
NATURAL WATER

Chemical Assessment of Sambhar Soda Lake, a Ramsar Site in India¹

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Abstract—The Sambhar Soda Lake situated in Rajasthan, is the largest inland salt lake. The chemical assessment of this lake water is studied with respect to its abiotic characters. Monsoon and winter water sample analyses revealed that the lake water is hypersaline and highly alkaline in nature. The average maximum pH is 9.5 and salinity 30%, which is one of the unique features of this lake. As compared to monsoon water sample the winter sample contains remarkable concentration of various ions like sodium (9930 mg/L), chloride (7356 mg/L), bicarbonates (6080 mg/L), sulfate (9152 mg/L). Various metals were recorded from this sample analysis. The considerable amount of lead (1359 µg/L), cadmium (1416 µg/L), copper (2099 µg/L), and cobalt (2453 µg/L) metals were found from winter 2010 sample. As compare of to other saline lake and sea water the Sambhar Lake water chemistry is different, and require continuous monitoring.

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INTRODUCTION

The Sambhar Lake, one of the largest inland saline depression in western desert of India, is the largest and single salt source situated in Rajasthan state. It is saline alkaline lake located in Thar Desert of Rajasthan India (26°52'–27°2'N, 74°53'–75°13'E) [1–2].

It is an elliptical and shallow lake, with the maximum length of 22.5 km. The width of the lake ranges from 3.2 to 11.2 km. The total catchments area of the lake is 7560 km², most of which lies to the north and north-east. The lake occupies an area of about approximately 225 Sq. Km and average depth of water is about 1 m and the maximum depth is about 3 m [3–6]. The Sambhar Lake has attracted a lot of attention over the past century and a number of hypothesis have been proposed to explain its pronounced hyper salinity. Sambhar Lake falls in the rain shadow for south west monsoon with an annual rainfall of 100–500 mm [2, 4].

The principal source of water to the lake basin is atmospheric precipitation and inputs from seasonal streams mainly Roopangarh and Mendha rivers during the monsoon season (Yuly to September). It has been declared as Ramsar site in 1990 for receiving large number of migratory birds like flamingos, pelicans every year [7].

Comprehensive and continuous monitoring of this extraordinary ecosystem will help to develop and conserve this site. Present study is therefore, aimed at examination of surface water quality of Sambhar Lake and development of seasonal database of various water quality parameters.

EXPERIMENTAL

The present work includes field visits and sample collection in the Sambhar Lake region.

Sampling and Analysis

Water samples were collected from three different sampling stations located in main lake and toward Sambhar Lake city.

Monsoon and late winter samples were collected in August and January respectively in presterilized bottles. The samples collected from each station were average of ten samples spanning the whole sampling point.

¹ The text was submitted by the authors in English.

Water Analysis

The parameters, like temperature, pH, were measured at the time of sampling by using digital thermometer and digital pen pH meter respectively. Samples were transported to laboratory in a cold box. The samples were filtered and stored in refrigerator during investigation [8].

Various physicochemical parameters were determined for both the samples individually. Total solids (TS), total dissolved solids (TDS), total suspended solids (TSS) were analyzed according to procedures described in APHA. The salinity was measured by using Refractometer (Erma, Tokyo). The dissolved oxygen content (DO) was determined by the azide modification method, Biological oxygen demand (BOD) by 5 days incubation methods. Chemical oxygen demand (COD) was performed by potassium dichromate oxidation method. Chloride was determined by argentometric and sulfate by gravimetric methods. Sodium and potassium were measured directly using the flame photometer (Model Elico CL 361). Carbonates and bicarbonates were measured titrimetrically. Calcium and magnesium were determined by EDTA titrimetric method etc.

Metal ions like Fe, Mn, Zn, As, Cr, Pb, Cu, and Cd were directly analyzed by atomic absorption spectrophotometry (Model S2 Thermo, USA) [9–10].

RESULTS AND DISCUSSION

Physical and Chemical Properties of Water

Chemical composition of Sambhar Lake water significantly varies in monsoon and winter seasons. The maximum 31.7°C and minimum 21.3°C temperature of surface water was recorded in monsoon 2011 and in winter 2010 respectively, considerable difference in aerial and water temperature was observed. Influence of high salt concentration could be the possible reason for reduced water temperature. The rotten egg like smell was recorded in winter at the time of sample collection. The minimum and maximum pH value recorded for water sample was 9.2 in 2011 monsoon and 10.8 in winter 2010 respectively, surface algal blooms and eutrophication of lake was also observed in peripheral locations.

The conductivity of lake water was recorded highest as 159766 us/cm for winter 2011 sample. The maximum TS and TDS were recorded as 151383 and 88709 mg/L in monsoon and winter 2010 respectively (table).

Abiotic characteristics of Sambhar Lake water collected in year 2010 and 2011

| Parameter | Monsoon Sample | | Winter Sample | |
|--|--------------------|-------------------|--------------------|--------------------|
| | 2010 | 2011 | 2010 | 2011 |
| Temperature (°C) | 28.1(±1.31) | 31.7(±1.16) | 21.3(± 0.17) | 22.37(±0.31) |
| pH | 9.4(±0.40) | 9.2(±0.36) | 10.8(± 0.16) | 10.53(±0.21) |
| Total Solids (mg/l) | 151383.3(±1281.61) | 146293.3(±508.36) | 104106.7(±827.10) | 131050(±878.45) |
| Total Dissolved Solids (mg/l) | 38610(± 619.92) | 48966.7(±568.62) | 88709.7(±898.86) | 88263.3(±742.53) |
| Total Suspended Solids (mg/l) | 112773.3(±1854.36) | 97326.7(±788.31) | 15397(±458.23) | 42786.7(±1216.15) |
| Alkalinity as CaCO ₃ (mg/l) | 4310(± 311.93) | 4093.3(±135.77) | 5600(±454.61) | 5973.3(±139.12) |
| DO (mg/l) | 6(±1.53) | 7.8(±0.82) | 7.37(±1.14) | 11.0(±1.11) |
| BOD (mg/l) | 78(± 7.55) | 101.6(±10.41) | 133.3(±12.47) | 203.3(±30.91) |
| COD (mg/l) | 233.3(± 35.12) | 320(±10.00) | 393.3(± 28.67) | 436.7(±33.99) |
| Conductivity (us/cm) | 89426.7(±1366.39) | 96270(±757.83) | 131493.3(±1826.35) | 159766.67(±955.73) |
| Salinity (%) | 21.7(±1.53) | 21.6(±1.53) | 29.67(±1.25) | 30(±0.82) |
| Total Hardness as CaCO ₃ (mg/l) | 7856.7(±241.73) | 7890(±210.00) | 10783.3(±62.36) | 11373.3(±151.95) |
| Sodium (mg/l) | 3180(±131.15) | 3813.3(±102.63) | 9063.3(±143.84) | 9930(±80.42) |

(Contd.)

| | | | | |
|-------------------------------------|-----------------|-----------------|------------------|------------------|
| Potassium (mg/l) | 79.3(±6.71) | 97(±7.21) | 126.67(±17.00) | 194.3(±11.44) |
| Chloride (mg/l) | 3139.3(±194.01) | 2993.3(±110.15) | 6633.67(±332.32) | 7356.7(±124.72) |
| Carbonates (mg/l) | 310(±36.06) | 286.6(±49.33) | 343.3(±46.43) | 396.7(±17.00) |
| Bicarbonates (mg/l) | 4050(±150.0) | 4300(±173.21) | 5242.67(±90.12) | 6080.67(±156.75) |
| Calcium (mg/l) | 783.3(±40.41) | 716.6(±75.06) | 1396.67(±36.82) | 1550(±64.81) |
| Magnesium (mg/l) | 870(±81.85) | 796.6(±56.86) | 1654.67(±67.48) | 1870(±85.24) |
| sulfur (mg/l) | 1070(±115.33) | 1213.3(±85.05) | 2696(±119.27) | 3110(±43.20) |
| Nitrate (mg/l) | 34(±5.29) | 64(±10.58) | 66.67(±3.40) | 75.7(±5.25) |
| Phosphate (mg/l) | 320(±36.06) | 413.3(±136.50) | 858(±37.35) | 996.7(±89.57) |
| Sulfate (mg/l) | 3380(±206.64) | 3863.3(±102.63) | 8719.33(±377.43) | 9152.7(±154.32) |
| Sulfides as H ₂ S (mg/l) | 0.01(±0.01) | 0.02(±0.01) | 0.02(±0.01) | 0.03(±0.01) |

Note. Values mentioned in table are mean of triplicates and values mentioned in parenthesis are standard deviation.

Lake water was considerable turbid and opaque. The salinity of lake varied from 21 to 30%. The highest salinity of water samples was at the level of saturation (30 to 35%). The highest value was found in winter 2011. Low rainfall and high temperature are the principle reasons for uncommon highest salinity of water. The alkalinity was ranged in between 4093 to 5973 mg/L. There was steep fall in the total alkalinity during monsoon. Dissolved oxygen is important parameter for survival of aquatic life, it ranges from 6.0 to 11.0 mg/L. Depletion of dissolved oxygen was recorded in monsoon sample. Low dissolved oxygen of the water is indication of the presence of organic matter resulting in higher biological oxygen demand.

The BOD and COD recorded were 203 and 436.7 mg/L respectively from winter 2011 sample. The highest total hardness as CaCO₃ of lake water was 11373 mg/L in winter 2011. The sulphate content of water was found highest, i.e. 9152.7 mg/L. The highest 1550 mg/L calcium content was recorded in winter 2011. The maximum phosphate and nitrate concentration was 996.7 and 75.7 mg/L respectively in 2011 winter. Carbonate amount was low as compared with bicarbonates concentrations in both years. The amounts of sodium and potassium ions varied from 3180 to 9930 mg/L and 79.3 to 194.3 mg/L respectively. The highest chloride content was measured as 7356.7 mg/L in 2011 winter sample. Various metals were also recorded in this water sample analysis (Figs. 1, 2).

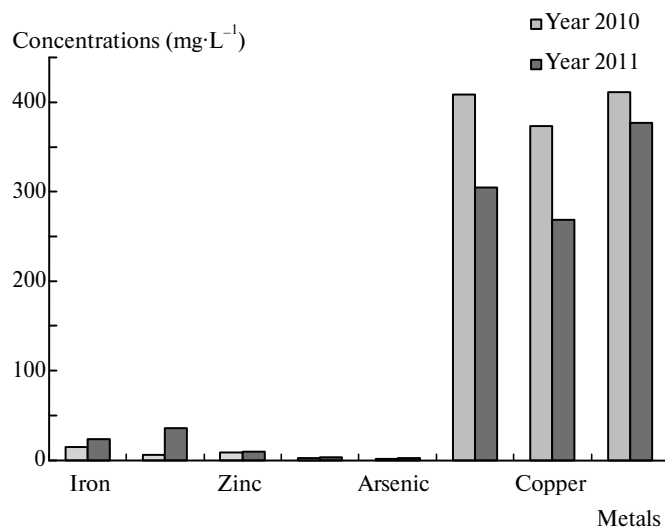


Fig. 1. Variation of metal ion concentration in monsoon sample.

In the winter sample the high metal concentration was recorded. The distribution of dissolved metals in both samples exhibited a unique seasonal pattern. Trace amount of chromium and arsenic were recorded. The

concentration of lead, cadmium, copper and cobalt were higher as compared to others. Heavy metal ion concentration of Sambhar Lake was also compared with Great Salt lake and other saline lakes. The comparative analysis showed that cobalt, copper, lead and cadmium metal concentrations were far more than these lake data of metal ions [11–14]. Results obtained also indicate that sample analysis significantly resemble with water chemistry of Dead Sea.

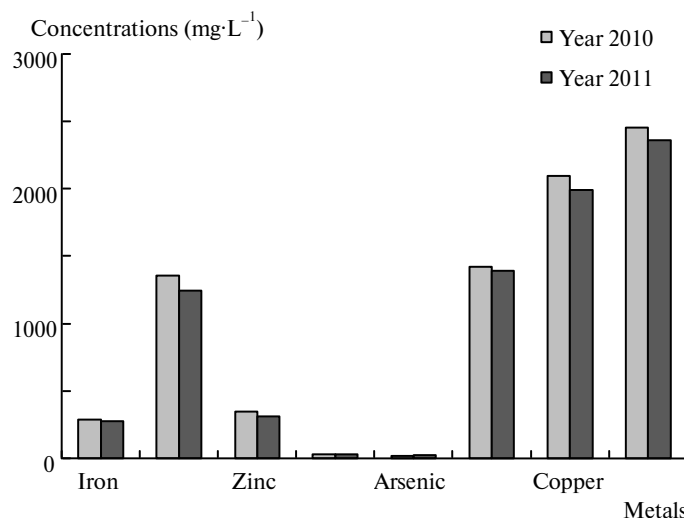


Fig. 2. Variation of metal ion concentration in winter sample.

CONCLUSIONS

Being largest inland intermittent salt lake frequent analysis of Sambhar water chemistry is essential. Unavailability of comprehensive analysis in recent years stimulated us to study the various features of lake water. This water analysis will help to design suitable experiments for determination of community structure of Sambhar Lake. We also believe that this data will help to design suitable experiments for exploration of microbiota of this unique system.

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