SEDIMENTOLOGY OF INDIAN SOLAR SALTWORKS

K. PONNUCHAMY[1], ABDUL A. RAHAMAN[2] and SOSAMMO ESSO[2]

[1]Chairman & Managing Director,
Hindustan Salts Limited & Sambhar Salts Limited
(A Government of India Enterprise), Jaipur – 302017 India.
[2]21, Vidhya Nagar, Erode – 638009 India.

EXTENDED ABSTRACT

Soil plays an important role in the recycling of nutrients in such a way that it forms a substrate for the growth of decomposers. Earlier authors point out importance of organic load of the soil either from the decaying algae or from the metabolites of *ArtemiA*in the evaporation pond in the solar salt production. The overall objective of the present study is to evaluate the soil chemistry in relation to salinity gradient of two different solar salt works.

Soil samples were collected from feeder channel and evaporation ponds for sedimentological studies. The samples were dried in hot air oven at 60° C for 48 hours and were analyzed for various factors such as grain size organic carbon and organic matter total phosphorus, calcium and magnesium concentration. The samples were ground, after which these were sieved through a 2mm diameter mesh screen for textural analysis. The result were analyzed statistically to find out their interrelationship.
The correlation coefficient analysis of sedimentological factors and salinity of water revealed that, all the sedimentological factors were highly significant and positively correlated with salinity of water at all the stations. Water calcium and magnesium showed positive correlation with calcium and magnesium concentration of soil respectively.

Comparatively higher values of organic carbon, organic matter, total nitrogen and total phosphorus were recorded during peak summer months. Incidentally summer months were characterized by steady increase in salinity. This becomes a physiological stress to stenohaline algal species resulting mortality. The accumulated dead algae contributed to the high organic content of the soil.

The steady increase in the salinity of water due to solar evaporation causes partial precipitation of various salts. For eg; calcium sulphate usually precipitates at salinities around 150 ppt. This explains the reason for the high concentration of calcium in the soil at higher salinities during summer season. Comparatively low concentration of magnesium than calcium in the soil reveals that the magnesium salts precipitate out only at very high salinities above 300ppt. A comparison of calcium and magnesium concentration of water to that of soil also agrees with this observation. The main finding of this study is that high salinity plays a greater role in the constitution of soil chemistry of hyper saline solar salt works and also how the concentration of one element influences the other as in the case of calcium and magnesium.

Keywords : Saline soil sedimentology.

INTRODUCTION

Soil plays an important role in the recycling of nutrients in such a way that, it forms a substrate for the growth of decomposers. Jones *et al* (1981) point out the importance of organic load of the soil either from the decaying algae or from the metabolites of *Artemia* in the evaporation pond in the solar salt production. Only a few published works are available about the sedimentology of hypersaline habitats. Merchant and Williams (1977a) estimated the organic content of some saline lakes sediments in western Victoria. In Indian solar saltworks, Ramamoorthy and Thangaraj (1980) and Ansari (1987) estimated the percentage of organic carbon in *Artemia* habitats at Tuticorin and Bombay respectively.The overall objective of the present soil study is to evaluate the soil chemistry in relation to salinity gradient at Kelambakkam and Vedaranyam solar saltworks.

STUDY AREA

The industrial salterns are located at Kelambakkam (K), Chennai (12^0 08' N,80^0 02'E) and another one at Vedaranyam(V) (10^0 01' N, 70^0 50' E) having a series of evaporators, reservoirs and crystallizers were selected for study.

MATERIALS AND METHODS

Soil samples were collected from feeder channel (K-I and V-I) and the evaporation ponds (K – II, K – III, V – II and V-III) for sedimentological studies. The samples were analysed for various factors such as grain size (sieve and pipette method – FAO , 1970), organic carbon and organic matter (Walkley and Black, 1934), total phosphorous (Strickland and Parsons, 1972) Calcium and Magnesium concentration (EDTA titration method). The samples were ground, and sieved as per conventional methods used for chemical analysis. The results were analysed statistically to find out their interrelationship (Snedecar and Cochran, 1967).

RESULTS

Kelambakkam solar saltworks

Grain size analysis

Soil at station K-I had a composition of 89.73 % sand, 5.80% silt and 4.47 % clay. and slight variation was present in K-II, K-III stations, the soil was composed of 94.85%, 4.74 % and 0.39 % of sand, silt and clay respectively. At K – III also, the composition was almost the same. The analysis revealed that, K –I was more sandy silt and others were sandy in texture.

Organic Carbon

The percentage of organic carbon in the soil varied from 0.18 in October to 2.99 in August, 0.15 in October to 3.95 in August at K –I, K-II and K-III respectively during 1990-'91. In general, the lowest percentage was recorded during October – December and highest during July – August. Season wise, the summer encountered the maximum percentage of organic carbon and post summer the minimum.

Organic matter

It showed maximum and minimum values of 0.33 in October and 4.96 in August in first year and 0.55 in October and 2.65 in August in succeeding year at K-I. The values were found to increase during pre summer '92. At K-II and K-III maximum values during summer and minimum values were recorded during post summer months.

Total Nitrogen
The percentage varied from 0.08 in May to 0.99 in August, 0.05 in October to 1.10 in August and 0.17 in October to 1.36 in August at K-I and K –II and K-III respectively. Pooled up data revealed a high percentage of total nitrogen during the summer and low during the post summer in all the stations studied.

Total Phosphorus
The concentration of total phosphorus fluctuated from 4.03 in December to 23.76 g /g in August in the first year and 5.12 in December to 18.6 g/g in August in the succeeding year at K-I. Similar variation was recorded at K-II and K-III stations. High seasonal values were recorded during summer and low during post summer except at K-III, where higher values were recorded during pre summer in the first year.

Calcium
The concentration in the soil varied from 146.07 x 10^{-3} in October to 4004 x 10^{-3} mg/g in June 1835.03 x 10^{-3} in December to 7602 x 10^{-3} mg/g in July and 784.3 x 10^{-3} mg/g in October to 8356.5 x 10^{-3} mg/g in March at K-I, K-II and K-III respectively. It also showed definite seasonal variation. The higher values were recorded during summer months which declined to the low levels during post summer in the first year followed by an increase during pre summer of next year.

Magnesium
It had a low value of 118.23 x 10^{-3} in December, 121.60 x 10^{-3} in October and 713.5 x 10^{-3} mg/g in October at K-I, K-II and K-III, and 568.7 x 10^{-3} in December, 941.58 x 10^{-3} in November and 682.4 x 10^{-3} in January at the above stations in the first and second year respectively. It had higher values during summer at K-I and K-II in both the years (792.11 $\pm$ 230.28 x 10^{-3} and 869.17 $\pm$ 99.43 x10^{-3} mg/g at K-I and 2570.16 $\pm$ 1032.10 x 10^{-3} and 3226.86$\pm$ 432.26 x 10^{-3} mg/g at K-II in the first and second year respectively). These values were reduced during post summer of first and second year respectively.

Statistical analysis
The sedimentological factors were analysed statistically to find out the relation between these factors with salinity of over lying water. At K-I, the salinity of water was found to have highly significant positive correlation with organic carbon, organic matter, total nitrogen, total phosphorus, calcium and magnesium of the soil. Significant positive correlation was found between calcium concentration of water and soil as well as magnesium concentration of water and soil. The same type of relationship was observed at K-II and K-III also.(Table 1)

Table 1: Correlation Matrix of Sedimentological factors at Kelambakkam I and Vedaranyam I

		Soil O.C	Soil O.M.	Soil $T.N_2$	Soil Po_4	Soil Calcium	Soil Magnesium
Salinity	K I	0.91**	0.89**	0.88**	0.97**	0.85**	0.87**
	V I	0.873**	0.858**	0.871**	0.971**	0.916**	0.908**
Water Calcium	K I					0.86**	
	V I					0.84**	
Water Magnesium	K I						0.56**
	V I						0.90**

* Significant (5%)
** Highly significant (1%)

Table 2: Correlation Matrix of Sedimentological factors at Kelambakkam II and Vedaranyam II

		Soil O.C	Soil O.M.	Soil $T.N_2$	Soil Po_4	Soil Calcium	Soil Magnesium
Salinity	K II	0.905**	0.904**	0.905**	0.93**	0.93**	0.89**
	V II	0.88**	0.88**	0.881**	0.89**	0.87**	0.87**
Water Calcium	K II					0.49*	
	V II					0.18	
Water Magnesium	K II						0.92**
	V II						0.80**

* Significant (5%)
** Highly significant (1%)

Table 3: Correlation Matrix of Sedimentological factors at Kelambakkam III and Vedaranyam III

		Soil O.C	Soil O.M.	Soil $T.N_2$	Soil Po_4	Soil Calcium	Soil Magnesium
Salinity	K III	0.925**	0.964**	0.965**	0.932**	0.93**	0.89**
	V III	0.83**	0.83**	0.83**	0.833**	0.831**	0.835**
Water Calcium	K III					0.53*	
	V III					0.71**	
Water Magnesium	K III						0.92**
	V III						0.90**

* Significant (5%)
** Highly significant (1%)

Vedaranyam solar saltworks

Grain size analysis

The grain size analysis of soil sampled from V-I revealed composition of 90.35 % sand, 4.80 % silt and 4.85 % clay.

Organic Carbon

The percentage in the soil was comparatively high at Vedaranyam solar saltworks than Kelambakkam. The seasonal analysis revealed that, the percentage of organic carbon was high during summer and low during post summer or pre summer months.

Organic matter

The percentage in the soil fluctuated between 0.26 in December and 2.42 in August, and 0.24 in December and 4.67 in August in the first and second year respectively at V-I. Seasonally, high values were recorded during summer and low values during post summer or pre summer months.

Total nitrogen

Pooled up data revealed that, summer months encountered high values and pre summer low values except at V-II, where low values were recorded during post summer in the first year. In the following year, higher values were recorded during summer and lower during post summer months.

Total Phosphorus

Seasonal analysis revealed that the total phosphorus concentration reached the peak points during summer and then declined in postsummer and reached the lowest levels during presummer in all the stations.

Calcium
The minimum values of calcium in the soil were recorded during December and maximum during second half of summer period.

At V-I, the concentration of calcium in the soil during summer'90 was 1499.5 $\pm$ 294.89 x 10^{-3} mg/g. It declined during postsummer and the minimum values of 945.26 $\pm$ 95.37 x 10^{-3} mg/g was recorded during presummer '91. Again it increased to 1522.99 $\pm$ 462 x 10^{-3} mg/g during summer '91 followed by a decline to 414.07 $\pm$ 467.54 x 10^{-3} mg/g during postsummer. The concentration was found to increase during presummer '92. The pattern of variation was the same at V-II and V-III also.

Magnesium
The concentration varied from 54.87 x 10^{-3} in December to 2343 x 10^{-3} mg/g in August and 43.08 x 10^{-3} in December to 3361.72 x 10^{-3} mg/g in August at V-I in the first and second year. The seasonal variation of magnesium was same as that of calcium concentration in the soil. The concentration was found to increase during presummer'92 at all the stations.

Statistical analysis
The correlation coefficient analysis of sedimentological factors and salinity of water revealed that, all the sedimentological factors were highly significant and positively correlated with salinity of water at all the stations. Water calcium and magnesium showed positive correlation of soil respectively (Table 1).

DISCUSSION

In a typical solar saltwork, the incoming water of low salinity is progressively concentrated by solar evaporation as it flows through the series of evaporation ponds. In salinities of 70 ppt the carbonates and borates of calcium and calcium sulphate above 150 ppt precipitate from the brine and form a crystalline crust over the bottom of evaporation ponds (Britten and Johnsen, 1987). In the biological point of view, there is more biological diversity, greater productivity in low saline water and as the salinity increases biological diversity decreases due to their incapability to thrive in the hypersaline medium. The decomposed algal matter form an important source of organic matter in the hypersaline soil.

During the course of this work, the percentage of organic carbon, organic matter, total nitrogen and total phosphorus in the soil were found to follow an ascending trend with salinity. This may be due to the decay of accumulated dead algae. The estimated values of organic carbon are comparable to those reported earlier by Ramamoorthy and Thangaraj (1980) and Ansari (1987) from Tuticorin and Bombay salt ponds respectively.

Comparatively higher values of organic carbon, organic matter, total nitrogen and total phosphorus were recorded during peak summer months. Incidentally summer months were characterized by steady increase in salinity. This becomes a physiological stress to stenohaline algal species resulting in their death (Lin Zhili and Lin Xuexian, 1990). The accumulated dead algae contribute to the high organic content of soil.

The steady increase in the salinity of water due to solar evaporation causes partial precipitation of various salts (Harvie *et al* ., 1980). For eg: calcium sulphate usually precipitates at salinities around 150 ppt. This explains the reason for the high concentration of calcium in the soil at high salinities, especially during the summer season. Comparatively low concentration of magnesium than calcium in the soil reveals that the magnesium salts precipitate out only at very high salinities (300 ppt). A comparison of the calcium and magnesium concentration of water to that of soil also agrees with this observation. The main finding of this study is that high salinity plays a greater role in the constitution of soil chemistry of hypersaline solar salt works and also shows how the concentration one element influences the other as in the case of calcium and magnesium.

ACKNOWLEDGEMENT

This publication is a result of research for which the author(AAR) was sponsored by the Ministry of Environment & Forests, Government of India, New Delhi.

REFERENCES:

Ansari, S.K.R. (1987) The brine shrimp *Artemia*, *Ecology, cyst hatching,* development and mass culture. M.Sc., Thesis, University of Bombay, India, 325 PP

Britten,R.H. and R. Johnsen (1987),An ecological account of a Mediterranean salina: the salin de giraud, canargue (S. France),Biological Conservation, 42 : 185 – 230

Harvie, C.E., J.H. Wear, Hardie and H.P Eugster (1980) Evaporation of seawater: calculated mineral sequences. Science, 208: 498 – 500

Jones, A.G., Ewing, C.M. and M.V. Melvin (1981) Biotechnology of solar salt fields *Hydrobiologia,* 81 : 391 – 406.

Liu Zhili and Liu Xuexian (1990) Algal mat formation in Yinggchai saltworks, *Proc Internal Symp. on "Biotechnology of Salt ponds,* Sept. 17-22, 1990, Tanggu, Tianjin, P.R. China, 165 pp.

Merchant, R. and W.D. Williams (1977) (a), Organic content of some saline lake sediments in Western Victoria. Aust. J. mar. Freshwat. Res. 28: 269-275

Ramamoorthy, K and G.S. Thangaraj (1980), Ecology of *Artemia* in salt pans of Tuticorin, south India. *In: The brine Shrimp Artemia,* Vol.3 Ecology, Culturing, Use in Aquaculture. Universa Press, Wetteren, Belgium, 456 pp.

Snedecor, G.W. and W.G. Cochran (1967), Statistical methods. 6^{th} Ed., The State University Press, Ames Lowa, USA, 593p

Strickland, J.D.H. and T.R. Parsons (1972), A practical hand book of seawater analysis (2^{nd} Edition). *Bull. Fish Res. Board*. Can., 167: 310 pp

Walkley, A and I.A. Black (1934), Base exchange properties of nursery soils and application of potash fertilizers. J. Forestry, 38: 330-332