Seshaiyana

Quarterly newsletter of ENVIS on Indian estuaries, mangroves, coral reefs and lagoons

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Instructions to authors

We welcome research and popular articles, notes, news, snippets and cartoons or any scientific information on our core subjects—estuaries, mangroves, coral reefs and lagoons in and around Indian waters.

The articles should not exceed five typed pages in double space.

Figures should be clear for good reproduction.

References should be limited and cited in the text by name and year. *Council of Science Editors Style* may be referred to for listing references at the end.

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We invite comments, suggestions and constructive criticism on *Seshaiyana* from the authors and readers.

Dear readers,

To our surprise, unintentionally, this issue has turned out to be almost like a special issue on mangroves, with five out of seven articles on mangroves.

Articles on page 1 and the back cover are on the mangroves of Gujarat which has the second largest mangrove area in our country, next to Sundarbans. The first article is on the occurrence of Kandelia candel *in Gujarat. As it has not been reported earlier from that region, it is a new distributional record for the north-west coast of our country.*

We are really 'touched' by the article on the back cover, which briefly explains how the people from two villages in Gujarat are taking efforts to conserve their mangrove—our country would be transformed to a heavenly peninsula if such panchayats or priests (or anything similar) who save the mangroves are there in all the mangrove areas.

The second article focuses on the consequences of sea level rise on Sundari tree, the 'beauty' of Sundarbans, and the possible conservation measures to be taken to save it.

The third article explains the need to undertake extensive research on mangrove endophytes in view of their varied uses.

The fourth article indicates the capability of oysters to filter sea/ brackishwater.

The fifth article is for those who are not yet aware of the fact that the marine organisms constitute an important source of medicines for dreadful human diseases.

The sixth article is on the agarolytic bacteria isolated from the brackishwater of Bhitarkanika mangroves, Orissa.

We have some information on a few upcoming research meets on the inside back cover.

We will be very happy to receive feedback from all of you.

Prof. T. Balasubramanian
Prof. S. Ajmal Khan

CONTENTS

A peep into a mangrove!

(for the front cover photo)

Recently, a group of researchers from our Centre had been to the Tuticorin harbour to collect samples for the COMAPS (Coastal Ocean Monitoring And Prediction System) project. They came across a good patch of mangroves with a dangerous viper. They captured what they saw in camera and the same is adoring the cover page of this issue.

The strong and healthy prop roots of the mangrove species—*Ceriops decandra* (Griff.), which is known as 'Pannukuchi' in Tamil—drew their attention first. This species occurs in West Bengal, Orissa, Andhra Pradesh, Tamil Nadu and Karnataka besides Andaman and Nicaobar Islands. The extract from the bark, fruit and leaves of this plant is used for treating hepatitis and ulcers.

A branch of root traversing horizontally, and above that another branch arching upwards were noticed. It is really fascinating to know that these roots are capable of growing up to several meters long when they grow horizontally, and the direction of growth can also be downwards or upwards.

It is obvious that this photograph was taken during the low tide. It appears that the snake had taken advantage of the low tide and swallowed a considerable quantity of prey like crabs or frogs.

A well-grown algal mat covering the mangrove soil is quite evident. The algal mats are useful for the mangrove ecosystem, except for the fact that they hinder the settling of the viviparous hypocotyles of the mangroves.

In the right-middle edge of the photograph, two specimens of gastropod mollusc *Cerithedia cingulata* (Gmelin, 1791) are there. They make the mangrove soil organically rich. That way they play an important role in the health of the mangroves in that ecosystem.

Just below the snake, an attractive red-coloured leaf (carrying the page numbers of this issue) was seen. The base of that leaf was found buried in the soil. Mangrove leaves are adapted to store more water, with thick cuticle, small hair and with no prominent veins. The water storing cells help to prevent the excess heat from the sunlight.

The fallen leaves change colours from green to yellow, yellow to red and red to brown. As soon as they fall, potassium is leached faster; tannin is the last compound to be leached. Presence of tannin prevents bacterial action and decomposition of the leaves. Since most of the mangrove leaves have more tannin, they take longer time to get decomposed.

Small white nodules are visible on the mid-surface of the leaf. They could be the salt-nodules excreted by the mangroves—mangrove leaves and roots are adapted to deal with the salty environment.

(We sincerely thank Dr. K. Kathirasan, Professor in our Centre, for the scientific facts presented in this write-up and Dr. S. Vijayalakshmi, Scientist, COMAPS, of our Centre, for providing us the cover photo.)

First record of *Kandelia candel* (L.) Druce in Gujarat

Kandelia candel (L.) Druce is a true mangrove species of the family Rhizophoraceae; its occurrence has been reported in Southeast Asia, China, Taiwan and Japan (Tomlinson, 1986; Kathiresan and Rajendran, 2004). In India, it has been found to occur in the east and west coasts and Andaman and Nicobar Islands (Kumudranjan Naskar, 1999; Debnath, 2004).

In the west coast of India, this species is found to be common in the States of Kerala, Karnataka, Goa and Maharashtra (Kothari and Singh, 1998; Kathiresan and Bingham, 2001; Kathiresan and Qasim, 2005; Anon., 2008). However, this species was never reported from Gujarat earlier (Shah, 1978; Singh, 1999; Pandey *et al.*, 2005, Anon., 2008).

During the recent floristic survey carried out by a team of Gujarat Ecological Education and Research (GEER) Foundation in June 2009 for the project 'Study of Floristic Diversity and Natural Recruitment of Mangrove Species in the Selected Mangrove Habitats of South Gujarat' sponsored by IUCN, a single tree of this species was found at the mouth of Par River, Magodh Dungari (20° 32′ 08.9″ N and 72° 53′ 29.5″ E) of Valsad District, Gujarat. The location of the plant is shown in Fig. 1.

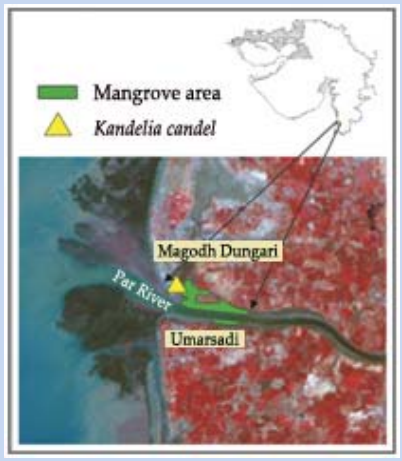

Fig. 1. Location of *Kandelia candel* found in the mouth of Par River, Magodh Dungari, Valsad District, Gujarat.

The single tree of *K. candel* found during the survey was 5 ft tall and was in reproductively matured condition; it had buds, flowers and developing propagules. Other descriptions are as follows:

Bark	Smooth, reddish brown
Leaves	Olive green, petiolate, opposite, oblong elliptic-lanceolate, apex obtuse, margin entire, 6.5–7.8 cm long and 2.3–2.8 cm wide
Inflorescence	Axillary, bifurcating with four flowers
Buds	1.5–2.0 cm length, 0.3–0.5 cm wide
Flowers	1.5–2.0 cm long, pentamerous, complete
Calyx	1.0–1.2 cm long, 0.3 cm wide, persistent, refluxed at anthesis
Petals	Filamentous, 5–6 mm long
Stamen	Numerous, irregular in length, filamentous
Floral disk	Cup-shaped, ovary-inferior, tricarpelary and unilocular
Propagule	Slender, tapering at both ends (Banerjee and Nayar, 1989; Naskar, 2004)

The photographs of the plant were sent to Dr. K. Kathiresan, Centre of Advanced Study in Marine Biology, Annamalai University, for confirming the identity of the species, and it was confirmed as *K. candel*.

Fig. 2. Tree (a), flower (b) and propagule (c) of *Kandelia candel*.

Only a single tree of the above species was found. However, no recruitment was seen taking place in that area. Apart from *K. candel* four other mangrove species were also found in that area, *viz.*, *Avicennia marina*, *Acanthus ilicifolius*, *Aegiceras corniculatum* and *Sonneratia apetala*.

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Consequences of sea level rise on Sundarbans with special reference to Sundari tree, *Heritiera fomes* Buch.-Ham.

Introduction

Sundarbans is the largest single mangrove block, as well as one of the ancient mangroves, of the world, situated on the northern-most shore of Bay of Bengal, spreading over India (*ca* 40%) and Bangladesh (*ca* 60%). It occurs in the deltaic regions of the three large rivers, *viz*., Ganges, Meghna and Brahmaputra, which cover an area of *ca* 10,000 sq km. This mangrove supports the lives of millions of people living therein.

The name 'Sundarbans' literally means 'beautiful jungle' or 'beautiful forest' (*Sundar*, 'beautiful' and *bans*, 'forest' or 'jungle'). The name might have been derived from the 'Sundari tree' (*Heritiera fomes*) which is found there in large numbers.

Sundarbans covers an area of 4262 sq km in India. The core area of 1330 sq km has been declared as a world heritage site by UNESCO in 1997 for conservation purposes (*source*: <http://www.wb.nic.in/westbg/sundarban.html>, accessed on 20th November, 2009).

Sundarbans is well-known for its rich biodiversity. *Excoecaria agallocha*, *Heritiera fomes*, *Ceriops decandra*, *C. tagal*, *Phoenix paludosa*, *Sonneratia alba*, *S. apetala*, *Avicennia* spp., *Rhizophora apiculata*, *R. mucronata*, *Xylocarpus granatum* and *Bruguiera* spp. are the commonly found mangrove species in Sundarbans.

Fisheries constituted by crabs, shrimps and fishes thrive well in Sundarbans. It also offers shelter for other organisms, such as olive ridley, hawks bill, ground turtle, river terrapin, estuarine crocodile, sea otter, Gangetic dolphin, etc. The famous man-eating Royal Bengal Tiger (*Panthera tigris*) population is found only in Sundarbans.

Sundari tree—very common and pioneer species of Sundarbans

It is a tall (grows up to 20 m) and beautiful tree having majestic appearance, found only in Sundarbans. It is quite prominent among the other mangrove trees. The shiny silvery white scales of its leaves glitter, and it is very attractive to see them from a distance. It requires little less salinity to thrive compared to the other true mangrove trees. The wood of this species is used for building boats and constructing houses.

Impact of sea level rise on Sundari tree

Sea level has been rising in Sundarbans coast at the rate of 4 mm/year. It is much higher than the global rate of 2 mm/year (Hoque *et al*., 2006). Due to this more areas are getting inundated by tidal water. As a result of seawater intrusion due to tides, salinity increases in the low saline zones. The salinity of the soil also increases.

Sundari tree, which can thrive well only in less-saline zones, is very much affected by the increasing salinity. That way it is becoming endangered. As it gets stressed due to high salinity, it becomes susceptible to the diseases.

The roots of Sundari tree are unable to absorb the nutrients and oxygen, which makes it very weak, and gets affected by the diseases. Top-dying disease is commonly seen in it. Excess sodium and chloride in the water and soil make its leaves necrotic and results in premature abscission (Hoque *et al*., 2006). The beauties are dying helplessly, and we are only witnessing it happening.

Freshwater flow to Sundarbans

The freshwater flow to the Sundarbans area is becoming lesser due to various reasons. One of the main reasons is the construction of dam, which has directed more freshwater towards the inland area, away from Sundarbans.

Also, if the Himalayan Glaciers, which are the sources for these rivers, melt away due to the global warming, the rivers may become dry and no freshwater flow may be expected in Sundarbans. Then, we can expect that except for the true mangroves which can thrive well close to the seashore, other plants will get dried up.

How to save the Sundari tree?

By following the options given below, we may be able to save the Sundari tree and other flora and fauna inhabiting Sundarbans:

- Biology of Sundari tree to be understood thoroughly.
- Salinity-tolerant, genetically engineered varieties of Sundari tree to be developed and grown.
- The importance, or the role, of Sundari tree in the mangrove ecosystem of Sundarbans to be understood.
- Salinity changes and salinity gradient zones in Sundarbans area to be estimated.
- Planting of Sundari tree in the low-saline areas (<10 ppt) to be experimented.
- Reforestation techniques to be practiced for mangroves.
- Obstacles for the freshwater inflow, such as development of agricultural or aquacultural farms, to be removed.
- River banks to be re-vegetated with natural grass.
- Sundarbans ecosystem to be monitored periodically by remote sensing and GIS mapping.
- Any unnecessary human intervention to be prohibited.
- Awareness programmes to be conducted to public about the importance of Sundarbans.
- Since the native tribes of Sundarbans will have unique information, which could still be unknown to science, this information has to be collected and used properly.
- Last but not the least, the Himalayen glaciers should be saved and protected from excessive melting due to global warming.

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Mangroves, a potential source for microbial endophytes too!

Introduction

Bacon and White (2000) defined endophytes as: "Microbes that colonize living, internal tissues of plants without causing any immediate, overt negative effects", and it has become a widely accepted definition. Endophytes are ubiquitous with rich diversity. It is noteworthy that each of the nearly 300,000 plant species that exist on the earth is the host to one or more endophytes (Strobel and Daisy, 2003). It is estimated that there may be as many as 1 million different endophyte species; however only handful of them are described (Guo *et al.*, 2008).

Uses of microbial endophytes

The uses of microbial endophytes (bacteria, fungi, actinomycetes) to their hosts, humans and environment are remarkable. For example, they help their hosts in effecting nitrogen fixation, production of phytohormones, biocontrol of phytopathogens and in enhancing the availability of nutrients and minerals among others (Rosenblueth and Romero, 2006).

Production of the volatile substances such as 2,3-butanediol and acetoin by endophytic bacteria seems to be a newly discovered mechanism responsible for plant growth promotion (Ryu *et al.*, 2003).

The endophytes have also been reported (Balagurunathan and Radhakrishnan, 2007) to produce novel bioactive metabolites, which are used in pharmaceutical and nutraceutical industries to produce antibiotic, antidiabetic, antiviral, antiinflammatory, anticancer, antioxidant and immunosuppressive drugs and therapeutic agents. A well-known example is the discovery of Taxol (Paclitaxel), the first billion dollar anticancer drug from an endophytic fungus *Taxomyces andreanae* of yew (*Taxus* sp.)—the first recognized source for Taxol (Strobel and Daisy, 2003).

Recent research has provided a clue that endophytes might be partially responsible for the degradation of environmental toxins. Research work done at the University of Iowa has shown that a newly described endophyte *Methylobacterium populum* (Aken *et al.*, 2004) is involved in the degradation of 2,4,6-trinitro toluene (TNT) and hexahydro-1,3,5-trinitro 1,3,5-triazine (HMX). Improvement in phytoremediation of water soluble and volatile organic pollutant by selected endophytic bacteria has also been reported (Barac, 2004).

Endophytes of mangroves

Although mangroves are the potential source for many bioactive compounds, reports on the usefulness of the microbial endophytes of mangroves with respect to the above aspect are scanty. Only a few attempts have been made to study the mangrove fungi.

Endophytic fungi are recognized as a potential source of high value metabolites. About 51% of bioactive metabolites reported from endophytic fungi are previously unknown. Mangrove fungi constitute the second largest ecological group of marine fungi (Sridhar, 2004). More than 200 species of endophytic fungi have been isolated and identified from mangroves and these belong mainly to the genera *Alternaria, Aspergillus, Cladosporium, Colletotrichum, Fusarium, Paeciamyces, Penicillium, Pestalotiopsis, Phoma, Phomopsis* and *Trichoderma* (Liu *et al.*, 2007).

In Pichavaram mangrove ecosystem, about 24 endophytic fungal genera have been reported from the leaves of *Rhizophora apiculata, R. mucronata, Aegiceras corniculatum, Avicennia marina, A. officinalis, Bruguiera cylindrica, Ceriops decandra, Excocaria agallocha* and *Lumnitzera racemosa* (Kumaresan and Suryanarayanan, 2001).

Table 1 shows few examples of bioactive compounds being produced from the mangrove endophytic fungi. In addition to the compounds given in Table 1, eight new indole triterpenes named shearinines D–K, along with shearinine A, paspalitpem A and paspaline, have also been isolated from a mangrove endophytic fungus *Penicillium* sp. Shearinines D, E and G exhibited significant *in vitro* blocking activity on large conductance calcium-activated potassium channels (Cheng *et al.*, 2009). It is reported that in addition to bioactive metabolites, enzymes such as protease, lipase, cellulase, chitinase, laccase, and tyrosinase are produced by endophytic fungi of certain mangroves (Maria *et al.*, 2005).

Unlike endophytic fungi, endophytic bacteria have been less studied in mangroves. New cyclopentenone derivatives have been reported from an endophytic *Streptomyces* sp. isolated from the mangrove plant *Aegiceras comiculatum* (Lin *et al.*, 2005). Three germacrane-type sesquiterpene alcohols were isolated from an endophyte *Streptomyces griseus* subspecies from a mangrove plant *Kandelia candel* (Guan *et al.*, 2005).

Presently, endophytic actinomycetes are being tested and seriously considered for use in controlling plant diseases.

Though India is a pioneer in mangrove research, bioprospecting of microbial endophytes from mangroves has not even reached the stage of infancy. Therefore, efforts should be taken for judicious and gainful utilization of mangrove endophytes.

Table 1. Bioactive compounds isolated from mangrove endophytic fungi

Compound	Endophyte	Activity
Cytosporone B	*Dothiorella* sp.	Antifungal and anticancer
Anthraquinones	*Fusarium proliferatum*	Antimicrobial
Enniatin G	*Fusarium* sp.	Antitumor
Enalin A and B	*Verruculina enalia*	Antimicrobial
Xyloketal A	*Xylaria* sp.	Acetylcholine esterase inhibitor

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Crassostrea—a natural purifier of water

The fast growing and widely distributed oysters belonging to the genus *Crassostrea* (Bivalvia: Ostreidae) thrive well in the brackishwater and in the sea. Their dense beds (oyster reefs) are commonly seen in the intertidal and subtidal regions of estuaries, and coastal lagoons all over the world.

The body of the *Crassostrea* spp. is irregular and variable in shape. Normally they can grow up to 20 cm (maximum width), sometimes more also, and live up to 30 years.

These oysters are sedentary in nature and are found attached to rocks, pillars or sandy and muddy bottoms. Being filter feeders they filter food from the water column. Their food includes mainly the phytoplankton and other protozoic organisms. Interestingly, for example, the Pacific oyster *Crassostrea gigas* (Thunberg, 1793) can filter about 5 l/g/h which can increase up to 25 l/g/h (Ren *et al*., 2000). Such filtering capability makes the oysters good indicators of heavy metal pollution besides other chemical pollutants. That way they play an important role in purifying the water.

Crassostrea cuttackensis (Fig. 1) is a common oyster species in the Orissa coast, especially in the Bahuda estuary, Rushikulya estuary (Pati *et al*., 2008) and in the outer channel area of Chilika lagoon (ZSI, 1995). It appears that *C. cuttackensis* is able to thrive in the wide ranges of physico-chemical parameters.

Colonies of *Crassostrea* spp. serve as a habitat and also as food for a variety of organisms such as sea stars, polychaetes, crabs, damsel fishes, ducks, wading birds, borers, sea otters, etc. Thus they play a vital role in aggregating different faunal groups, thereby increasing the biodiversity in the oyster beds.

The faecal material produced by the oysters is used by the microbenthic and microphytic organisms, followed by the meiobenthic and macrobenthic organisms. So it also plays a critical role in benthic–pelagic trophic relationship.

Fig. 1. An oyster colony.

The hard shells of the oysters can be used for decorative purposes and for the extraction of lime.

However, excess colonisation of this bivalve in the intertidal zone restricts the space to other organisms inhabiting the same ecological area. Other than this negative feature, the water purifying capability of the oyster *Crassostrea* besides other uses are remarkable one. Its ability to accumulate toxic chemical and other substances in its body makes it an ideal test organism for ecotoxicological studies. More studies must be carried out to unfold the other secrets behind this wonderful organism.

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Ocean and human health

Introduction

Since time immemorial, man has taken advantage of nature's ability to produce remedies to treat infection, inflammation, pain and many other ailments. In some parts of the world natural medicines are still the only treatments available. Today over 50% of the marketed drugs are either extracted from natural sources or produced by synthesis of natural products as starting material.

Initially medicines have come from the natural resources of land. As scientists have screened almost all the terrestrial microorganisms, plants and animals which have yielded many useful drugs, now they have turned their attention to the oceans, which cover more than 70% of earth's surface, to obtain novel drugs, in view of the uniqueness of many organisms which occur only in the oceans.

Role of marine environment in human health

One reason why marine organisms are so interesting to scientists is because of their adaptation to various ocean environments. They have evolved fascinating repertoires of unique chemicals to help them survive. The reason why the marine plants, animals and microbes produce chemicals that are useful as pharmaceuticals is due to their sessile nature and occurrence in densely populated habitats where competition for food and space is intense. As a result, they have evolved unique metabolites used for their defense, reproduction and communication (Morse and Morse, 1991; Paul, 1992; Pawlik, 1993). These metabolites also interact with receptors and enzymes involved in human disease processes.

Best example for the above-mentioned fact is a sponge trying to prevent another sponge from invading its space; it may produce chemicals to prevent another sponge's cells from growing and dividing. It is not unusual therefore that these chemicals may also be effective in inhibiting the uncontrolled growth of cancer cells. Based on this principle drugs are being extracted from marine environment and since drug discovery in marine frontier is relatively a young field only a few marine derived drugs are in use today and some of the drugs and their roles have been briefly described here.

Compounds for treating fungal infection

Marine natural products having anti-fungal property have been isolated from sessile organisms like sponges. In general these products can be grouped into the following four major categories:

1. Polyketides such as Aurantosides (Sata *et al*., 1999).
2. Macrolide such as Phorboxazole A (Searle and Molinski, 1995), Halishigamide A (Kobasyashi *et al*., 1997), Halichondramide (Kernan *et al*., 1988).
3. Alkaloids such as Fascaplysin (Roll *et al*., 1988), Meridine (McCarthy *et al*., 1992), Pitcomycalin A (Kashman *et al*., 1989), Haliclonadiamine (McDermott *et al*., 1996).
4. Fatty acid esters such as Bengazole A (Searle *et al*., 1996).

The majority of anti-fungal compounds from marine sources are highly cytotoxic. It is for this reason that they have not been considered as promising anti-fungal agents for clinical trials. However efforts are on to find out the right dosage and also to modify the compounds themself to make this class of anti-fungal agents available for medicinal use in future.

Compounds for treating tuberculosis

The second category of marine compounds is those used for tuberculosis. Several notable compounds have been identified for use against multi-drug-resistant strains of *Mycobacterium tuberculosis* and these include (+)-8-Hydroxymanzamine A which was first isolated from the sponge *Pachypellina* sp. (Ichiba *et al*., 1994) and is found to be very potent against *Mycobacterium tuberculosis* H37RV. Another compound Axisonitrile 3 is a cyano sequi terpene isolated from the sponge *Acanthella klethra* and is quite potent against *Mycobacterium tuberculosis.* Pseudo-pteroxazole and Ergorgiaene are compounds from the West Indian Gorgonid *Pseudopterogorgia elisabethae* and have been demonstrated to inhibit the growth of *Mycobacterium tuberculosis* (Rodriguez *et al*., 1999; Rodriguez and Ramirez, 2001).

Compounds for treating helmintic parasitism

The third group of marine natural compounds is those used for anti-helmintic activities. The parasitic nematode poses a great threat to both livestock and human beings. These compounds assume significance in the backdrop of growing resistance of nematodes to anti-helmintic drugs necessitating discovery of new and potential bioactive compounds against nematodes. Dihydroxy tetra furan

shows selective nematocidal activity (Capon *et al*., 1998). Another compound the amphilactams isolated from the sponge *Amphimedon* sp. also exhibits active nematocidal activity.

Compounds for treating bacterial infection

The urge to find new compounds for treating bacterial infection has increased. Several marine compounds have been demonstrated to have anti-bacterial activity. The squalamine isolated from dogfish shark *Squalus acanthias* showed potent anti-bacterial activity. The following compounds have also been identified to have anti-microbial activity: Cribrostatins (isolated from blue sponge, *Cribrochalina* sp.) (Pettit *et al*., 2000); Bromosphaerone, a Diterpene (isolated from a red alga occurring in Morocco Coast) (Etahiri *et al*., 2001); a Jorumycin, a Dimeric Isoquinalone Alkaloid (isolated from mantle and mucus of the Pacific nudibranch *Jorunna funebris*) (Fontana *et al*., 2000).

Compounds for treating viral infection

The nucleoside Ara A is a semi-synthetic compound based on Arabinosyl nucleosides purified from the sponge *Cryptothethia crypta* and its related derivatives are all showing anti-viral activity. In addition the Didemnins isolated from Caribbean tunicate *Tridemnum solidum* also showed promising anti-viral activity (Rinehart *et al*., 1984a). Eudistomins family of β Carbolin Alkaloids isolated from a tunicate are reported to have great anti-viral potency (Rinehart *et al*., 1984b). The Mycalamide isolated from New Zealand sponge *Mycale* sp. can inhibit *Herpes simplex* and poliovirus (Perry *et al*., 1988).

Compounds for treating cancer

Presently twelve different marine natural compounds have been identified to show anti-cancer activity. These are under various stages of clinical trials. These include LAF 389 (amino acid derivative from sponge), Bryostatin I (Polyketide from Bryzoan), Dolostatin 10 (peptides from sea slug), ILX651 (Peptide from sea slug), Camedotin (Polyketide from sea slug), HT1286 (Tripeptide from sponge), Yondelis (Isoqinalone from sea squirt), Kahalalide F (cyclic dipeptide from sea slug and alga), KRN7000 (α Galactosylceramide from sponge). Squalamine lactate (amino steroid from shark), IPL512602 (steroid from sponge), ET743 (alkaloid from sea squirt) (Haefiner, 2003).

Anti-inflammatory compounds

The following marine natural compounds are under clinical trials for inflammation/asthma, wound healing and psoriasis IPL576092 (from soft coral), Manolide (from sponge) (Haefiner, 2003).

New tools for discovery

To optimize the chances of identifying novel drugs from marine resources, use of the best tool for discovery at all stages of exploration, new locations, collection of organisms never before sampled and identification of chemicals with pharmaceutical potential, are imperative.

Although there exist some specialized tools and chambers that allow deep water organisms to be maintained under ambient conditions, there is a very good need for developing versatile bioreactors that can be deployed and operated under extreme conditions (e.g., hyper saline vent, anoxic and deep sea habitats). Such bioreactors could be used for collection, maintenance and evaluation so that their metabolites could be studied under physiological conditions that are similar to ambient conditions.

Another approach to the identification of new products is the incorporation of miniaturized biosensors into both collection tools and bioreactors for rapid *in situ* analysis of marine organisms for bioreactive compounds. A number of miniaturized biosensors and probes are under development. Development of *in situ* biosensors could enhance our ability to probe the expression of metabolites in response to various stimuli, leading to better understanding of the role of secondary metabolites in nature thereby providing clues for the potential biomedical utility of these compounds.

Marine models

As our understanding of the biochemistry behind a variety of diseases has improved, better methods have been developed for rapidly determining the biomedical potential of metabolites produced by marine organisms. Marine organisms as model system offer the potential to understand and develop treatments for diseases based on normal physiological roles of their secondary metabolites.

For example the big purple slug offers researchers clues about learning and memory, the toadfish teaches lessons about balance and equilibrium and the spiny dogfish shark besides horse shoe crab provide a glimpse of mechanics of vision.

Study of animals such as sea stars, sea squirts and sharks has enormously enhanced our understanding of how our human body fights against diseases. Likewise study on sea urchins has revolutionized understanding of how cells divide, paving the way for exciting new researches into the diagnosis and treatment of cancer.

Moreover marine and fresh water resources provide zebra fish as aquatic mouse model, swordtail aquarium fish as models for genomics and variety of small freshwater species for toxicological pathway elucidation and much more.

Use of marine animals as models of human physiological processes is helping researchers in the better understanding and in treating a variety of diseases and decipher much more.

The darker side of marine environment

Role of ocean in spreading diseases

Ocean is home to several types of disease causing viruses and bacteria (pathogens). The water borne disease can either originate in ocean or originate on land and be transmitted through sea water. Most water borne agents enter the human body when people eat tainted seafood or swallow contaminated sea water. Some agents can however enter through broken skin or mucous membrane. The free swimming larvae of Avian Schistosomes can even penetrate unbroken human skin causing a problem called Swimmer's Itch.

Microbes belonging to genus *Vibrio* are an example of bacterial pathogens that originate in the ocean. Most

common *Vibrio* infections are caused by *Vibrio vulnificus* and *V. parahaemolyticus* and infections occur most frequently in Gulf Coast region.

Threat of harmful algal blooms

Microscopic marine algae called phytoplankton serve a similar role in sea as do the plants on land. However some of them produce toxins that are harmful to human beings. Algal toxins can interfere with neural processes causing paralysis, amnesia, nausea, diarrhea, respiratory distress depending upon the toxin produced.

In addition to producing toxins, phytoplankton can multiply in enormous numbers and when they die, the decay process depletes oxygen causing fish and other sea creatures to flee or perish. Harmful algal blooms also known as 'red tides' may pose a serious threat to the health of humans and marine ecosystems alike.

Scientists are now developing exciting new technologies for identifying algal blooms, including way to spot them from space. Scientists have also been designing a number of promising tools to detect the presence of algal toxins rapidly and to track their route of transfer in the environment. Being able to predict when an algal bloom will become dangerous for humans, would make health officials better prepared to make management decisions that protect the public from exposure, such as temporary beach and fishing closures.

Conclusion

The benefits of ocean and ocean sciences for improving our health and well being are enormous. The discovery of marine derived medicines, research tools and other products coupled with basic and applied research leading to new discoveries are already improving the lives of people all around the world. Ocean is essential for developing effective ways of protecting communities from harmful toxins such as those produced by harmful algal blooms and dangerous pathogens such as *Vibrio cholerae* as well as potential dangers from sewage leaks transmitted through sea. Exciting new researches on mechanisms of disease transmission can help public health systems in preventing human exposure to illness in costal areas and hundreds of miles inland.

The ocean touches the lives of billions of people in countless ways. Ocean helps us to predict and mitigate various threats we face and to develop new products to improve human health.

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Agarolytic bacteria from brackishwater of Bhitarkanika mangroves, Orissa

Several reports are available on microbial agarase (which degrades agar) from marine habitat (Ohta *et al.*, 2004; Wang *et al.*, 2004). Few bacteria, such as *Pseudomonas*, *Bacillus*, *Arthrobactor*, *Alteromonas*, etc., have been reported as agarase enzyme producers (Osumi *et al.*, 1998; Kim *et al.*, 1999; Kirimura *et al.*, 1999; Lee *et al.*, 2000; Kang *et al.*, 2003; Suzuki *et al.*, 2003). As the Bhitarkanika mangrove has not been studied thoroughly in this regard so far, an attempt has been made to isolate and characterize the agarolytic bacteria from this mangrove.

Bhitarkanika mangroves is situated in the State of Orissa (20° 4′–20° 8′ N latitude; 86° 45′–87° 50′ E longitude) along the east coast of India. For this study, 37 water samples were collected from six different zones of Bhitarkanika area: Khola (11 samples), Balizore (12 samples), Dangmal (4 samples), Bramhamari creeks (3 samples), Mahishmari creeks (3 samples) and Brahmani (4 samples). The water samples were collected in the month of April 2005, on a single day, using a country boat.

The bacteria were isolated from the water samples on seawater agar medium (Hi Media) containing peptic digest of animal tissue (5 g), yeast extract (5 g), beef extract (3 g), sodium chloride (24 g), potassium chloride (0.7 g), magnesium chloride (5.3 g), magnesium sulphate (7.0 g) and agar (15 g) of pH 7.0. Various types of bacteria with different morphologies, textures and colours were obtained. Among them the present bacterial isolate formed a clear zone around its colony in the Petri plates, which were subjected to analyse the population count of bacteria and zone-forming bacteria. Subsequent sub-culturing of the isolates in the same medium also showed agar depression around the bacterial growth.

The bacterial isolate produced almond coloured, slimy, opaque and irregular colony within 72 h of growth at 30°C. It was non-motile, gram-positive cocci. It was positive to methyl red test and negative to catalase, citrate, VP and H_2S. The isolate produced acid from sucrose, dextrose, lactose, manitol and glycerol. No growth was observed in pH of 9.6. Based on cultural, morphological and biochemical tests, the isolate was identified as *Streptococcus* sp.

The isolate was subjected to salt treatment while grown in the seawater agar medium supplemented with 1–20% NaCl. Data on the growth of bacteria and zone diameter after 96 h of incubation were collected.

The total count of bacteria exhibited variation among water samples studied. The maximum bacterial count was found in Khola region (Table 1). The highest count of zone-forming bacteria was found in the Balizore region. The zone-forming isolate was found in almost all water samples collected from various zones. The maximum percentages of zone-forming bacterial counts were observed in Balizore and Dangmal regions, which had low salinity. The higher count of agarolytic bacteria was detected in low saline brackishwater than that in the open seawater. The variation in occurrence of the bacteria may be due to the difference in the level of salinity in the study area (Shome *et al.*, 2000). The pH of water samples ranged between 6.75 and 8.12.

Table 1. Total and agarolytic bacteria in the waters of six zones in Bhitarkanika mangrove

Sampling places	Total bacterial count ($\times 10^6$ CFU/ml)	Agarolytic bacterial counts	
		($\times 10^6$ CFU/ml)	Percentage
Khola	2–39	0–2	0–25
Balizore	3–15	0–4	0–40
Dangmal	3–19	1–3	5–33
Bramhamari	0–19	0–3	0–16
Mahishmari	4–32	0–2	0–25
Brahmani	7–23	0–4	0–17

Experiment conducted to find out the influence of salt stress on the growth and zone formation showed decrease in growth and zone formation with increasing concentration of NaCl (Table 2). The growth of bacteria was best under controlled condition of seawater agar when only 2% NaCl was present. Results showed inhibition of growth of bacteria under high salinity which also indirectly affected the enzyme activity. This observation is in agreement with the finding of Shome *et al.* (2000) who reported that percentage of agarolytic bacteria varies with salinity and physicochemical properties of sediments. Ohta *et al.* (2004), however, reported that b-agarase enzyme is not inhibited by high saline conditions. Kang *et al.* (2003) reported the stability of agarase enzyme from *Pseudomonas* at high pH of 8–9. The results of the present study are significant as the bacteria isolated from the Bhitarkanika mangroves and their agarase enzyme activity are salt tolerant which may be favourable for industrial use.

Table 2. Effect of NaCl on growth and agarolytic activity of bacteria

Concentration of NaCl (%)	Growth of colony (cm^2)	Agar clearing zone (cm)
1	15	3.3
2	14	3.2
3	12	2.8
4	10	2.6
5	5	1.5

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Fig. 2. The priest (standing in the middle) showing a site of Auranga river mangroves which is being protected.

The above two examples show how local communities have conserved their mangrove resources without the intervention of outside agencies including the forest department. These efforts have been the result of awareness among the community members about the importance and uses of mangroves.

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Contact : Conference Secretary: *e-mail*: icest@vip. 163.com
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Date : **26–29 April 2010**
Title : Biotech world 2010: Startups and Biotechnology
Venue : Oran, Algeria
Contact : Organization committee: *tel*.: +213-771-337-781; *fax*: +213-41-31-96-03; *e-mail*: biotech-oran2010@aca-dz.org
Website: : <http://www.biotex.webnode.com>

Date : **28–29 April 2010**
Title : Water and Environment 2010: CIWEM's Annual Conference
Venue : Olympia Conference Centre, London, UK
Organized by : Bob Earll, CMS
Contact : Lauren Goozee
Website : <http://www.ciwem.org/events/annual_conference>

Date : **3–5 May 2010**
Title : Environmental Economics 2010: Third International Conference on Environmental Economics and Investment Assessment
Venue : Limasoll, Cyprus
Organized by : Wessex Institute of Technology, UK, and The National Technical University of Athens, Greece
Contact : Claire Shiell, Conference Secretariat, Environmental Economics 2010, Wessex Institute of Technology, Ashurst Lodge, Ashurst, Southampton, SO40 7AA, UK. *Tel*.: +44-(0)-238-029-3223; *fax*: +44-(0)-238-029-2853; *e-mail*: cshiell@wessex.ac.uk
Website : <http://www.wessex.ac.uk/10-conferences/environmental-economics-2010.html>

Date : **4–6 May 2010**
Title : Environmental Toxicology 2010: Third International Conference on Environmental Toxicology
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Organized by : Wessex Institute of Technology, UK
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Date : **11–13 July 2010**
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Venue : Mansfield College, Oxford
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