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Editors note…..

Dear All,

This issue of guide.net is dedicated to 'Mangroves'. Kachchh coastal belt in particular and Gulf of Kachchh in general has the largest mangrove formation in the west coast of India. The yeoman ecological, economic and aesthetic services mangroves as a prominent ecosystem of Kachchh renders are enormous. Similar to other Kachchh ecosystems there are considerable gaps in our knowledge about Kachchh mangroves borne out of inadequate studies on this ecosystem. For that matter, in spite of its prominent presence, mangroves of Gujarat are least studied academically, calling for more attention and devotion of research time to this important ecosystem. Though every university in Gujarat has a strong Botany/Life Sciences department, scholars desirous to take up mangrove studies are highly disproportionate to the physical extent of this ecosystem and their number is dwindling day by day. Even those few who take up mangrove ecological studies are faced with huge fund and manpower shortages. States like Tamilnadu and Kerala whose mangrove extent is less than 5% of that of Gujarat has a strong manpower presence in mangrove science with well-trained scholars and scientists in mangrove ecology. This calls for a renewed interest on the part of scholars and scientists of life sciences in Gujarat who could evince interest and take up advanced scientific studies on mangrove ecosystem. It is high time we awoke to this need.

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Contents

1. Mangrove seeds as an alternate source of food in Gulf of Khambhat

Gulf of Khambhat with extensive mudflats and high currents is dominated by single mangrove species viz., *Avicenna marina*. Due to harsh climate and high salinity the mangroves in the region show stunted growth and reach maximum height of 2-3 m. These mangroves protect the shoreline from coastal erosion and during the drought years sustain the cattle population of the coastal villages as the leaves are favored source of fodder.

During the MFF funded project study, the scientist of Gujarat Ecology Society came across unique case of seeds of mangroves being used as alternate food by the coastal communities. During the month of '*Sharavan'*, artisanal fishermen collect the ripened seeds, which are then sold in the market. Demand for the seeds is high among the Patel community. The mangrove seeds are high in tannin content and to remove tannin, the seeds are first boiled in water for 20 minutes and the water discarded. The boiled seeds are then split opened, cooked in vegetable oil with the addition of spices. The dish is consumed with curd and serves as alternative to vegetable, which is scarce during this month.

This practice adds to the income of the fishermen, during their off season. But at the same time there is concern over the natural regeneration of the mangroves, as the collection of large quantity of mangrove seeds is done when the tide recedes and mud flats exposed. Women and children indulge in the collection of seeds. There is need to document similar practices followed elsewhere along the coastline of Gujarat and for other mangrove species as well. The finding would be important for conservation of the species in the longer run.

Stunted mangroves in front of fisherman hamlet of Zamdi village

Collected mangrove seeds

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2. The need for regular monitoring of mangroves

Mangroves are tropical plants which grow along the tropical coastlines of the world. They are found growing along shallow sheltered coasts. Mangroves are responsible for several economic as well as ecological services. Mangroves are found along the coasts of all the maritime states of the country in addition to the Andaman and Nicobar Islands. In terms of extent of mangrove cover, Gujarat stands next to West Bengal with a cover of 1103 sq. Km. in 2013. In Gujarat, they are distributed mainly along the Indus deltaic region, Gulf of Kachchh, Gulf of Cambay and along the estuaries of South Gujarat. Kachchh District has the largest area under mangrove cover while the Purna Estuary in South Gujarat has the highest diversity of mangroves in Gujarat. Gujarat is also the only state which has seen a consistent increase in the extent of mangrove since 2001. This has been largely due to the plantation efforts of the forest department and coastal industrial establishments in addition to natural regeneration.

Gujarat is one of the fastest developing states in the country and has seen the establishment of a large number of industries along the coast. With the establishment of the Delhi-Mumbai Industrial Corridor (DMIC) and the Dedicated Freight Corridor (DFC), the industrial development in central and south Gujarat has received a major boost. This has resulted in an increased demand for land for industrial development. The availability of land near the coast which has been classified as "*Kharabo*" has been one of the major sources of land. However, with increasing demand, land in the intertidal areas have also been used taken up for industrial development. The major industry that has come up in this area is the aquaculture industry. The ever increasing demand for land for aquaculture development and the decreasing availability of land in the intertidal areas has led to an increase in incidents of mangroves being destroyed for the development of aquaculture ponds. These areas are mostly located at the edges of existing ponds. The fact that mangrove cover in the state is increasing steadily masks the fact that several mangrove areas are being actually cleared for such developmental activities. A large number of such changes are not being recognized due to the remoteness and generally inaccessible locations of such sites and secondly due to a lack of regular monitoring of the mangrove cover at the local level. Figure 1 below shows the satellite images for a small part of Olpad Taluka in Surat district of Gujarat for the years 2011 and 2015. These images clearly indicate the clearing of mangroves near Bhagwa Village (indicated by the areas highlighted in yellow) for the development of aquaculture ponds. Incidentally according to the State of the Forest reports the mangrove cover of the district has witnessed a increasing trend during the period.

This conversion of mangrove and salt marsh vegetation for developmental activities is not an isolated incident and several such instances have been observed in the recent years in different parts of the state. While the State of Forest Reports (SFRs) at an interval of every two years reveals the broad trends of change in forest cover, large scale plantation activities and natural regeneration generally do not let such destruction activities to get noticed. This calls for a detailed taluka-level change detection monitoring of mangroves to ensure their conservation. Such studies not only highlight changes in areas but they also clearly specify where such changes (either an increase or decrease) occur. Such monitoring activities should be undertaken by agencies responsible for their conservation like the forest department or the coastal zone management authorities and can be even be entrusted to academic institutes and organizations that have the necessary expertise in the matter.

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3. Mangroves – the Sentinels of the coast

The oceans are the cauldrons of life. Life emerges from here. They support diverse and complex ecosystems ranging from the most fragile coral reefs to the oldest and most resilient wetland forest on the planet. The mangroves are the protectors of our coastlands. A product of millions of years of evolution adapted to the saline intertidal zones. Mangroves are the most productive and biodiverse wetland forest on earth found mainly in the tropical and subtropical regions of the world. These coastal ecosystems occupy 15.2 million hectares. These tropical coastal lines support the world's richest ecological diversity, primary productivity, supporting the livelihoods of millions of people across the world. Growing where ocean meets land, mangrove creates a natural barrier against coastal erosion, storms and wave surges.

According to experts every year mangrove forest contribute more than 18 million metric tons to the long-term storage of carbon globally. Mangroves and coral reefs share symbiotic relationship. The tangled network of mangrove roots trap muddy sediment preventing them from reaching the coral reefs and smothering them. The corals in turn act as a barrier and protect the mangroves from the strong wave surges. Coral reefs and mangroves are each home to hundreds of species of fish. The mangroves also provide a refuge and habitat of some commercially important reef fish during the earlier stages of their life cycle. Many mangrove species let their seeds germinate while still attached to the tree, this increases their chances of survival when ready they drop off and stick in the mud

or float around till they find a suitable anchor. These adaptations help the mangroves to propagate rapidly and expand the forest. Detritus and other protein rich food from the mangroves sustain millions of crabs, prawns and young fish. The tangled network of roots is a natural nursery for many species, a secure home for thousands of life forms.

Almost 20% of India's population lives within 50 Kms of these coastlines and depend on the ocean for their livelihood. Mangroves cover almost 4639 Sq.km. of India's coastline. 39 species of mangroves and 89 associated species can be found here. On the eastern coast of India and the western coast of Bangladesh lies the Sunderbans, which is the largest mangrove ecosystem in the world. The Sunderbans are the UNESCO recognized world heritage site and a biosphere reserve. The Sunderban delta is a home to 58 species of mammals, including the tiger. All are adapted to the saline and harsh conditions of the mangrove forest. The shallow intertidal flood pulse zone of the mangroves is a crucial support system for needed life forms. Here prawns and fish nurture themselves on detritus larvae and other highly nutritious food items derived from the mangroves, within a few weeks by feeding the rich diet their size can increase almost seven times.

The Bay of Bengal acts like a basin allowing nutrients to build up. River discharge water and huge mass of organic nutrients added from the mangroves creates one of the largest brackish water zones enabling these species to survive yielding around 2 million tons of fish every year. If the mangroves disappear much of this productivity would disappear too. The mangroves of Sunderbans support nearly 2.3 million local communities that have lived here.

The mangrove forests of the Sunderbans also provide natural resources including food, firewood, timber, alluvial rich fertile land for farming and honey gathering. Numerous medicines are also derived from mangroves, useful for skin and stomach disorders, ulcers and even some cancers. But the coastal communities are worried since the fish catches are falling and many species are disappearing. Coastal and marine resources are dwindling at an alarming rate. In spite of the ecological importance, mangroves are under great pressure.

In many parts of the world mangroves are still being destroyed or degraded mostly due to deforestation, degradation, fresh water diversion and conversion to other land use like intensive shrimp farming and agriculture. Huge areas of mangrove forest have been cleared to make way for residential areas, coastal industries and roads. As forest disappears communities have to penetrate deeper into the forest to get the firewood. Agricultural runoff, organic and inorganic pollution caused by chemicals and heavy siltation has killed many species of flora and fauna. Some species of fish have disappeared and others are very rare.

During the past 50 years, over 40% of mangrove cover has been lost worldwide and the losses continue year by year. In India too mangroves were severely threatened. Fortunately over the last few years of tsunami, awareness and importance of mangrove ecosystems has been growing leading to legislative changes towards protection and better management of these valuable and vital resources.

The progress and success in India in terms of collective interest to restore and conserve the mangrove is very good in specific locations in many states of India. We have to scale up those successes and disseminate more effectively to the countries in areas that are still losing mangroves. In our ignorance we may have destroyed the most powerful and abundant natural resources threatening not only our food security but even jeopardizing the lives of over three billion people on the planet. Fortunately, we are the only species on earth that can reverse the damage. The urgent need is for a collective effort on mangrove restoration and protection in order to return the ecosystem the health and restore the balance between man and nature.

The collaborative effort by the government, civil society organizations, communities and global agencies like the IUCN initiative will help mangroves to recover and regain their equilibrium ensuring a sustainable and secure future not only for billions of people but also for the silent guardians and protectors of our coastlines – the mangroves.

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4. Mangrove crabs as eco-drivers for restoration of mangrove ecosystem: a prelude for gulf of Kachchh, Gujarat

Curtain Raiser

To trigger the talk, let us plunge into knowing about mangroves in a short overview. Mangroves are intertidal, tropical and sub-tropical woody plants, which are halophytic trees (salt tolerant), and are very well-adapted to survive the harsh coastal conditions; containing a very complex salt filtration system and complex root system that helps the plant to cope with immersion in salt water, and also the wave action. They are adapted to extremely low oxygen (anoxic) conditions of water-logged and muddy coastal regions. **Finlayson and Moser (1991)** stated that the total mangrove areas in the world are about approximately 14 million hectares. Of which, the old-world tropical mangroves such as the tropical Australia and the Indo-West Pacific tropical zones have the highest mangrove extent. These zones are of very importance in respect with the species diversity and species richness of the mangroves, mangrove abundance, and successions. **Naskar (1985)** has reported that more than 50% of the total mangrove land in Sundarbans in last two centuries has been reclaimed as agricultural fields, brackish water fisheries, and rural habitations. **Chanda (1977)** also reported that more than 50% of Sundarbans mangrove areas have been reduced in the last two decades.

Mangroves Characteristics

Mangrove plants usually grow in areas like intertidal flat deltaic lands; funnel shaped bays, broad estuarine mouths, and frequently tidal inundated coastlines **(Thom, 1982)**. These plants are well adapted to newly silted clay loam and salt marshes. Ideal atmospheric temperature for thriving and regeneration of these plants is between 20 ^{0}C and 35 ^{0}C. Mangroves boost up in humid atmosphere (60%-90%) with moderate to high annual rainfall, between 1000 mm and 3000 mm **(Tomlison, 1986)**. The mangrove plants customarily are impregnated by nutrients from the tidal seawater; river courses and the mangrove ecosystems provide natural food to the mangrove dwelling fauna **(Odum and Heald, 1972)**. The impenetrable mangrove forests accelerate the siltation process; checks the soil erosion, and protect the coastal areas or deltaic lands from frequent tidal thrust, cyclonic storm and annihilating surges from the bay **(Naskar, 1988)**.

Holistic Scenario

Gujarat is the western-most state of India, having total coastline of about 1640 km, facing the Arabian sea westwards; situated within the longitude 68 ^{0}E and 73 ^{0}E, and latitude 20 ^{0}10' N and 23 ^{0}10' N. The authors have undertaken the study in the Nakti Creek, Gandhidham, southern end of northern Gulf of Kutch (GoK), Gujarat **(Fig. 1)**. **Kulkarni (1957)** reported about 2,483 ha and 12,800 ha mangrove zones in the northern and southern coastal zones, respectively in the Gulf of Kutch. In this area, the mangroves are scrubby, stunted (about 2 m height), and form discontinuous narrow patches. The mangroves in this region survive strenuous condition *i.e.* high salinity, extreme temperature variations, and scanty rainfall. Browsing by cattle and camels, and use of mangroves as firewood are also the major causes for the rapid degradation of mangrove patches. These facts conclusively have led to the naked and barren lands leaving behind few pneumatophores, though wide spread near Mundra jetty, Kandla port and sparse mangroves are observed at Okha, Poshitra, Pindhara Dhani, Narara, Sikka, Jindra, Pirotan Island, and Jakhau port.

Significance of Crab Behavior

Till date, many studies have been taken up to understand the productivity of mangrove ecosystem including floral and faunal studies in past. In the nascent phase of the investigation, the authors have noticed the myriad numbers of crabs and crab burrows in the study area. On further exploration, it was noticed that most of the crabs were characteristically exclusive to mangrove ecosystem. Mangrove crabs belong to many different species, genera, and families based on the type of

mangrove forest. They are ecologically significant in many ways. They store the utmost energy within the forest by burying and consuming the leaf litter. Along with burrowing in the ground, these crustaceans are arboreal and their feces may form the basis of a coprophagous food chain, contributing to secondary production of mangroves. The larvae of mangrove crabs form dominant food source for the juvenile fishes that inhabit the adjoining waterways. The adult crabs serve as food resource for threatened bird species such as the Crab Plover. Their burrows tend to alter the topography along with the sediment grain size of the mangrove. They also help to aerate the sediment improving the gaseous exchange. Removing these crabs from an area will cause a drastic increase in sulfides and ammonium concentrations in the sediment, which will in turn affect the productivity and reproductive output of the vegetation. The present findings support the hypothesis of the authors that the mangrove crabs are keystone species for survival and rejuvenation of mangrove ecosystem.

Fig. 1. Map showing Study Area

Crab-Soil-Mangrove Interactions

The study area (Nakti Creek, Gandhidham, GoK, Gujarat) was chosen based on the number of vegetative species of mangroves present therein. It was found to be an impeccable site for the study as it had monospecific patch of mangrove species *Avicennia marina*. Besides, *Perisesarma bidens* was found to be the dominant species among mangrove crab species. This made it easy to understand the pattern and link between the mangrove plants, mangrove crabs and their effects on the sediment too. The study was carried out on bi-monthly basis for two years (2013-2015), and the sediment was tested in the environmental lab for studying nutrient profiling. This clearly showed that the sediment of dense mangrove patch (DM) **(Fig. 2)** was more nutrient rich than that of sparse mangrove patch (SM) **(Fig. 3)** and non-mangrove patch (NM). Dense mangrove patches were also found to harbor more number of mangrove crabs compared to sparse mangrove patch; this in turn is happened owing to the more amount of litter fall on the forest floor of DM compared to SM. The litter fall form an elementary food source for the mangrove crabs. The mangrove crabs feed extravagantly on the fallen leaves for an effective decomposition. Mangrove crabs primarily pull these fallen leaves in their burrows, where they nibble on them, and use it as feed source. The feces that are loaded with the nutrients, later on gets mixed up, enriching the sediment nutrient profile; thus establishing a phenomenal link between the mangrove plants, mangrove crabs and mangrove sediment.

Fig. 2. Dense Mangrove Cover (DM)

Fig. 3. Sparse Mangrove Patch (SM)

Habitat-Species Nexus

In the initial phase of the study (2013), sparse mangrove patches were noticed around the denser patches along the creek and the relocate to sparse patches in need of more food during their reproductive

phases for attaining early maturity and reproduction. Moreover, to avoid the competition for food with other faunal species such as fiddler crabs and mudskippers, they might be forced to conquer their territoriality for a successful range extension into sparse mangrove patches. During later period of 2015, it was noticed that these sparse mangrove areas, which once had the stunted growth of mangroves, now are thriving in a better way by harboring dense growth of mangroves in terms of their heights, profuse growth, and sustainable canopy than earlier. This may be due to more traversing of these areas by mangrove crabs in search of food, burrow formations, feeding, range extension, expansion of home territoriality, and enrichment of soil nutrients in particular. Such phenomena might influence nutrients flux and trophic budget of mangrove sediment, which in turn might enhance the growth of mangrove vegetation. The findings of the present study clearly revealed that we could introduce mangrove crabs into degraded mangrove habitats, which could save, survive, and sustain them as healthier mangroves, and could be an innovative practice of reintroduction of the mangrove crab species into eroded coastal habitats for the restoration of mangrove forests.

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5. Actinomycetes – Role of a Mangrove associated entrant in pharmaceutical industry

Background

Mangroves are a group of trees and shrubs located in tropical and subtropical intertidal coastal regions. The mangrove ecosystem is becoming a hotspot for natural product discovery and bioactivity survey. Mangrove associated actinomycetes are known to produce many bioactive components against marine microbial communities. This valuable microbial community produces various types of fascinating and structurally complex natural products with biological activity. Numerous researches have indicated that the secondary metabolites of mangrove associated actinomycetes have potential as new antibiotics, anti-tumor agents, immunosuppressive agents and enzyme inhibitors. Till now, about 23,000 bioactive compounds produced by microorganisms have been reported and more than 10,000 among these compounds were isolated from actinomycetes. It is worth mentioning that of 10,000 compounds, about 80% have been obtained from *Streptomyces* which is the most productive genus in the microbial world. Recently, bioactivity studies of secondary metabolites from mangrove actinomycetes have gained more attention. Very meager work on bioactive compounds from actinomycetes has been done on mangroves of Kachchh, Gujarat. Hence, an attempt has been in this paper to consolidate and summarize the latest studies on mangrove actinomycetes for exploring their immense potential in producing novel bioactive compounds.

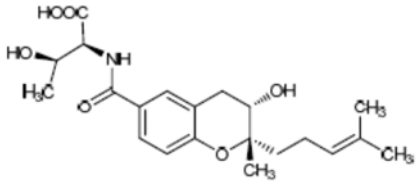
Mangrove actinomycetes

Actinomycetes play a vital role in natural ecological system and also a potent candidate for pharmaceutical industries in the production of antibiotics, anti-tumor agents, enzymes, enzyme inhibitors and immuno-modifiers. Actinomycetes resides under extreme environments have received little attention from the researchers. The mangrove environment is an important source for the isolation of antibiotic-producing actinomycetes. An antibiotic compound, beta-unsaturated gama-lactone isolated from *Streptomyces grisebrunneus* showed broad spectrum of antimicrobial activity. *Streptomycetes* produce cellulase that degrades cellulolytic waste materials. The actinomycetes *viz*., *S. alboniger, S. vastus, S. violaceus, S. moderatus and S. aureofasciculus* inhabiting in the sediments of mangrove environment at Vellar estuary are effective in producing bioactive compounds exhibiting antibiotic properties. *S. albidoflavus* isolated from the Pichavaram mangrove environment exhibited anti-tumor activity.

Bioactive compounds

Diverse mangrove actinomycetes as promising and productive sources are worth being explored and uncovered. About, 73 novel compounds and 49 known compounds were isolated from mangrove actinomycetes including alkaloids, benzene derivatives, cyclopentenone derivatives, dilactones, macrolides, 2-pyranones and sesquiterpenes. Many exciting compounds have been proven as potential new antibiotics, antitumor and antiviral agents, anti-fibrotic agents and antioxidants. Furthermore, some of their biosynthetic pathways have also been revealed. A novel nitrogenous cyclic dipeptide isolated from the broth of *Streptomyces* sp. 124092 showed moderate cytotoxicity against SMMC-7721 from rhizosphere soil of the mangrove plant *Heritiera littoralis*. An Indole Alkaloids, Xiamycin and its methyl ester were obtained from *Streptomyces* sp. GT2002/1503, an endophyte from the mangrove plant *Bruguiera gymnorrhiza*. Xiamycin showed selective anti-HIV activity which specifically blocked R5 tropic HIV-1 infection and its methyl ester was more active in antimicrobial, cytotoxic and antiviral biological assays. Three novel indolosesquiterpenes, xiamycin B, indosespene, sespenine compounds have been proved to have strong antimicrobial activity. These compounds were isolated from the culture broth of Streptomyces sp. HKI0595, an endophyte of mangrove tree *Kandelia candel* in China. Streptocarbazoles A and B showed significant cytotoxicity from *Streptomyces* sp. FMA.

Naphthyridine was isolated from *Streptomyces albogriseolus* MGR072 originating from mangrove sediments collected in the national mangrove reserve in Fujian Province of China. The best-studied secondary metabolite from mangrove actinomycetes is Salinosporamide A (12) with γ-lactam-β-lactone bicyclic core. *Salinispora tropica* CNB-392 collected from a mangrove environment produced seven other related γ-lactams. These compounds showed varying degrees of anticancer activities. In addition, they indicated that the chloroethyl moiety played a major role in the enhanced activity of salinosporamide A in the NCI's 60-cell-line panel. A new cyclizidine analog named JBIR-102 was obtained from *Saccharopolyspora* sp. RL78 in mangrove soil collected in Japan. A novel protonated aromatic tautomer of 5'-methylthioinosine without obvious antibacterial activity from a novel actinomycete strain *Micromonospora* sp. K310 isolated from Ghanaian mangrove river sediment in Butre, Ghana. An anti-fibrotic benzopyran compound (Fig. 1) was produced by *Streptomyces xiamenensis* 318 isolated from mangrove sediment of China, showed multiple inhibitory biological effects on lung excessive fibrotic characteristics by cell adhesion. 2-Allyloxyphenol, as an important synthetic drug and chemical intermediate was obtained firstly from a new species *Streptomyces* sp. MS1/7 isolated from sediments of the Sundarbans mangrove forest, India and later the strain named *Streptomyces sundarbansensis* inhibits 21 bacteria and three fungi and possessed strong antioxidant activity. A novel nitrogenous compound named as p-tolyl-3-aminopropanoate was produced by *Streptomyces* sp. 124092, was proved to be moderately cytotoxic against SMMC-7721.



A

Fig-1. Structure of novel benzopyran derivative (source: http://www.mdpi.com/1660-3397/12/5/2590)

A series of nine-membered dilactone antimycins isolated from mangrove actinomycetes were also reported. Antimycin A18 with a higher activity against plant pathogenic fungi than blasticidin S (a commercialized fungicide) was isolated from an endophytic *Streptomyces albidoflavus* I07A-01824 isolated from the leaf of *B. gymnorrhiza*. A novel dilactone was obtained from an actinomycete strain (N2010-37) in the bottom mud of the Zhanjiang mangrove which proved to be cytotoxic against human chronic granulocytic leukemia cell line K562. Divergolides A-D with complex and diverse structures was isolated from an endophyte *Streptomyces* sp. HKI0576 of the mangrove tree *Bruguiera gymnorrhiza* in China. Divergolide A showed the strongest activity against *Mycobacterium vaccae*, whereas divergolide D was more active against *Bacillus subtilis* and *Staphylococcus aureus* and displayed prominent activity

to lung cancer (LXFA 629L), pancreatic cancer (PANC-1), renal cancer (RXF 486L), and sarcoma (Saos-2). A new macrocyclic dilactone named as JBIR-101 with potential anti-MPM (malignant pleural mesothelioma) activity was obtained from *Promicromonospora* sp. RL26 from mangrove soil. A new conjugate pentaene macrolide named fungichromin B was isolated from *Streptomyces albogriseolus* HA10002 collected from mangrove sediment in China, showing nematicidal activity against 2-stage juveniles of *M. incognita* and *M. javanica* and a wide antifungal spectrum. The first reported compound from mangrove actinomycetes was the novel chalcomycin B isolated from the culture broth of a marine *Streptomyces* sp. B7064 isolated from mangrove sediment of Hawaii which showed antimicrobial activity. Two new macrocyclic lactones were isolated from *Streptomyces* sp. 211726 which was isolated from mangrove rhizosphere soil of *Heritiera globosa* collected in Wenchang, China. Recently, another seven new azalomycin F analogs were identified from this strain which showed broad-spectrum antimicrobial activity and moderate cytotoxicity.

Conclusion

Mangrove actinomycetes have received significant attention for its bioactive products. Among mangrove actinomycetes, the genus *Streptomyces* is the richest source of chief natural products with Indol alkaloids including indolosesquiterpenes and indolocarbazoles, macrolides and benzene derivatives. This is followed by the genus *Micromonospora* which produces major secondary metabolites like alkaloids and sesquiterpenes. Apparently, the study on mangrove actinomycetes and their secondary metabolites is just beginning and mangrove actinomycetes need an urgent exploitation as an important source of natural products. The use of novel strategies such as screening model building, sequence-based screening, genome mining or selective isolation from new species may improve the efficiency of discovering original natural products from mangrove actinomycetes.

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GUIDE

6. STATUS OF LICHENS IN INDIAN MANGROVES

Lichens are the organisms formed from obligate mutualism between a fungus (mycobiont) and alga (phycobiont). Generally, the second species is an alga, but in few cases such as cyanolichens, it may be a blue-green alga commonly known as cyanobacterium. In some of the cases, more than one fungus can be found in the lichenized association and this fungus provides a proper shape to the lichens. The fungal filaments found into the algal cells provide a proper shape to the whole thallus. Though the combination is of two different individuals the whole body is considered as a single organism. Lichens are also called as lichenized fungi, though the fungus is lichenized by an alga.

Lichenized fungi are unique group of organisms with an ability to grow on any stable substratum and geographical region. Lichens are extremely sensitive to micro-climatic conditions and well-known indicators of air pollution; hence they are also used in bio-monitoring studies (Nayaka, 2012). Lichens can grow on stable and reasonably well-lit surfaces like soil, rock, or even the barks of trees. Lichen may take up some nutrients where it grows, but it is mostly independent in nourishing itself *via* photosynthesis in the algal cells (photobiont).

Lichens are generally found in areas with persistent moisture and other nutrients. In the absence of moisture, lichen tissues get dried up and become very brittle. Lichens quickly absorb water when the moisture is once again available and become soft and fleshy. During the dryness, the pieces of lichens may flake-off and results in the form of new lichen (Isaac, 1996).

Roccella montagnei Bel. was the first lichen recorded in India on *Mangifera indica* L. during 1838. Later the species was reported in abundance on mangroves and trees of coastal region, especially *Cocos nucifera* L., *R. montagnei* is also called as mangrove lichen or litmus dye lichen. During these recent years, lichens present in mangroves have received special attention and researchers started exploring lichens from mangroves especially from Sundarbans, Pichavaram, Muthupet, etc.

Sundarbans is the India's largest mangrove ecosystem and also biosphere reserve with vast floral and faunal diversity. A total of 167 species of lichens were reported from Sundarbans biosphere reserve, out of those, 142 species were reported growing on mangrove species. *Excoecaria agallocha* L. bears 89 species of lichens followed by *Xylocarpus* sp. with 63, *Ceriops* sp. with 56, *Avicennia* sp. with 54 and *Rhizophora* sp. with 43 species (Jagadeesh Ram et al., 2012).

Pichavaram mangroves, located in the southeast coast of India, is a reserve forest with 12 lichen species belonging to 9 genera and 6 families. Among the 12 species, crustose lichens are the dominant ones with 7 species, followed by 4 foliose and one fruticose species. Pichavaram is dominated by members of Caliciaceae family with 6 species and 4 genera followed by Graphidaceae with 2 species, Roccellaceae with one species and rest of the species are present in the considerable numbers. *Roccella montagnei* Bel. Found to be more dominant in Pichavaram mangroves (Logesh, 2012). Muthupet lagoon mangroves located at Point Calimere was also fairly explored with 13 species belonging to 10 genera and 9 families. In these mangroves, Rocellaceae was the dominant family (Logesh, 2013).

Lichen studies in Gujarat coast revealed the occurrence of 39 species, of which 26 belong Roccellaceae. Only 11 species of lichens were recorded from mangroves and mangrove associated trees and rest were found on *Prosopis juliflora* (Sw.) DC., a most dominated tree species in Gujarat coast (Nayaka et al., 2013). Lichens growing on mangroves of Andaman and Nicobar Islands were studied extensively (Sethy et al., 2012), reported 29 species along with 5 new records for India.

While comparing with all mangroves, Sundarbans Biosphere Reserve is dominated with 100 species of lichens growing on mangrove trees followed by Andaman Islands with 29 species. Mangroves have affluent diversity of distinctive lichen flora especially crustose groups of Roccellaceae. Also *Roccella montagnei* Bel. is found exclusively on the mangrove species and not anywhere in the terrestrial ecosystem. Similar to Bhitarkanika mangroves, Gulf of Mannar and Gulf of Kachchh mangroves should be given with more importance for the exploration of lichens in the future.

Roccella montagnei Bel. on *Rhizophora* tree in Pichavaram Mangrove Forest.

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7. Rampant urbanization- an amassed warning to Cochin Mangroves

The tropical and subtropical coastlines are sheltered by the characteristic littoral plant formations called the mangroves. They are well adapted to grow in harsh environmental conditions such as high salinity, high temperature, extreme tides, high sedimentation and muddy anaerobic soils. Mangroves are the most productive and biologically important ecosystem of the world providing a wide range of goods and services to the coastal population. They play a major role in stabilizing shorelinesand reducing the devastating impacts of natural disasters such as tsunamis and hurricanes. They provide an excellent breeding and nursing grounds for marine and pelagic species. The local community also receives the benefits in the form of food, medicine, fuel and building materials. But during the recent years the increasing population pressure, industrial and urban development has significantly destroyed this pristine ecosystem. Worldwide, more than 60-80% of the mangrove forest cover has been removed over the last few decades due to increasing human interference. Indian mangroves were spread over 6740 km^2 (Krishnamurthy et al., 1987) which was about 7% of the Indian coastline. Later, due to wanton human destructions the mangrove cover has

declined to 4628km^{2}constituting about 3% of the global mangrove vegetation and 8% of Asian mangrove cover(India State of Forest report, 2013). Kerala also supported a dense and healthy mangrove patch along its coast. But the ecological importance of these ecosystems was never realized and was destroyed on large scale. The mangrove cover decline from 700km^2 to about 6km^2 was clearly depicted in the reports of India State of Forest survey (2013).The mangroves of Cochin, Kerala are no exception in facing such a threat. Eventhough the Cochin mangroves are typically good breeding, feeding and nursery grounds for many estuarine and marine organisms, they were considered as a waste, sterile and unhealthy marsh for a long time.

Acid burned mangrove patch near LNG site, Puthuvypu, Cochin.

At present, Puthuvypu in Ernakulam district is one among the fast depleting wetlands of Kerala. Over the last five years, the Puthuvypu mangrove cover has been reduced from 314 acres to 185 acres in the area between the Liquefied Nitrogen Gas (LNG) regasification terminal and Goshree junction. Development of Goshree main road and other link roads resulted in the loss of nearly 23 acres of mangroves while another 11 acres were reclaimed for setting up the office of Center for Marine Living Resources and Ecology, Govt. of India. Besides, from the clear-cutting these ecologically fragile areas are also affected by the waste and other byproducts dumped from the construction sites. On an average of 200 tanker lorries were used to transport slurry from different construction sites to the area outside the LNG terminal. Experts have warned that Puthuvypu mangrove population will further come down drastically, with the setting up of the proposed Kochi Oceanarium project estimated at Rs.480 crore. Kerala Cricket Association (KCA) Stadium proposed to be built in Cochin as the home ground for the Kerala Cricket Association. The proposed site at Pampayimoola near Edakochi had a natural bio-shield of mangroves with adjacent paddy fields. KCA had cleared 4.10 acres of mangrove wetlands and paddy fields for construction of the stadium without obtaining necessary permission, thus violating Kerala Conservation of Paddy land and Wetland Act, 2008. Besides these, the Valanthakadu mangrove also faces a similar threat due to the proposed plans for expanding work by Sobha developers. There was a recent loss of a thick mangrove cover following a fire that remains an example of the indiscriminate destruction of a natural line of protection for the coast even though the reason for the incident remains unknown. In Panangad, nearly 70 acres of the mangroves were reclaimed for setting up the Kerala University of Fisheries and Ocean Sciences and for settlements on the northern side of the campus.

According to the Coastal Regulation Zone Notification-1991, as per para 6(1) under Annexure-1 sub-heading Costal Zone Regulation-I, mangroves are declared as Costal Zone Regulation-I (CRZ-I). CRZ-I is the most ecologically sensitive and important area, which requires protection of the highest order to strictly protect all the sensitive coastal and marine living ecosystems.In spite of knowing this significant facts mangroves are destroyed on large scale by the

Road construction on Puthuvypu Island

man-made activities of different forms causing serious damage to these ecosystem and is silently becoming one of the reasons for global warming and climate change.It is clearly alarming that the mangroves that are shielding the coastline from tsunami waves might become rare due to the population growth, fast rate of urbanization and unsustainable economic development. Reclamation of the green cover for

various infrastructure projects has taken a toll on the ecological balance of this ecosystem and if this massive reclamation continues in Cochin, then the area will soon be bereft of its ecological green shield – mangroves.

To effectively counter the mangrove loss their restoration should be given the prime importance. Even though various steps have been initiated by few organizations to recover these already damaged and destroyed ecosystems, relatively few were only successful in long term rehabilitation. The long term restoration usually fails as the scientific aspects of these ecosystems are not being met. The scientific restoration method includes proper understanding on the ecology, reproduction and distribution patterns, of the mangrove species at the disturbed sites. The success of these efforts could be possible only by participation of scientific communities and public sector. Social awareness would bring in public participations for better conservation and management of these ecosystems.

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8. Mangrove ecosystem – an incredible Blue carbon Source

The ecosystems and its ecological services are always a topic of discussion in the scientific world. Among this blue carbon is a new terminology which is used to indicate the carbon storage as biomass or in sediments of oceans and coastal systems. Mangroves which cover around 15.2 million hectares around the world with its unique adaptations provide a pristine environment to store carbon for a long period. Even though mangroves are small scattered patchy environments compared to large rain forests in the world, this ecosystem can store 50 times more carbon in a square kilometer than tropical rainforests. Scientific studies reported that mangroves are able to sequester approximately 1.5 tonnes of carbon per hectare per year which is approximately equivalent to the amount of carbon a motor vehicle releases to the atmosphere each year [1].The famous mangrove scientist Mark Spalding said "mangrove **forests are among the most carbon-rich habitats on the planet**. That, although they occupy just a fraction of the world's surface, they pack a punch". These ecosystem store carbon through different mechanisms as biomass of flora and fauna and sediment burial which is a major mechanism that increase its sequestration capacity compared to rain forests. It was found that the total carbon storage in mangroves could reach an average of 1023 Mg/ha [2]. The global strategies for addressing climate change are now looking keen to this ecosystem. However, little is known concerning the carbon stocks of this ecosystem, particularly below-ground.

The mangrove plant above ground including litterfall and below ground biomass contributes a high productivity that makes it the third most productive ecosystem compared to tropical rain forests and coral reefs. The major portions of carbon in mangroves was stored below ground due to its complex root system but are highly susceptible to disturbances which lead to the release of greenhouse gases. This complex root system traps organic and inorganic particles from the adjacent aquatic ecosystems and the litter from the mangrove ecosystem. Estimates indicate that belowground biomass contributes a significant part (10–55%) of the total mangrove biomass and the global average of net primary productivity through mangrove plant biomass was 149 mol C/ m^2 /year[3].

The role of fauna especially crabs which act as the key stone species is significant in carbon sequestration through its burrowing activity and herbivory. Some crabs consume living leaves and propagules, whereas others (eg. *Ucides cordatus*, *Perisesarma messa*) remove and shred leaf litter. By consuming leaf litter, mangrove crabs substantially reduce export of nutrients to adjacent aquatic ecosystems and shorten decomposition time, and also enhance nutrient cycling. Moreover, the bioturbation activity enhances retaining of organic matter within the mangrove ecosystem. Laboratory experiments concluded that the absence of this macrofauna lead to the collapse of the system by affecting the forest structure and productivity[4]and similar trend could also be observed in Cochin mangroves, south west coast of

India. Less carbon content was observed in the sediments of mangrove areas devoid of burrowing activity of crabs[5].

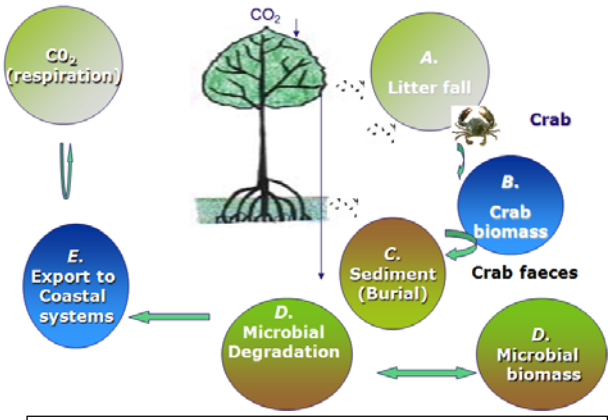

Fig.1 Different pathways in carbon cycle in mangrove ecosystem

Thus mangrove ecosystems are considered as model zones which store and release carbon (standing crop, organic matter, energy content) from the sediment to the water phase; to the different organisms, and vice-versa and thus play a major role in the utilization as well as maintaining the stability of the trophic tier. So, any modification in the ecosystem could change the carbon assimilation, release or transfer in different compartments of the trophic pathway leading to major hydro-biological alterations possibly, even serious climatic changes. The proper management of these ecosystems that act as carbon sinks are among the cheapest and prudent solution to reduce greenhouse gas emissions and promote adaptation to climate change. But the question is always debatable whether mangroves act as sink or source? When these mangroves are destroyed, the carbon stored in the ecosystem as biomass will be lost and when the below ground biomass is disturbed, it leads to greenhouse gas emission. There is an alarming rate of deforestation of mangroves globally which increases loss of natural CO_2 sink capacity. Various studies reported that conversion of mangrove forest to aquaculture farm is another global issue that also increases the emission of greenhouse gases. Thus disturbing and destruction of mangrove ecosystem leads to conversion of the sink of carbon to source of greenhouse gases and causes climate change. It is estimated that a loss of about 35% of the world mangroves has resulted in a net loss of 3.8 x 10^{14} g of carbon stored as mangrove biomass[6]. In India, the pristine mangrove habitats are continuously destroyed due to anthropogenic pressure and studies reported a decrease in mangrove cover during the last few decades with the exception of Gujarat state[7]. The south west coast of India faces a random deterioration of mangrove plants and the current status of Cochin mangroves represent only 14 species of mangroves and among them valuable mangrove species like *Avicennia marina* that enhances more crab activities and in turn enhances more carbon storage, is representing only a few trees in the entire region [5]. The other states in the west coast except Gujarat are facing reduction in species diversity. This will definitely create a startling situation in the west coast due to the release of this prized blue carbon as greenhouse gases. So, proper management practices, strategies and legislation is needed for conservation and restoration of these destroyed habitats to recover the precious blue carbon in the marine habitats.

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9. Medicinal Aspects of Mangroves

Mangrove is one of the most productive ecosystems and is a rich source of biodiversity including phytoplankton, microalgae, endophytes and higher plants. Mangroves are the intertidal salt tolerant group of plants having wide applications in folk medicine since ages. They are found mainly in the tropical and subtropical intertidal zones of the world largely confined to the region between 30° north and south of the equator. Their ability to survive under very stressful condition has led them to unique morphology and unusual physiological processes.

Despite considerable progress in the healthcare and medical field search for newer drugs continues because the existing synthetic drugs have several limitations. In recent years, there has been a great interest in finding naturally extracted drugs from plant materials to replace synthetic ones which are

being restricted due to their carcinogenicity. Vast numbers of medicinal plants have been used for centuries as remedies for human diseases. Among them extracts from different parts of mangroves and mangrove associates are widely used throughout the world. The marine world offers an extremely rich resource for important compounds of structurally novel and biologically active metabolites and extracts from mangrove species have proven inhibitory activity against human, animal and plant pathogens. The use of plants as source of remedies for the treatment of many diseases is a prehistoric practice and people of all countries have this old tradition. Plants have the major advantage of being effective and cheaper alternative source of drugs. Mangroves are biochemically unique vegetation that produce wide array of natural products with immense medicinal potential.

Mangrove based medicinal plants are one of the richest bio resources of folk medicines and traditional systems of medicines and also provides supports for food supplements, nutraceuticals, pharmaceuticals and chemical entities for synthetic drugs. Mangrove plants are the best choice to isolate potent bioactive compounds against many pathogenic bacteria and virus.

Several species of mangrove produce bioactive compounds that may control microbial growth. Mangrove extracts can also be the possible sources of mosquito larvicides, antifungal, antiviral, anti-cancer and anti-diabetic compounds and also shows **analgesic, anti-inflammatory, antitumor, aphrodisiacs properties.**

The major families and genera of mangroves being extensively used in medical field are Acanthaceae, Myrsinaceae, Avicenniaceae, Lecythidaceae, Leguminosae, Rhizophoraceae, Clusiaceae, Euphorbiaceae, Arecaceae, Pandanaceae, Fabaceae, Tamaricaceae, Convolvulaceae and Sterculiaceae. Some of mangrove varieties having a wide range of therapeutic activities are listed below:

Plant Name	Parts used as medicine	Medicinal properties
Acanthus ilicifolius	Bark, Fruits, Leaves, Roots	Analgesic, anti-inflammatory, blood purifier, antidiabetic, anti- viral
Aegialitis annulata	Bark, Leaves and Stem	Anti viral, anti inflammatory, anti-diabetic
Aegiceras corniculatum	Bark, Leaves and Stem	Antidiabetic, cure asthma, antiviral
Aegiceras majus	Bark and Leaves	Treatment for haematuria, antidiabetic
Avicennia africana Avicennia alba	Bark, Leaves	Anti cancer and antiulcer
Avicennia ebracteatus	Fruits	Blood purifier, treatment of boils and snake bite
Avicennia germinans	Bark, Leaves	Treatment for throat pain, ulcers
Avicennia marina	Stem	Treatment for small pox, ulcers, rheumatism
Avicennia nitida	Bark, Leaves, Seed	Cure for thrush and ulcer
Avicennia officinalis	Bark, Fruits and Leaves	Aphrodisiac, cure for hepatitis and leprosy
Avicennia tomentosa	Bark, Stem	Treatment of rheumatism
Bacopa monniera	Leaves	Nerve tonic

Bruguiera caryophylloides	Bark and Leaves	Treatment of ulcers
Bruguiera conjugata *Bruguiera cylindrica* *Bruguiera rumphii* *Dalbergia ecastophyllum* *Heritiera macrophylla* *Kandelia candel* *Kandelia rheedii* *Rhizophora conjugata* *Rhizophora gymnorrhiza* *Rhizophora mangle*	Stem, Bark Fruits, Roots Leaves Bark and Leaves Bark Leaves Whole plants Bark, Fruits and Leaves Bark Bark Bark and Leaves	Antidiabetic
Bruguiera exaristata	Bark	Anticancer
Bruguiera gymnorrhiza	Fruits	Treatment for eye diseases
Bruguiera parviflora *Bruguiera sexangula*	Bark Bark	Anticancer, antidiabetic
Ceriops decandra	Bark, Fruits and Leaves	Treatment for hepatitis, antiulcer
Ceriops roxburghiana	Whole plant	Antiulcer, antidiabetic
Ceriops tagal	Bark	Treatment for haemorrhages
Derris trifoliata	Whole plant	Stimulant, laxative
Derris uliginosa	Bark and Fruits	Antispasmodic, stimulant

Excoecaria agallocha	Whole plant	Uterotonic, purgative, antidiabetic
Heritiera littoralis	Stem, Bark, Fruits and Leaves	Treatment for diarrhoea, antifungal
Heritiera minor	Whole plants	Treatment for diarrhoea
Intsia bijuga	Bark	Antiulcer
Nypa fruiticans	Leaves and Fruits	Antidiabetic, treatment for snake bite
Oncosperma tigillarium	Flowers	Antispasmodic
Rhizophora apiculata	Bark, Flowers, Fruits and Leaves	Antimicrobial, antiviral, antiseptic
Rhizophora lamarckii *Pluchea indica*	Flowers and Leaves Leaves and young shoots	Treatment for hepatitis **Treatment of Back pains and rheumatic pains, Gangrenous ulcers**
Rhizophora racemosa *Rhizophora stylosa*	Flowers and Leaves Leaves, roots and seeds	Antiviral, antidiabetic
Rhizophora mucronata	Bark, Fruits, Flower, Roots, Leaves	Antiviral (antiHIV), antiulcer
Salicornia brachiata	Leaves and Stems	Antiviral, antidiabetic, toothache

Sonneratia acida	Barks and Leaves	Antiulcers, treatment for asthma
Sonneratia alba	Fruits	Treatment for swelling and sprains
Sonneratia apetala	Leaves	Treatment for hepatitis, antiviral
Sonneratia caseolaris	Fruits	Stop bleeding, treatment for piles
Sonneratia ovata	Fruits	Stop bleeding, antidiabetic
Thespesia populnea	Bark, Stem	Antibacterial and antisteroidgenic
Xylocarpus granatum *Xylocarpus moluccensis*	Bark Bark, Fruits	Treat fever, malaria, cholera and antidiabetic Treat fever, malaria, naphrodisiac and antidiabetic

Increased human needs, commercial activities and urban development demands are leading to the rapid conversion of mangrove forest vegetation. Mangroves are considered as a rich source of natural materials for pharmaceutical industries and therefore sound management strategies needed to conserve the mangroves for their medicinal values.

Scientific research programmes are going on to obtain physical, chemical, biochemical and biological properties of drugs, drug substances or potential drugs from mangroves for the discovery of new medicine to treat various diseases in human being without disturbing the mangrove vegetation.

Subhashree Priyadarshini Swain
M.Tech Dissertation Student

10. Physiological Salt Soaking Adaptation Mechanism of Mangroves

Mangrove plants are saline tolerant angiosperms, which are present along the banks of estuaries, creeks and muddy coastal shores. The distinctive characters of mangroves are that they are tolerant to water salinity fluctuations. Prop root and stilt root system of mangroves form a firm anchorage in the sinking substratum as well as trap the fine suspended particles in water column that leads to expansion of sediment and formation of the mudflats. The mudflats improve the settlement and growth of diverse mangrove species and their associated organisms.

Mangroves possess some unique physiological mechanism for growing in high salt and low moisture conditions. The physiological processes facilitate mangroves to survive in the frequently changing ecosystem where land meets the sea. A mangrove must have some specialized physiological characters to compete with drying effect of sun and moon, osmotic inconsistency caused by seawater salinity, waterlogged soils and lacking oxygen content. It also has the ability to resist the tidal fluctuations, effect of cyclone and storm surges, elevated river water inflow and seasonal fluctuations of temperature.

Mangroves have three physiological mechanisms to withstand in saline ecosystem. One way is to reduce or exclude the uptake of salt. The salt exclusion is one mechanism to exclude salt which is achieved due to the presence of ultra filtration mechanism in their root systems. In this process when the water is absorbed the salt ions remain as filtered out. Salt extrusion gland is present in mangrove leaves which aid to expel the salt crystals on the upper leave surface. Avicennia sp. is the most proficient salt extruding species and can grow in high saline condition. Salt tolerance of mangroves may be controlled by the presence of slat extrusion gland, succulent nature of leaves and viviparous germination.

Another physiological mechanism for dealing with the surplus salt is to expel through salt secreting glands. Some mangrove genera like Avicennia and Aegiceras are emitting thin layer of white salt crystals on the leaf surfaces through salt secreting gland. Some of the salt passed in the transpiration flow to the leaves, which is absorbed by the growing tissues for osmoregulation processes and the excess of salt is secreted by the glands that ion concentrations are maintained physiological tolerance level. These mangrove species are usually salt tolerant than other mangroves.

The other physiological mechanism is called salt accumulation, in this process all mangroves accumulate

the inorganic ions for osmoregulation of leaves and tissues. In general, species which are incapable to exclude salt at the root system or expel salt from salt glands in their leaves. The salt accumulator species like *Excoecaria*, *Sonneratia* and *Xylocarpus* that employ the strategy of dropping their leaves when the osmotic particles level became intolerable. These mangrove genera also deposit sodium and chloride in the stem and pneumatophore bark. The review suggests that mangroves are salt tolerant species that can grow higher than seawater salinity. The physiological mechanisms in mangroves may provide a protection from rapid changes in seawater salinity which is very common in tropical and subtropical coastal system of the world.

G. Thirumaran,
GUIDE

Events in GUIDE

- 19th Annual General Meeting and 69th Board of Governors of Gujarat Institute of Desert Ecology (GUIDE), Bhuj-Kachchh was held on 23rd October 2015 at GUIDE.
- Prof. Uriel Safriel, an eminent desert scientist of Israel visited GUIDE during the period between 27th November and 3rd December 2015. He played instrumental role in establishing GUIDE during 1995.
- As part of the UKIERI project, the UK team members (Dr Debbie Bartlett, Dr Sarah Milliken, Mr. Richard Baines, Mr. Vincenzo Iannuzziello and Ms. Eulalia Gomez Martin) visited GUIDE between 19th and 30th December 2015.
- A workshop of the ongoing UKIERI project was organized at VRTI, Mandvi on 29th December 2015 with the active participation of village presidents of coastal villages of Mandvi, Abdasa and Lakhpat talukas along with officials from NGOs and Forest/Revenue Departments. Issues of climate change and its social implications were discussed in this workshop.
- Shri. Ashwin C. Shroff, Chairman and Managing Director of Excel Industries Limited visited GUIDE on 25th December 2015 and discussed on the possibilities of research and joint ventures between GUIDE and C. C. Shroff Research Institute (CCSRI). As a follow-up, GUIDE has signed a MoU with CCSRI on 1st January 2016 for research collaborations and joint training and conference programmes.
- **Dr. V. Vijay Kumar,** Additional Director attended the Climate Change and Transformation meeting at IIT, Mumbai held on 27th and 28th October 2015. The meeting was attended by project partners from IIT-Mumbai, Sussex University-UK, NIVA-Norway, SARAI-New Delhi, IIHMR-Kolkata and All India Disaster Mitigation Institute-Ahmedabad.
- **Dr. B. Anjan Kumar Prusty,** Sr. Scientist has participated in UNESCO regional capacity development workshop on “Ensuring water security in changing environment scenario for water professionals of cluster countries” organized by Indian Institute of Technology, Bombay; National Institute of Hydrology, Regional Centre, Bhopal; and National Institute of Technology, Hamirpur during November 26-27, 2015.
- **Dr. Rachna Chandra,** Sr. Scientist attended a workshop on “Basic GIS understanding on Use of GIS Application conducted by Arid Communities and Technologies (ACT)” at Bhuj during 19-21 Nov 2015.
- **Dr. Arun Kumar Roy Mahato,** Scientist has participated and presented a paper entitled "Social Composition and Activity Schedule of Aquatic birds in Hamir Sar Lake, Bhuj, Gujarat" in the International seminar on "Exploring the Modern Approach in Biological Science: From Genome to Organism" organized by the Department of Zoology, Sidho-Kanho-Birsha University, Purulia, West Bengal, held on 25th-27th October, 2015.
- **Dr. Nikunj B. Gajera,** Scientist was invited as Key Resource Person in “National Training Programme on Conducting Research on Wildlife and Habitats” on 21st to 27th November 2015 at Gujarat Forest Rangers College, Rajpipla-Gujarat. Also invited as Key Resource Person in “State Level Orientation Training Programme on Conducting Research on Wildlife and Habitats” on 15th to 18th December 2015 at Jessor Sloth bear Wildlife Sanctuary, Banaskantha-Gujarat.

RECENT APPOINTMENTS IN GUIDE

Dr. A. R. LOGESH, *Project Scientist*

Dr. Logesh joined GUIDE as Project Scientist in November 2015, having 6 years of research experience in taxonomy, ecology and bioprospection of lichens. He has got his Bachelors and Masters in Microbiology from Periyar University during 2009, later completed his Doctor of Philosophy in Marine Microbiology during 2013 from Annamalai University and CSIR-NBRI, Lucknow. He worked out the lichens along mangroves of southeast coast of India for his doctoral thesis. With his academic credentials, he has published more than 16 research articles on different aspects including lichen systematics, ecology, bio-prospection and environmental pollution in journals of national and international repute along with 2 technical reports and one patent. He discovered two lichen species new to science and described 17 new distributional records for India. Dr. Logesh worked at Mizoram University as Research Associate in a CSIR sponsored project during 2014-2015, explored lichens of Mizoram, Assam and Manipur states of northeastern India evidenced with publications. He is a founder member of Society of Tropical Plant Research and serving as an Editorial Board Member in "Tropical Plant Research" journal and also he is serving as a reviewer for various environmental and ecology related journals. He is currently involved in environmental and marine monitoring projects at GUIDE also involved in the lichen study of Gujarat and Rajasthan.

Ms. OZHAKKAL ANJALI THOMAS, *Environmental Engineer*

Ms. Thomas recently joined GUIDE, has completed her B.E. in Environmental Engineering from LD College of Engineering (Gujarat Technological University), Ahmedabad in June 2015. Earlier she worked at GEMI (Gujarat Environment Management Institute) for her summer internship and Bachelors' dissertation. She did her project on Dispersion Modeling in Air pollution at GEMI. She stood first in Youth Parliament competition, XITIJ 2014 held at LDCE, Ahmedabad. She has volunteered during techfest in 2012 and have been the event manager for Dexter's Lab, TEQNIX in 2014. She has participated in RANG AMAIZI wall painting competition and PRAKARSH, techfest of SVIT, VASAD. She was selected twice in the inter-zonal basketball team at university level. She has coordinated many other programs apart from college activities and maintained Distinction in her curriculum.

Mr. MAHESH KUMAR P. DAFDA, *Chemist*

Mr. Dafda joined GUIDE as chemist during December 2015 is a Masters' and Bachelors' in Chemistry from KSKV Kachchh University, Bhuj. Earlier he worked for Excel Crop Care Limited as QA officer and Adani Wilmar Limited, Mundra as chemist. He has completed a certificate course in disaster management from Kachchh University and experienced in clinical research.

Mr. ABEY FRANCIS, *Junior Research Fellow*

Mr. Francis has completed his Master's in Life Sciences from the Devi Ahilya University, Indore during 2012-2014. He did his Masters' dissertation from Sálim Ali Centre for Ornithology and Natural History (SACON), Coimbatore and worked on "Potential of Bird Droppings in Environment Contamination Studies. " He worked as a Junior Editor in ScriptoSphere during 2014-2015. Recently he joined as a Junior Research Fellow at GUIDE working in a UNESCO funded project on "A critical evaluation of selected Persistent Inorganic and Organic Pollutants in the hydrological system A case study on Keoladeo National Park (KNP), a UNESCO World Heritage Site in India".

Upcoming Conferences

- ✓ International Conference on Agriculture and Biotechnology (ICABT). 26th December 2016. Tirupati, Andhra Pradesh, India
- ✓ ACN – International Conference on Agriculture and Biotechnology (ICABT). 02nd January 2016, Chennai, Tamilnadu, India. Organized By Academic Conference Network.
- ✓ National Conference on Environment and Natural Science (NCENS-2016). 2nd January 2016, Bangalore, Karnataka, India. Organized By National Conference Network.
- ✓ National Conference on Recent Innovations in Science, Engineering and Technology (NCRISET-2016). 3rd January 2016, Goa, India. Organized by Academic Conference Network.
- ✓ International Conference on Agriculture and Biotechnology (ICABT-2016). 3rd January 2016. Nagpur, India. Organized By Academic Conference Network.
- ✓ National Conference on Algal Technologies (NCAT - 2016). 04th January 2016, Andhra University Platinum Jubilee Guest House, Andhra University, Visakhapatnam. Organized By Seva Educational Society.
- ✓ International Conference on Agriculture and Biotechnology (ICABT-2016). 9th January 2016, Hyderabad, Andhra Pradesh, India. Organized by Academic Conference Network.
- ✓ National Conference on Environment and Natural Sciences (NCENS). 17th January 2016, Chennai, Tamilnadu, India. Organized by National Conference Network.
- ✓ ACN – International Conference on Science, Technology, Engineering and Management (ICSTEM). 23rd January 2016, Cochin, Kerala, India. Organized by Academic Conference Network.
- ✓ International Conferences on Recent Innovations in Science, Engineering and Technology (ICRISET - 2016). 24th January 2016, Hotel Park Plaza, Goa, India. Organized by Institute of Research and Journals.
- ✓ Workshop on Application of Statistical Tool in Research and Data Analysis. 08 – 11 February 2016, Dhanbad, Jharkhand, India. Organized by Indian School of Mines, Dhanbad.
- ✓ International Conference on New Approaches in Biotechnology and Biosciences (NABB - 2016). 18 – 20th February 2016, Agra, Uttar Pradesh, India. Organized by Department of Biotechnology, Raja Balwant Singh Engineering Technical Campus, Bichpuri, Agra.
- ✓ National Conference on Marine Bioresources and Coastal Livelihoods. 4 – 5th March 2016, Bhuj, Kachchh, Gujarat, India. Organized by Gujarat Institute of Desert Ecology, Bhuj.
- ✓ National Conference on Recent Trends in Environment, Science and Technology (RTEST-2016). 11th March 2016, Mohali, India. Organized by University School of Sciences, Rayat-Bahra University.
- ✓ Technological Innovation in ICT for Agriculture and Rural Development (TIAR - 2016). 15 -16th July 2016, Chennai. Organized By Eswari Engineering College & Technology, Chennai.

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