Int. J. Econ. Environ. Geol. Vol. 10 (1) 36-41, 2019
Journal home page: www.econ-environ-geol.org

Open Access
ISSN: 2223-957X

Monthly Variation of Physico-Chemical Parameters of Haleji lake, Sindh, Pakistan

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Received: *4 March, 2019* ***Accepted:*** *24 March, 2019*

Abstract: Present work is based on the physico-chemical parameters of Haleji lake. Physical factors and chemistry of lake water were analyzed with regular intervals. The color of water showed variation from light green to yellowish green, air temperature ranged between 20 °C to 35 °C, water temperature between 17 °C to 33 °C , pH 5.5 to 7.5, dissolved oxygen 2.04 mg/L to 6.44 mg/L, salinity 0.32 mg/L to 1.1 mg/L, alkalinity from 30 mg/L to 100 mg/L, acidity 10 to 96 mg/L, sulphate 4.5 mg/L to 305 mg/L, phosphate from 1 mg/L to 190 mg/L, and nitrates 9 mg/L to 270 mg/L during 2006, 2007 and 2008 respectively.

Keywords: Haleji lake, variation, physico-chemical characteristics, Sindh.

Introduction

Haleji lake is situated at a distance of 55 miles from Karachi in Thatta district and is located between latitude 28.48° North and longitude 67.47° East. It has about 6.5 sq.km surface area. The light penetration is limited due to dense aquatic weeds and suspended materials. The bottom of the lake is sandy cum muddy and is covered with a thick deposition of dead and decayed plants (Baqai et al., 1974 a).

The relationship between biotic and abiotic substances is evident. Singh et al. (1980) described seasonal diurnal variation in physico-chemical variables of water and planktons. Baqai et al. (1974 a, b) worked on limnological studies of Haleji and Keenjhar lakes. Siddiqui and Saqib (1994) examined Haleji lake and showed marked seasonal and vertical variation of phosphate and nitrate. Nandini (1999), recorded variations in physical and chemical factors like temperature, pH, dissolved oxygen, phosphorus, nitrate and chlorophyll-*a*, in a series of sewage-stabilization ponds.

Jahangir et al. (2000) analyzed different physico-chemical parameters such as hardness, conductivity, TDS, chloride, alkalinity, nitrate, dissolved oxygen, silica, orthophosphate, sodium, potassium, calcium, and magnesium metal ions in Keenjhar and Haleji lakes. Mahar et al. (2000) described the quality of water of Manchar lake, Sindh, and discussed the effects of different physico-chemical parameters on micro-organism present in water.

Leghari *et al*. (2000), investigated some lakes of district Badin to examine the water quality and biological life present in these lakes. Among physico-chemical parameters, pH, conductivity and salinity were determined. Leghari *et al*. (2001) analyzed water samples from two springs of Dhabeji. They conducted experiments to determine pH, TDS, chloride, hardness, nitrogen, ammonia, nitrate - nitrogen and hydrolysable phosphate phosphorus. The purpose of present study was to estimate the present physico-chemical status of the lake water because water quality testing is an important part of the environmental monitoring. When water quality is poor it not only affects the aquatic life but the surrounding ecosystem as well.

Materials and Methods

To study the physico-chemical parameters of Haleji lake, regular trips were made on a monthly basis. Sample collection was made during 5 am to 11 am at the main site near the rest house. Glass stoppered bottles and reagents were taken in carriers and samples were examined and fixed at the spot. The color was observed and temperature of water was recorded by dipping a mercury thermometer directly into the lake and in air by holding in hand through a thread. The pH was determined through "Merck Rollen Form Art.9564". Dissolved oxygen was examined by Winkler's method. 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.

Statistical Analysis

The result of present investigation was subjected to statistical analysis by using MINITAB Release 14. Mean and Standard Deviations were taken for physico-chemical factors. ANOVA was also performed to find out significance of the ecological parameters.

Results and Discussion

The physico-chemical parameters of Haleji lake during 2006, 2007, and 2008 were depicted in Table 1, 2 and 3 respectively. The color of Haleji lake during 2006, 2007 and 2008 was observed green in most of the months. Light green was noticed in February and December, while yellowish green in October and

November. During February and December, the duration of solar illumination was not favorable for the phytoplankton blooming so it may be a big cause of light green appearance. As far as October and November are concerned, yellowish coloration was linked with the lowering rate of green pigments available in phytoplankton.

Table 1 shows the highest pH (7.5) during July and lowest in December (5.5) 2006. It was also noted that pH was increasing from January (6) to July (7.5). April, May, and June have the same (7) value. The pH value in 2007 was almost similar to that of 2006 except January, August, and November in which it was recorded to be 6.5, 7.5, and 6.5 respectively. During

Table 1. Physico-Chemical parameters of Haleji Lake during 2006.

Parameters	**Jan.**	**Feb.**	**Mar.**	**Apr.**	**May**	**Jun.**	**Jul.**	**Aug.**	**Sept.**	**Oct.**	**Nov.**	**Dec.**
Colour Temperature (C°)Air	Green 21	Light Green 28	Green 32	Green 31	Green 33	Clear Green 35	Clear Green 31	Green 33	Green 35	Yellowish Green 27	Yellowish Green 26	Light Green 23
Temperature (C°)H_2O	19	26	28	26	28	30	29	31	33	25	24	21
pH	6	6	6.5	7	7	7	7.5	7	6	6.5	6	5.5
Diss. Oxygen (mg/L)	6.44	5.07	4.21	3.65	4.86	3.12	2.43	3.25	4.85	2.26	5.23	6.08
Salinity (mg/L)	0.32	0.56	0.46	0.56	0.36	0.46	0.5	1	0.66	0.46	0.56	0.66
Akalinity (mg/L)	40	60	85	45	65	95	30	50	100	60	35	80
Acidity (mg/L)	18	59	30	14	96	48	13	29	27	11	36	30
Sulphates (mg/L)	32	8.8	190	75	11.6	5.1	280	11.1	5.1	60	305	12.2
Phosphates (mg/L)	5	13.4	1	3	3	10	31	26	52.5	4	190	22
Nitrates(mg/L)	12	52	14	19	270	26	26	200	30	11	17	180

Air temperature was variable throughout 2006 to 2008 and ranged between 20ºC (January) to 35ºC (June and September). It was increasing from January to March and July to September, while decreasing from September to December (2006 and 2007). During 2008 it showed gradual increment from January to June and July to September, while gradually decreased from October to December. The mean value ranged between 20.33 to 35 ºC during the whole study period (Table 4).

Temperature of surface water showed decreasing trends from September to December in all the studied years (Tables 1, 2 and 3). It ranged between 19ºC (January) to 33ºC (September) in 2006 and 18ºC (January) to 32ºC (June and September) 2007. It fluctuated between 17°C (January) to 33°C (June and September) during 2008. A gradual increase was noticed from January to June and July to September (2006 and 2008), whereas decreasing from September to December (2006, 2007 and 2008). The mean value ranged between 18 to 32.67 ºC during the study period (Table 4).

2008, it ranged between 5.5 (December) to 7.5 (August and July). From April to June it remained same (7). A gradual decrease from July to December was noticed. An increasing trend was noticed from February to August. The mean value ranged between 5.50 to 7 during the study period (Table 4).

Peak of dissolved oxygen during 2006 was recorded in January (6.44 mg/L) while lowest value was in October (2.26 mg/L). An increasing value from October to December was noted in all the three studied years while a decreasing trend was observed from January to April during 2006. The highest value of

Table 2. Physico-Chemical parameters of Haleji Lake during 2007.

Parameters	**Jan.**	**Feb.**	**March**	**April**	**May**	**June**	**July**	**August**	**Sept.**	**Oct.**	**Nov.**	**Dec.**
Colour Temperature(C°)Air	Green 20	Light Green 30	Green 33	Green 32	Green 34	Clear Green 35	Clear Green 32	Green 33	Green 35	Yellowish Green 32	Yellowish Green 27	Yellowish Green 22
Temperature(C°)H_2O	18	27	30	29	31	32	30	30	32	29	25	20
pH	6.5	6	6.5	7	7	7	7.5	7.5	6	6.5	6.5	5.5
Diss.Oxygen(mg/L)	6.33	5.86	4.51	5.23	5.51	3.29	4.25	3.54	4.63	2.04	4.82	6.23
Salinity(mg/L)	0.44	0.54	0.36	0.56	0.46	0.36	1.1	0.67	0.54	0.46	0.64	0.56
Akalinity(mg/L)	35	65	75	50	60	85	40	50	90	55	30	75
Acidity(mg/L)	24	49	22	15	88	29	14	25	19	11	30	29
Sulphates(mg/L)	28	6.5	145	63	9.5	4.5	210	9.5	4.5	56	280	14
Phosphates(mg/L)	4.7	14	2	4	4	12	29	23	55	3	178	19
Nitrates(mg/L)	11	47	17	21	175	19	24	190	26	9	28	165

dissolved oxygen during 2007 was noted in January (6.33 mg/L) and lowest was in October (2.04 mg/L). A gradual decreasing trend of values was noted from January to March. Highest and lowest values of DO were observed in the same months of 2008 as were noted in 2006 and 2007, but with different values i.e 6.38 mg/L and 2.16 mg/L respectively (Table 1, 2 and 3). The mean value ranged between 2.15 to 6.38 in the study period (Table 4).

In 2006, the highest value of salinity (1 mg/L) was noted in August whereas lowest (0.32 mg/L) was in January. It exhibited increasing trend from May to August in 2006, which was same as the findings in 2008. While in 2007, the highest ratio was recorded in July (1.1 mg/L) while lowest was in March and June (0.36 mg/L). The mean value ranged between 0.37 to 0.89 during the study period (Table 5).

Highest alkalinity (100 mg/L) during September and lowest in July (30 mg/L) were noted in 2006 and 2008. Great fluctuation was observed throughout the study period (2006, 2007, and 2008). During 2007, maximum value (90 mg/L) was recorded in September whereas minimum value (30 mg/L) was noted in November. The mean value ranged between 33.33 to 96.67 in the study period (Table 5).

Table 3. Physico-Chemical parameters of Haleji Lake during 2008.

Parameters	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Colour	Green	Light Green	Green	Green	Green	Clear Green	Clear Green	Green	Green	Yellowish Green	Yellowish Green	Light Green
Temperature(C°) Air	20	29	32	33	34	35	32	33	35	30	29	21
Temperature(C°) H_2O	17	26	30	31	31	33	30	31	33	27	26	19
pH	6.5	6	6.5	7	7	7	7.5	7.5	6.5	6.5	6	5.5
Diss.Oxygen(mg/L)	6.38	5.61	5.22	4.46	3.65	3.23	4.63	3.62	4.31	2.16	4.73	6.16
Salinity(mg/L)	0.36	0.54	0.39	0.54	0.42	0.46	0.94	1	0.58	0.43	0.59	0.52
Akalinity(mg/L)	40	65	70	45	65	95	30	50	100	60	35	80
Acidity(mg/L)	20	52	24	12	90	36	14	26	20	10	32	28
Sulphates(mg/L)	29	8.2	154	65	10.3	5.8	240	10	5.5	57	290	11.4
Phosphates(mg/L)	4.6	12.9	1.2	3.6	4	10	31	24	54	3	170	20
Nitrates(mg/L)	12	50	15	19	180	21	25	165	27	10	23	158

Table 4. Standard deviation and mean of air and water temperature (°C), pH and Diss. Oxygen of Haleji lake during (2006-2008).

	Air Temp. (°C)	Water Temp. (°C)	pH	Diss Oxygen (mg/L)
Months	**Mean ±SD**	**Mean± SD**	**Mean±SD**	**Mean±SD**
January	20.33±0.58	18.00±1.00	6.33±29.00	6.38±0.06
February	29.00±1.00	26.33±0.58	6.00±0.00	5.51±0.40
March	32.33±0.58	29.33±1.15	6.50±0.00	4.65±0.52
April	32.00±1.00	28.67±2.52	7.00±0.00	4.45±0.79
May	33.67±0.58	30.00±1.73	7.00±0.00	4.67±0.94
June	35.00±0.00	31.67±1.53	7.00±0.00	3.21±0.09
July	31.67±0.58	29.67±0.58	7.50±0.00	3.77±1.18
August	33.00±0.00	30.67±0.58	7.33±0.29	3.47±0.19
September	35.00±0.00	32.67±0.58	6.17±0.29	4.60±0.27
October	29.67±2.52	27.00±2.00	6.50±0.00	2.15±0.11
November	27.33±1.53	25.00±1.00	6.17±0.29	4.93±0.27
December	22.00±1.00	20.00±1.00	5.50±0.00	6.16±0.08

Maximum value of acidity was recorded in May (96 mg/L) while minimum was in October (11 mg/L). During 2006, a decreasing trend of acidity was noted between February to April. In 2007, it was noted to be 88 mg/L, in May (highest) and 11 mg/L in April (lowest). In 2008, the maximum value was 90 mg/L in May and minimum was 10mg/L in October. The mean value ranged between 11.67 to 91.33 in all the studied years (Table 5)

Table 5. Standard Deviation and Mean of Salinity, Alkalinity and Acidity of Haleji Lake during (2006-2008).

	Salinity(mg/L)	Alkalinity(mg/L)	Acidity (mg/L)
Months	**Mean ± SD**	**Mean ±SD**	**Mean ±SD**
January	0.37±0.06	38.33±2.89	20.67±3.06
February	0.55±0.01	63.33±2.89	53.33±5.13
March	0.40±0.05	76.67±7.64	25.33±4.16
April	0.55±0.01	46.67±2.89	11.67±2.08
May	0.41±0.05	63.33±2.89	91.33±4.16
June	0.43±0.06	91.67±5.77	37.67±9.61
July	0.85±0.31	33.33±5.77	13.67±0.58
August	0.89±0.19	50.00±0.00	26.67±2.08
September	0.59±0.06	96.67±5.77	22.00±4.36
October	0.45±0.02	58.33±2.89	12.67±2.08
November	0.60±0.04	33.33±2.89	32.67±3.06
December	0.58±0.07	78.33±2.89	29.00±1.00

During 2006, the maximum quantity of sulphate was recorded in November (305 mg/L), while minimum was in June and September (5.1 mg/L). The ratio of sulphate was similar to that of 2007. However, the values were different. A decreasing trend of values was observed from March to June (2007 and 2008). In 2008, the maximum value was in November (290 mg/L), whereas the minimum quantity was noted in September (5.5 mg/L). The mean value ranged between 5.03 to 291.67 during the study period (Table 6).

Table 6. Standard deviation and mean of sulphate, phosphate and nitrate of Haleji lake during (2006-2008).

	Sulphate (mg/L)	Phosphate (mg/L)	Nitrate (mg/L)
Months	**Mean ±SD**	**Mean ±SD**	**Mean ±SD**
January	29.67±2.08	4.77±0.21	11.67±0.58
February	7.83±1.19	13.43±0.55	49.67±2.52
March	163.00±23.81	1.40±0.53	15.33±1.53
April	67.67±6.43	3.53±0.50	19.67±1.15
May	10.47±1.06	3.67±0.58	208.33±53.46
June	5.13±0.65	10.67±1.15	22.00±3.61
July	243.33±35.12	30.33±1.15	25.00±1.00
August	10.20±0.82	24.33±1.53	185.00±18.03
September	5.03±0.50	53.83±1.26	27.67±2.08
October	57.67±2.08	3.33±0.58	10.00±1.00
November	291.67±12.58	179.33±10.07	22.67±5.51
December	12.53±01.33	20.33±1.53	167.67±11.24

The maximum phosphate value during 2006 was noted in November (190 mg/L), whereas minimum value was observed in March (01mg/L). Phosphate level showed fluctuation throughout the year. The similar

result was noted in 2007 and 2008 but with different values. The mean value ranged between 1.40 to 179.33 during the study period (Table 6).

During 2006, the highest ratio of nitrate was found in May (270 mg/L), while the lowest (11mg/L) was recorded in October which was similar to the findings in 2008 but with different values. While in 2007, its content showed maximum quantity in August (190 mg/L) and minimum was recorded in October (09 mg/L). Nitrate values showed great fluctuation during 2006 to 2008. The mean value ranged between 10 to 208.33 during the study period (Table 6). Analysis of variance of all physico-chemical variables revealed that they were non-significant (Table 7).

The color of water was green throughout the year although it became more clear and lighter in some months. It turned into yellowish green during October and November. Runoff from urban areas can make water grey, while suspended particles may color water green which are mostly microscopic algae (Schmitt, 2005). Baqai, *et al*. (1974a) observed green color of water in Haleji lake during most of the months of a study year except February, March, September and October when it was dark green or dark brown. Aquatic vegetation and phytoplankton give green color to water.

Air temperature was between 20°C–35°C in all studied years and water temperature fluctuated between 17°C to 33°C. The observed temperature is strictly attributed to weather conditions and suitable for production of plankton in tropical ponds (Jhingran, 1991, Begum *et al*. 2003). Baqai, *et al*. (1974a) also noticed minimum temperature (18°C) in January in Haleji lake. 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).

The pH ranged between 5.5–7.5 in all the studied years. Highest pH was noted during July (2006, 2007, 2008) and August (2007 and 2008), while least value was noted in December. 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).

Lowest dissolved oxygen was noted in October (2006-8), while highest contents were present in January (2006-8). Bosserman (1983) stated that the amount of oxygen is related with photosynthesis and respiration. In present study the water at all sites shows low contents of dissolved oxygen. The major factors for this are addition of silt laden water from Indus river, that already has poor contents of it , consumption by zooplankton and fish, less movement of water, temperature and chemical pollution in water from surrounding that decrease the growth of plants (Baqai, *et al*. 1974). In summer months it decreased due to increased temperature of water (Naz and Turkmen, 2005).

Highest value of salinity was noted in August (2006 and 2008) and July (2007), whereas minimum level was noted in January (2006 and 2008) March and June (2007). It was observed that highest salinity was noted during summer and lowest values were noticed in colder months. Kumar et al. (2002) also reported increase in salinity during summer and decrease in winter. In summer, water loss occurred due to evaporation that ultimately increased the salinity in lake (Hammer, 1990).

Highest quantity of alkalinity observed in September in all studied years and least value was in July (2006 and 2008) and in November (2007). The high range may be due to fall in water level as it was noted in pre- and post-monsoon seasons. 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). Korai *et al*. (2008) noted minimum alkalinity during July in Keenjhar lake.

The maximum values of acidity were noted in May while least quantity was noted in October in all the three years. In some lakes industrial wastes organic acids may contribute to acidity (Abbasi, 1998). Anaerobic condition in the sediment (basin of the lake) is responsible for the biodegradation of the organic matter into short chain organic acids like acetic, propionic, butyric acids etc. (Ali et al., 2004).

Sulphate was in maximum quantity during November (2006, 2007 and 2008), while least values were noted in June (2006, 2007) and September (2006, 2007 and 2008). It may also indicate enrichment due to insufficient inflow of rainwater (Chennakrishnan *et al*. 2008).

Highest and lowest quantities of phosphate were observed in November and March (spring season) respectively during 2006, 2007 and 2008 respectively. Boström (1981) analyzed the remarkable decrease in phosphate level in spring season in Erken lake due to increased phytoplankton 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 noted highest in May (2006 and 2008) and August (2007), while least quantity was calculated in October (2006-8). Annual cycle of evaporation and precipitation maintained the

seasonality of various physico–chemical factors (Arora and Mehra, 2009). Siddiqui and Saqib (1994) noted suitable range of nitrate during June to December in Haleji lake. High temperature allows water to mix and that's why the water was rich chemically during summer months (Singh et al. 1980).

Table 7. One-way ANOVA of all physico-chemical parameters of Haleji lake from 2006-08.

Parameter	F-Value	P-Value	Remarks
Air Temperature(C°)	0.10	0.905	Non Significant
Water Temperature(C°)	0.24	0.789	Non Significant
pH	0.17	0.844	Non Significant
Diss. Oxygen (mg/L)	0.01	0.987	Non Significant
Salinity (mg/L)	0.03	0.975	Non Significant
Alkalinity(mg/L)	0.06	0.945	Non Significant
Acidity (mg/L)	0.15	0.861	Non Significant
Sulphate (mg/L)	0.06	0.944	Non Significant
Phosphate (mg/L)	0.00	0.996	Non Significant
Nitrate (mg/L)	0.09	0.911	Non Significant

Conclusion

The physico-chemical parameters of Haleji lake were found to be well in the permissible limit of WHO and ICMR except in few months. Increased values of nutrients show that the lake is going towards eutrophication, which may be due to anthropogenic activities in the area and input of nutrients along with other organic and inorganic substances through water runoff from agricultural fields.

Acknowledgement

Authors are thankful to Dean Faculty of Science for financial support to conduct this study. I am also thankful to Mr. Zulfiqar (Lab attendant, Department of Zoology) who assisted me in collection of samples.

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