ROLE OF MICROALGAE FOR QUALITY SALT PRODUCTION IN SOUTH INDIAN SOLAR SALT PRODUCTION

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EXTENDED ABSTRACT

The organisms living in every solar salt works constitute a biological system, which are able to aid to harm salt production. Systems aiding salt production maintain stable species composition and concentrations, they produce and accumulate sufficient organic matter to power the biota, prevent leakages and also increase the solar energy absorption. Sodium chloride production from solar salt works depends upon location, favourable climate and the living microorganisms growing in the concentrating ponds and crystallizers. These essential microorganisms constitute a biological system, which serves two important functions in saltproduction. The microorganisms produce a thick, many layered mat on the bottom of the ponds which prevents leakage of the brine. The microorganisms also occur the brine by producing floating, coloured cells in high concentrations. The coloured cells increase the absorption of solar energy, which raises brine temperature, and thus improve evaporations. Solar salt works consists of three distinct biological areas (Reservoir, Condenser and Crystallizer), which can be conveniently considered as a function of salinity. Salt has played a predominant part in the development of man's activities. One reason for its overwhelming influence is that it is the source of sodium and chloride, two of the twelve dominant elements in the human body. The technique of solar saltproduction involves fractional crystallization of the salts in different ponds to obtain sodium chloride in the purest from possible. Temporal patterns of interaction between salinity and water depth can be important determinants of the biological community of the saline system and the hydrobiological activity determines the quality and quantity of salt production in the solar salt operation. The major chemicals found in the seawater are sulphate and carbonate of calcium, chlorides of sodium, magnesium, potassium and sulphate. The order of separation of the dissolved salts depends on their relative solubility. Calcium carbonate being the least soluble salt, separated out first. The highly soluble magnesium salts are separated last. Correlations between aquatic - chemical conditions and the occurrence of planktonic and benthic diatom species in the field have been used traditionally to interpret the preference of taxa to single selected environmental factor and likewise, the distribution of diatom taxa has been used to infer certain environmental characteristics of aquatic systems. Microalgae *Dunaliella salina, Coccochloris* present in the crystallizer pond played an important role in quality saltproduction. It will reduce the moisture, insoluble matter, sulphate, calcium and magnesium content in the salt there by improved the salt quality.

KEYWORDS: Solar saltpans, microalgae, salinity, condenser pond, brine.

INTRODUCTION

Microalgae are of increasing economic importance as sources of biomass for health, food and aquaculture. Algal based systems have also been practiced for the removal of toxic minerals such as Pb, Cd, Hg, Sn, Ni, As and Br in Seawater (Wilde and Benemann, 1993). The ability of algae to produce oxygen in photosynthesis as well as their uptake rates of N and P make them effective components of any biological waste treatment system. The production of common salt is one of the most ancient and widely distributed industries in the world. The physical and chemical compositions of salt production from various sources are varied widely depending upon the manufacturing techniques, climatic conditions and processes adopted. The organisms living in every solar saltworks constitute a biological system, which are able to aid or harm saltproduction. Systems aiding saltproduction maintain stable species composition and concentrations, they produce and accumulate sufficient matter to power the biota, prevent leakages (Jones *et al.*, 1981) and also increase the solar energy absorption (Coleman and White, 1992). Sodium chloride production from solar salt works depends upon location, favourable climate and the living microalgae growing in the crystallizers. The microalgae produce a thick, many layered mat on the bottom of the ponds which prevents leakage of the brine. The microalgae also colour the brine by producing floating coloured cells in high concentrations (Oren *et al.*, 1992). Solar salt works consist of three distinct biological areas (Reservoir, condenser and crystallizers). The first area includes ponds whose salinity vary from that of seawater to approximately three times greater than the salinity. The second ranges from three to seven times and the last more than seven times salinity to saturation in respect to sodium chloride. Reservoir pond consists of nineteen species of microalgae in three divisions Bacillariophyta, Chlorophyta and Dinophyta. Condenser pond consists of six species of above three divisions. The crystallizer pond consists of two species of two divisions *Coccochloris sp.* (Bacillariophyta) and *Dunaliella salina* (Chlorophyta). It is the place where sodium chloride crystallized. South Indian solar salt productions are situated in and around Kanyakumari at 8°04'N latitude and 77° 68' east longitude. The objective of the investigation was to study the role of microalgae *Dunaliella salina* and *Coccochloris sp.* for quality salt production in Thamaraikulam solar saltpan.

MATERIALS AND METHODS

Materials for the present study were collected in all the four seasons of the two years study period 2005 and 2006. In each season, water samples were collected four times per season in twenty five litre polythene cans, fixed in Lugol's iodine and preserved in 4% formaldehyde. The fixed samples were transported to the laboratory and kept undisturbed for 48 hours to settling the plankton mass and later the biomass were concentrated to 10ml or 50ml (depending on the abundance of plankton) by siphoning out the supernatant solution with a plastic tubing, one end of which was closed with a bolting silk (30μm) to prevent the loss of buoyant phytoplankton. Numerical estimation of phytoplankton was made by Sedgwick-Rafter cell method (Trivedi and Goel, 1986). Identification of phytoplankton species was made as per the observations made by Prescott (1962), Sarma and Khan (1980). Phytoplankton abundance (%) in different ponds were carried out. The water temperature was measured using thermometer (Hermes, India, sensitivity 1°C). The salinity of water in all ponds was measured by using a salinity Refractometer (New 100 Thanka Sanjiro Co. Ltd., Japan 1 ppt sensitivity). pH was measured using pH meter, Salt quality analysis by standard procedures.

RESULT

The average water pH, temperature and salinity for the study period 2005 and 2006 is shown in table - 1. Crystallizer pond showed the pH of 7.33 ± 0.13 and 7.56 ± 0.08 in season I, 7.53 ± 0.083 and 7.50 ± 0.071 in season II, 7.48 ± 0.109 and 7.50 ± 0.122 in season III and 7.63 ± 0.083, 7.48 ± 0.042 in season IV.

Temperature of I 32.20 ± 1.062 and 32.35 ± 2.77 in season I, 31.76 ± 1.52 and 32.83 ± 0.9 in II season, 32.45 ± 1.076 and 32.45 ± 1.076 in III season and 30.93 ± 1.047, 31.58 ± 0.781 in IV season.

Salinity of 188.25 ± 7.14 and 200.50 ± 5.80 in I season, 207.50 ± 8.43 and 204.75 ± 7.14 in II season, 195.25 ± 7.27 and 209.25 ± 9.11 in III season and 204.75 ± 5.5, 196.00 ± 3.92 in the IV season.

Abundance of microalgae (%) in the crystallizer pond of Thamaraikulam solar salt production for the study period 2005 and 2006 in shown in table – 2. There are only two species of microalgae found were *Coccochloris sp.* and *Dunaliella salina* belongs to the division Bacillariophyta and Chlorophyta. *Coccochloris sp.* showed 42.85 and 57.14 (%) respectively in the I season, II season 25.00 and 37.50 (%). III season 27.30 and 28.50 (%) and during the IV season 45.46 ± 40.80. *Dunaliella salina* showed 57.15 and 45.86 % in the I season, 75.10 and 62.50 during the II season, 72.70 and 71.42 % in the III season and 54.54, 60.00 % in the IV season. Of the two years study period *Dunaliella salina* showed maximum abundance than that of *Coccochloris* in all the four seasons.

Salt quality parameter (%) observed in the crystallizer pond of Thamaraikulam solar saltproduction during the study period 2005 and 2006 in shown in table - 3.

Moisture of 2.45 ± 0.206 and 2.28 ± 0.148 in I season, 2.73 ± 0.083 and 2.25 ± 0.050 in II season, 2.75 ± 0.050 and 2.33 ± 0.179 in III season and 2.70 ± 0.071, 2.18 ± 0.109 in the IV season.

Insoluble matter of 0.02 ± 0.005 and 0.03 ± 0.003 in the I season, 0.03 ± 0.005 and 0.03 ± 0.006 in the II season, 0.02 ± 0.004 and 0.03 ± 0.004 in the III season and 0.03 ± 0.008, 0.03 ± 0.003 in eh IV season. Sulphate content in the crystallizer water was 0.53 ± 0.006 and 0.53 ± 0.005 in season I, 0.50 ± 0.008 and 0.50 ± 0.009 in season II, 0.52 ± 0.009 and 0.52 ± 0.008 in III season and 0.51 ± 0.011, 0.51 ± 0.011 in the IV season.

Calcium content of 0.011 ± 0.001 and 0.01 ± 0.001 in the I season, 0.02 ± 0.003 and 0.02 ± 0.003 in the II season 0.01 ± 0.001 and 0.01 ± 0.001 in the III season and 0.01 ± 0.001, 0.01 ± 0.001 in the IV season.

Magnesium content of 0.15 ± 0.006 and 0.14 ± 0.005 in I season, 0.14 ± 0.002 and 0.14 ± 0.002 in the II season, 0.15 ± 0.005 and 0.14 ± 0.005 in the III season and 0.15 ± 0.003, 0.15 ± 0.003 in the IV season.

Sodium chloride content of 96.62 ± 0.000 and 96.82 ± 0.03 in the I season, 96.39 ± 0.08 and 96.96 ± 0.03 in the II season, 96.01 ± 0.47 and 96.71 ± 0.06 in the III season, 96.47 ± 0.02 and 96.47 ± 0.02, 97.12 ± 0.04 in the IV season. This result showed that microalgae definitely played an important role in salt production.

Table 1: Average physical parameters in the crystallizer pond of Thamaraikulam solar saltproduction during the study period 2005 and 2006

Season	pH		Temperature		Salinity	
I	7.33±0.13	7.56±0.08	32.20±1.062	32.35±2.277	188.25±7.14	200.50±5.80
II	7.53±0.083	7.50±0.071	31.76 ± 1.52	32.83±0.9	207.50±8.43	204.75±7.14
III	7.48±0.109	7.50±0.122	32.45±1.076	32.45±1.076	195.25±7.27	209.25±9.11
IV	7.63±0.083	7.48±0.042	30.93±1.047	31.58±0.781	204.75±5.5	196.00±3.92

* Each value is a mean of four data

Table 2: Abundance of microalgae (%) in the crystallizer pond of Thamaraikulam solar saltproduction during the study period 2005 and 2006.

Algae Name		Abundance							
Order	Division	Season I		Season II		Season III		Season IV	
Coccochloris sp (Nitzchiales, Bacillariophyta)		42.85	57.14	25.00	37.50	27.30	28.58	45.46	40.00
Dunaliella sp (Volvocales, Chlorophyta)		57.15	45.86	75.00	62.50	72.70	71.42	54.54	60.00

* Each value is a mean of four data

Table 3: Salt quality parameters observed in the crystallizer pond of Thamaraikulam solar saltproduction during the year 2005 and 2006.

Content (%)	Season I		Season II		Season III		Season IV	
Moisture	2.45 ± 0.206	2.28 ± 0.148	2.73 ± 0.083	2.25 ± 0.050	2.75 ± 0.050	2.33 ± 0.179	2.70 ± 0.071	2.18 ± 0.109
Insoluble matter	0.02 ± 0.005	0.03 ± 0.003	0.03 ± 0.005	0.03 ± 0.006	0.02 ± 0.004	0.03 ± 0.004	0.03 ± 0.008	0.03 ± 0.003
Sulphate	0.53 ± 0.006	0.53 ± 0.005	0.50 ± 0.008	0.50 ± 0.089	0.52 ± 0.009	0.52 ± 0.008	0.51 ± 0.011	0.51 ± 0.011
Calcium	0.10 ± 0.000	0.01 ± 0.001	0.02 ± 0.003	0.02 ± 0.003	0.01 ± 0.001	0.01 ± 0.001	0.01 ± 0.001	0.01 ± 0.001
Magnesium	0.15 ± 0.006	0.14 ± 0.005	0.14 ± 0.002	0.14 ± 0.002	0.15 ± 0.005	0.14 ± 0.005	0.15 ± 0.003	0.15 ± 0.003
NaCl	96.62 ± 0.00	96.82 ± 0.03	96.39 ± 0.08	96.96 ± 0.03	96.01 ± 0.47	96.71 ± 0.06	96.47 ± 0.02	97.12 ± 0.04

* Each value is a mean of four data

DISCUSSION

Salt has played a predominant part in the development of man's activities. One reason for its overhelming influence is that it is the source of sodium chloride, two of the twelve dominent elements in the human body. These two elements have important functions in the metabolism of the body. Lack of these elements leads to decay and death. The science of Chemistry has used salt as an important raw material in today's industry. Sodium chloride plays a key role in the metabolism of the body of the heart muscles, the peristaltic movement of the digestive tract and the transmission of impulses by nerve cells. Hydrochloric acid required for digestion is produced by the chloride ion (Aggarwal 1956).

Sodium chloride is formed as cubic crystal. It is colourless, odourless and has a characteristic taste. It has a specific gravity of 2.165 and a molecular weight of 58.45. The technique of salt manufacture involves fractional crystallization of the salts to obtain sodium chloride in the purest form possible. According to the typical standard adopted in the developing countries the purify required is 99.5 % for Grade – I industrial salt 98.5 % for Grade – II, 96 % for edible common salt and 97 % for table salt (Sorgeloos and Tackaert, 1990).

The quantity and quality of salt production in a solar salt work is determined by the hydrobiological activity (Sorgeloos *et al*., 1983) *Dunaliella salina*, whose cells accumulate carotenoids, when grown in high salt concentrations and therefore appear red. The red colour of the concentrated saltern pond is often regarded as a significant contribution to the solar salt production process (Reginald *et al*., 2004). Light energy absorbed is converted into heat, thus increasing the heat accumulation of the water and so improving the salt corl in salterns (Sorgeloos, 1983). The coloured microorganisms present increase the absorption of solar energy which raises brine temperature and these enhans evaporation. *Dunaliella salina* release organic carbon under different conditions also improves the salt quality (Giordano *et al*., 1994).

Coccochloris present in the saltworks coloured the water into deep green. The cells of the *Coccochloris* secreted sufficient mucilage to make the brine quite viscous. Abnormally high concentrations of organic matter, particularly excessive *Coccochloris* mucilage, decrease sodium chloride crystal size and increase coloured inclusions in the crystals (Persoone *et al*., 1979).

Even though the algal blooms are beneficial to the salt farms, their decomposed products act as chemical traps and finally prevent early precipitation of gypsum. This contaminates the sodium chloride in the crystallizer and thus the salt quality is reduced (Sorgeloos, 1986). The present study confirmed that microalgae played very important role in quality salt production.

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