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Research Article

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A Correlative study of the rates of artificial evaporation of the brines of various saltpans of Kanyakumari District, Tamil Nadu, India

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ABSTRACT

Salt, an inexpensive and abundant commodity, plays a prominent role in the development of man's activities. Exceeding sodium level in food causes hypertension, heart, liver and kidney diseases. The present paper focuses on the rates of evaporation and chemical parameters of salt obtained from both natural and artificial pans. A correlative study of the rates of artificial evaporation of the brines of various saltpans is presented here. The parameters studied are percentages of moisture content, insoluble impurities, calcium sulphate, magnesium sulphate, magnesium chloride and sodium chloride. The presence of heavy metals like zinc, copper, iron, cadmium and manganese was also analysed. The study unfolds the fact that the percentages of moisture content and insoluble impurities of the salt samples showed a marked difference. Other parameters were almost similar though salt was separated from different pans.

Keywords: Salt pans, artificial evaporation, bittern, brine

INTRODUCTION

Salt evaporation ponds, also called saltpans are shallow, artificial ponds designed to produce salt from sea water or other brines. The ponds also provide a productive resting and feeding ground for many species of water birds, which may include endangered species [1]. Due to variable algal concentrations, vivid colours – from pale green to bright red are created in the evaporation ponds. The slow transition of a liquid to a gaseous, vaporized state is called evaporation. A broad area and shallow depth allow a given volume of water to absorb more sunlight. The ideal depth of the brine in salt-works is between 150 to 200mm [2]. The sun evaporates the water and as it does, the salt remains behind, creating more saline water and finally leaves behind a layer of salt crystals. When the concentration becomes 30° Be, the liquor is called bittern, because of its bitter taste [3]. Time is important because an untimely rain can ruin days of evaporation. Excessive dilution by heavy rains can be an important factor responsible for lowering down the values of different ions in brine[4]. So, some salt evaporation operations use very large indoor ponds, which are protected from the weather. Though the process for solar evaporation of brines is same around the world, manufacturing techniques and product quality vary considerably[5]. The present piece of work is the outcome of the results of chemical analysis of salt obtained from artificial and natural pans as well as the rates of evaporation from artificial pans. The study has revealed the heavy metal contamination in bittern.

EXPERIMENTAL SECTION

Samples were collected from three different sources for the study of artificial evaporation, namely Samithoppu where backwater brine is used, Puthalam where subsoil brine is used and Kovalam where sea brine is used. Ten litres of brine samples were collected separately and exposed to sunlight in plastic buckets. The reduction in volume and brine density were monitored daily. The chemical parameters of bittern were determined using standard procedures[6]. The results are presented in the following tables.

RESULTS AND DISCUSSION

A study on the rates of artificial evaporation using backwater, subsoil and sea brines was carried out. During the course of evaporation, gypsum crystallised between 16 $^\circ$Be and 25 $^\circ$Be. Sodium chloride crystallized between 25 and 29.5 $^\circ$Be. The crystals were collected, dried and weighed separately. The quantity obtained is given in Table I.

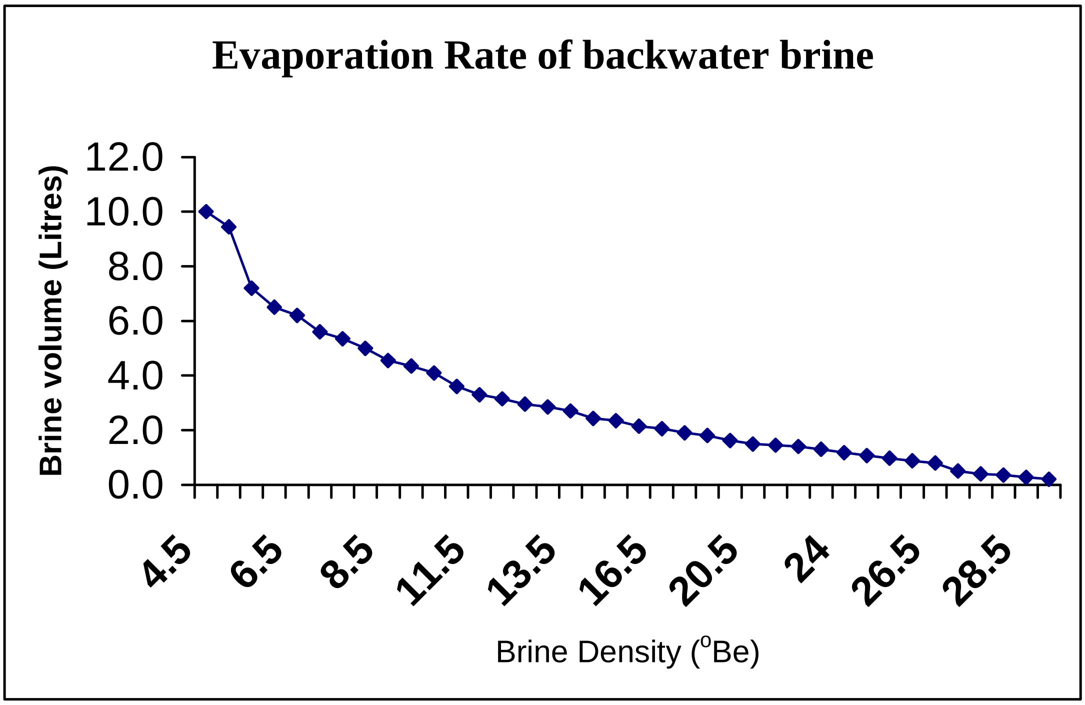
Table 1: Yield of salts from artificial pans

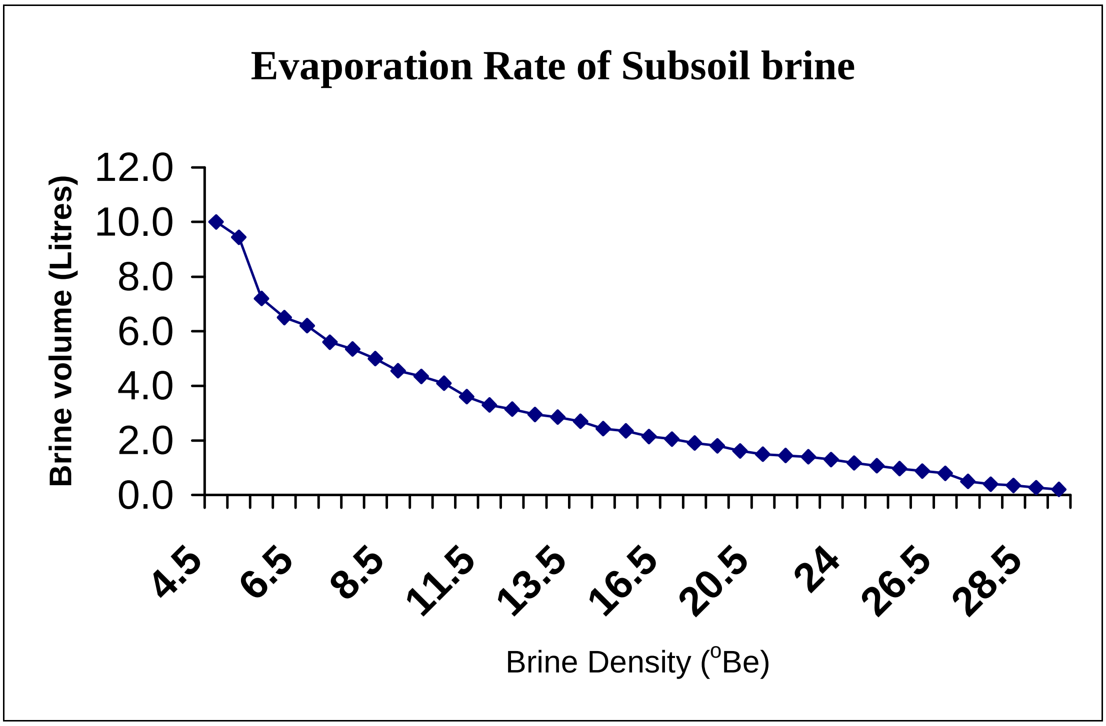
No.	Source	Volume of sample (litres)	Weight of gypsum (gms)	Weight of sodium chloride (gms)
1.	Backwaters	10	28.511	285.518
2.	Subsoil	10	25.564	293.930
3.	Sea Brine	10	35.941	346.870

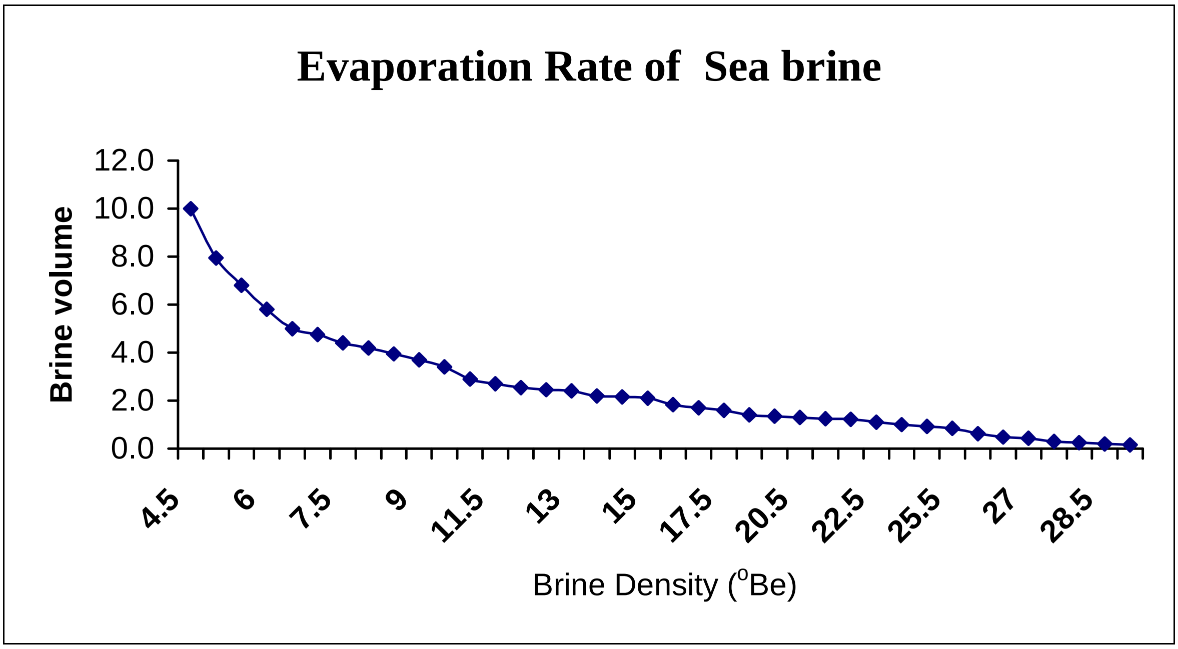
Evaporation proceeded with a gradual decrease in the volume of brine and at 30 $^\circ$Be, the volume of backwater, subsoil and sea brines were reduced to 200 ml, 200ml and 150ml respectively.

Table II. Rate of artificial evaporation

Brine Density ($^\circ$Be)	Backwater Brine Volume (litres)	Subsoil Brine Volume (litres)	Sea brine volume (litres)
4.5	10.000	10.000	10.000
5.0	9.450	9.100	7.950
5.5	7.200	6.950	6.800
6.0	6.500	6.400	5.800
6.5	6.200	6.100	5.000
7.0	5.600	5.500	4.750
7.5	5.350	5.350	4.400
8.0	5.000	4.800	4.200
8.5	4.550	4.700	3.950
9.0	4.350	4.500	3.700
10.0	4.100	3.950	3.400
11.0	3.600	3.600	2.900
11.5	3.300	3.300	2.700
12.0	3.150	3.150	2.550
12.5	2.950	2.900	2.450
13.0	2.850	2.825	2.400
13.5	2.700	2.625	2.200
14.5	2.425	2.550	2.150
15.0	2.350	2.400	2.100
16.0	2.150	2.300	1.825
16.5	2.050	2.200	1.700
17.5	1.900	1.950	1.600
18.5	1.800	1.900	1.400
20.0	1.625	1.750	1.350
20.5	1.500	1.625	1.300
21.0	1.450	1.500	1.250
21.5	1.400	1.475	1.225
22.5	1.300	1.450	1.100
24.0	1.175	1.275	1.000
25.0	1.075	1.050	0.925
25.5	0.975	0.925	0.850
26.0	0.875	0.600	0.625
26.5	0.800	0.550	0.475
27.0	0.500	0.500	0.425
27.5	0.400	0.400	0.300
28.0	0.350	0.325	0.250
28.5	0.275	0.250	0.200
30.0	0.200	0.200	0.150


Evaporation Rate of backwater brine
Brine volume (Litres)
12.0
10.0
8.0
6.0
4.0
2.0
0.0
4.5
6.5
8.5
11.5
13.5
16.5
20.5
24
26.5
28.5
Brine Density (°Be)


Evaporation Rate of Subsoil brine
Brine volume (Litres)
12.0
10.0
8.0
6.0
4.0
2.0
0.0
4.5
6.5
8.5
11.5
13.5
16.5
20.5
24
26.5
28.5
Brine Density (°Be)



In the beginning, the rate of evaporation was found to be the maximum for sea brine and the rate of evaporation of subsoil brine was higher than backwater brine. But as the density increased, the rate of evaporation was maximum in backwater brine, medium in subsoil brine and least in sea brine, because the concentration of ions in sea brine was maximum, when compared to that of subsoil and backwater brines.

Table III

Density range (° Be)	Reduction in volume (litres) Back water	Subsoil	Sea brine
4.5-10.0	5.900	6.050	6.600
10-15.0	1.750	1.550	1.300
15-20.0	0.725	0.675	0.650
20-25.0	0.550	0.675	0.425
25-30.0	0.875	0.850	0.775

The salt samples collected from the various brines through artificial evaporation were subjected to chemical analysis. The values were correlated with that obtained from Natural evaporations and the parameters are given in Table –IV.

Table –IV Chemical parameters of salt from natural and artificial pans

Parameter	Backwater		Subsoil		Sea brine	
	Natural	Artificial	Natural	Artificial	Natural	Artificial
Moisture (%) content	1.78	0.91	1.82	0.94	1.97	0.96
Insoluble impurities (%)	1.26	0.48	1.34	0.54	1.42	0.54
Calcium Sulphate (%)	1.30	1.35	1.48	1.52	1.42	1.40
Magnesium Sulphate (%)	1.10	1.12	1.14	1.17	1.29	1.32
Magnesium Chloride (%)	1.04	1.06	1.07	1.08	1.10	1.09
Sodium Chloride (%)	87.10	85.24	88.20	87.04	92.39	94.52

The percentage of Moisture content was found to be higher in natural pans as storage in large heaps preserve moisture. The percentage of insoluble impurities was also maximum in natural pans due to exposure to impurities by strong winds. Since the exposure area in artificial pans were less, the percentage of insoluble impurities were also minimum. The percentages of calcium sulphate, magnesium sulphate, magnesium chloride and sodium chloride were almost similar for the salt samples obtained from artificial and natural pans as there is no variation in the concentration of various ions.

The heavy metal concentration of bittern from the two salt samples obtained from natural and artificial pans were also determined and the values are given in Table V.

Table V. Heavy metal concentration of bittern from natural and artificial pans

Heavy Metals	Backwater		Subsoil		Sea brine	
	Natural	Artificial	Natural	Artificial	Natural	Artificial
Zinc (ppm)	1.030	1.035	0.750	0.690	3.340	3.350
Copper (ppm)	0.590	0.600	0.380	0.410	0.510	0.535
Iron (ppm)	3.160	3.080	2.820	2.729	3.610	3.590
Cadmium (ppm)	ND	ND	ND	ND	ND	ND
Manganese (ppm)	0.820	0.790	0.430	0.390	0.620	0.580

ND-Not Detectable

Regarding the presence of heavy metals, Zinc was found to be maximum in the bittern obtained from sea brine with a value of 3.350 ppm. The presence of zinc suggests strong indication of contamination by river discharge and land run-off. High zinc level may be due to heavy influx of monsoonal flood which carried surface run-off from the land (Riley and Chester, 1971) [7].

Copper was found to be maximum in the backwater pan of Swamithoppu. Iron was found to be maximum in the sea brine of Kovalam. A remarkable feature in iron was its higher concentration in sea brine compared to other heavy metals. It may be due to the transportation of weathering, intensive sand mining and quarrying. Cadmium was present in ND amounts except in all the samples. The level of Manganese was maximum in backwater brine of Swamithoppu.

The concentration of heavy metals were almost the same for artificial and natural pans of the backwater, subsoil and sea brine samples of bittern.

CONCLUSION

The data suggests that the quality of salt obtained from artificial pans is of remarkable quality. The yield of sodium chloride was maximum from sea brine and minimum from backwater brine. The rate of evaporation of sea brine was maximum in the beginning, gradually decreased and became minimum due to the high concentration of ions. The percentages of calcium salphate, magnesium sulphate, magnesium chloride and sodium chloride obtained from the salts of natural and artificial pans of the subsoil, backwater and marine brines did not show much fluctuations because there is no variation in the concentration of ions.

But the percentage of moisture content was maximum in natural pans due to storage in heaps. The percentage of insoluble impurities was also maximum in natural pans due to large surface area exposed to strong winds. The concentration of heavy metals in the bittern samples of backwater, subsoil and marine brines under natural and artificial evaporation conditions did not show much fluctuations. The above study reveals that the quality of salt obtained under artificial evaporation tops in quality.

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