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Sambhar salt lake: a hydrochemical approach

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ABSTRACT

Sambhar salt lake, is an Athalassic and endorheic lake and is always changing. Water spread Area, depth, temperature and hydro-chemical conditions vary with season and year to year. Shoreline of the lake shifts dramatically as it lies in a broad and relatively flat basin. The present work focuses on the hydro-chemical study carried out during 2013. Total rainfall during the period was 348 mm. Average Temperature variations were from 7 to 37°C., pH 6.54 to 8.87, water Density 3-25 Be, Alkalinity Nil-2670 mg/L, Hardness from 28-115 mg/L, Salinity 0.53–162.21% and Dissolved oxygen from Nil-3.6mg/L. Total anoxic condition prevailed during most of the months while Free Carbon di-oxide was recorded only once during July-13 value being 25 ppm. Nutrient were in low concentration as Nitrate and Phosphate fluctuated between 1.16 -7.21 µg/L and 1.9-8.94 µg/L. NaCl content in lake brine was 98.67% in Jan-13 while post monsoon the values lowered to 88.56%. A steady increase in NaCl concentration was recorded again reaching 98.27% in Dec-13.

Key words : *Athalassic, Endorheic, Salinity*

Introduction

Saline lakes are most common in the arid and semi-arid regions of the biosphere, because two preconditions for the formation of salt lakes occur there most frequently: evaporation exceeding precipitation and the presence of endorheic drainage basins. Rajasthan, the largest state of India (3,42,269sq. km) is largely an arid state. Area estimates of various wetland categories for Rajasthan carried out using Satellite remote sensing, Geographic Information System (GIS) revealed total wetland area of 782314 ha that is around 2.29 per cent of the geographic area. Major wetland types observed in the state are Reservoirs/Barrages, Tanks/Ponds, River/Stream, Lakes/Ponds, Man-made Waterlogged area and Salt pans (NWA, 2010).

The arid zone of Rajasthan possess five main saline lakes, namely Pachpadra in Barmer district, Kuchaman lake, Deedwana lake in Nagour district, Phulera and Sambhar lake in Jaipur district (Kulshreshtha *et al.*, 2013). The Sambhar Lake, is the largest natural saline lake of India, covering an area of 230 Sq. km. Sambhar Lake was declared a Ramsar Site in 1990 by Govt. of India and Ramsar Bureau. Sambhar lake wetland has played a pivotal role in maintaining cultural, economical and ecological wealth of the area. It is one of the prime contributors in maintaining faunal particularly avian diversity in Rajasthan. A large number of endemic species are wetland dependent. Despite international recognition no habitat protection or Conservation measures are proposed, though shooting is prohibited. It has mainly been focused for salt extraction for centuries. Unregulated exploitation and diversion of lake water by salt industries has put this unique ecosystem at peril. The fast pace of shrinkage and alteration of the lake area may lead to its disappearance from landscape.

Wetlands and water sources are common entities and their protection and conservation is an uphill task, unless a multidirectional approach is involved. Therefore apart from government regulation, there is a necessity for research in the formulation of strategy to understand the dynamics of these rich ecosystems. India being one of the signatories of Ramsar

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convention for conservation and sustainable use of wetlands, should strive for updated knowledge of significant Indian wetlands's physical, chemical and biological characters and conserve them. The present study is a small step towards assessing these hydrological systems. An ongoing hydro-chemical evaluation can help make good management decisions.

History and Evolution

The area of Sambhar lake varies from 190-230 Sq. km and it receives run-off from a catchment area of about 552,000 ha and has no outlet. Sambhar is fed by four main streams: Roopnagar, Mendha, Kharian, and Khandel. Phulera. A 5.16-km long dam (Gudha Jhapok Dam), supporting a railway line divides the lake into two sections: the reservoir and salt-pans, and the main lake area. The railway track used by the salt company is major hindrance in faunal assemblage around the dam area.

Sambhar Lake is state-owned. A part is leased out to the Sambhar Salts Ltd, a Government of India enterprise. The surrounding areas are partly state-owned and partly privately owned

Material and Methods

The study was carried out from Jan-13 to Dec-13 and included all four season of the year. Sampling site was designated near Guda- Jhapok dam and water samples were collected monthly in sterile bottles. All the Physico-chemical analysis was done by standard methods (APHA, 2005). pH and Temperature were measured on the site by Digital meters. Brine density was recorded with hydrometer.

Results and Disscussion

Geography and climate

The climate largely determines the salinity and the stages of depositions of the salts from saline lakes. The climate of Sambhar lake is subtropical monsoonic. During the present study a total 348mm rainfall was received, with maximum 152mm being recorded in Aug-13. Past precipitation record shows that both, the total and annual rainfall, and its period of occurrence and intensity during the season, exhibit wide variations, resulting in frequent spells of droughts and floods (Gopal and Sharma, 1994). Humidity values varied from 45 -92%.

Average minimum and maximum water temperature recorded was 7 °C and 37 °C respectively Sambhar lake's shallow depth exposes much of the surface area to the air, and is subject to its seasonal temperature fluctuations. Sambhar Salt Lake has a much greater surface-area-to-volume ratio than other lakes in the region. As a result, a tremendous amount of water evaporates from the lake.

Hydro-chemical Results

Sambhar lake water level changes a lot from year to year prominently affecting all the hydro-chemical characters. The year under present study received 348 mm precipitation, almost half as compared to previous year (603 mm). Changes in lake elevation are accompanied by changes in salinity, that primarily governs all other factors at this saline lake. Salin-
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and maximum values being recorded in Aug-13 and June-13. Less water inflows into the lake was reflected by early receding shoreline and drying up. A few consecutive years of below- or above-average precipitation can produce dramatic changes in salinity of lake. Water salinity in a endorheic basin is increased by evaporation and modified by precipitation of salts (Wetzel, 2001).

Salinity is directly correlated to the density of water. Lall (1987) observed that density of concentrated brine doesn't go beyond 28° Be in the Sambhar lake and at this density water becomes oily and viscous. During the present study the density of lake brine reached maximum 27 Be during May-13. Water density decreased with down pour and a again increased steadily post monsoon that continued till the next monsoon.

High salinity and pH often coincide, because of the way salt lakes develop. The resulting hypersaline and alkaline lakes are considered some of the most extreme aquatic environments on Earth (Grant, 2006). The result of the present study also revealed alkaline nature of Sambhar lake as pH values ranged from 6.54 to 8.87. Lowest values were recorded in July-13 during monsoon season. Though pH was always on alkaline side, yet it was quite lower than soda lakes that are mainly know for their highly alkaline nature.

To maintain a fairly constant pH in a water body, a higher alkalinity is preferable. Alkalinity of the Sambhar lake was always high with total alkalinity fluctuating between Nil to 2670 mg/L. Carbonate alkalinity ranged from Nil-1170 mg/L. whereas bi-

carbonate alkalinity dominated with values ranging from 560 to 1500 mg/L. Minimum and Maximum carbonate alkalinity values were recorded in July-13 and June-13 respectively. Higher alkalinity values in summer season were also reported by Jakher *et al.* (1990). A mixture of carbonate and bicarbonate alkalinity generally encountered in water of pH ranging from 8.5 to 10.5 (Ayyanna and Narayudu, 2013.). Since pH lowered to 6.54 during July-13, a complete depletion of carbonate alkalinity and sudden appearance of free carbon-di-oxide was observed. Alkaline nature of brine from Didwana lake nearby area has also been reported by Kumar *et al.* (2011). Alkalinity itself is not harmful to human beings; still water supply with less than 100 mg/L of alkalinity is desirable for domestic use. According to USPHA maximum permissible is 120 mg/L (Gupta *et al.*, 2011).

In lakes dissolved oxygen is found distributed throughout the water column. Oxygen, which is saturated in the surface water, declines with the depth with the decay of settling organic detritus. Sambhar being a shallow lake lacks such stratification, further saline nature of the lake limits dissolved oxygen even in the surface layers. This is evident with the DO values recorded from Nil to 3.6 mg/L. Maximum DO values were recorded in Aug-13, with maximum downpour (152mm). Oxygen was found dissolved in the lake water only during four months witnessing rainfall and low salinity. Total anoxic condition prevailed in most of the months under study. The presence of DO in water is due to direct diffusion from air and photosynthetic activity of autotrophs (Gupta *et al.*, 2011), but the saline nature of water poses restriction in diffusion of oxygen and sustenance of autotrophs in the lake .

"Hardness" is a measure of calcium and magnesium in brine or water. Because hardness varies greatly due to differences in geology, there aren't general standards for hardness. The hardness of water can naturally range from zero to hundreds of milligrams per liter (or parts per million). Hardness below 300 mg/L is considered potable but beyond this limits cause gastro-intestinal irritation (ICMR 1975). Hardness of the Sambhar lake was found to show wide variations from 28-115 mg/L. The variations showed a trend of decrease from Jan-13 onwards with minor increase in between. Peak hardness value was recorded in Jan-13 and the fall was seen in Nov-13. As per Kannan (1991) classification Sambhar lake water falls in soft water category ex-

Table 1. Variations in Hydro-chemical parameters of Sambhar Salt lake

Months	Temperature (°C)		Rainfall (mm)	NaCl Content (%)	Humidity (%)	*Degree of water (Be)	pH	DO Mg/L	CO_2	Alkalinity		Hardness mg/L	Chloride mg/L	Salinity p	Nitrate mg/L	Phosphate
	Max	Min.								CO_3	HCO_3					
Jan-13	24	10	14	80%	98.67	13	8.68	0	0	741	1094	115	28,900	52.2	7.21	8.94
Feb-13	26	12	17	81%	*	15	8.78	0	0	767	1145	73	49,679	89.7	6.89	8.11
March-13	33	15	Nil	67%	98.63	18	8.69	0	0	842	1390	57	63,567	114.8	4.4	6.56
April-13	34	21	Nil	60%	96	22	8.75	0	0	895	1431	48	76,954	139.02	5.75	6.47
May-13	37	27	Nil	45%	*	27	8.8	0	0	1074	1478	53	87699	158.44	4.24	5.98
June-13	37	28	63	78%	*	-	8.82	0	0	1170	1500	41	89787	162.21	3.80	4.46
July-13	36	27	62	81%	*	-	6.54	0.2	25	0	1169	35	1599	2.89	3.24	2.45
Aug-13	32	26	152	92%	*	-	8.85	3.6	0	356	789	63	295.9	0.53	6.78	3.89
Sept-13	36	24	30	85%	88.56%	3	8.72	0.8	0	321	746	50	6499	11.7	4.5	1.9
Oct-13	36	20	10	77%	*	5	8.72	0.3	0	205	560	42	6439	11.6	1.16	3.25
Nov-13	34	12	Nil	78%	*	6	8.87	0	0	362	1055	28	13,954	25.2	1.74	8.92
Dec-13	29	7	Nil	72%	98.27%	13	8.61	0	0	600	2010	36	27,599	39	2.6	3.18

cept initial two months when water can be categorized as moderately hard. According to Circular by Hindustan Salt Ltd., in general, the salt produced at Sambhar Lake is of low Calcium and Magnesium contents thus has low hardness as compared to Marine Salt. Salt with low hardness is one of the desirable requirements of industries Hard water usually derives from the drainage of calcareous deposits (Wetzel, 2001). Apart from this natural water sources, pollution by domestic wastewater adds calcium, magnesium, and other cations from the cleaning agents and faeces, imparting to their hardness but since Sambhar lake lies in isolation and no direct domestic discharge is possible, human induced hardness is ruled out.

The dominant ions in most salt lakes world wide are probably Na and Cl^- (Kilham, 1990). Biological diversity is limited by high sodium concentration due to osmotic stress in case of Sambhar and a nearby saline lake Didwana (Jakher *et al.*, 1990). A high proportion of sodium ion is balanced by chloride ions, that occur in all types of natural waters in concentrations ranging from parts of mg/L to thousands of g/kg (Brine). Their presence in water is naturally associated with leaching from minerals and saline deposits. During the present study 295.5 to 89787 mg/L Cl^- Concentration was recorded.

Wetlands can be sources, sinks or transformers of nutrients. Nutrients are derived from external inputs to the lake or by internal recycling from the decay of organic matter and dissolution from bottom sediments. The level of primary production that occurs in wetlands vary considerably, primarily depending on the nutrient status of water that enters the wetland (Maltby and Barker, 2009). Results of the present study shows wide fluctuation in Nutrient levels with nitrate values falling between 1.16 - 7.21 µg/L and Phosphate recorded between 1.9 -8.94 µg/L. Maximum values of both the nutrient were observed in Jan-13 while lowest nitrate and phosphates were recorded during Oct-13 and Sept-13 respectively. Nutrient enrichment during winters can be related to large congregation of flamingoes and water birds at the lake. Sundaresan *et al.*, (2006) reported that inflow of rainwater into the Sambhar lake basin brings the nutrients in and contributes to algal growth at low salinity. A sudden increase in nutrients was evident during monsoon and a sharp fall was seen post monsoon probably due to utilization of nitrate-phosphate by growing algal bloom. A couple of months later when salinity of lake again increased an increase of nutrients was recorded that may be attributed to death and decay of much of the flora and fauna of lake. Mortimer (1942) revealed that depletion of oxygen in lake waters and the onset of anoxia results in the remobilization of phosphorus and other elements from lake sediments. A total depletion in oxygen was also prevailed in most of the months.

Wetlands are inevitable influenced by the growing competition for the water and increasing human conflicts associated with its use (Ward 2002). Sambhar salt lake is facing similar threats. Diversion of lake water for salt production alters water level and in tern many hydro-chemical factors, eventually reducing floral and faunal diversity. Over extraction of water dwindles the existence of this unique ecosystem. Research is still far from any complete description or Understanding of the dynamics of Sambhar salt lake. Successful restoration of wetland relies on a good understanding of their hydrology and establishment of the conditions suitable for ecological succession and maturity of the system.

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