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A Study on Ionic Regime of Waters of Devikund Sagar Village Pond at Bikaner, Rajasthan, India

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Abstract - A limnological investigation was carried out in order to understand the physical -chemical limnology with particular reference to the ionic regime of the medium (Devikund Sagar Bikaner). A general trend of anions was recorded as HCO3 > C1 > SO4 > CO;. On annual mean basis. it was found that bicarbonates were the major (213 mg/l) and chlorides. carbonates. and sulphates were the minor anions (57-76 mg/1). Among cations. the trend was recorded as Na 2 Ca > K ≥ Mg depicting that sodium and calcium were the major cations (annual mean 54-55 mg/l). With the slight difference in annual average, the concentration of sodium and calcium ions was almost at par. Further, while during winter and monsoon the sodium was greater than calcium, a reverse condition prevailed during summer. The Pearsall's cationic ratio Na + K)/(Mg + Ca) was calculated as 1.045 which indicated low trophy as compared to some other waters of the region.

I. Introduction

Desert limnology is best defined in terms of hydrography and limited to regions where no run off reaches the sea. Surface waters in the hot deserts are scarce and stressed resources. These are prone to harsh environmental conditions and are therefore, characteristic in their physical, chemical and biological features. Wide daily and seasonal thermal variations. better illumination, closed shallow basins, high evaporative loss leading to concentration of electrolytes, characteristic ionic composition and long dry periods are the common features experienced by such waters. These typical biotopic features are responsible for characteristic community of both plants and animals in these ecosystems.

Two main groups of arid land waters have been identified and named. Sodium chloride waters, similar to concentrated ocean brine or brackish waters (best described as dilute sea water) are called thalassohaline. Other quite different from sea water in relative ionic content are called athalassohaline (Cole, 1979). Most of the waters in the Indian desert belong to latter category.

The present study was planned to investigate the ionic regime of a typical desert water ecosystem and its dynamics in relation to time and space under the influence of environmental conditions.

II. Material and Methods

The study was carried out on Devikund Sagar Pond situated about 5km east of the Bikaner city in the western arid region of Rajasthan. The study was carried out during December 2014-November 2015. The maximum depth of the pond is 3.5 m. The pond having muddy basin has much disturbance due to human and cattle activities in littoral region. The pond is surrounded by brick walls on three sides while, southern part acts as catchment. The pond is used for washing and bathing by village people and daily a number of tankers on bullock and camel carts are filled and transported from here. It causes great disturbance in shallow water regions. The clay at the pond bottom is used for brick making on the bank sides of the pond. The colour of water is sandy and no macrophytes other than hydrilla are present. Some birds including Debchicks and Black Winged Stilts are seen wading in the pond.

Water samples were collected from four study stations. The sampling was carried out during morning hours between 0.600 and 11:30 hours. The samples were collected with the help of a plastic bucket of 15 l capacity, and were transferred to well rinsed polyethylene bottles for the analysis of physical and chemical parameters!. The sample bottles were brought to the laboratory on ice. The samples were kept in deep freeze until analyzed. Abiotic parameters monitored included air and water temperature, depth, transparency, pH, electrical conductance (EC), total dissolved solids (TDS), dissolved oxygen (DO), total hardness, total alkalinity, carbonates, bicarbonates, chlorides, sulphates, sodium, potassium, calcium and magnesium. Among cations sodium, potassium, calcium and magnesium were studied. First two cations were estimated by flame photometry while latter titrametrically.

Depth, transparency, temperature, pH, EC, TDS, DO and alkalinity were assessed on the spot. Factors like temperature, pH, EC and TDS were analyzed with the aid of a portable water analyzer kit (Century : CK 710). Transparency was recorded with the help of a standard Secchi disc of 20 cm diameter. For the analysis of various chemical variables, the methods as prescribed by Strickland & Parsons (1972), Golterman et al.(1978) and APHA-AWWA-WPCF (1981) were followed.

III. Results & Discussion

Table 1 provides data on physical-chemical limnology of the pond. Table 2 projects the correlations among various physical-chemical variables of the water.

No natural water is pure in true sense but it always contains certain amount of salts dissolved in it. The common salts include carbonates, bicarbonates, chlorides, sulphates, phosphates and nitrates of calcium, magnesium, sodium, potassium, iron and manganese. These salts on dissociation yield both cations and anions. The significant cations are sodium, potassium, calcium and magnesium while anions are carbonates, bicarbonates, chlorides and sulphates.

High ionic concentration is characteristic of desert waters and high rate of evaporation is noted as one of the major factors responsible for it (Cole, 1968). Among Indian waters too, the desert waters are, in general, richer in electrolytes as compared to those of central India and other benign parts (Patil et al., 1985; Unni, 1985, Singh & Rai,1988; Kaushik & Saksena, 1995). Similar observations have also been made by Saxena (1998) who summarized the physical-chemical conditions of surface waters in the Indian desert. The values presented by him for various parameters are comparable with the present records.

Relative ionic concentrations are not uniform in all desert waters. Many factors contribute and affect the chemical composition, which, obviously, include the interrelationships of temperature, precipitation, evaporation, basin sediments, nature of influent water, lithology of the drainage basin and biotic effect. The dilute lakes of Victoria (Australia) are largely sodium waters with relatively high chloride content.

Williams (1964) has reported the following relative ion abundance: Cl > CO; > SO4 and Na > Mg > Ca> K. A precisely same abundance trend of ions was reported by Jakher et al. (1990) in closed basin Didwana lake of Rajasthan and somewhat similar trend by Olsen & Sommerfeld (1977) in a desert lake in Arizona (C1 > HCO;>SO4; Na> Mg >Ca > K).

In present study, a general trend of anions was observed as HCO3 > C1 > SO4> CO3, which is in precise concomitance with the findings of Mittal(1996) and Chadha (1999) from the same arid region of Rajasthan. Bicarbonates in excess of chlorides were also recorded by Gianesella Galvao & Arcifa (1988) in ten Brazilian reservoirs and by Kaushik & Saksena (1995) in some central Indian lakes. While accounting for major and minor anions on annual mean basis, it was found that bicarbonates were the major (213 mg/I) and chlorides, carbonates and sulphates were the minor anions (52 75.5 mg/l). Chadha (1999) also recorded bicarbonates as major anions, however, in her study chlorides too were not less.

Among cations, the trend was recorded as Na > Ca > K > Mg depicting that sodium and calcium were the major cations (annual mean 53-54 mg/1) while potassium and magnesium were the minor cations (annual mean 17-19 mg/1). Most of the studies on desert waters reveal sodium in excess of calcium (Williams, 1964; Olsen & Sommerfeld,1977 ; Gianesella Galvao & Arcifa, 1988; Jaker et al., 1990), while in some of the studies calcium is reported in excess of sodium (Wetzel, 1975,Haan & Voerman, 1988 in winter; Kaushik & Saksena, 1995, Mittal, 1996; and Chadha, 1999). Present records show that with the slight difference in annual average, the concentration of sodium and calcium ions was almost at par. Further, while during winter and monsoon the sodium was greater than calcium, a reverse condition prevailed during summer.

The selection of Pearsall's (1922) cationic ratio (Na + K)/(Mg + Ca) was a somewhat subjective attempt to incorporate information on the major cations into the concept of trophic state without adding each cation as an individual indicator. Shannon & Brezonik (1972) felt that this ratio should be inversely related to increasing eutrophy as many workers have found a general correlation between high productivity and Ca and Mg concentration. Although seldom used, this ratio was suggested by Zafar (1959) as potentially effective in differentiating lake trophic type. Shannon & Brezonik (op. cit.) found the cationic ratio to be a reasonably good trophic indicator with high values of inverse ratio (1/CR) indicative of eutrophic condition in Florida lakes. During present study the cationic ratio was calculated as 1.045 and inverse cationic ratio 1/CR) as 0.95.Saxena & Chadha (2002) applied the Pearsall's cationic ratio as an index of trophy in some

Indian desert waters. They found the 1/CR to range from 2.887 to 3.732 in order of increasing trophy. In this light the present ratio indicates low trophy in the concerned village pond.

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Table **1. Physical-Chemical Variables of the Water of Devikund Sagar Pond, Bikaner**

Variable/Months	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Annual Mean
Air temp C'	15.5	20.5	18.5	22	31.1	33.5	45	31	36	35	31	30	29.592
Water temp C'	10.2	15.5	14.5	17.2	25.2	28	41	25	31.5	30.5	28.5	27	24.750
Depth(m)	2.2	1.9	1.5	1.1	0.9	0.6	1.5	2.6	2.5	2.5	1.8	2	1.896
pH	8.5	8.3	8.55	8.1	7.6	7.5	7.9	8.3	8.5	8.25	8.25	7.5	8.113
EC(mmhos)	0.6	1.6	0.4	0.6	0.9	1.4	0.8	0.2	0.1	0.3	0.1	0.2	0.6

		3	4	7	3			1	7		6	1	26
DO (mg/l)	6.50	6.91	5.95	5.2	5.85	5.50	6.62	8.95	7.39	8.50	9.4	8.5	7.50
Sodium	38.243	183.92	50.727	42.531	51.578	47.244	43.910	37.243	45.98	41.531	32.030	37.243	55.265
Potassium	10.512	10.166	12.948	46.920	50.83	40.077	29.325	7.82	3.128	7.820	7.820	7.520	19.599
Calcium	46.25	105.325	46.063	65.83	85.578	70.762	55.947	25.316	20.747	52.632	42.126	26.316	54.491
Magnesium	15.102	34.497	15.102	20.559	28.028	23.179	18.33	8.633	6.469	15.102	14.801	7.633	17.37
Carbonate	58.089	157.66	50.79	58.089	74.685	79.664	56.429	33.193	24.895	33.193	29.874	33.193	58.396
Bicarbonate	211.57	579.69	183.06	213.57	274.59	292.896	207.468	122.04	92.53	123.04	109.836	124.04	213.028
Chloride	54.19	106.3	53.19	70.92	140.8	142.8	90.14	35.46	70.92	53.19	50.29	36.46	75.31

		8			4	2							7
Sulphate	22.133	35.502	60.03	122.476	72.045	76.848	58.116	39.384	3.842	98.461	95.28	40.844	60.413
Phosphate	0.001	0.008	0.005	0.009	0.009	0.012	0.012	0.015	0.002	0.019	0.019	0.012	0.001
Silicate	3.70588	3.5294	4.70588	3.35294	1.1764	4.7058	2.794	0.8823	1.065	1.249	1.617	2.352	2.595
Nitrate	0.496	0.528	.560	0.528	3.96	1.32	0.924	0.528	0.627	0.726	0.92	1.32	1.037

Table 2. Correlation coefficient among various abiotic factors

*** p > 0.001 ; ** p > 0.01 ; * p > 0.1

	Air temp	Water temp	pH	EC	Na^+	K^+	Ca^{++}	Mg^{++}	CO_3^{--}	HCO_3^-	Cl^-	SO_4^{--}	PO_4^{--}	SiO_2^{--}	NO_3^{--}	DO	Depth
Air temp	1.000	0.996***	-0.397	-0.191	-0.342	0.066	-0.239	-0.259	-0.378	-0.378	0.149	0.072	0.628**	-0.528*	0.218	0.237	0.053
Water temp		1.000	-0.409	-0.204	-0.337	0.042	-0.258	-0.278	-0.385	-0.385	0.119	0.067	0.620**	-0.507*	0.191	0.253	0.062
pH			1.000	-0.466	-0.115	-0.570*	-0.424	-0.426	-0.295	-0.295	-0.604**	-0.295	0.146	0.083	-0.606**	0.223	0.604**
EC				1.000	0.695**	0.507*	0.889***	0.902***	0.920***	0.920***	0.813***	0.051	-0.546*	0.513*	0.206	-0.608**	-0.642**
Na^+					1.000	-0.104	0.692**	0.696**	0.899***	0.899***	0.345	-0.216	-0.358	0.230	-0.105	-0.124	-0.022
K^+						1.000	0.560*	0.573*	0.266	0.266	0.716**	0.522*	-0.432	0.098	0.593*	-0.765**	-0.859***
Ca^{++}							1.000	0.997***	0.885***	0.885***	0.753***	0.322	-0.529*	0.291	0.354	-0.551*	-0.620**
Mg^{++}								1.000	0.899***	0.899***	0.763***	0.292	-0.561*	0.316	0.358	-0.559*	-0.638**
CO_3^{--}									1.000	1.000	0.614**	-0.063	-0.571*	0.433	0.097	-0.412	-0.394
HCO_3^-										1.000	0.614**	-0.063	-0.571*	0.433	0.097	-0.412	-0.394
Cl^-											1.000	0.135	-0.297	0.205	0.605**	-0.651**	-0.769**
SO_4^{--}												1.000	-0.023	-0.109	0.155	-0.238	-0.498
PO_4^{--}													1.000	-0.651**	-0.177	0.638**	0.533*
SiO_2^{--}														1.000	-0.259	-0.445	-0.447
NO_3^{--}															1.000	-0.254	-0.507*
DO																1.000	0.722**
Depth																	1.000