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NUTRIENT DYNAMICS OF SAMBHAR SALT LAKE: EFFECT OF SALINITY

Archana Gaur

Dept. of Zoology, J.N.V. University, Jodhpur

ABSTRACT

Variation of salinity values and the resulting effect on nitrate and phosphate utilization and recycling was observed in Sambhar Salt lake in the year 2012-13. Total 650mm precipitation was recorded that mainly contributed to salinity variation. Density of lake brine varied from 3 to 25 Baume (Be). Salinity of the lake ranged from 0.34 to 158‰. Nitrate and phosphate values were found to fluctuate between 1.3 to 9.6 g/L and 3.9 to 15.1µg/L respectively. Results show nutrient uptake and recycling is influenced by salinity variations. Increase and decrease in nutrient concentration coincided with low and high salinity values. A strong positive correlation between salinity and nitrate and phosphate was recorded. Salinity-Nitrate regression relationship showed a positive linear interaction with $R^2 = 0.74$. Highest value of R^2 was determined in relationship between Salinity-Phosphate (0.9). Na^+ and Cl^- are dominating ions in the lake.

INTRODUCTION

Wetlands, as low-lying areas in the landscape, receive inputs from all hydro-logically connected uplands. Many wetlands are open systems receiving inputs of nutrients from upstream portions of the watershed that generally include agricultural and urban areas. The major inorganic nutrients entering wetlands are nitrogen and phosphorus. In the wetland, nitrogen and phosphorus are removed from the surface water and transferred to the sediment, wetland plants or atmosphere. In most cases nutrients are recycled within the wetland.

Nutrients are the most essential elements in all biological systems and changes in their uptake and metabolism are of particular interest. Salinity stress can lead to deficiency or accumulation of these compounds (Greenway and Munns 1980). Some ions such as sulfate aggravate salinity effect (Pilbeam and Kirkbby 1992). In a saline system, role of nutrients remains largely unquantified. Studies related to nutrient processing in saline lakes and streams are also meager (Baldwin et al. 2006, Kulp et al. 2007, Arce et al. 2014). To our knowledge no research has evaluated the influence of Salinity on Nutrient dynamics in Sambhar lake. Salt is a natural component of Sambhar lake landscape. Wide salinity fluctuation is an obvious feature of the lake. Elevated salinities cause substantial alteration in biological community of aquatic ecosystem altering nutrient dynamics. The present work is an endeavor to ascertain salinity stress on nutrient uptake and dynamics in the Sambhar Salt lake.

MATERIALS AND METHODS

Water samples collected from the lake were transported to the laboratory and were analyzed following standard methods (APHA 1989).

RESULTS AND DISCUSSION

High and varied Salinity is an obvious feature of Sambhar Salt lake. Distilling effect of evaporation and diluting effect of precipitation on salinity was evident during the present study. A total 603mm precipitation was recorded during the year 2012-2013. Salinity of the lake fluctuated from almost freshwater to hyper saline condition (Table 1). Minimum salinity value (0.34‰) recorded in Aug -12 coincided with maximum down pour (333mm). Maximum salinity values were recorded in the month of June-12 (158‰). This level of high salinity was a result of rapid evaporation of lake water in summers and nil rainfall in the preceding months. A progressive increase in salinity values from 72 to 158‰ was recorded from Jan-12 to June 12 (Table 1).

Salinity influences all the biochemical processes occurring in an aquatic ecosystem especially nutrient dynamics. The runoff brings nutrients from catchment into the lake. In lakes and wetlands nutrient uptake comprises a set of processes that includes assimilation into the biomass of the biota under aerobic condition. While Under anaerobic conditions NO_3

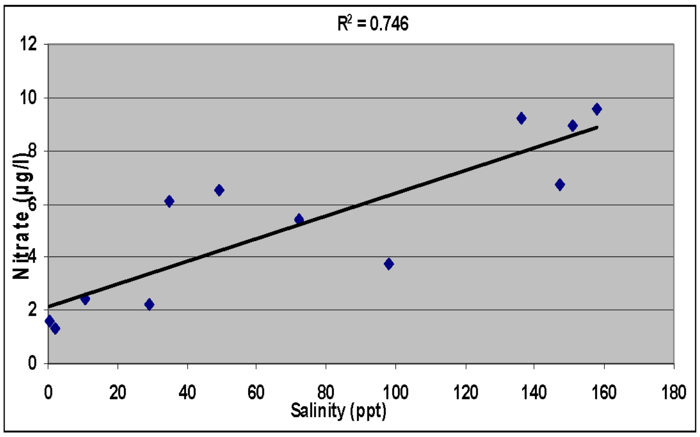
Table 1. Various Parameters recorded at Sambhar Salt lake

Months	Rainfall (mm)	Water Temp. (℃)	NaCl Content (%)	Density Be	Salinity (ppt ‰)	Nitrate (µg/l)	Phosphate (µg/L)
Feb-12	Nil	14.7	-	16	72	5.38	9.27
Mar-12	Nil	19.1	-	17	98	3.74	9.9
Apr-12	Nil	29.3	-	20	136	9.25	13.7
May-12	Nil	34	-	-	151	8.94	15.1
June12	Nil	31.8	-	-	158	9.6	12.5
July-12	64	28.7	-	7	147	6.7	11.6
Aug-12	333	27	-	3	0.34	1.6	3.9
Sept. 12	192	29	88.56	5	1.96	1.3	4.7
Oct-12	Nil	23.2	98.31	8	10.5	2.4	3.8
Nov-12	Nil	21	98.56	10	29	2.2	3.21
Dec-12	Nil	18.2	98.80	13	35	6.1	6.1
Jan-13	14	10.5	98.67	14	49	6.5	8.2

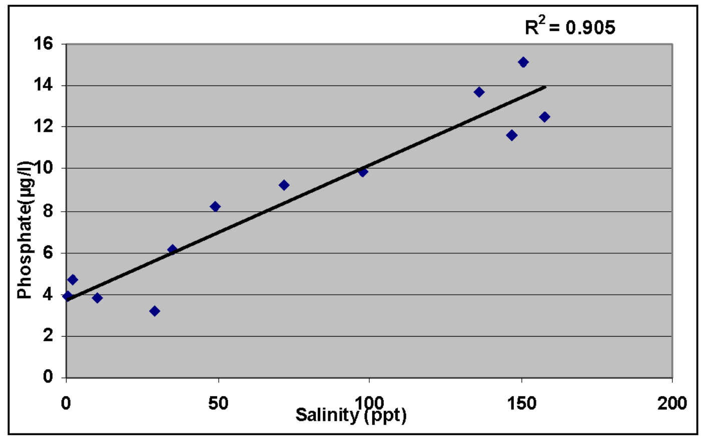
is reduced to gaseous form of nitrogen through denitrification process and is lost permanently later from the aquatic system (Mulholland et al. 2008). Sambhar lake being surrounded by Aravalli hills and villages receives no agriculture runoff therefore the nutrient enrichment of the lake is low. Nitrate values ranged from 1.3 to 9.6µg/L. In the phase of flooding and low salinity lake water supported a number of algal, cynobacterial and planktonic species. Thus after the period of blooming lowest nitrate values were recorded in Sept-12. Before these monsoon months, a period of nil rainfall and high temperature preceded. Scarce precipitation limits nutrient input (Alvarez Cobelas et al. 2005) and elevates water salinity. Though the nutrient inflow was low, yet maximum nitrate value was observed during this period which can be attributed to high salinity led death and decay of flora and fauna of the lake. Increased salinity also decreases nitrate uptake and results in its accumulation in water. Arce et al. (2014) also studied nitrate uptake and denitrification rates across a salinity gradient in semiarid streams and observed stress-induced reduction in capacity to process this nutrient. Salinity alters composition and function of microbial communities, particularly for all the microbial groups associated with N cycling (Santoro 2010).

The phosphorous content of natural waters is generally low (Table 1). Agriculture and urban activities are major source of phosphorous and nitrogen to aquatic ecosystems (Carpenter et al. 1998). During present study, phosphate was recorded in a range of 3.9 to15.1 µg/L. Minimum values recorded in the post monsoon coincides with lowest salinity. The maximum phosphate content was recorded in May-12 when the salinity of the lake was quite high, the second peak value was also observed during summer. This increase in phosphate may be a result of evaporative concentration of nutrients or release from sediments owning to increased salinity. Salinity of water has a great influence on dissolution of phosphate. Atkinson (1987) reported a decrease of 0.3 µM in dissolved phosphate with salinity increase from 35 to 65g/L. In contrast, Clavero et al. (1990) reported that salinity stimulates phosphate release from sediment.

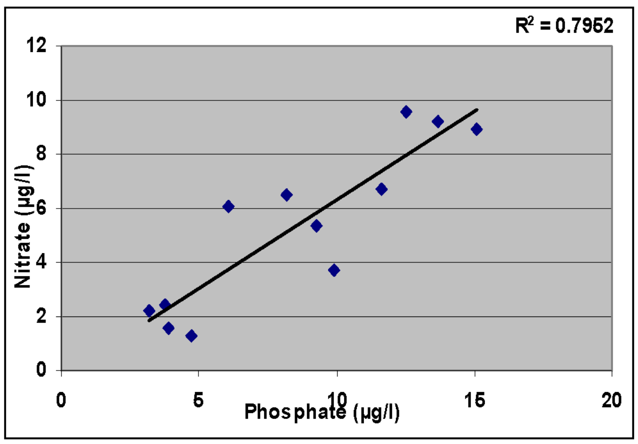
The results showed a progressive increase in nutrients with salinity increase and vice versa. Thus a strong positive correlation between salinity, nitrate and phosphate was recorded during the study suggesting reduced uptake of nutrients resulting in their accumulation with increased salinity (Fig. 1). Muniz et al. (2001) also observed a significant relationship between nitrate and phosphate with salinity. Decrease in nitrate and phosphate uptake above 100 mM NaCl Conc. was observed by Parida and Das (2004) who studied influence of varying level of salinity (0, 100, 200 and 400 mM) on nutrients and enzymes related to their metabolism.



A



B



C

Fig 1. Regression lines showing relationship between Salinity-Nitrate (A), Salinity – Phosphate (B) and Nitrate-Phosphate (C).

Statistical analysis of the results revealed a linear regression between Salinity-Nitrate with R^2 = 0.74 and Salinity-Phosphate with R^2= 0.9. Sinha et al. (1990) also studied Sambhar lake in 1984-85 and reported a linear correlation between Salinity-Nitrate (R^2=0.105) and Salinity-Phosphate (R^2 =0.195). Coste et al. (1971) also found a linear correlation between nitrate and salinity with R^2 of approximately 0.8 in sea waters.

Relation between phosphate and nitrate is also significant as these nutrients have similar re-mineralization within the biogeochemical cycle (Muniz et al. 2001). A positive linear relationship between nitrate and phosphate was recorded (0.79). Similar findings was recorded by Chester (1990) in sea water with R^2= 0.93. According to Chester (1990) the organic nitrate is associated with the soft tissues of organisms and mineralizes mainly through bacteria thus involving fast mineralization.

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