ISSN:2372-0743 print
ISSN:2373-2989 on line
International Journal of Ground Sediment & Water
Vol. 06
2017

Research Paper

# Distribution Pattern Assessment of Physicochemical Components of Keenjhar Lake Water, Sindh, Pakistan

Adnan Khan*, Asal Eghbal Bkhatiari, Sumaira Asif Khan, Muhammad Arsalan

Department of Geology, University of Karachi, Karachi, Pakistan.

* Corresponding author E-mail: adkhan@uok.edu.pk

**Abstract:** Keenjhar Lake is one of the largest fresh water lakes in Pakistan which is present in Thatta district, Sindh. It is the main source of drinking water supply for Karachi city. The present study was carried out to assess the depth controlled variation pattern of physicochemical components of Keenjhar lake water. For this purpose, water samples were collected at three depth interval (1. Surface 2.Depth of 30 m 3.Near bottom). Studied parameters include physical character (color, odor, taste, temperature, pH, electrical conductivity, hardness, oxidation reduction potential) major chemistry (Na, K, Ca, Mg, $HCO_3$, $SO_4$, Cl, $NO_3$) and minor/trace elements (Fe, Cr, Co, Mn, Cu, Ni and Zn). Data reveal that there is no significant variation in the physical parameters and chemical components with depth change. All parameters in lake water are in compliance with the guideline values of WHO set for drinking water. The lake water is suitable for the survival and sustenance of aquatic life.

**Keywords:** Keenjhar Lake, physicochemical parameters, depth variation, distribution pattern.

## Introduction

Lakes are large bodies of inland water which serve as source for drinking, irrigation as well as industrial purpose. The quality and quantity of lake water depend upon the climate, catchments, geography of the area and the inputs and outputs both natural and manmade. Many fresh water reservoirs have been degraded due to a number of anthropogenic activities along with draught conditions during last several years (Pourang et al, 2005). Anthropogenic discharge of waste water such as untreated agricultural, industrial, and domestic effluents in fresh water bodies reduces surface water as well as groundwater quality (Kahlown et al, 2004, Malik, 2000). Keenjhar Lake (KL) is one of the largest artificial fresh water lakes of Asia which is being used as major source of drinking water for about 200 million people of Karachi city and about one hundred thousand people of Thatta and surrounding areas (Yahaya et al, 2016). River Indus is the main feeder of Keenjhar Lake through canal system. Since Indus River is used as conveyer belt of sewage and industrial effluents transportation along the transact of whole country. It is possible that Keenjhar Lake may get contaminated by the industrial discharge and sewage related solutes. These dissolved constituents create concentration gradient depth wise by influencing the density of water (Boehrer and Schultze, 2008). It is therefore imperative to assess the concentration and distribution pattern of major ion with respect to depth. Up to the knowledge of author, very limited studies have been carried out so far on Keenjhar Lake which includes the seasonal study and periodical pattern assessment of chemical pollutants (e.g. Lashari et al. 2009; Yahya et al. 2016; Farha et al. 2013). However, these studies did not cover the middle depth of lake to give a complete insight of overall pattern and trends of solute distribution in the lake. Moreover the role of rocks forming Keenjhar basin is not explained yet. Therefore, present study is aimed at assessing the depth controlled variation pattern of physicochemical components of Keenjhar lake water. Other objective is to evaluate the water quality evaluation for drinking and other purpose.

**Location and Climate**

The Keenjhar Lake is located 122km away from Karachi city and about 18km from Thatta city, Sindh (Fig. 1). National Highway lies on the east of this lake while it is bordered by Jhampir village to the west. Dimensionally, KL is an elongated lake stretched over an area of about 80km$^2$ (Lashari et al., 2009) which is NE-SW trending parallel to Indus river in the east. It is fed by Indus River through Kalri baghar feeder canal (Mahar et al., 2007).


**Figure 1** Map showing the location and sampling sites of Keenjhar Lake.

Climate of the study area is semi-arid, subtropical with an average annual temperature and rainfall of 26.8 °C and 210 mm respectively (Kureshy, 1977; Haq, 1999; Memon, 2005).

## Geology of Study Area

Keenjhar Lake is situated at Jhampir fault (a splay of Surjan master fault) passing through the lake along with minor normal splays (Akhtar et al., 2012). Structurally this lake is resting on Keenjhar Syncline which is situated at the north east of Kirthar Range. It is bounded by Lakhra, Makli and Matting Jhampir anticlines to the north, south and west respectively (Fig. 2). The surrounding rocks are gently dipping (2-5 degrees) towards west of the lake (Akhtar et al., 2012) due to which Indus river water is disconnected from Keenjhar Lake.

The margins of this lake constitute the limestone of Laki Formation while base of the lake is resting on Surface rocks of study area revealed that it is bounded to the NE and SW by Lakhra Formation of Paleocene which is limestone with subordinate sandstone, shale and minor clay while Laki Formation of Eocene is spread over north to south following the west. Soneri shale member of this Formation. Rock succession beneath this lake and surrounding areas is given in Table 1.

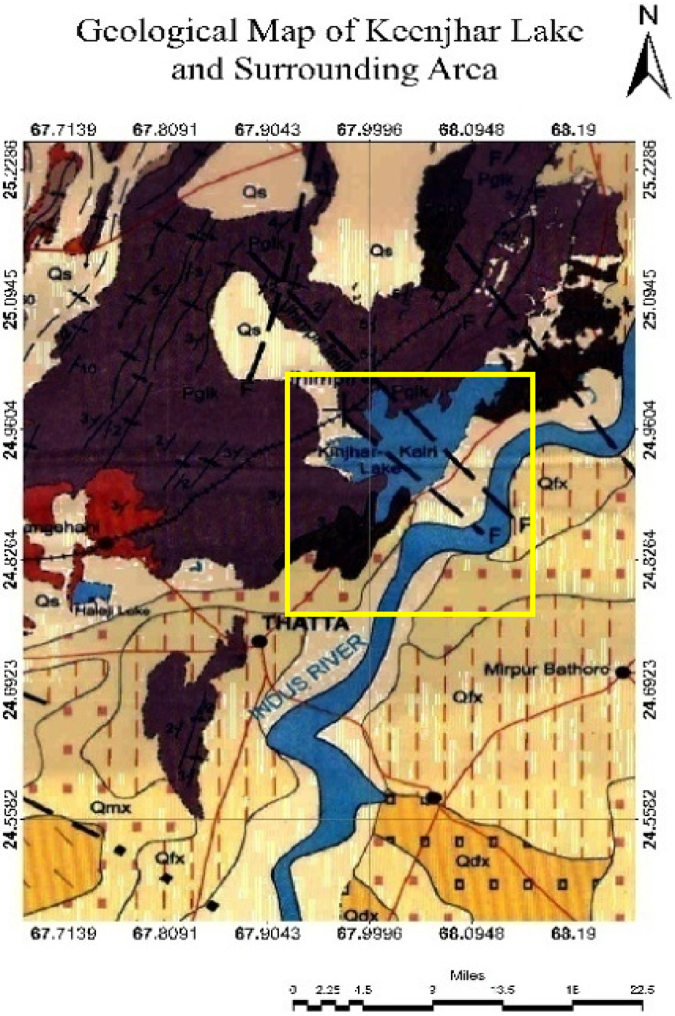


**Figure 2** Geological map of Keenjhar Lake and surrounding areas (after GSP).

Laki Formation is mainly comprised of 4 members including fossiliferous limestone, calcareous shale and marl with lateritic clay in minor quantity (Shah, 1977; Kadri, 1995).Alluvial deposits of Quaternary age which is mainly comprised of sand, silt and clayey material (Akhtar et al., 2012) occur on then northwest and east of Keenjhar Lake.

**Table 1** Showing the surface rocks surrounding the Keenjhar Lake (Akhtar et al., 2012)

| Age | Formations | Lithic Description |
|---|---|---|
| **Quaternary** | Superficial Alluvium deposits (Qs) | Silty-clay with subordinate sand |
| **Eocene** | Laki Formation (Plk) | Limestone followed by shale, sandstone and lateritic clays. |
| **Paleocene** | Lakhra Formation (Pgpl) | Limestone with subordinate sandstone, shale and minor clay |

## Materials and Methods

Sample Collection

A total of 29water samples were randomly collected across the transact of Keenjhar lake from ten different locations in post monsoon season. Sample location of each station was marked by Global Positioning System (Magellan, Triton). Three samples each from ten stations were collected at depth interval of surface SF (0.2m), middle MD (15m) and near bottom NB (30m). Samples from all depth were collected in two polystyrene bottles of 1000ml and 100ml capacities. 2ml boric acid was poured in each 100ml bottle to preserve the sample for nitrate detection. Sample in1000mlbottle was used for the determination of other physico-chemical parameters.

Sample Analysis

Aesthetic characters (odor, color and taste) were checked in-situ while other properties such as temperature, EC and TDS were measured by portable EC meter (Eutech Cyber Scan Con 11) at sampling point. SimilarlypH meter (JENCO 6230N) coupled with oxidation reduction potential (ORP) probe was used to measure pH andORP. All the samples were analyzed for their major cations (Ca, Mg, Na, K), anions (Cl, $HCO_3$, $SO_4$, $NO_3$) minor element (Fe) and by standard methods which have been listed in Table 2.

**Table 2** Equipment/methods used to analyze collected groundwater samples from Keenjhar Lake

| S. No. | Parameters | Equipments |
|---|---|---|
| | Turbidity | Turbidity meter, Lamotte, model 2008, USA |
| 1 | Electrical Conductivity/TDS | EC meter (Eutech Cyber Scan CON 11) |
| 2 | pH | pH meter (JENCO 6230N) |
| 3 | Alkalinity | 2320 Standard Method (1992) |
| 4 | $CO_3$ mg/L | Titration Method, (USSL, 1954) |
| 5 | $HCO_3$ mg/L | Titration Method, (USSL, 1954) |
| 6 | Ca mg/L | EDTA Titration Method |
| 7 | Cl- mg/L | Argenometric Titration Method |
| 8 | Mg mg/L | Titration Method |
| 9 | K mg/L | Flame photometer (JENWAY PFP7) |
| 10 | Na mg/L | Flame photometer (JENWAY PFP7) |
| 11 | $SO_4$ mg/L | Spectrophotometer (DR 2800) |
| 12 | $NO_3$ mg/L | Spectrophotometer, HACH-8171 |
| 13 | Hardness as $CaCo_3$ | EDTA titration standard method (1992) |
| 14 | Fe | Spectrophotometer (Model: U-1100, HITACHI) |

## Results and Discussions

### Physical Parameters

Water samples (*n=29*) collected from three depth intervals i.e. surface (SF), middle (MD) and near bottom (NB) are found to be odorless. Only samples collected from surface are slightly yellow in color while at MD and NB water is colorless. It suggests that organic matter decomposition is active at surface where yellow color is attributed to the occurrence of natural organic matter which contains Fe and $NO_3$.Organic activity at Lake surfaceis likely due to sunlight penetration and oxygen mixing in that photic zone. Strong correlation of Fe with $NO_3$ ($r=0.7$) support that both these ions are strongly associated with each other (Table4). Association of iron with nitrate indicates eutrophication process which increases the plant growth. Phytoplankton occur in the freshwater lakes which can take up nutrients from ambient environment (Xing and Liu, 2011). Many studies have shown iron uptake mechanism of phytoplankton (e.g. Cornelis and Andrews, 2010; Hudson et al., 1990). These phytoplankton releases their metal load once died and decomposed within the system. Although Keenjhar Lake water contains high pH and dissolved oxygen content but some studies have shown that reduction of ferric iron can also occur in such surface waters (Aldrich and Van den Berg, 2001; Emmenegger et al., 2001).

**Table 3** Physical parameters of collected water samples at three depth intervals (SF, MD and NB)

| | | Temp. | pH | ORP | EC | TDS | Hard. |
|---|---|---|---|---|---|---|---|
| Range | Surface | 29-33 | 7.95-8.2 | 33-179 | 577-750 | 290-378 | 125-150 |
| | Middle | 26-30 | 8-8.2 | 160-188 | 545-752 | 272-376 | 130-150 |
| | Bottom | 25-29 | 8.1-8.3 | 158-172 | 658-742 | 329-370 | 135-155 |
| SD | Surface | 1.50 | 0.08 | 42.69 | 70.34 | 34.75 | 140 |
| | Middle | 1.14 | 0.07 | 8.00 | 66.79 | 30.53 | 141 |
| | Bottom | 1.36 | 0.05 | 5.23 | 29.22 | 14.44 | 141.6 |
| Mean | Surface | 31 | 8. | 150.3 | 676 | 338.9 | 7.4 |
| | Middle | 28.6 | 8.1 | 170.1 | 690.6 | 345.5 | 7.0 |
| | Bottom | 28.09 | 8.1 | 166.22 | 711.88 | 355.77 | 6.1 |

Temperature at each station varies in the range of 29.5-32.5$^0$C, 28-30$^0$C and 25-29$^0$C for SF, MD and NB respectively (Table 2). Temperature contributes to density differences in water where atmosphere imposes a temperature signal on the lake surface. As a result, thermal stratification can be established during the warm season if a lake is sufficiently deep (Boehrer1 and Schultze 2008). Similar is observed for Keenjhar Lake where variation pattern reveals that temperature intensity decreases with increasing depth (Fig. 4) which is due to high sunlight illumination at surface (Shedayi et al, 2016) which fade away down depth.

The pH of water varies in the range of 7.9-8.2, 8-8.2 and 8.1-8.3 for SF, MD and NB respectively. The mean pH noted at all the depths is found to be uniform which is slightly alkaline (±8.1).This even distribution of pH at all depths suggests that very low organic activity is prevailing in the lake water especially at MD and NB. Buffering mechanism to maintain the water pH may be other explanation as Keenjhar Lake is surrounded by limestone rocks which serve as pH buffer. Similarly, the alkaline nature of lake is due to the inflow of sufficient amount of water from Indus River and nearby hill torrents (Mahar et al., 2000; Veizer and Karim, 2000).The Electrical conductivity (EC) and total dissolved solids (TDS) show insignificant variation in lake water from surface to bottom with mean values of 692µs/cm and 346ppm respectively.EC is positively correlated with TDS (*r= 0.99*). Increasing conductivity values are the product of decomposition and mineralization of organic materials. Correlation between TDS and $NO_3$ decrease with increasing depth as shown by strongly positive at SF (*r =0.5*) followed by MD (*r =0.3*) while inverse (*r = -0.5*) relationship at NB depth. It further supports the pronounced organic activity at surface layers of Keenjhar Lake water.

**Table 4** Correlations matrix among all physico-chemical parameters.

| | pH | EC | Hardness | Na | K | Ca | Mg | Cl | SO4 | $HCO_3$ | $NO_3$ | Fe |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| pH | 1 | | | | | | | | | | | |
| EC | -0.21 | 1 | | | | | | | | | | |
| Hardness | -0.05 | 0.08 | 1 | | | | | | | | | |
| Na | -0.02 | 0.37 | 0.58 | 1 | | | | | | | | |
| K | -0.15 | 0.40 | 0.41 | 0.78 | 1 | | | | | | | |
| Ca | -0.43 | 0.17 | 0.27 | 0.49 | -0.01 | 1 | | | | | | |
| Mg | 0.32 | -0.08 | 0.56 | 0.43 | 0.33 | -0.65 | 1 | | | | | |
| Cl | 0.15 | 0.40 | 0.33 | 0.50 | -0.27 | 0.25 | 0.05 | 1 | | | | |
| $SO_4$ | 0.06 | -0.075 | 0.06 | -0.05 | -0.27 | -0.01 | 0.06 | 0.01 | 1 | | | |
| $HCO_3$ | 0.06 | -0.03 | 0.30 | 0.31 | 0.15 | -0.05 | 0.28 | 0.003 | 0.24 | 1 | | |
| $NO_3$ | -0.47 | 0.27 | -0.06 | -0.01 | 0.26 | -0.01 | -0.28 | 0.28 | -0.11 | -0.23 | 1 | |
| Fe | -0.16 | 0.46 | -0.07 | -0.15 | -0.02 | 0.09 | -0.13 | 0.31 | 0.10 | -0.44 | 0.36 | 1 |

The hardness of Keenjhar lake water at all depths varies between 125-155mg/L with mean of 140mg/L. Hardness of the lake is mainly influenced by the rainwater passing through the catchment area comprising hills of Kirthar Mountain (Mahar et al., 2000). Data revealed that the hardness is mainly governed by the occurrence of Mg in Keenjhar Lake which is reflected by positive correlation of Mg with hardness (0.5) and Ca. Relatively high concentration of Mg is due to the occurrence of dolomitic limestone of Laki Formation.

Oxidation reduction potential (ORP) values measured in all samples ranges between 145 -188mV with mean value of 162mVwhich suggests that the lake water is highly oxic in nature. Relatively low concentration of redox sensitive ions such as $NO_3$, $HCO_3$ and Fe in Keenjhar Lake explains why variation in physicochemical parameters is low. Seasonal fluctuations in physicochemical parameters and similar rise in dissolved oxygen content in winter season has been reported by different workers (Rao, 1986; Singh et al., 1980). During cold season dissolved oxygen increases due to reduction in microbial decomposition of dead organic matter, low organism respiration demand, increased growth of submerged macrophytes and solubility of atmospheric oxygen due to decreased temperature (Mahar et al., 2000). Conversely, high rate of organic matter decomposition and low content of dissolved oxygen remain in the water during summer. Since samples were collected during cold season this may be the reason why Fe and $NO_3$ showed strong association only on surface collected samples.

**Chemical Parameters**

Major cations

*Sodium (Na) and Potassium (K)*

Sodium distribution is highly variable in surface samples (range: 7-68 mg/L) but relatively uniform at middle and near bottom sites (MD: 58-68mg/L; NB 54-66 mg/L).Very low K concentration (range: 6-7 mg/L) is determined at all depths (SF, MD and NB) but its distribution is homogenous (mean: ≤ 6.52 mg/L) throughout the lake. Na (mean: 61 mg/L) and K (mean: 6.4 mg/L) contents are more than double the corresponding concentrations (Na: 23.8 mg/L; K: 2.7 mg/L) in Indus river (Aziz-ur-Rahman and Chughtai, 2014). Na revealed strong correlation with K ($r=0.5$) indicating that both these elements are somehow linked with each other. These ions may be derived from atmospheric deposition, evaporite dissolution and silicate weathering.

**Table 5.** Chemical constituents of collected water samples at three depth intervals (SF, MD, NB).

| | | Ca | Mg | Na | K | Cl | $HCO_3$ | $NO_3$ | $SO_4$ |
|---|---|---|---|---|---|---|---|---|---|
| Range | Surface | 20-32 | 14.6-20.6 | 52.5-68 | 6-7 | 67.35-99.26 | 105-120 | 0.02-1.25 | 16.28-138.4 |
| | Middle | 20-28 | 17.01-20.6 | 58-68 | 6-7 | 67.35-99.26 | 105-120 | 0.06-2.29 | 8.14-97.7 |
| | Bottom | 20-32 | 15.8-25.5 | 54-66 | 6-6.5 | 79.76-99.26 | 105-120 | 0.08-0.76 | 40.7-244 |
| SD | Surface | 3.32 | 2.02 | 4.626 | 0.43 | 9.75 | 5.05 | 0.3 | 33.02 |
| | Middle | 2.06 | 1.42 | 3.07 | 0.23 | 4.71 | 4.77 | 0.9 | 28.21 |
| | Bottom | 3.46 | 2.78 | 3.99 | 0.25 | 5.65 | 4.33 | 0.2 | 63.57 |
| Mean | Surface | 26.2 | 18.1 | 56.8 | 6.45 | 89.33 | 113.3 | 0.6 | 78.95 |
| | Middle | 25.6 | 18.7 | 63.65 | 6.52 | 94.29 | 112.75 | 0.8 | 62.67 |
| | Bottom | 26 | 18.6 | 62.38 | 6.33 | 91.77 | 113.33 | 0.4 | 81.4 |

*Calcium (Ca) and Magnesium (Mg)*

Calcium content varies in the order of SF+NB (20-32 mg/L) > MD (20-28 mg/L) which is found to be uniform (mean: 26 mg/L) with slight variation. This low content of calcium (Ca< 33 mg/L) in Keenjhar lake water is consistent with its concentration (mean: 36 mg/L) in Indus River (Aziz-ur-Rahman and Chughtai, 2014). Similarly, Mg shows uniform distribution at all three depths. Mg concentration (mean: 18 mg/L) of Keenjhar Lake is three times higher than the Indus River where it is reported up to 5.8 mg/L. Although watershed and Keenjhar lake itself rest on the carbonate rocks (Laki Formation of Eocene age) but low concentrations of both Ca and Mg in the lake indicates that either the water is saturated in terms of carbonate minerals or the lake water is not actively reacting with surrounding rocks. Other possibility is the continuous flow of water from Indus River to Keenjhar Lake through canal which is serving as diluting mechanism for such ions.

Major anions

*Chloride (Cl) and Bicarbonate ($HCO_3$)*

Chloride content widely varies at all three depths but variation range is found to be same (67-100mg/L) for SF and MD (Table 2). Relatively more stable content (79.8-99.3 mg/L) of $Cl^-$at NB environment suggest more steady movement of water due to the shear stress exerted by the bottom sediments on nearby water layers. Although variation range of $Cl^-$ concentration is same for SF and MD but standard deviation for SF (9.7) is higher than the MD (4.7) samples. It clearly indicates the role of atmospheric intervention with the surface layer of Keenjhar Lake. Dragging of surface water molecules by wind energy may cause dispersion of solutes in uneven pattern. Chloride concentration in Keenjhar Lake is double its content in Indus River (mean: 41 mg/L). Chloride is pollution indicating parameter which is related to sewage contamination and degradation products. Many huts have been constructed along Keenjhar Lake for the tourists who come for picnic and stay over nights for parties. The sewage generated in the toilets of such huts is directly drained into the lake which is increasing the dissolved load of lake water.

Bicarbonate distribution is found to be uniform where it varies in the range of 105-120 mg/L at all three depths. The mean value of $HCO_3$ for SF, MD and NB is found to be 113.3, 112.75 and 113.33 mg/L respectively which are relatively higher than its content in the Indus River (87.5 mg/L). High $HCO_3$content in Keenjhar Lake is attributed to high rate of organic matter decomposition during which $CO_2$ is liberated which reacts with water to form $HCO_3$ (Aziz-ur-Rahman and Chughtai, 2014). Similarly, interaction of lake water with adjacent Laki limestone may have contributed the excessive amount of this ion in Keenjhar Lake.

*Sulphate ($SO_4$) and Nitrate ($NO_3$)*

Sulphate distribution revealed the heterogeneous pattern where it varies in the order of NB (mean: 81.4 mg/L) > SF (78.95 mg/L) > MD (62.7 mg/L). Interestingly, $SO_4$ in

Keenjhar Lake is found to be double its concentration in Indus River. Near bottom samples not only have largest mean but also show highest standard deviation which suggest that $SO_4$ concentration is strongly influenced by biogeochemical processes at near bottom environment. On the other hand, nitrate occurs in very low concentration ($NO_3$< 3 mg/L) at all depth intervals. The mean nitrate content is found to be relatively higher in MD (0.8 mg/L) followed by SF (0.6 mg/L) and lowest at NB (0.4 mg/L). Relatively low nitrate but high sulphate content suggests that bacteria mediated organic matter oxidation is quite slow in Keenjhar Lake where oxygen intake from sulphate is not yet reached.

## Conclusion

Water column study with respect to depth of Keenjhar Lake revealed that slight variation in temperature occurs downward. No significant variation in concentration or distribution is found for major cations (Na, K, Ca, Mg) and anions ($HCO_3$, $NO_3$). However, Sulphate showed heterogeneous pattern at all depth and Cl at surface layer of Keenjhar Lake. The concentration of major dissolved load is found to be higher than the Indus River which is feeding this Lake through canal. However, the ions occur within the permissible limit required for agriculture purpose, human use and aquatic life.

## Acknowledgement

Authors are thankful to Dean, faculty of science, University of Karachi for providing the logistic support to collect samples. We are also indebted to Department of Geology, University of Karachi to provide analytical facilities. Thanks are also due to instrument technician Mr. Wasi Haider for analyzing samples precisely and accurately.

## References

Akhtar, M. J., Rizvi, Y., Muhammad. A., Tagar, M. A. 2012. Geological map of Sind, Pakistan. 1:600,000 scale, Geological survey of Pakistan.

Aldrich, A.P., van den Berg, C.M.G., Thies, H., Nickus, U. 2001. The redox speciation of iron in two lakes. *Marine and Freshwater Research.* 52 no: 885-890.

Aziz- ur- Rahman, Chughtai, M. O. 2014. Regional interpretation of river Indus water quality data using regression model. African *Journal of Environmental Science and Technology*, 8(1) no: 86-90.

Boehrer,B. and Schultze, M. 2008. Stratification of lakes. Review of geophysics. *American geophysical union* 46 no: 1-27.

Cornelis, P. and Andrews, S. 2010. Iron uptake and homeostasis in microorganisms. Caister Academic Press: Norwich, UK. 302.

Emmenegger, L., Schonenberger, R.R., Sigg, L. and Sulzberger, B. 2001. Light-induced redox cycling of iron in circum-neutral lakes. Limnology and Oceanography, 46 no: 49-61.

Farah A., Azmat R., Jabeen F. and Bila, B. 2013. A Comparative Study of Physicochemical Parameters of Keenjhar Lake, Thatta, Sindh, *Pakistan Int. J. Adv. Research* 1(6) no: 482-488.

Haq, B. U., 1999. Past, Present and Future of Indus Delta. In: A. Meadows, P. S. (Eds), The Indus River. Biodiversity Resources, Humankind, Linnaean Society, L. London Oxford University Press,UK. no: 231-248.

Hudson, R.J.M. and Morel, F.M.M. 1990. Iron transport in marine phytoplankton: Kinetics of cellular and medium coordination reactions. *Limnology and Oceanography* 35 no: 1002- 1020.

Kadri, I. B. 1995. Petroleum Geology of Pakistan, Pakistan Petroleum Limited. 275 pages.

Kahlown, M.A., Tahir, M.A. and Sheikh, A.A., 2004. Water Quality Status in Pakistan: Second Report 2002-2003, Pakistan Council of Research in Water Resources, Islamabad, ISBN: 969-8469-13-3.

Karim, A., and Veizer, J., 2000, Weathering processes in the Indus River Basin: implications from riverine carbon, sulfur, oxygen and strontium isotopes. *Chemical Geology* 170 no, 153–177.

Kureshy, K. U. 1977. Geography of Pakistan, 4th edn. (ed). Oxford University Press, USA. 212p.

Lashari, K. H., Korai, A. L., Sahato, G. A. and Kazi, T. G. 2009. Limnological studies of Keenjhar lake, District Thatta,Sindh,Pakistan. Pak. J. Analys. Environ. Chem 10(1&2) no: 39-47p.

Mahar, M. A., Jafri, S. I. H., Laghari, S. M. and Khuhawar, M. Y. 2000. Studies on water chemistry and fish production of Manchar Lake, Dadu, Sindh, (Pakistan). *Pakistan journal of Biological Sciences*, 3(12) no: 2151-2153.

Mahar, M.A., Leghari, S. M., Khuhawar, M.Y. and Abbasi, M. A. 2007, Microcystis Kutzing Ex Lemmermann (Cyanophyta) as pollution indicator in Keenjhar Lake, Pakistan. 3 no: 91-96.

Malik, S.B., 2000. An overview of geothermal resources of Pakistan, in Proceedings of the World Geothermal Congress, Kyushu, Tohoku, Japan.

Memon, A.A. 2005. Devastation of Indus River Delta. Proceedings, World Water & Environmental Resources Congress 2005, American Society of Civil Engineers, Environmental and Water Resources Institute, Anchorage, Alaska, May 14-19, 2005.

Pourang, N.; Nikouyan, A. and Dennis, J.H., 2005. Trace Element Concentrations in Fish, Surficial Sediments and Water from Northern Part of the Persian Gulf Environment Monit. Assess. no: 109,109-293.

Rao, K.J. 1986. Studies on the seasonal and diurnal variation in some physicochemical conditions of a fresh water pond under prawn culture. *Proc. Nat. Symp. Fish and Environ.* no: 96-102.

Shah, S.M.I. 1977. Stratigraphy of Pakistan, Geological Survey of Pakistan. Memoir 12-138.

Shedayi, A. A., Bano S., Xu M., SehrishS. and Naseer, I. 2016. Physico-Chemical Analysis of Water Quality of Khalti Lake Guips, Ghizer, Pakistan. *Int. J. sci.,* 28(2), no: 1327-1332.

Singh, R.N., Srivasta, N.P. and Desai, V.R. 1980. Seasonal and diurnal variations in physico-chemical conditions of water and plankton in biotic sector of Rihand Reservoir (U.P) *J. In land Fish. India*, 12 no: 100-111.

Xing, W. and Liu, G. 2011. Iron Biochemistry and Its Environmental Impacts in Freshwater Lakes. *Fresenius Environmental Bulltein*, 20(6) no: 1339-1345.

Yahya, S.M, Rahman A. and Chughtai M.O. 2016, Study on Environmental Impact Of Chemical Pollutants And Interpretation Of Characteristics Using Statistical Technique In Water Quality of Keenjhar Lake Located In Sindh Pakistan. *J. Mater. Environ. Sci.* 7(2) no: 648-659.

**Journal Website: http://ijgsw.comze.com/**
**You can submit your paper to email: Jichao@email.com**
**Or IJGSW@mail.com**