TRADITIONAL SALT PRODUCTION IN GOA- INDIA ENRICHES DIVERSE MICROBIAL RESOURCE

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ABSTRACT

The paper reviews most of the results of an effort, to study the crude salt production units "Salt pans" (Mitagor) of Goa- India, located between 15^0 44' 30" N, and 73^0 45' and 74^0 26' E. Annually, local villagers construct "Salt pans" on stretches of low lying, inter-tidal wetland by draining off water, compacting the soil and dividing the area of the holding through low mud barriers/ walls, into a series of interconnected rectangular subunits which serve as a shallow soil -based –basins distinguished as : Collection- basin, Condenser –basin & Crystallizer- basin. At high tide, saline water from estuary flows through a sluice gate. Salt workers regulate the flow of water by plugging and de-plugging the communicating access between the shallow basins. Saline water evaporates, condenses to brine and eventually crystallizes to crude salt within the timed cycles of tidal - influx and tidal - efflux. Crystals from supersaturated brine are collected with the help of wooden devices, heaped up and marketed. Chemically crude salt is a mixture of NaCl (80 -85%); $MgSO_4$, (2-3%), $MgCl_2$, (2-3%). $CaSO_4$ (0.8-1.5%) and 2.5 to 3.0 ppm of iodine per gram. The salt pan constructions are seasonal, the holding gets filled with monsoon–runoffs and remains submerged during the South-West- Monsoon. The studies of near two decades, reviewed herein indicate that the physicochemical process of recovery of salt (largely NaCl), through salt pans favors growth of micro-flora that develops against the back drop of sodium chloride gradients that range from sea water to crystalline salt, and sets up a unique, seasonal, transient, econiche , that harbors diverse retrievable microbial community of non-halophilic, euryhaline and halophilic: bacteria, cyanobacteria, and fungi besides the haloarchaea. The haloarchaea and cyanobacterial, either singly or as consortium exhibit high tolerance to heavy metals such as, Cd^{+2}, Ni^{+2} , Fe^{+2}, Mn^{+2} , Zn^{+2}, Pb^{+2} & Cu, crude oil and

constituent of hydrocarbons, are able to remove metals ions from saline waters, clarify industrial waste- waters, fix nitrogen, produce valuable pigments, enzymes, PHA's and bioactive molecules. In conclusion salt production in Goa – India, through salt pans, besides producing crude salt; provides a natural reservoir of biotechnological important microbes, therefore promote traditional salt production, through salt pans in Goa –India, and harnesses the benefits of microbial resources".

Key words: Sat-pans of Goa-India, Crude-salt, Microbial-resource

INTRODUCTION

Goa located between 15^0 44' 30" N, and 73^0 45' and 74^0 26' E, on the mid-west coast of the Indian subcontinent has several estuaries running into the hinterland of some of its eleven "talukas". The tidal effects of the rivers are felt for 40 – 45 Km in the hinterland. Approximately marshy estuarine, reclaimed through a primitive method of embankment, dykes and tidal water flow inlets called sluice gates are used as "Mitagor"/"Salt-Pans" for production of crude salt from the sea or from estuarine waters. Reports available in 1991, documented the role played by the salt industry in the economic growth of Goa, through the export of salt during Medieval, colonial and post-colonial-times[1]. Hence efforts were made by the author and her team of students to study the salt pans of Goa for architecture/design of salt-pan, salt production process, environmental features, micro-flora, and the biotechnology significance of the micro-biota. This paper reviews most of the result of studies of nearly two decades, which indicate that the physicochemical process of recovery of salt (largely NaCl), through salt pans favors growth of biotechnologically significant micro-flora.

METHODOLOGY

Study Site: "Mitaagor" or "Salt Pans" Goa – India were studied for their construction, Salt production process: its hydrological and physicochemical parameters and microbiological community.

Evaluation of Microflora : Water samples from 3-4cm high column of stagnate saline waters from shallow soil -based –basin of salt pan facility were collected and examined for micro-flora microscopically and by growing in appropriate growth media with and without any one of essential nutrients, i.e., carbon or nitrogen. Retrived cultures were characterized using conventional and chemotaxonomic methods[20]. Biochemical capabilities were analyzed using specific substrates/ toxicants such as metal or hydrocarbon.

RESULTS

Two hundred active "Mitaagor" or "Salt Pans" were located on stretches of marshy land at the mouth of tidal rivers of Goa, namely Tiracol, Chapora, Mandovi, Zuari and Sal, during 1991-1994. The small holdings produced quality crude salt consisting of NaCl (80-85%); $MgSO_4$, (2-3%), $MgCl_2$,

(2-3%), $CaSO_4$, (0.8-1.5%) which was exported and used by locals. During 2000-2006, however, only 30% of salt pans were found to be active.

Architecture of the "Salt Pans"

Annual during summer, stretches of low lying, inter-tidal marshy land at the mouth of the tidal river is maneuvered into a salt pan through a primitive, ecofriendly architecture, (possibly conceived by the village locals) by draining off water, manually compacting the soil to form an uniform hard surface and dividing the area of the holding through low mud barriers/walls (approximately 10cm in height and 8-12 cm broad), into a series of interconnected rectangular subunits which serve as a shallow soil-based–basin (Tapovanim) for spreading saline waters to 3-4cm high column for rapid evaporation by action of sun and wind. A given basin is distinguished, on the basis of its role in the process of salt production, as : Collection-basin, Condenser –basin & Crystallizer- basin. The construction and maturation of a salt pan basins is completed in 20-25 days[1-2].

Salt Production Process

At high tide, water from estuary flows through sluice gates into the adjoining shallow soil-based–basin (Tapovanim), located at the mouth of estuary and due to the topographical layout of salt pan spreads across the entire floor area of the holding. Salt–workers regulate this flow of water by plugging and de-plugging the communicating access between the shallow basins such that the water stagnates, evaporates, condenses and then moves to Condenser – basin to yield brine and eventually crystallizes to crude salt or is moved into the Crystallizer-basin for crystallization. The scale of production of crude salt is governed by the timed cycles of tidal influx and efflux. During the process, the temperature ranges from 28 to 47 ^{0}C, the pH ranges from 6 to 8.3, the salinity varies from that of sea water to that of saturated brine. Chemically crude salt is a mixture of NaCl (80 -85%); $MgSO_4$, (2-3%), $MgCl_2$, (2-3%), $CaSO_4$ (0.8-1.5%). Crystals from supersaturated brine are collected with the help of wooden devices, heaped up and marketed as crude salt.[1-3]

Micro-flora in salt pans

The evaporation of tidal waters results in the enrichment of salts which in turn sets in gradients of salt, and favors the growth of salt-dependent micro-flora which can be grouped into: non- halophilic, euryhaline, halophilic (slight, moderate and extreme) bacteria, cyanobacterial and fungi, besides the haloarchaea. Planctonic cyanobacterial and haloarchaea grow on surface of stagnating water or benthic mats, consisting of various cynoforms which lie on the floor of the shallow basins and prevent the salt from mixing with sediment.

Cyanoflora

The dominant cyanotypes observed and cultured were Microcoleus sp, Apanothece clathrata, Apanothece littoralis. Anabaena, Spirulina, Phormidium, LPP types, Synechococcus and Synechocystis[3-5]Fungi

The culturable fungi belonged to Paecilomyces, Acremonium, Hemicola, Aspergillus, Taleromyces, Penicillium and Hortea [6]

Eubacteria

The retrieved eubacteria were characterized as belonging to Halomonas, Gluconobacter, Acinetobacter, Planococcus, Alcaligens and Micrococcus[7]

Haloarchaea

Based on salt requirement, cellular morphology and cellular lipids composition several bacterial forms were characterized as Haloarchaea, belonging to Halobacterium, Haloccocus, Haloarcula, Haloferax, Halorubrum, Halobaculum, Halogeometricum, Halorhabdus, Haloterrigena, Natrialba, Natronobacterium Natromonas, Natrinema, Natronococcus, Natronorubrum[8,20].

Several of these isolates grew in mineral salts medium with simple or complex carbon and nitrogen source / metal ions[8-10] of Cd^{+2}, Ni^{+2}, Fe^{+2}, Mn^{+2}, Zn^{+2}, Pb^{+2} & Cu (singly / in combination) / crude oil and constituent of hydrocarbons[11-13]. Effort to unveil the biotechnological capabilities of these isolates have proven without doubt that some of these cultures are a potential source of Bioemulsifiers (enhancing solubility of BETX compounds[12]) and can serve to scavenge heavy metal ions from saline[14] and industrial waste waters[15], Pigments[17] (carotenoids, bacterioruberins, bacteriorodhopsin), , PHAs[19] (Biodegradable plastics), Halocins[19] (small peptide antibiotics), Enzymes (amylases, proteases, chitinases),

CONCLUSION

Salt production in Goa – India, through salt pans beside producing crude salt; provides a natural reservoir of biotechnological important microbes. Therefore "promote traditional salt production, through salt pans in Goa –India and harness the benefits of microbial resource".

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