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Limnological Studies of Keenjhar Lake, District, Thatta, Sindh, Pakistan.

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Abstract

Limnological studies of Keenjhar Lake were carried out during January 2003 to December 2005. The present study deals with physico - chemical parameters such as, temperature, pH, alkalinity, chlorides, conductivity, total dissolve solids, turbidity, dissolve oxygen, calcium and magnesium. The maximum and minimum range of physico - chemical properties were as, temperature 18 - 33 ^{0}C from station 2 in January and August respectively, pH 7.3 - 8.9 in September and June respectively, alkalinity 160 - 240 mg L^{-1} in July and January respectively, minimum chlorides 30 mg L^{-1} in September and maximum 85 mg L^{-1} in December, conductivity 320 µS cm^{-1} in September and 496 µS cm^{-1} in December, total dissolve solids were 240 mg L^{-1} in September and 391 mg L^{-1} in October, turbidity was 30 NTU in December and 78 NTU in May, dissolve oxygen was 7.0 mg L^{-1} in January and 9.0 mg L^{-1} in July, calcium 50 mg L^{-1} in July and September and 78 mg L^{-1} in October, magnesium 21 mg L^{-1} in August and September, 35 mg L^{-1} June, and it is concluded that the variation in parameters were due to rain and flow of River Indus.

Keywords: Physico - chemical properties, Keenjhar Lake, Thatta

Introduction

The province of Sindh has great freshwater fishery potential since it has over 65% of the freshwater resources of Pakistan. Inland fishery resources include the River Indus, its tributaries and extensive canal system, number of dhands (small standing waters bodies), fish ponds and natural lakes (Manchar, Bakar, Phoosna, Hub, Haleji, Hadero and Keenjhar Lake) in almost all districts of the province Sindh. Lakes in Sindh are important for a number of different reasons, such as sources of drinking water, irrigation and wildlife habitats and as sources of a cheap diet rich in protein. The sites of these lakes are important for local population, which are directly or indirectly dependent on these lakes.

Keenjhar Lake was created by linking two natural lakes, Keenjhar and Sunheri (‘Green’ and ‘Golden’) by dynamiting the separating hills in (1958) to make one lake, which was originally called Kalri Lake. In (1972) this artificial tropical lake was renamed Keenjhar Lake. The lake is situated nearly 120 km from Hyderabad at 24°47′ N and 68°2′ E [1]. It is 27.2 km long and covers an area of 80 km^2. It receives water from the River Indus via a canal called the Kalri Baghar Feeder, which starts at Ghulam Mohammad Barrage. The lake was initially nearly 25 m deep, but continuous siltation and the deposition of decaying plants have decreased the depth to 6 - 8 m.

To cover the maximum Lake area possible, six stations were selected at various sites for sample collection (Fig. 1).

1. Sunheri: inlet from the Indus via Kalri Baghar feeder.
2. Helaya station: the main boat basin.
3. Noori station: the center of the lake.
4. Boating spot: also the main boat basin.
5. Resting spot: surrounding of the lake.
6. Khumbo station: outlet of the lake.

In aquatic habitats, environmental factors include various physical properties of water such as the solubility of gases and solids, light penetration, temperature and density. Chemical factors such as

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hardness, phosphate and nitrates are very important for growth of primary productivity. Estimation of water quality is among frequently conducted research activities in Sindh [2-5]. Hence, the present study was based on the examination of the physico-chemical parameters of Keenjhar Lake district Thatta, Sindh, Pakistan.

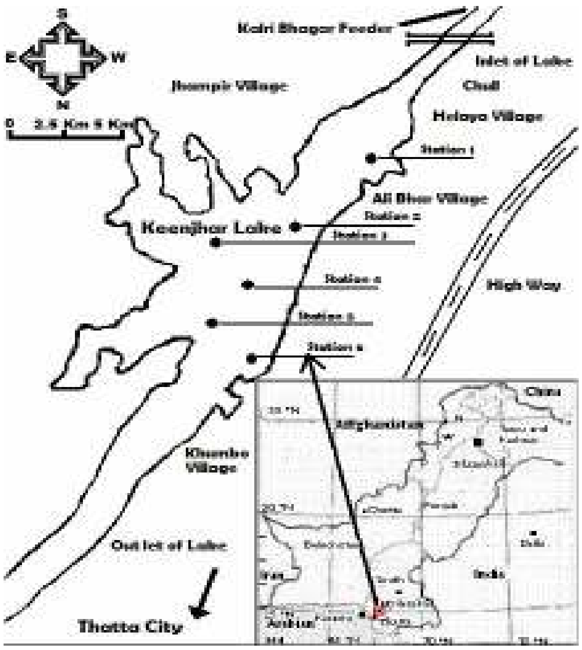

Figure 1. **Location of sampling sites in the Keenjhar Lake area: Station 1) Sunheri (Inlet source of water from Kalri Bhaggar Feeder); Station 2) Helaya spot (Main boat basin); Station 3) Noori spot (Center of the Lake); Station 4) Boating spot (Main boat basin); Station 5) Resting spot (Surrounding of the Lake); Station 6) Khumbo spot (Out let of the Lake).**

Material and Methods

Estimation of physico-chemical properties of lake water was carried out with 864 samples (6 sampling sites × 2 replications × 2 sampling frequency × 36 months). Water samples were collected from surface and bottom layers by using Van Dorn plastic bottles (1.5 L capacity) from 2 spots of each station randomly, were kept in polythene plastic bottles, previously soaked in 10% nitric acid for 24 h and rinsed with ultra pure water obtained from ELGA Lab water system. After reaching at the laboratory 2 water samples collected from each station were mixed in acid washed bucket to make one composite sample, rinsed with ultra pure water and kept under 4 °C till further analysis. The analytical data quality was ensured through careful standardization and duplicate samples. The determination of physico - chemical parameters were done by Standard methods of analysis (APHA, 1998) [6]. Temperature was measured with a mercury thermometer and pH with an Orion model 420 pH meter. Dissolved oxygen samples were collected in colored bottles and analyzed by a modified Winkler Method, Conductivity and total dissolved solids were determined with a WTW LF 320 Conductivity meter. Standard titration methods were used to determine alkalinity (With Sulphuric acid), hardness (with EDTA) and Chloride (with Silver nitrate). The physico-chemical parameters were determined in laboratory following the standard protocols [6]. The analytical procedure and units of physico-chemical parameters are summarized in (Table 1).

Table 1. **Physicochemical parameters of Keenjhar Lake and their analytical procedure during 2003 to 2005.**

Variables	Abbreviations	Units	Analytical methods
Temperature	Temp	˚ C	Mercury thermometer
pH	pH	pH unit	pH meter
Total Alkalinity	Alkaline	mg L^{-1}	Titration (H_2 SO_4)
Chloride	Cl^-	mg L^{-1}	Titration (Silver nitrate)
Conductivity	EC	µS cm^{-1}	Conductivity meter
Total Dissolved Solids	TDS	mg L^{-1}	WTW LF 320 TDS meter
Turbidity	Tur	NTU	Nepholmetric turbidity unit
Dissolved Oxygen	DO	mg L^{-1}	Winkler method
Calcium	Ca	mg L^{-1}	Titration (EDTA)
Magnesium	Mg	mg L^{-1}	Titration (EDTA)

Data treatment by statistical method

Data were statistically analyzed using one way of variance ANOVA. MINITAB program was used.

Results and Discussion

Lakes are an important natural resource for population lived around the vicinity. They provide water for domestic and industrial uses, fisheries and irrigation. Knowledge of Lake Hydrology is essential for their proper use and conservation. The physicochemical parameters and nutrient content of water play a significant role in the distributional patterns and species composition of primary organisms Sahato at al [7]. In aquatic habitats, environmental factors include various physical properties of water, such as solubility of gases and solids, light penetration, temperature and density. Chemical factors such as pH, hardness, phosphate and nitrate are very important for growth and dispersal of the phytoplankton on which zooplankton and higher consumers depend for their existence. The results showed that the parameters studied were effective in identifying and monitoring water bodies affected by organic sewage discharges. Hydrographic condition of Keenjhar Lake, seasonal and physico- chemical change in water column affect the abundance and distribution of biodiversity.

Temperature

Temperature is important in terms of its effect on aquatic life. Temperature fluctuations are evident seasonal patterns in aquatic ecosystems. Its influence on limnological phenomena such as stratification, gas solubility, pH, conductivity and planktonic distribution are well known Singh et al [8]. Temperature measurements are useful in indicating trends for various chemical, biochemical and biological activities. An increase in temperature leads to faster chemical and biochemical reactions. The growth and death of microorganisms and the kinetics of the biochemical oxygen demand are also regulated to some extent by water temperature Khuhawar and Mastoi [9]. Water temperature in the study lake was closely followed by air temperature, with maximum in summer and minimum in winter. Air and water temperatures showed a very characteristic annual cycle, with higher values during the day, and lower values in the dry season. The air temperature showed an annual variation about (18–33 ˚C) at the sampling stations as shown in (Fig. 1). We concluded that some points have extensive natural vegetation which causes lower values in the water temperature, even in summer, when related to other collection points in the same season. A higher water temperature was observed from July to August, with a maximum (33°C) in August, particularly at station 6, during 2003 (Fig. 2, Table II), values were similar to those reported by, Sahato and Arbani, [2] for Keenjhar lake district Thatta, by Sahato et al [3] for Phoosna Lake district Badin. Minimum temperature was 18˚C at station 2 in month of January, consistent result of [1, 9]. The mean values show two peaks, one in July and the other in August. Temperature is a controlling factor for growth of phytoplanktons Nazneen et al [10]. In tropical and subtropical regions, (Fig. 2) during 2004 and 2005.

pH

pH is a measure of the acidity or alkalinity of an aqueous solution. The difference between pH values at different stations in various months of the year was significant. This variation in pH is due to the presence or absence of free carbon dioxide and carbonate and planktonic density during various months. The low value of pH was 7.3 at station 3 and 6 in months of September and July, and maximum was 8.9 at station 3 in month of March and June. The high pH resulted in high photosynthetic due to the abundance of the algal population Sahato et al [7]. Maximum value were higher than those reported by Korai et al [1] from Keenjhar and Haleji Lake district Thatta, minimum value was also higher than reported by Muhammad et al [5] for Makhi Lake district, Sanghar and Korai et al [1] for Keenjhar Lake district, Thatta. The pH is as important factor for the growth of aquatic vegetation, the range of pH during present study showed variation at the sampling sites (Fig. 3). It is well documented that pH is directly related to CO_3 and inversely related to free carbon dioxide Zafar [11]. Among biotic factors, high photosynthetic activity due to increased production of phytoplankton may support an increase in pH. This type of observation has also been reported by Das and Srivastava [12]. The pH did not fluctuate much and ranged from 7.3 to 8.9 (Fig. 3, Table II), during 2003, 2004 and 2005.

Total alkalinity

The capacity of water to neutralize a strong acid is known as alkalinity and is characterized by the presence of hydrogen ions; most of the alkalinity of water is due to dissolution of carbonate. The maximum alkalinity value 240 mg L^{-1} was noted at station 2 and 4 in January and minimum value of alkalinity was noted 160 mg L^{-1} at station 3 in the month of July. Increase in alkalinity values may be due to decreases in the water level. Bicarbonate increases with decreases in water levels have also been reported by Singhal et al [13]. Rutne [14] reported that the accumulation of lesser quantities of carbonate during summer results in the liberation of free CO_3 during decomposition of bottom deposits, which possibly converts insoluble $CaCO_3$ into soluble Ca $(HCO_3)_2$. The gradual decrease in alkalinity from July to August is attributed to a low rate of nutrient recycling by reduced microbial activity and bicarbonate utilization by phytoplankton, which exhibit luxuriant growth during this period. Our findings are not in agreement with those of, Jayangoudar and Ganapati [15]. The total alkalinity is shown in (Fig.4, Table 2) during 2003, 2004 and 2005.

Chlorides

Natural water generally contains low concentrations of chlorides and higher levels always originate from contamination by sewage. Higher values 85 mg L^{-1} were observed in December, during dry season (Fig. 5) during 2005, whereas lower values 30 mg L^{-1} were observed in September due to the entry of fresh water (Fig. 5) during 2003. The maximum concentration 85 mg L^{-1} of chlorides was found at station 6 in December (Fig. 5) during 2005, and the minimum value 30 mg L^{-1} was recorded at station 1 in

September (Fig. 5) during 2003. The increase in chlorides in winter is in agreement with the observations of Munawar [16]. Harrison [17] reported that the chlorides concentration depends on the water level, when the water level decreases, the chlorides concentration increases. They further observed that when water level rises due to rain, the consequent dilution decreases the chloride concentration. Kumar et al [18] Suggested that this is probably because organic matter does not accumulate at a particular spot in flowing water and is washed away before it is broken down, (Fig. 5, Table 2) during 2004.

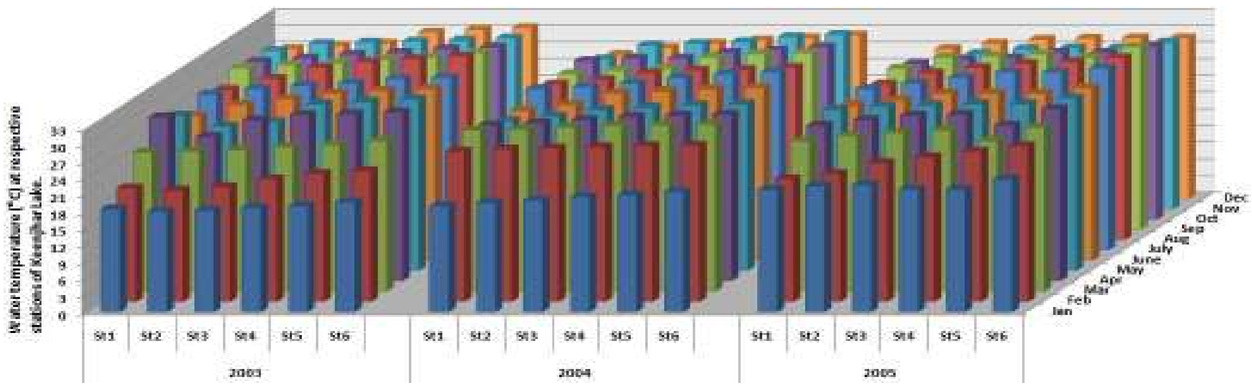

Figure 2. **Water temperature (°C) during 2003, 2004 and 2005 at respective stations from Keenjhar Lake.**

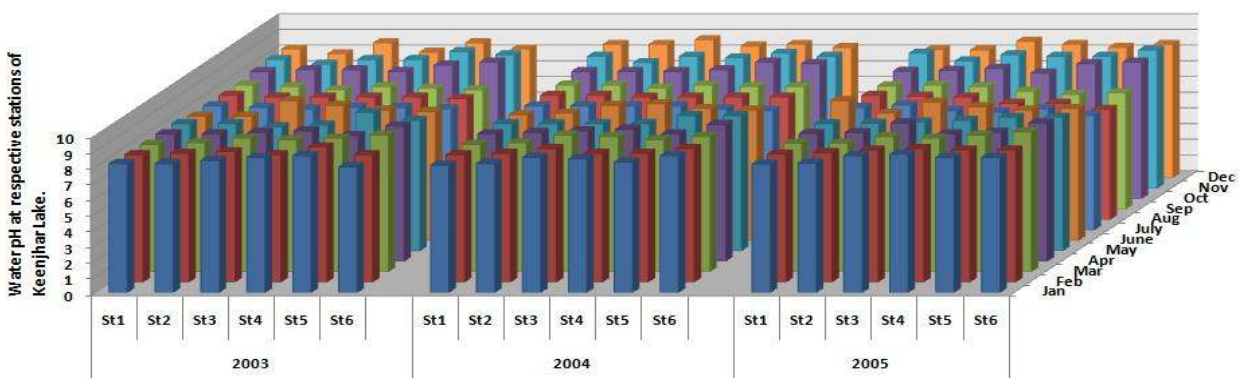

Figure 3. **pH during 2003, 2004 and 2005 at respective stations from Keenjhar Lake.**

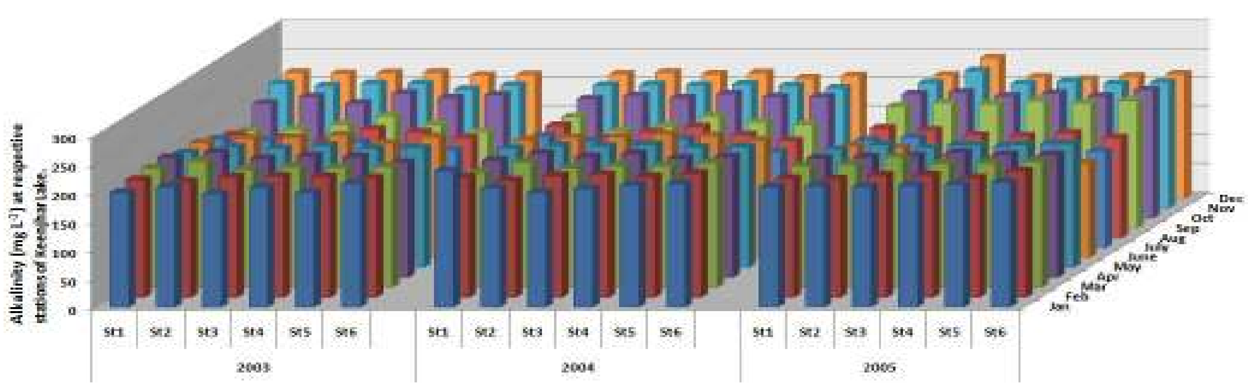

Figure 4. **Alkanity (mg L^{-1}) during 2003, 2004 and 2005 at respective stations from Keenjhar Lake.**

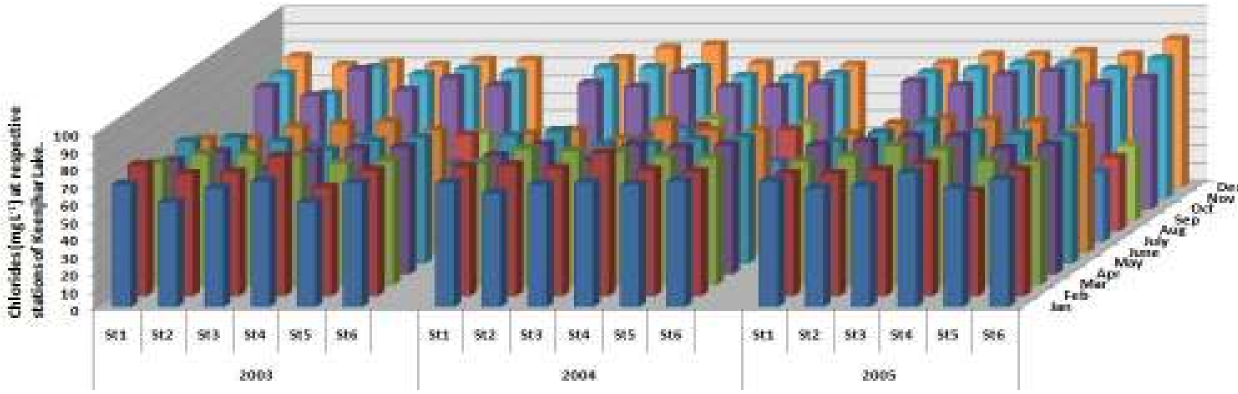

Figure 5. **Chlorides (mg L^{-1}) during 2003, 2004 and 2005 at respective stations from Keenjhar Lake.**

Table 2. **Mean (±Std) and ranges of physico-chemical water parameters of Keenjhar Lake during 2003–2005.**

Parameters	Maximum	Minimum	Mean	±Std
Temperature	August 33 °C	January 18 °C	26 °C	±1.85
pH	March/ June 8.9	July/ September 7.3	8.1	±0.23
Total Alkalinity	January 240 mg L^{-1}	July 160 mg L^{-1}	193 mg L^{-1}	±7.22
Chloride	December 85 mg L^{-1}	September 30 mg L^{-1}	57 mg L^{-1}	±2.19
Conductivity	March/ December 496 µS cm^{-1}	September 320 µS cm^{-1}	392 µS cm^{-1}	±12.84
Total dissolved solids	October 391 mg L^{-1}	September 240 mg L^{-1}	304 mg L^{-1}	±11.97
Turbidity	May 78 NTU	December 30 NTU	56 NTU	±3.2
Dissolved oxygen	July 9 mg L^{-1}	January 7 mg L^{-1}	7.8 mg L^{-1}	±0.43
Calcium	October 78 mg L^{-1}	July 50 mg L^{-1}	59 mg L^{-1}	±3.82
Magnesium	June 35 mg L^{-1}	August/ September 21 mg L^{-1}	27 mg L^{-1}	±2.45

Conductivity

Conductivity, natural water has low conductivity, but contamination increases the level. Most of the salts dissolved in water are in ionic form, and thus water can conduct electricity. Thus, the electrical conductivity of water depends on the concentration of ions and its nutrient status. The range of electrical conductivity was 320 - 496 µS cm^{-1}, the lowest value 320 µS cm^{-1} was recorded at station 4 in September (Fig. 6, Table 2), during 2003, and the highest 496 µS cm^{-1} at station 3 in March and December (Fig. 6), during 2004. The electrical conductivity during the annual season cycle showed significant changes. The change in water electrical conductivity followed the same seasonal pattern as that of salinity. In Kawar Lake, India, a similar range of conductivity has been recorded, George [19]. Station 1, inlet source of Lake (Fig. 1), where there is still presence of residues with high levels of dissolved ions. During 2005 the conductivity is summarized in (Fig. 6).

Total dissolved solids

The minimum amount of total dissolved solids (TDS) was recorded in autumn (August and September) and the maximum amount in winter February and March (Fig. 7), during 2003. This Lake has high TDS in winter and low TDS in autumn Jayangoudar and Ganapati [15], in contrast to ponds and smaller water bodies, where as TDS were maximum in autumn and minimum in winter. This may be due to the size of the water body, inflow of water, consumption of salt by algae and other aquatic plants, and the rate of evaporation. Our data coincide with those of Jayangoudar and Ganapati [15] from Keenjhar and Haleji Lake district Thatta, but disagree with observations of Verma et al [20]. pH was maximum in the months of March–June. Compared to pH, salinity was maximum during winter, i.e. in the month of February, and minimum in summer July. Salinity and TDS showed similar behavior during winter and summer. During winter, the hardness was lower owing to the presence of carbonates and large amounts of dead aquatic plants Shukla et al [21]. A rapid increase in TDS occurs in the hot season due to an increase in the amount of bicarbonate. However, during the rainy season the amount of TDS was low due to dilution effects. During 2004 and 2005 TDS are given in (Fig. 7, Table 2).

Turbidity

Turbidity in water is caused by the presence of suspended matter such as clay, silts, finely divided organic and inorganic matter, plankton and other microscopic organisms. Silt gives the advantage that it checks light penetration in certain area of the Lake, including the inlets. Chlorination can never be an effective disinfectant in the presence of suspended matter in water, which provides a sanctuary for various pathogenic organisms. It is therefore a prerequisite that reasonably safe and wholesome drinking water must have very low turbidity to qualify as first class water in any domestic water supply system. In this context, Singh et al [22] investigated the physico-chemical characteristics of water and their effect on the algal spectrum. The latter observed a direct correlation between the algal spectrum and turbidity. Turbidity was variable during present studies (Fig. 8, Table 2) during 2003, 2004 and 2005.The results were consisted with those of Nazneen et al [10] for Keenjhar Lake district Thatta. Keenjhar Lake was observed to be more turbid during spring, summer and autumn.

Dissolved oxygen

The oxygen supply in water mainly comes from two sources (a) atmospheric diffusion and (b) photosynthetic activity of plants. Oxygen diffuses in water very slowly. The quantity of dissolved salts and temperature greatly affect the ability of water to hold dissolved oxygen. The solubility of dissolve oxygen increases with decreasing temperature Singh et al [22]. Dissolved oxygen, which supports biological life in water, was present at adequate levels in Keenjhar Lake. Oxygen is the most important parameter in assessing the productivity of aquatic habitats, depending on two factors, temperature and the algal population. DO concentration in the study Lake generally was close to saturation. The minimum recorded concentration of DO was 7 mg L^{-1} (Fig. 9) recorded at station 6 in January, during 2005. This lowest dissolve oxygen level in Lake may be explained by decaying algal cells or because of the decay of macrophytes beds with age and changing season, which used up the available dissolve oxygen in the water column, thus could cause oxygen depletion. The maximum 9 mg L^{-1}, (Fig. 9) during 2003 was recorded at station 6 in July. These results are identical to those reported by Leghari et al [23] for Sonharo, Mehro, Pateji and Cholari lakes district Badin, and by Korai et al [1] for Keenjhar Lake, district Thatta. The pattern of dissolved oxygen content closely followed the change in water temperature, with an inverse relationship. The inverse relationship between dissolved oxygen and free carbon dioxide is well known Rao [24]. The low oxygen-retaining capacity of water due to the increase in organism respiratory demand at high temperatures may also be the reason for low values of dissolved oxygen [24, 25]. During 2004 dissolve oxygen was (Fig. 9, Table 2).

Carbonates and bicarbonates

The hardness of the natural water is mainly caused by the presence of carbonates, bicarbonates, sulfates and chlorides of calcium and magnesium. Other cat ions that affect the hardness are iron and magnesium. Carbonate and bicarbonates are the predominant anions in the lake, with calcium the major cation. Singh and Singh [26] Inferred that changes in the concentration of oxidizable organic matter in tropical waters did not influence the development of blue–green algae, as its concentration reaches a limiting factor for algal growth. Maximum calcium level 78 mg L^{-1} was recorded at station 1 in month of October, and minimum value of calcium 50 mg L^{-1} at station 1 and 2 in month of July (Fig. 10) during 2003, our finding are not in agreement with those of Leghari et al [23], suggesting that calcium is possibly one of the factors controlling Cyanophyta growth.

This assumption is supported by the fact that several Cyanophyceae members grow profusely on calcareous substrates, including the shells of mollusks and corals. The levels of oxidize able organic matter coupled to poor concentrations of dissolved oxygen, with a minimum in July–August (Fig. 9), during 2003. Munawar, Leghari et al [16, 23] suggested that Cyanophyceae grow with great variety and abundance. Whether this plays an individual role or in combination with other factors can only be confirmed by culture studies. The winter favoring of green algae is chemically distinct from that of blue–green algae and diatoms Singh and Singh, Wetzel [26, 27]. Planktonic Chlorococcales are widely distributed in waters of different alkalinity and salinity Munawar, Jahangir et al [16, 28]. The representation of Bacillariophyta in Keenjhar Lake may be due to the relatively high concentrations of carbonate and bicarbonate in the water. Carbonates and bicarbonates were variable during present studies (Fig. 10, Table II) during 2004 and 2005 for calcium. Minimum Magnesium level 21 mg L^{-1} at station 1 in August and September, and maximum magnesium level 35 mg L^{-1} at station 5 In June (Fig. 11, Table 2) during 2003, 2004 and 2005 for magnesium. Peak value of Magnesium level were found summer at station 5 in June, the visitors use to visit at Keenjhar Lake especially in months of summer, which increases the bathing activities ultimately the value of magnesium is elevated. In Keenjhar Lake, Pakistan a similar range of Magnesium has been recorded Khuhawar and Mastoi [9].

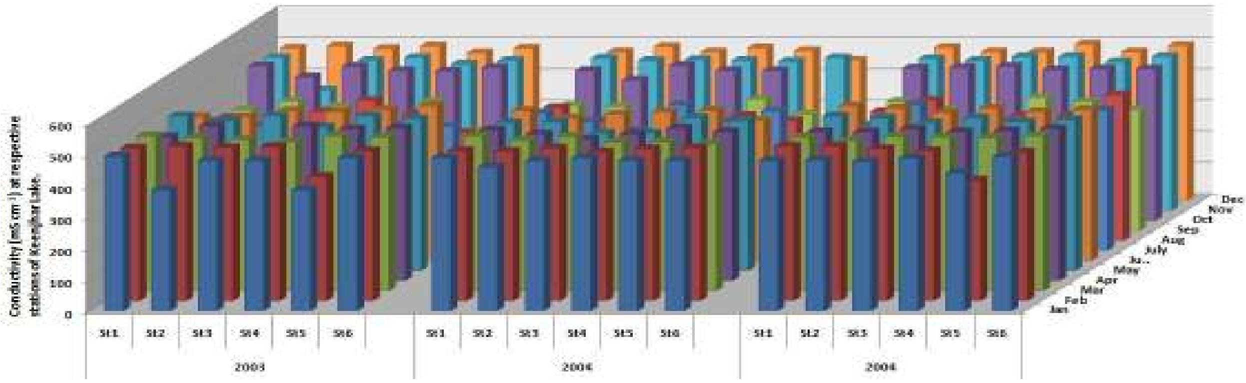

Figure 6. **Electrical conductivity (mS cm^{-1}) during 2003, 2004 and 2005 at respective stations from Keenjhar Lake.**

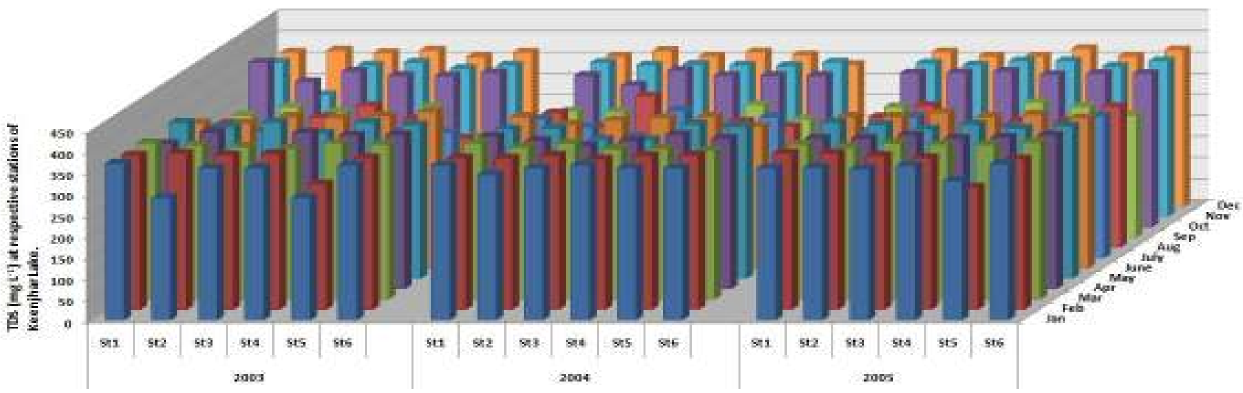

Figure 7. **Total dissolve solids (mg L^{-1}) during 2003, 2004 and 2005 at respective stations from Keenjhar Lake.**

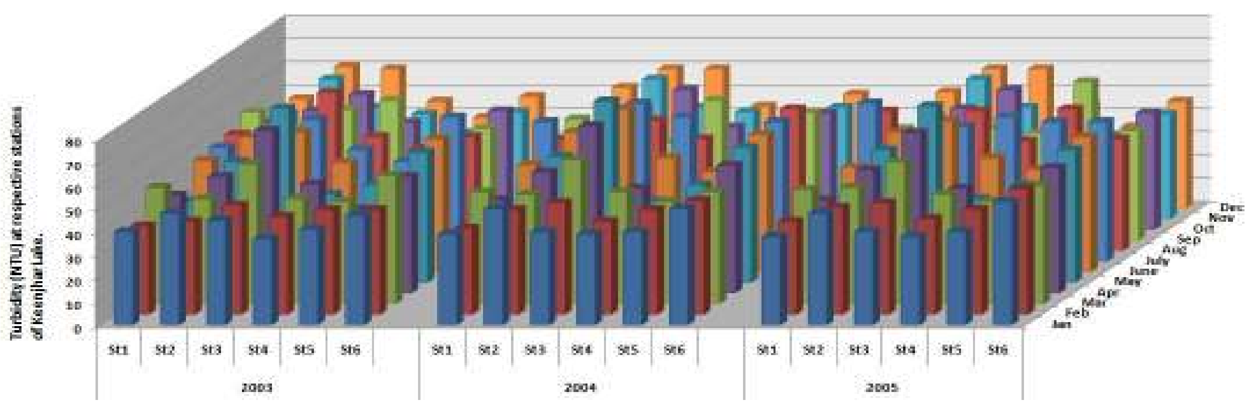

Figure 8. **Turbidity (NTU) during 2003, 2004 and 2005 at respective stations from Keenjhar Lake.**

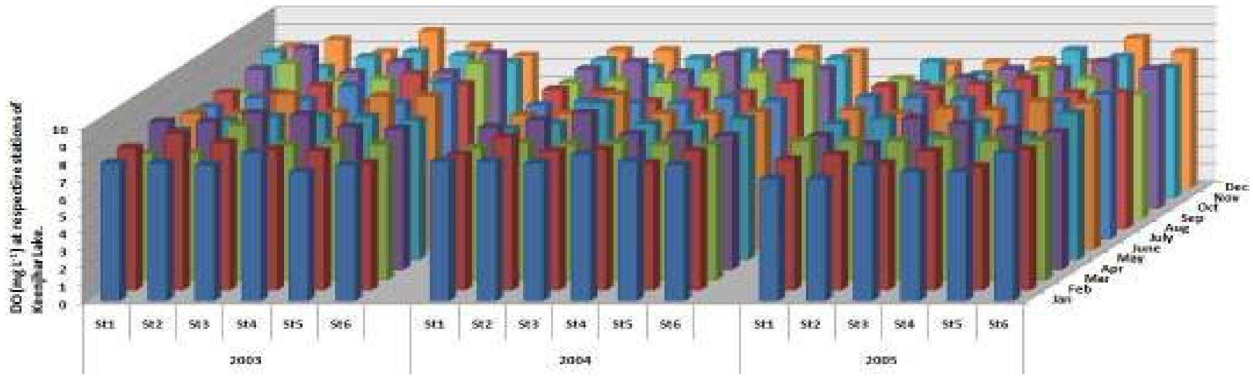

Figure 9. **Dissolve oxygen (mg L^{-1}) during 2003, 2004 and 2005 at respective stations from Keenjhar Lake.**

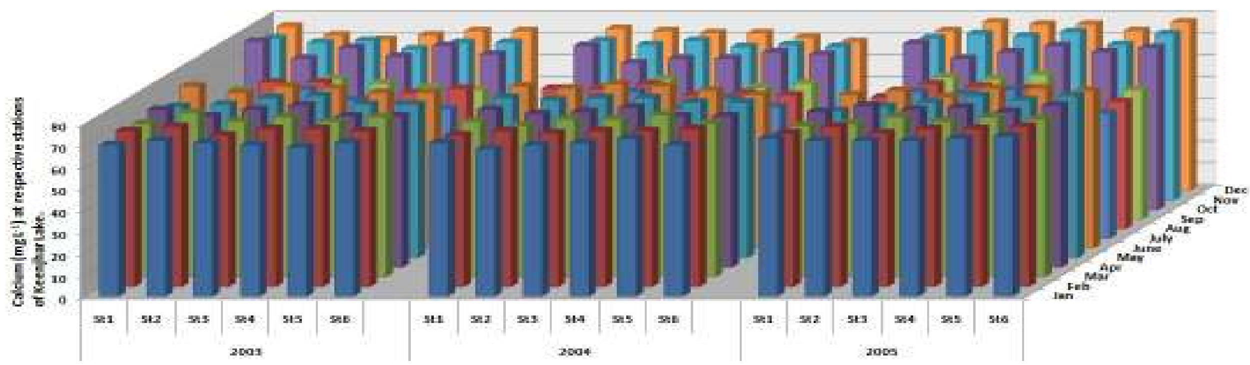

Figure 10. **Calcium (mg L^{-1}) during 2003, 2004 and 2005 at respective stations from Keenjhar Lake.**

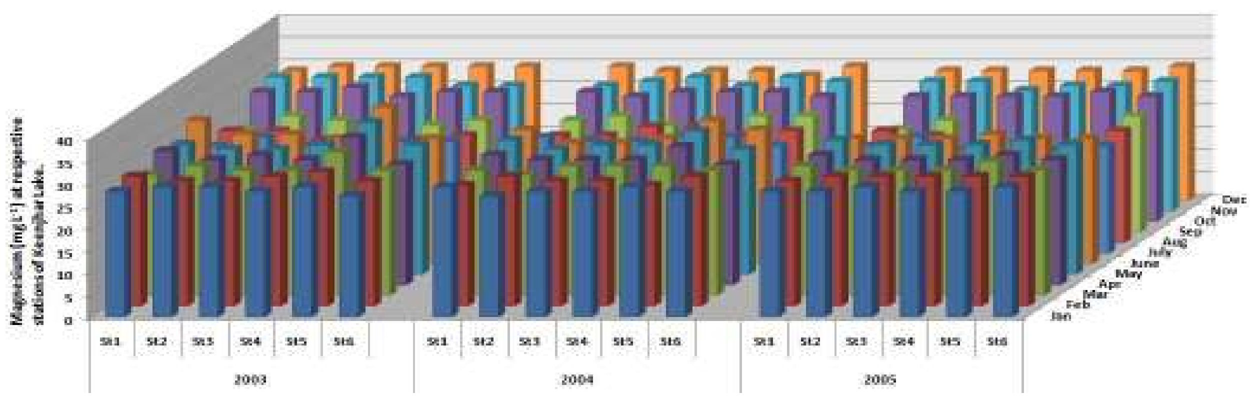

Figure 11. **Magnesium (mg L^{-1}) during 2003, 2004 and 2005 at respective stations from Keenjhar Lake.**

Conclusion

The present study shows both temporal and seasonal variations in water quality of Keenjhar. Physico- chemical properties of Keenjhar Lake were within tolerance limit for aquatic biota of Lake, no excessive concentration of any parameters was recorded during study period, and therefore the water of Keenjhar Lake was safe limit and for the growth of aquatic life, plants either animal.

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