Importance of Halophyte Community in Refining Saline Soil Quality and Maintaining Healthy Coastal Ecosystem

Aditya P. Rathore*
Central Salt & Marine Chemicals Research Institute, Gujarat
Email: prakash.aditya97@rediffmail.com

Coastal ecosystem isa meeting zone ofterrestrial and marine ecosystems.This transition region creates a unique environment which harbours a great biodiversity. Salt marshes, wetlands, bays and estuaries comprise some of the coastal areas. India has 7516.6 km of coastline area, while Gujarat alone has 1600 km which is the longest coast line and covers around 24% of India sea coast.

Coastal areas are saline in nature with higher pH (alkaline). It is observed that soil's chemical, physical and biological properties are severely affected by high salt concentration, which leads to destruction of vegetation and, finally, soil desertification.These areas are not suitable for growth and reproduction of normal living forms because of harsh saline condition, but it is said that god hasn't created anything in thisworld without any reason. If a place on this earth, is not suitable for someoneso, it doesn't mean that the place is not for others. These harsh conditions are optimum for creatures who not only tolerate but also require severe environmental conditions for their proper growth and survival. The organisms that can tolerate and grow in saline conditions are called halophiles (salt-loving organisms). These creatures have adapted themselves to salty environment through mechanisms like regulating the expression of stress responsive genes, and production of osmoprotective molecules, etc.

Coastal vegetation (halophytes) protects us from heavy storms and waves and playsan important role in increasing soil quality by reducing soil salinity and addition of important

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* Mr. Aditya P. Rathore, Ph.D. Scholar from Division of Marine Biotechnology & Ecology, CSIR- Central Salt & Marine Chemicals Research Institute, Gujarat, is pursuing his research on "Study of Nutrient Cycling, Phenology and Population Dynamics of Halophytes in Coastal Saline Ecosystem of Gujarat." His popular science story entitled "Importance of Halophyte Community in Refining Saline Soil Quality and Maintaining Healthy Coastal Ecosystem" has been selected for AWSAR Award.

nutrients.Plant influences soil characteristics, microbial community structure and enzyme activityby the release of root exudates, lysates, sloughed-off cells and exogenous enzymes into the rhizospheric soil. Root exudes of halophyte provide carbon and energy source to microbesand the concentration of these exudates change with different plant species, metabolism type,plant growth stage and season and, simultaneously, microbial community structure also changes. These microbial communities involves in decomposition of complex substrates by the use of hydrolysing enzymes and cycling of nutrients. This way, coastal vegetation significantly requires nutrient cycling and maintaining huge biodiversity, which differentiates barren soil (without vegetation) from vegetation covered soil.

So, the study of this special ecosystem will definitely enhance our knowledge about halophyte soil microbe interaction and how salty environment influences ecosystem function. Most of the previous studies were conducted on agricultural fields but scarce information is available about coastal ecosystem. To address this, we did a comparative study of soil characteristics, microbial community structureand enzyme activities of halophytes covered soil vs barren (control) soil during three seasons (rainy, winter and summer).

For this interesting research work we have selected Dharabandar site (20°49.04'N, 71°13.47'E) which is in Amreli District of Gujarat, India. This site is unique in term of vegetation types because many perennial and annual halophytesgrow luxuriantly and complete their life cycle. For this study, we have chosen four perennial halophytes (Aeluropuslagopoides, Arthrocnemumindicum, Heleochloasetulosa and Suaedanudiflora) because perennial plants are one of the most influential factors in coastal areas which affect ecosystem processes.

At Dharabandar site, we randomly selected 5 m × 5 m plots (3 replicates) for vegetation covered soil and control soil collection. The soil samples were collected in rainy, winter and summer seasons. After collection of soil samples, they were immediately transported to laboratory and sieved with 2 mm sieve. Soil samples were then stored at room temperature for chemical analysis and at -20°C for enzyme activities and PLFA analysis.

The air-dried soils were used for the analysis of electrical conductivity (EC), pH, organic carbon, soil mineral nitrogen (nitrate and ammonium), available phosphorus, soil potassium and sodium contents. The -20°C stored soils were used for PLFA analysis and enzyme activity estimation of three important enzymes like β-glucosidase, urease and alkaline phosphatase which involve in carbon, nitrogen and phosphorus cycling, respectively.

Soil salinity is measured in terms of electrical conductivity while pH tells us about the acidity or alkalinity of soil. Organic carbon works as a source of food for microbes because they utilize organic carbon and degrade complex compounds into simpler one and finally increase the concentration of soil nutrients such as nitrate, ammonium and phosphorus. So, the study of enzyme activities, works as a useful indicator of soil quality. Potassium is very useful ion which plays an important role in normal functioning of cells while halophytes accumulate sodium ion for osmotic adjustment so, the availability of these ions is essential in soil. PLFAs (Phospholipid fatty acids) are vital components of livingmicrobial cell membrane which are produced by microorganisms through different pathwaysand can be used as biomarkers to examinethe soil microbial community structure.

We observed that pH, EC, soil nutrients, enzyme activities and microbial community structure were significantly influenced by vegetation type and seasons.The activities of all three enzymes urease, β-glucosidase, and alkaline phosphatase and total PLFA content (microbial content) were significantly higher in halophyte's root zone soils than in control soil. The highest β-glucosidase activity was observed in *Suaeda* covered soil during rainy season, *Heleochloa* in winter season and *Arthrocnemum* during summer. The alkaline phosphatase activity was higher in rainy and summer seasons than in winter season. In all seasons, halophytes showed more or less similar alkaline phosphatase activities while control soil showed the lowest activity. In all seasons, similar urease activity was observed. The highest urease activity was in *Heleochloa* and *Suaeda*covered soils and the lowest in control soil.

In winter and summer seasons, significantly higher concentrationsof total, GM-ve, GM+ve, total bacterial, actinomycetes and fungal PLFAs were observed than during rainy season. *Arthrocnemum* and *Heleochloa* halophytes showed higher concentrations of total, GM-ve, GM+ve, total bacteria and actinomycetes PLFAs followed by *Suaeda* and *Aeluropus* while the lowest content in control soil.The amount of fungal biomarker PLFA was higher in *Arthrocnemum* and *Suaeda* followed by *Aeluropus*. Similar to enzyme activities different halophytes showed variation in higher concentration of PLFA biomarkers in different seasons. The NMS (nonmetric multidimensional scaling) study also suggested that the microbial community structure varied significantly in control and halophyte-covered soils as well as in all seasons.

Our study has proved that the ecophysiological approaches developed by halophytic plants altersoil's chemical and biological structures in positive manner than that of barren soil. The root zone processes like release of root exudates were strongly linked with halophyte species andseasons in saline soils. We found amazingdifferences in the soil chemical and microbial properties in different seasons and between vegetation covered soils vs control soil. Halophyte root zone soils were higher in enzymeactivities and microbial content compared with control soil because of the availability of carbon and energy sources and less salinity. Halophytes reduce soil salinity for maintaining their own osmotic balance and through this mechanism; they not only reduce salinity stress on microorganisms and enzyme activities but also play an important role in restoration of coastal ecosystem.

Our results also suggest that not a single halophyte species enough for healthy functioning of coastal ecosystem because different species of halophyte showed higher microbial content in different periods of time likewise enzyme activities also were higher in different halophyte covered soil at different seasons. So, it can be suggested that all halophytes at community level are very important for maintenance of coastal ecosystem.

Our serious concern is that this unique ecosystem is in danger because humansare continuously degrading it to fulfil their greed. So, it is our moral duty to protect this because these halophytes being a plant also absorb large amounts of CO_2 from the atmosphere and help us in reducing a potent greenhouse gas. However, coastal ecosystems are also sensitive to changes in the environment, and it already been studied that some coastal areas are now struggling to maintain their biodiversity due to anthropogenic effect.