pH might be due to rain water (Lashari, *et al.,* 2009). Higher pH (alkaline) during summer supported algal blooming (Baloch *et al*., 1998).

In present results, the highest oxygen was observed in January (2006, 2007 and 2008) when the temperature was lowest. This may be due to temperature alone, as the solubility increases with the decrease in temperature (Singh, 1990). The lowest oxygen was noted in May and July (2006) and August (2007 and 2008). Dissolved oxygen contents decreased with rising temperature (Welch, 1952). Lashari et al., (2009), suggested that this fluctuation is due to rain water and inflow from Indus river.

The maximum salinity was noted in July (2006), August (2007) and March (2008) while minimum value was in September (2006) and November (2007 and 2008). It was observed that the highest salinity was noted during summer and lowest values were noticed in colder months. Kumar et al., (2002) also reported an 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).

Alkalinity during 2006 and 2008 showed maximum values in April and during 2007 it was in September. Lowest quantities were measured in July (2006, 2007 and 2008) and January (2007). The high range may be due to fall in water level as it was noted in pre- and post-monsoon season. Bicarbonate increase with fall in water level has also been reported by Singhal *et al*,. (1986).

Acidity was 08 mg/L to 110 mg/L. Highest value was noted in February (2006, 2007 and 2008) while lowest acidity was observed in April (2006, 2007 and 2008) and also in August (2008). In natural unpolluted waters, the acidity is mainly contributed by the dissolved carbon dioxide. In polluted waters, weak acids like acetic acid may contribute significantly to total acidity. In some industrial wastes, organic acids may also contribute to acidity (Abbasi, 1998).

The highest value of sulphate was noted in July (2006, 2007, 2008), while the lowest quantity was observed in June (2006, 2008) and November (2007). Sulphate concentration was high during summer season due to evaporation (Garg, et al., 2010). Highest values were during summer and pre-monsoon period in 3 different lakes of Chennai. It may also indicate enrichment due to insufficient inflow of rainwater (Chennakrishnan *et al*., 2008). High temperature allows water to mix and that's why the water was rich chemically during summer months (Singh et al., 1980).

Highest value of dissolved phosphate was evident in September (2006 and 2008), July (2006), and in May (2007) while least quantity was noted in April (spring season) in all years. Boström (1981) analysed the water samples of Erken lake and concluded a remarkable decrease in phosphate level in spring season. It was also noted that during that time, phytoplankton increased up to 50% of its maximum population. Pettersson (1979) suggested that surplus phosphorus is taken up by phytoplankton that influenced its higher population and decreased phosphate level in water. Fluctuation in total phosphorus quantity shows fluctuated trophic status of the lake (Baloch and Suzuki, 2009).

Nitrate contents were highest in August (2006 and 2008) and September (2007), whereas lowest quantity was noted in April (2006, 2007 and 2008). Annual cycle of evaporation and precipitation maintained the seasonality of various physico–chemical factors (Arora and Mehra, 2009). A high concentration of nitrate in the water may increase the phosphorus binding in the sediment (Stumm and Morgan, 1970, Ripl, 1976).

Conclusion

By assessing the physico-chemical factors, the water quality was within desirable limits. Based on the values of the obtained physico-chemical factors, it can be concluded that the Keenjhar lake water quality was near optimal range except in few months. The results obtained from the present study shall be useful in future management of the Keenjhar Lake.

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