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Significance of Marine Salt Pans as Imminent Source of Bioactive Secondary Metabolites

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Abstract: **The marine environment is an interesting source for research and development. The potential of the domain in the discovery of new microorganisms capable of producing novel and useful bioactive secondary metabolites remains largely unexplored. Solar salt pans are hypersaline ecosystems and thus extreme environments. They consist of a series of inter-linked enclosures with a discontinuously increasing salinity gradient, due to the evaporation of seawater. Salinities here vary from 3.5 to 350 psu. Besides the obvious high salt content in the salt pans, the other stress conditions also include high temperature and heavy solar radiations. The salinity in these ecological niches supports halotolerant and halophilic microorganisms. Such an environment imposes a selective pressure on the residing organisms and thus the organism may be compelled to produce metabolites to make its surrounding conducive for its survival. Many new species of microbes have been identified and reported from the salt pans. However research applications are still in infancy, considering the wealth of the novel species existing in salt pans, as most of these studies are based on culture methods. In India, major saltpans are located along the coastal regions of Gujarat, Tamil Nadu, Maharashtra, Karnataka, Orissa, West Bengal and Goa. Bioprospecting of microbes from salt pans in India is comparatively still unexplored though few reports are available from Indian salterns. Some of the products reported from salt pans around the world include bacteriorhodopsin; compatible solutes; enzymes (hydrolases & isomerases); and biopolymers (biosurfactants, exopolysaccharides, liposomes, poly (γ-D-glutamic acid), lectins & bioplastics). However, as compared to other marine ecosystems, the least number of bioactive products have been isolated from marine salterns. Hence, salt pans are still unexplored potential environments having a wide scope for research in finding novel bioactive secondary metabolites.**

Keywords: Marine, salt pans, secondary metabolites.

I. INTRODUCTION

Marine organisms are of great value for two main reasons. Firstly, they constitute a major share of the earth's biological sources. Secondly, marine organisms often possess unique metabolic pathways, reproductive systems and sensory and defense mechanisms because they have adapted to extreme environmental conditions ranging from cold polar seas (-2°C) to hot hydrothermal fluids (300°C) at the sea floor("Hydrothermal Vents") and also to very high hydrostatic pressures (500-1000 atm). Another unique feature of these organisms, including microbes, is their ability to tolerate high salt concentrations (even up to 10-35% NaCl in salt pans). Numerous bioactive metabolites with antimicrobial, cytotoxic, antiviral, anti-inflammatory, anticoagulant and antiparasitic properties have been reported from marine invertebrates, seaweeds, fish, sea snakes, marine mammals, microbes and also from microbes associated with marine flora and fauna [1, 2]. Several researchers have described and reviewed the biomedical potential of marine natural products [3, 4]. Bioactive secondary metabolites reported from the marine environment are depicted in Fig. 1. Some bioactive metabolites have been harvested from marine solar salterns which is a habitat for hypersaline microbes. A unique feature of these microbes is their ability to tolerate high salt concentrations (even up to 10-35% NaCl in salt pans).

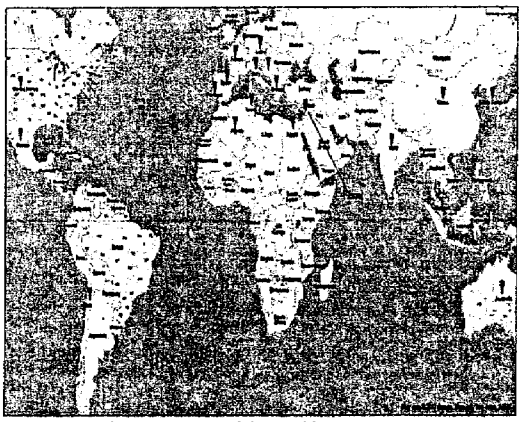

Figure 1: Explored salt pans of the world

Solar Salt Pans

Solar salt pans consist of a series of inter-linked enclosures with a discontinuously increasing salinity gradient, due

to the evaporation of seawater. These are man-made hypersaline environments, i.e. habitats with high salt contents, which are mostly found along the coastal regions and are known to commercially produce natural solar salt. Salinities here vary from 3.5 to 350 psu. Besides the obvious high salt content in the salt pans, the other stress conditions also include high temperature and heavy solar radiations.

Solar salt pans have been studied all over the world with respect to the diversity of the inhabiting microbes [5, 6]. The salinity in these ecological niches supports halotolerant and halophilic microorganisms. Inspite of harsh conditions wide spectra of microbes including heterotrophic and methanogenic Archaea; photosynthetic lithotrophs and heterotrophic bacteria, as also photosynthetic and heterotrophic eukaryotes are found to exist in these pans. The insight into the mechanisms involved in adaptation of salt pan microbes to extreme conditions such as varying degrees of salt concentrations, high temperatures, solar radiations have also contributed to major research findings. The halophilic and halotolerant microorganisms from salt pans exhibit diversity in terms of mechanisms used to withstand the large osmotic pressure exerted by their highly saline surrounding medium. These stressful conditions in such environments impose selective pressures on the residing flora & fauna and thus organisms may be compelled to produce metabolites to make its surrounding conducive for its survival [6, 7, 8]. The most widely studied salt pans from all over the world are presented in Fig.2.

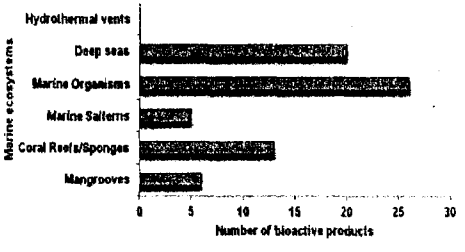

Figure 2: Bioactive compounds reported from the marine ecosystems

The research on salt pans published during 1970-2012 has been depicted in Fig.3. As seen from the figure there were maximum publications during 2001 to 2010. Many new species have been identified during 2001-2010 and the overall research on salt pans had got a major boost during this period. The research applications are still in infancy, considering the wealth of the novel species existing in salt pans, as most of these studies are based on culture methods. Currently the unavailability of novel molecules and increased rates of re-isolation of known molecules emphasizes a need to explore novel and more efficient molecules, utilizing the unexploited untapped salt pan resources.

A. Salt pans as habitats for microbes producing bioactive compounds:

Adaptation of microbes to these hyper saline environments is a result of the metabolic changes and thus the production of new bioactive compounds as metabolites is expected [9]. It is intriguing to investigate why microbes produce compounds with biological activities. Several reasons can be responsible for this. Microbes adapt to various environments by producing molecules which contribute in making their environment conducive to their survival.

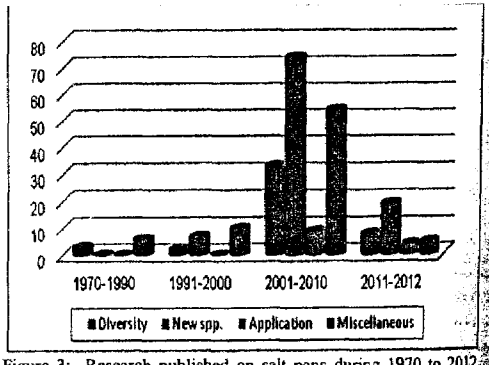

Figure 3: Research published on salt pans during 1970 to 2012 based on data from http://www.ncbi.nlm.nih.gov/pubmed/

Novel compounds may also be produced to help in competition in a given niche. In case of symbiotic microbes living with marine invertebrates, the microbes produce and secrete bioactive molecules which act as a chemical defense in protecting the host as well as themselves from predators and in turn the microbes get nutrition and a shelter from the host.

Marine microorganisms have already proven their capacity to yield novel molecules with bioactivity [10]. Many free-living and sediment inhabiting marine bacteria have been shown to produce secondary metabolites which exhibit antibacterial properties. The first antibiotic from a marine bacterium was identified and characterized by Burkholder et al. [11]. Being a marine environment, salt pans may contribute microbes having the potential to produce bioactive compounds [12]. Ventosa and Nieto [13] reviewed various biotechnological applications and potentialities of halophilic microbes. According to Oren [8], some applications of halophilic microorganisms are centuries old, and have existed since long before microbiological aspects of the processes were understood. Though most of the research on solar salt pans so far has focused on isolating and identifying novel microorganisms, application based research is already fast catching up.

B. Bioactive compounds and applications of hypersaline microbes:

Ventosa and Nieto [13] in 1995 have reviewed present or potential applications of halophiles such as the production of polymers (polyhydroxyalcanoates and polysaccharides), enzymes and compatible solutes as well as use of these microbes in enhanced oil recovery, cancer detection and biodegradation of toxic compounds. Halocins are bacteriocins produced by halophilic Archaea and a type of archaeocin. Antimicrobial and cytotoxic activities have also been demonstrated by bacteria from saltern in China [14]. Other products from salt pans include bacteriorhodopsin; compatible solutes; enzymes (lipases &isomerases); and biopolymers (biosurfactants

exopolysaccharides, liposomes, poly (γ-D-glutamic acid), lectins & bioplastics) have also been reported [7, 8]. Govender et al. [15] isolated and screened eighty seven bacterial isolates, from Sua pan evaporator ponds in Botswana, for xylanase, mannanase and cellulase activity. However, as compared to other marine ecosystems, least numbers of bioactive metabolites have been isolated from marine salterns (Fig.1). Hence salt pans are a valuable resource for research, inhabiting various microbes producing bioactive metabolites.

C. National scenario:

In India, major saltpans are located along the coastal regions of Gujarat, Tamil Nadu, Maharashtra, Karnataka, Orissa, West Bengal and Goa. Major findings have been reported from marine salterns near Bhavnagar, Gujarat [16]; the salt pans located in Vedaranyam, Thondi and Tuticorin, Tamil Nadu in the Palk Strait region of Bay of Bengal [17] and solar salterns in Kelambakkam, Marakanam and Vedaranyam, Tamil Nadu [18] and mainly have focused on the microbial diversity. Deshmukh [19] isolated ten species classified in six genera of keratinophilic fungi and related dermatophytes from the soil samples from twenty salt pans and their vicinity around Mumbai and Thane. Some novel species have also been reported from salt pans [20, 21]. Bioprospecting of microbes from salt pans in India is comparatively still unexplored. Few reports are available from Indian salterns [22]. Kamat and Kerkar [23] have highlighted the pharmaceutical potentials of bacteria from saltpans of Goa. Deepika and Kannabiran [24] have isolated Actinomycetes from marine soil samples collected at the Ennore saltpan and screened them for biosurfactant and heavy metal resistance activity. Few attempts have been made to explore microbes from salt pans as potential producers of antimicrobial agents [25].

II. CONCLUSION

Marine salt pans are important habitats to a wide variety of unexplored microbes with a potential to produce novel bioactive secondary metabolites.

III. ACKNOWLEDGEMENTS

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