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Assessment of Environmental Impact on Lonar Lake Water, (MS) India

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Abstract: Assessment of environmental impact was established to provide and evaluate the background picture of water quality of Lonar Lake water. Physico-chemical characteristics *viz.,* atmospheric and water temperature, electric conductance (EC), total solids (TS), total dissolved solids (TDS), total suspended solids (TSS), salinity, pH, dissolved oxygen (DO), HCO_3^-, Cl^-, SO_4^{2-}, Na^+, K^+, Ca^{2+}, Mg^{2+}, NO_3^-, PO_4^{3-} and turbidity were measured and used as indicators to evaluate the water quality of lakes. Results indicated that salinity ranged between 5.75 – 5.81ppt (hypersaline water). EC 19273.5- 19493.4 µmohs/cm. TS, TDS and TSS are very high. pH values were found to be in alkaline range i.e., 9.6-9.9. Total alkalinity is very high and ranged between 2857.4 - 2948.1 mg/l. Cl^- and SO_4^{2-} are very high in concentrations. Na^+ and K^+ are more in concentration than Ca^{2+} and Mg^{2+}. DO was near to depletion. The NO_3^- and PO_4^{3-} were also high in concentrations. Turbidity was higher in range at the time of monsoon. It was concluded that the Lonar Lake was unique saline aquatic ecosystem due to hyper saline and alkaline water.

Key words: Physico-chemical parameters · Saline ecosystem · Lonar Lake

INTRODUCTION

Inland saline lakes have received attention in recent years due to their sensitivity to climatic changes. Climatic conditions must reach a certain degree of aridity for effective removing of water by evaporation or freeze drying and so produce progressively concentrated brine [1,2] Changes in evaporation rates and precipitation can affect the physical and chemical characteristics in such lakes [3]. Lonar Crater is an impact crater situated in the Buldana District of the Indian state of Maharashtra. Geologically located at Latitude 19° 58'45''N and Longitude 76°.50' Altitude 1852 ft, of the lake is 1.83 km (6000 feet) in diameter and 170 meter in depth and its age is estimated to be 52000 ± 6000 years in the late Pliocene [4]. Mythology associated the crater with the underground abode of demon Lonasura, who was killed by Lord Vishnu. Scientific studies were carried out in recent times attribute the probable origin of Lonar crater by the impact of large meteoritic body [5] It is the largest impact crater in basaltic rock and partially filled by saline water. It was also once thought of to be volcanic origin. The crater was first noticed by an Englishman, C.J.E. Alexander in 1823. Lonar crater is now recognized as an impact crater created by a hypervelocity impact comet or meteorite.

The present study aimed to give complete information on the physical and chemical characteristics of Lonar Lake water.

MATERIALS AND METHODS

During this investigation 3 stations Station A (Near Kamljamata Temple), Station B (Near Ramgaya) and Station C (Near the farm) were selected as sampling stations. The distance between each station is about 500 m to 600 m long. The collection of water samples was made by using the screw capped air tight polythene containers of 5 lit capacities. The samples were preserved in an ice-box and returned immediately to the Laboratory. The chemical parameters were determined according to the method described in APHA [6, 7]. The atmospheric temperature was recorded with the help of a digital Thermo-hygrometer on the field. The water temperature recorded in field with the help of degree centigrade thermometer (°C). pH was measured on field with the help of Digital Pen type pH meter (Hanna). DO was determined by using Winklers method due to addition of Manganous

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sulphate and alkaline KI solution to sample. TS were measured by evaporating a known volume of well mixed sample at 105°C. TDS were determined by filtrating a volume of sample with glass micro fiber filter (GF/C) and a known volume of filtrate was evaporated at 180°C. TSS was directly obtained by subtraction of TS-TDS. The total alkalinity was determined titrometrically by using the phenolphthalein and methyl orange indicators. The phosphate and Nitrate were estimated photometrically by using the Spectrophotometer (Elico SL177) at 690 and 410 nm wavelengths. The Calcium and Magnesium of samples was estimated by using EDTA titration method and Murexide and Potassium chromate were used as indicators. The chloride content of the sample has been estimated by titrometrically with potassium chromate as an indicator. The sodium and potassium were estimated by using Flame photometer (Elico, CL 361). The electrical conductivity was estimated by using EC-TDS Analyzer (Elico, CM 183). The turbidity were estimated by using Nephlometer (Elico, CL 52D). The Salinity has been estimated titrometrically and values were calculated by using formula.

Statistical Analysis: The relationship between the studied physical and chemical parameters were assigned by computing the correlation coefficients (r) using Microsoft Office Excel (2003).

RESULTS AND DISCUSSION

The physical and chemical measurements in the Lonar Lake water are presented average values in Table 1. Results revealed that the high concentration values of most studied physical and chemical parameters during different season were recorded at station A, B and C.

Temperature is strong and great important factor for aquatic ecosystem, as it affects the organisms as well as physical and chemical characteristics of water [8]. As expect the high water temperature was recorded during the month of summer and lower values in winter due to more or less of air temperature. The area of Lonar Lake has mainly semi arid climate region with low and very variable rainfall, a long day summer, high evaporation rates and low humidity [9]. Atmospheric temperature average ranges from 29.4, 29.4 and 30°C. In the present study, the atmospheric temperature values possessed a strong positive relationship with pH, TS, TDS, TSS, T. alkalinity, PO_4^-, SO_4^-, Cl^-, Na^+, K^+, EC and salinity at $P< 0.05$ (r = 0.99, 0.35, 077, 0.72, 0.21, 0.96, 0.86, 0.66, 0.94, 0.53, 0.82, 0.95 and 0.94 at station A, 0.96, 0.60, 0.86, 0.81, 0.23, 0.93, 0.95, 0.64, 0.93, 0.45, 0.78, 0.93 and 0.93 at station B and 0.97, 0.28, 0.87, 0.83, 0.34, 0.96, 0.98, 0.69, 0.95, 0.49, 0.87, 0.95 and 0.95 at station C) during different season, respectively.

Table 1: Physico-chemical analysis of water in the Lonar Lake during 2009-10

Parameters	Station A	Station B	Station C
Atmospheric Temperature (°C)	29.4	29.4	30
Water Temperature (°C)	26.8	27.3	27.6
pH	9.6	9.8	9.9
Dissolved Oxygen (mg/l)	3.25	3.20	3.12
Total Solids (mg/l)	9685.5	9657.4	9610.5
Total Dissolved Solids (mg/l)	7962.4	7693.5	7817.5
Total Suspended Solids (mg/l)	1723.1	1963.6	1792.8
Total Alkalinity (mg/l)	2857.4	2923.5	2948.1
Phosphate (mg/l)	2.73	2.73	2.86
Nitrate (mg/l)	6.64	6.59	6.68
Calcium (mg/l)	169.7	168.2	174.2
Magnesium (mg/l)	150.0	145.7	150.9
Sulphate (mg/l)	114	112.8	114.4
Chloride (mg/l)	3191.8	3185.5	3219.9
Sodium (mg/l)	3589.4	3619.8	3607.8
Potassium (mg/l)	17.2	17.1	17.0
Electric Conductivity (µmohs/cm)	19273.5	19423.7	19493.4
Turbidity (NTU)	148.1	147.3	159.0
Salinity (ppt)	5.75	5.75	5.81

Water temperature average ranges from 26.8, 27.3 and 26.6°C at station A, B and C. water temperature values are positively correlated with pH, TS, TDS, TSS, T. alkalinity, PO_4^-, SO_4^-, Cl^-, Na^+, K^+, EC and salinity at $P<0.05$ (r = 0.35, 0.77, 0.71, 0.37, 0.88, 0.91, 0.74, 0.94, 0.54, 0.86, 0.97 and 0.94 at station A. 0.43, 0.84, 0.71, 0.37, 0.88, 0.91, 0.74, 0.94, 0.54, 0.86, 0.97 and 94 at station C) during different seasons, respectively. This indicates that there is a strong relationship among physicochemical attributes.

Lonar lake water classified undergoing highly alkaline water during all investigation season without spatial variation. The average ranges of pH values were 9.6, 9.8 and 9.9 at station A, B and C respectively. The pH values possessed a strong positive relationship with TS, TDS, T. alkalinity, Ca^{2+}, Mg^{2+} at $P<0.05$ (r = 0.50, 0.72, 0.16, 0.12 and 0.11 at station A, 0.63, 0.78, 0.59, 0.22 and 0.18 at station B and 0.34, 0.46, 0.24, 0.27 and 0.24 at station C) during different season, respectively. The pH was higher during summer and lower in the month of monsoon. Similar results were also found by [9, 10]. They recorded that, lake water was highly alkaline and pH was reasonably constant ranging from 10 to 10.5.

Lake water is very poor in oxygen during all investigation seasons. The DO average ranges from 3.25, 3.20 and 3.12 mg/l were found from selected sites. The DO values possess a strong positive correlation with pH, NO_2^-, Ca^{2+}, Mg^{2+} and Turbidity at $P<0.05$ (r = 0.40, 0.79, 0.70, 0.70 and 0.34 at station A, 0.21, 0.74, 0.67, 0.69 and 0.33 at station B and 0.76, 0.77, 0.78, 0.79 and 0.31 at station C) during different season, respectively. The very low DO near to depletion may be attributed to the nature of the close and hyper saline lake. Frequent occurrences of hypoxia due to sudden shutdown of DO have significant reduction of toxic algal blooms and biotic diversity. Similar results were found by Satyanarayana *et al*. [11]. They stated that the dissolved oxygen (DO) levels were observed to be too low i.e. <1.5 mg/l, which do not support to fish fauna and zooplankton.

Solids refer to suspended and dissolved matter in water. It is very useful parameters describing the chemical constituents of the water and can be considered as general edaphic relations that contribute to productivity within the water body [12]. However, the higher values of TS were recorded during summer due to the higher evaporation rates during summer which facilitate the accumulation of different dissolved salts Lake water. The TS average values ranges from 9685.5, 9657.4 and 9610.5 mg/l in the month winter and summer. The TS values were having a strong positive relationship with TDS, TSS, T. alkalinity, PO_4^-, SO_4^-, Cl^-, Na^+, K^+, EC and salinity at $P< 0.05$ (r = 0.89, 0.36, 0.71, 0.65, 0.36, 0.71, 0.47, 0.82, 0.76, 0.71 at station A, 0.88, 0.38, 0.88, 0.78, 0.50, 0.78, 0.54, 0.80, 0.82, 0.78 at station B and 0.94, 0.41, 0.90, 0.87, 0.49, 0.81, 0.49, 0.87, 0.83, 0.81 at station C) during different season, respectively.

TDS average value ranges from 7.962.4, 7693.5 and 7817.5 mg/l in the month of monsoon was lower and higher in summer season. The TDS values were having a strong correlation with Total alkalinity, PO_4^-, SO_4^-, Cl^-, Na^+, K^+, EC and salinity at $P< 0.05$ (r = 0.58, 0.55, 0.15, 0.63, 0.24, 0.74, 0.68, 0.63 at station A, 0.78, 0.76, 0.16, 0.68, 0.25, 0.63, 0.68, 0.68 at station B and 0.82, 0.81, 0.26, 0.77, 0.23, 0.83, 0.77, 0.77 at station C) during different seasons, respectively. TSS was average ranges from 1723.1, 1963.6 and 1792.8 mg/l. The TSS values exhibit strong correlation with turbidity at $P<0.05$ (r = 0.54, 0.37, 0.42 at station A, B and C). The TSS higher ranges were found in the month of monsoon and lower in winter. Similar findings were also obtained by [13].

The alkalinity shows major variation occurred in different studies, high salt content is the characteristics of this lake. High alkalinity may be due to the fact that there is no out flow from the lake and the concentration of lake water due to constant evaporation from Lake Surface for long period of time. The alkalinity average ranges from 2857.4, 2923.5 and 2948.1 mg/l. Higher alkalinity were observed in the month of summer and lower during the winter. The Total alkalinity values exhibit strong correlation with PO_4^-, SO_4^-, Cl^-, Na^+, K^+, EC and salinity at $P< 0.05$ (r = 0.87, 0.74, 0.93, 0.69, 0.79, 0.92, 0.93 at station A, 0.90, 0.67, 0.87, 0.53, 0.77, 0.85, 0.87 at station B and 0.97, 0.71, 0.94, 0.64, 0.85, 0.92, 0.90 at station C) during different season. The high concentration of CO_3^- and HCO_3^- in lake water may be related to increase in pH values facilitate in the formation of two ions. Dabhade, *et al*. [10] determined alkalinity and found the same ranges as of the present results.

The cycling of phosphorus within lakes and rivers is dynamic and complex, involving adsorption and precipitation reactions, interchange with sediments and uptake by aquatic biota [14] The phosphate average ranges from 2.73, 2.73 and 2.86 mg/l at selected different stations. The phosphorus values were having strong correlation with SO_4^-, Cl^-, Na^+, K^+, EC and salinity at $P< 0.05$ (r = 0.60, 0.95, 0.40, 0.81, 0.81, 0.95 at station A, 0.62, 0.93, 0.37, 0.75, 0.90, 0.93 at station B and 0.71, 0.97, 0.52, 0.86, 0.96, 0.97 at station C) during different season, respectively. These values indicate that the high nutrient content in the lake water which is again due to sewage intrusion into the lake water. Similar findings were recorded by [11, 15].

Nitrate is also one of the critical nutrients for the growth of algae and helps accelerating the eutrophication. In the present investigation the average nitrate concentration from 6.64, 6.59 and 6.68 mg/l were recorded. The nitrate values were having a strong correlation with Ca^{2+} and Mg^{2+} at $P< 0.05$ ($r = 0.84$, 0.87 at station A, 0.57, 0.64 at station B, 0.74, 0.80 at station C) during different season. Higher concentrations of nitrate were observed in the month of winter and lower concentration in summer season. The results were coinciding with [9, 10].

Calcium and Magnesium also occurs in all kinds of natural waters, but its concentration remains generally lower than the calcium. Like calcium, it is also one of the important cations imparting hardness to the waters [16]. The average calcium concentration ranges from 169.7, 168.2 and 174.2 mg/l. The calcium values were strong correlation with TDS and Mg^{2+} at $P< 0.05$ ($r = 0.24$, 0.96 at station A, 0.55, 0.98 at station B, 0.15, 0.98 at station C). The calcium was higher during winter season and lower in summer due to the evaporation rate was higher in summer season. The range of magnesium was 150.0, 145.7 and 150.9 mg/l. The obtained results were also matches with [9]. The magnesium values exhibit a strong correlation with pH and TDS at $P< 0.05$ ($r = 0.71$, 0.24 at station A, 0.56, 0.49 at station B and 0.44, 0.10 at station C) during different season, respectively.

SO_4^- is also an important anion imparting hardness to the waters [16]. In the present investigation the average range of sulphate was 114, 112.8 and 114.4 mg/l. The sulphate values were having a strong correlation with pH, TDS, Cl^-, Na^+, K^+, EC and salinity at $P< 0.05$ ($r = 0.52$, 0.63, 0.66, 0.55, 0.50, 0.63, 0.66 at station A, 0.98, 0.60, 0.72, 0.71, 0.71, 0.75, 0.71 at station B and 0.55, 0.41, 0.70, 0.74, 0.57, 0.73, 0.70 at station C). The relative increase in the sulphate concentration during hot period may be due to increase in the air and water temperatures followed by the high evaporation rate and these results coincide with [17].

The average chloride values were fluctuated in the ranges from 3191.8, 3185.5 and 3219.9 mg/l higher in summer and lower in the winter season. The chloride values were strong correlation with pH, Na^+, K^+, EC and salinity at $P< 0.05$ ($r = 0.65$, 0.48, 0.89, 0.94, 1 at station A, 0.30, 0.39, 0.83, 0.95, 1 at station B and 0.85, 0.46, 0.87, 0.95, 1 at station C). The high values in the chloride concentrations unexpected during autumn. This is mainly attributed to the dissolution of some ions especially chloride from the surrounding rocks and sewage or agriculture pollution. Similar findings were recorded [10, 17]. The increase in chloride concentration in Lakes, Rivers and dams is due to the discharge of municipal and industrial wastes as reported by [18].

The calculation of each cation revealed that, Na^+ is predominant cation (98.4%) and the other cations like K^+, Ca^{2+} and Mg^{2+} are very minor. The average sodium ranges from 3589.4, 3619.8 and 3607.8 mg/l. The sodium values established a strong correlation with pH, TDS, phosphate, Cl^-, K^+, EC, Turbidity and salinity at $P< 0.05$ ($r = 0.75$, 0.45, 0.19, 0.11, 0.49, 0.54, 0.24, 0.48 at station A, 0.80, 0.42, 0.23, 0.19, 0.61, 0.51, 0.13, 0.39 at station B and 0.60, 0.46, 0.07, 0.13, 0.49, 0.51, 0.25, 0.46 at station C). The average potassium ranges from 17.2, 17.1 and 17.0 mg/l during different seasons.

The water is undergoing significant fluctuations in EC. The EC values were recorded very high during all season especially in summer and lower values in winter. The average ranges for EC from 19273.5, 19423.7 and 19493.4 µmohs/cm. The electrical conductivity values were having strong correlation with pH and salinity at $P< 0.05$ ($r = 0.37$, 0.94 at station A, 0.23, 0.95 at station B and 0.52, 0.95 at station C). The increase in EC values at all investigated stations is related to the increase in total dissolved solids and water temperatures [12].

Turbidity is the suspended particles in water interfering with penetration of light. Turbidity is caused by wide variety of suspended matter. In the present investigation, the turbidity was higher during monsoon and minimum during summer season. High values of turbidity in monsoon influx of rain water, washout silts, sand and low transparency due to suspended inert particulate matter. The average turbidity ranges from 148.1, 147.3 and 159.0 NTU and similar results were recorded [10]. The turbidity values were strong correlation with DO, TS, nitrate, calcium, magnesium, sulphate, chloride, sodium, potassium and EC at $P< 0.05$ ($r = 0.24$, 0.21, 0.70, 0.59, 0.56, 0.79, 0.37, 0.43, 0.47, 0.32 at station A, 0.28, 0.11, 0.86, 0.44, 0.49, 0.81, 0.24, 0.66, 0.58, 0.25 at station B and 0.31, 0.12, 0.67, 0.71, 0.71, 0.68, 0.29, 0.41, 0.31, 0.24 at station C) during different seasons, respectively. However, low transparency occurred in summer may be due to clear atmosphere, evaporation of water and high light penetration.

Salinity is among the most important environmental factor and exerts various effects on the vitality of aquatic or saline organisms. The high values of salinity were recorded during summer season and lower during winter season. In present investigation, the average salinity ranges from 5.75, 5.75 and 5.81 ppt and similar findings were matches with [10]. The salinity values were having strong correlation with pH, Na^+ and Turbidity at $P< 0.05$ ($r = 0.64$, 0.10, 0.37 at station A, 0.30, 0.19, 0.24 at station B and 0.85, 0.13, 0.29 at station C).

In conclusion, Lonar Meteorite Lake appear to be a unique aquatic ecosystem among the saline lakes characterized by hypersaline, hyper alkaline, poor range in DO but all physico-chemical parameters in this region was beyond the permissible limit in different season only according to WHO and ISI standards. The correlation coefficient indicates significant positive and negative correlation of parameters with each other. The positive correlation mean one parameter increase with other parameters also increase.

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