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PHYSICO-CHEMICAL FACTORS OF SOLAR SALT FARMS WATER IN THE COASTAL AREA OF COX'S BAZAR, BANGLADESH

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ABSTRACT: Physico-chemical factors of water at different gradient of the salt production pans (reservoir, condenser and crystallizer) of the coastal area in Cox's Bazar were studied. Analyses of water temperature at different gradient of salt pans show almost similar values (31°C-32°C). The p^H values varied from 4.9 to 7.4. The acidic p^H values were recorded in Chakaria Sundarban area. Salinity ranged from 30.03‰ to 330.52‰, lowest salinity was found in reservoir pan and highest in crystallizer pan. Electric conductivity values fluctuated between 9.60 and 336.00 mmhos/cm and its values gradually increase from reservoir to crystallizer pans. Total hardness, Ca, Mg and HCO_3 varied from 8000 to 213600 mg/l; 2987 to 106300 mg/l, 5013 to 107300 mg/l and 36.6 to 146.4 mg/l respectively and their values were always found to be Reservoir < Condenser< Crystallizer. Alkalinity ranged from 50-570 ppm, the lowest values were recorded in reservoir pan and highest were found in crystallizer. Usually higher concentration of K was obtained in crystallizer pan and the highest value (15.2g/l) was recorded at Moheskhali sampling area.

KEY WORDS: Physico-chemical factors- solar salt farm water- Bangladesh coast.

INTRODUCTION

Salt is produced by solar evaporation of sea water in Bangladesh. There are 12000 ha of salt production area in the coastal regions of this country (Alam *et al.*1998), about 35000 labours are directly involve and produce more than 700000 metric tons of salt every year. Generally salt is produced from November to April/May. The saltpans are generally constructed of small dykes; leveling and compacting of saltpans at the onset of the dry season in November and flooding by the beginning of December/January. Harvesting of salt starts by the end of January and is continued until April/May (Alam *et al.*1998). Each individual salt pan is fragmented into about 3-6 parallel, mostly identical salt streets. Each salt street consists of a series of 6 consecutive pans with gradually decreasing size. Typically, there are 3 major types of pans in the overall evaporation sequence: reservoir-type evaporation pans, condenser and crystallizers (Fig.1). In the pans of reservoir and condenser sea water is gradually concentrated through evaporation, whereas the crystallizers are used for deposition of sodium chloride (Fig.2). The evaporators are mostly not larger than 350 m^2, while the crystallizer pans can be as small as 40 m^2.

Intake of sea water into the evaporation pans depends on local and elevation of the pan of either manual filling (i.e. with a water scooper or pump) and from the first evaporation pan the water flows by gravity towards the following evaporation pans and eventually reaches the crystallizers. During this process, generally the sea water gradually

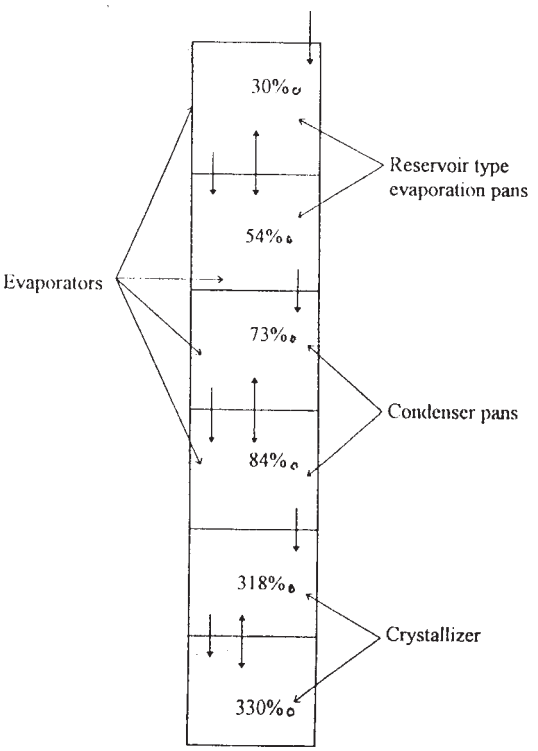

Fig. 1. Schematic layout of a typical salt street of Bangladesh.

Fig. 2. Deposition of salt (Sodium Chloride) in a salt farm of Bangladesh.

concentrates from about 30-40ppt in the first evaporation pan and 150-280ppt in the last evaporator. At this point the brine is transferred to the crystallizer pan, where the salt is deposited after further concentration of sea water to about one tenth of its original volume.

Water depth in the pan is very shallow and range from 6 to 10 cm in the first evaporation pan to a few (<5) cm in the crystallizers. After1-2 day's halite (NaCl) and other salts such as calcium sulphate, potassium chloride and magnesium sulphate begin to precipitate and salt is harvested from the crystallizers. In the natural evaporation of sea water climatic factors play an important role in the production of salt. The most important factors amongst these are temperature, wind velocity, relative humidity, sunshine and rainfall. There is no scientific report on solar salt production of Bangladesh. The present investigation is the first of its kind on physico-chemical factors of solar salt production farm's water from Cox's Bazar area, Bangladesh.

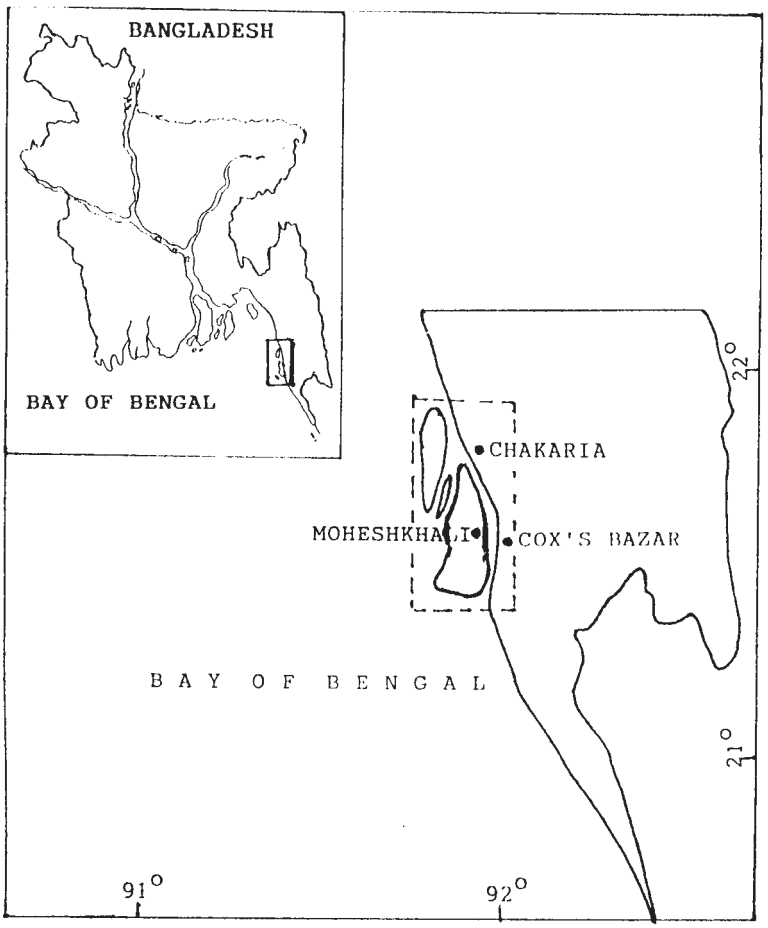

Fig. 3. Sampling locations of the studied area of Bangladesh.

MATERIALS AND METHODS

The area of investigation is situated in the coastal districts of Cox's Bazar is between 21º 31? and 21º 56? N latitude and 91º 50? to 92º 23? E longitude. Samples were collected from 3 stations (Fig. 3) in the salt pans areas of Cox's Bazar (Kuruskul), Moheskhali (Gorakghata) and Chakaria Sundarban (Darbeskhata) in March 1995. From each station water samples were taken from reservoir, condenser and the crystallizers pans with replicates. Concurrently water temperature was recorded by using a thermometer. P^H is determined by digital p^H meter. Salinity was obtained by standard Mohr-Knudsen method following Barnes (1959). Electrical conductivity was recorded by conductivity meter. Total hardness, calcium, HCO_3 and total alkalinity were determined by procedures describe by APHA (1976). K concentration was recorded by the procedure of Aitken (1984).

RESULTS AND DISCUSSION

Water temperature:

Water temperature varied from 31 to 32ºC. Among the three sampling stations highest (32ºC) water temperature was recorded at Moheskhali. Zafar (1994) reported that water temperature (29ºC) in March of Kutubdia channel. Mahmood *et al.* (1993) recorded the water temperature 26.93ºC in March of an aquaculture pond of Chakaria Sundarban. Ali *et al*. (1985) stated that in the Moheskhali channel water temperature was recorded 27.5ºC during this time. Mahmood *et al.* (1976) published that water temperature 29.69ºC in March of Karnafuli estuary. Mahmood and Khan (1980) reported that water temperature follows the air temperature in the parallel manner. The present investigation for reservoir pan is close agreement with the findings of the above mentioned results.

Hydrogen ion concentration:

p^H was found between 4.9 and 7.4 in the present investigated area. Very strong acidic p^H value (4.9) was found in crystallizer pond at Darbeskhata of Chakaria Sundarban area (Table 1). Ramesh and Subramanian (1985) reported the p^H value ranges from 7.8 to 8.8 at the solar salt farm near Madras. Mahmood *et al.* (1993) recorded the water p^H 7.6 in March of an aquaculture pond of Chakaria Sundarban. Mahmood and Saikat (1995) reported the acidic p^H values in soil of the Chakaria Sundarban area and they also mentioned that Chakaria Sundarban area has a reach reserve of pyrite in its soil, and noted that when acid sulfate soils are dried, oxidation takes place upon exposure to air and p^H goes down.

Salinity:

The most important feature of solar salt pans is the higher level of salinity. In the whole investigated area salinity was varied from 30.03 to 330.52 ‰. The salinity was gradually increasing from reservoir to crystallizer pan due to evaporation of water by solar heat. Belaluzzaman (1995) recorded the 36.67 ‰ salinity of Cox's Bazar coastal area in March. Chowdhury (1995) found 28.20 ‰ salinity in March at Moheskhali channel of Cox's Bazar. Mahmood *et al.* (1993) reported the salinity of an extensive aquaculture

Table 1. Physico-chemical factors of different gradient of salt farm in the three stations.

Gradient pans	St. No.	pH	Salinity ppt	Temp. °C	EC mmohs/cm	Total hardness	Ca mg/L	Mg mg/L	HCO_3 mg/L	Alkalinity ppm	K g/L
	1	7.1	30.03	31.5	93.6	8000	2987	5013	36.6	120	3.4
Reservoir	2	7	54.54	32	147.6	12500	5250	7250	48.8	140	4.97
	3	6.6	53.27	31	102.6	12000	5208	7692	36.6	50	7.56
	1	7.4	78.36	31.5	228	16000	7908	8092	36.6	140	4.49
Condenser	2	6.4	73.49	32	276	15000	7005	7995	61	240	4.65
	3	5.7	84.14	31	192	23000	10500	12500	ND	ND	5.09
	1	6.9	330.52	31.5	336	135200	65600	69600	146	570	8.87
Crystallizer	2	6.9	325.47	32	318	142600	70300	72300	146.4	520	15.2
	3	4.9	318.99	31	264	213600	106300	107300	ND	ND	10.67

EC = Electric Conductivity
Temp. = Temperature
ND = Not Detected
St. = Station
Station 1 = Cox's Bazar (Kuruskul)
Station 2 = Moheskhali (Gorakghata)
Station 3 = Chakaria (Darbeskhata)

pond at Chakaria Sundarban 34.84 ‰ in March. In the present investigation lower salinity (30.03 ‰) was recorded of the reservoir at station 1 (Kuruskul). The salinity of Kuruskul area of Cox's Bazar is directly influenced by Bankkhali river.

Electric conductivity:

Electric conductivity was gradually increasing from reservoir to crystallizer pans due to evaporation by solar heat (i.e. Reservoir <Condenser <Crystallizer). The minimum value was found to be 93.6 mmohs/cm in reservoir and highest 336 mmohs/cm in crystallizer at station 1. Ramesh and Subramanian (1985) observed that conductivity values of salt farms showed variation from pans to pans and they also mentioned that conductivity followed with increasing salinity because of the chemical complexity of brines. In the salt farm of Madras they measured the conductivity range between 18 and 106 mmohs/cm, but in present study conductivity was higher in all sampling stations of solar salt farm of Cox's Bazar, Bangladesh than that of solar salt farm near Madras, India.

Total hardness:

The hardness of sea water from the investigated area ranged from 8000 to 213600 mg/l. The minima always recorded at reservoir pans and maxima were in crystallizer pans. It was gradually increasing from reservoir to condenser and then crystallizer pan. Gradually higher values of hardness of $CaCO_3$ were found in Moheskhali Island and Chakaria Sundarban area.

Calcium:

The Ca concentration of three sampling stations of Cox's Bazar district varied from 2987 to 106300 mg/l. The lower concentration was recorded in reservoir pan and higher obtained in crystallizer. Ca from reservoir to crystallizer pan was increasing (reservoir <Condenser <Crystallizer). Ramesh and Subramanian (1985) stated that Ca concentration varied 551 to 3608 mg/l in the solar salt farm at Madras. The present investigated area had higher Ca concentration than Madras.

Magnesium:

Mg ion concentration in salt farm waters varied between 5013 mg/l and 107300 mg/l. Mg was also increasing from reservoir to crystallizer. Abu-Hena *et al*.(2000) reported that in an average 250.20±15.05 mg/l of Mg was present in sea water, when mean salinity 10.7±2.2 ‰ near at Bankkhali River, Bangladesh. In the present investigation Mg found between 5013 to 7250 mg/l in reservoir pans of Cox's Bazar salt production farms.

Bicarbonate:

The minimum concentration of HCO_3 (36.6 ml/l) was recorded in Chakaria and in this area HCO_3 was not detected in the condenser and crystallizer pans. The higher concentration of bicarbonate was recorded in the Moheskhali Island (146.4 mg/l) and its concentration was gradually increasing (reservoir <condenser <crystallizer) at station 1 and 2. Bicarbonate was found in the solar salt farm waters, where p^H value obtained above 6.3. Ramesh and Subramanian (1985) reported that 146-582 mg/l of HCO_3 was found in the solar salt farms at Madras.

Alkalinity:

Alkalinity values varied between 50-570 ppm in the area of investigation. It was not detected in condenser and crystallizer pans of the Chakaria Sundarban station, where p^H ranged between 4.9 and 5.7. Belaluzzaman (1995) stated that total alkalinity content in the intertidal water ranged from 100 to 150 ppm with a yearly mean of 127.08 ± 15.47 ppm in the sea shore of Cox's Bazar and he also recorded the total alkalinity (70-145ppm) in the surface waters of Bankkhali river estuary. The alkalinity concentration of reservoir pans at Kuruskul and Gorakghata solar salt farms is more or less similar with the results of Belaluzzaman, 1995.

Potassium:

Potassium concentration was found between 3.4 and 15.20 g/l in the investigated area. The highest value of K was recorded in the Moheskhali Island. Ramesh and Subramanian (1985) reported that K concentration varied from 0.825 to 5.78 g/l of the salt farm in Madras.

CONCLUSION

The physico-chemical factors of solar salt farm of Bangladesh were recorded for the first time during present investigation. This report would be helpful for farmers during salt production.

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