



Enviroscan

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From the Editor's Desk

This is the second issue of the Newsletter as also the research programme the Centre for Environmental Studies (CES) has undertaken. It has been most encouraging for the editorial staff of the CES about the way in which the first issue of *Enviroscan* has been received. Both appreciation and shortcomings pointed out by the readers have been welcomed by the editor in equal measure. In the present issue, a variety of research topics has been covered while still largely addressing the problems of the coastal ecology. The first article deals with the coastal erosion which largely includes beaches facing two types of waves, constructive and destructive. The destructive action of the waves predominates and, as a result, a large area of the coastline gets lost every year. Some of the remedial measures to control erosion have also been indicated. The second article on Deep Sea Mining is of great potential value for the future. The polymetallic nodules which cover a very large area of the seabed of the Indian Ocean are most promising for the extraction of strategic metals from them.

The next article gives a realistic account of researches on coral reefs in the country. It is really unfortunate that coral research which thrived in India for several decades, largely because of the efforts made by Dr. CSG Pillai, has come to an abrupt end. He was in his time not only an authority on coral reefs in India but was also recognised as one of the best coral taxonomists globally. He was working at the Mandapam Camp which was the Headquarter of the Central Marine Fisheries Research Institute (CMFRI) at that time, and a number of fringing-type of coral reefs fell within an easy reach of scientists. After Pillai, the next person in the country who has developed interest on corals and coral reefs is the author of the present article Dr. M.V.M. Wafar. His article is followed by an account on microbes which play a very important ecological role in the marine environment, including the coastal areas. The next article on the Notification of India's Draft Coastal Management Zone (CMZ) has been reviewed and some shortcomings have been pointed out. A number of suggestions have also been made on the improvements required in the Notification. The last article is a very realistic approach to the Indoor Air quality and its effect, which we are all facing today either working in our offices or while staying at home.

The wide array of topics covered in the present Newsletter gives a brief coverage of the diverse problems that we face in modern times, including in the coastal and marine environments. We are sure that the second issue of the Newsletter will prove to be as stimulating to the scientific and academic groups as the previous one did.

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Dr. S.Z. Qasim

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Plans provide for a sustained mechanism of support for reef work, but it is limited to only monitoring and management. Most other support is of ad hoc nature to diverse individual projects, often with a perceptible level of duplication. My suggestion is that we need to identify major targeted research areas, eg. Global warming, and channelise more funding for that instead of supporting projects in a piece-meal manner. This would call for a 'visionary' funding strategy and collective wisdom of the several funding agencies concerned now with reef research in India.

This article does not attempt to describe Indian reefs, their resources and threats to them, but rather to analyse some limitations to our efforts in reef research. The idea is to only point out the weaknesses that could be easily overcome and could make Indian reef research more rewarding and appreciable.



ROLE OF MICROBES IN THE ECOLOGY OF MARINE ENVIRONMENT

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Microbes are mostly unicellular microscopic living entities falling under the domains Bacteria, Archaea and Eukarya. They have multiple roles to play in the environment both for their own survival and towards maintaining ecological balance. A few such examples with regard to the microbes in the marine environment are discussed here.

The size of these microscopic organisms ranges from 1-10 µm. They have multiple roles to play as primary and secondary producers, degraders and mediators of many redox reactions. They also serve as food-source directly or indirectly in trophic webs. Microorganisms, in contrast to their small size, underpin many of the largest biogeochemical processes, which were earlier thought to be driven by chemical reactions alone. They participate in both oxidative and reductive cycles of carbon thus mediating either degradation or synthesis. Major processes mediated by these communities like the elemental cycles of carbon, nitrogen, and sulphur and are now increasingly being recognized to have a significant role in sustaining the balance in an environment.

Based on trophic status, heterotrophic bacteria (those which use organic carbon as the source of food) are some of the important groups. Chemosynthetic (those capable of fixing inorganic

carbon) microbial communities could be equally widespread. Archaea (both autotrophic and heterotrophic), non-photosynthetic protists, and extremely tiny (<2 µm) picoplankton are the other important groups. These communities regulate the supply of nutrients to the ocean's food webs.

Microbes are also significant in terms of biomass. They occur in the range of 10^7 - 10^9 cells per litre. In the marine environment they account for over 90% of the total biomass. There are estimated to be around 3.6×10^{30} microbial cells with a cellular carbon content of 3×10^{-17} grams per cell. The various ecological activities of the microbes can briefly be described as follows:

Metabolic diversity

Bacteria match their abundance and ubiquity by their versatility in metabolic activities.

The flexibility of bacterial metabolism is best illustrated by their ability to degrade xenobiotics and recalcitrant molecules. Such metabolic adaptation involves mechanism such as horizontal gene transfer (HGT), mutations, and DNA rearrangements.

Interactions and applications

Microbes efficiently modify and restore environmental conditions. Bioremediation is a technology of recovering from environmental pollution. The technique utilizes microorganisms for the bio-transformation of hazardous chemical substances like crude oil, sulfur compounds and aromatic hydrocarbons that otherwise tend to accumulate and magnify along the food chains. Marine microbes show promise for expanding this new technology.

- a) Interaction with metal ions : Bacterial interactions with metals have been used either to leach metals or to precipitate them as oxides or sulfides. The moderately thermophilic acidophile *Acidithiobacillus caldus* is a chemolithotroph that obtains energy for growth from reduced inorganic sulphur compounds but not from metal sulfides. Nevertheless, the organism can grow by the oxidation of sulfur while attached to the surface of pyrite. *At. caldus* has been found in the planktonic cell population of two pilot scale leaching bioreactors created to study the oxidation of arsenical pyrite and chalcopyrite. *At. caldus* has also been found in a full-scale arsenopyrite bio-leaching plant used for the recovery of gold. Others like *Halothiobacillus hydrothermalis*, *H. halophilus*, *Halothiobacillus neapolitanus*, *Halothiobacillus kellyi* and *Thiomicrospira* sp. are also thought to be important in bio-leaching. Sulfate reducing activity of bacteria has also

been gainfully used to precipitate metal as sulfides



Fig.1: Magnified view of microbes on the surface of pyrite. The bacteria are about 4 microns long.

Source: <http://www.ocean.udel.edu/deepsea/level-2/chemistry/bacteria.html>

- b) Interaction with organics : Besides mitigation of heavy metals in the environment, microbes also control organics. Biological treatment of hypersaline waste brines to reduce organics could reduce the environmental impact and cost of waste disposal. For example a halophilic *Alteromonas* isolate known to degrade organophosphate compounds, including a nerve-gas has been observed and an enzyme showing organophosphorus anhydase activity has been purified from a halophilic sulphate reducer.
- c) Interaction with biopolymers : Biopolymers like cellulose and xylanase are also easily degraded by bacterial action. The production of hemicellulose degrading enzymes, α -xylanase and α -xylosidase has been encountered in the extreme halophilic archaeon *Halorhabdus utahensis* from the Great Salt Lake, Utah, USA. Xylanases have been reported in mesophilic bacteria, marine algae, fungi, invertebrates, plants, psychrophilic fungi, thermophilic bacteria and alkalophilic microorganisms. Degradation of cellulose by halophilic bacteria has also been recorded.

Thus, many of the activities of microbes belonging to taxonomically diverse groups could be beneficial to the environment because they set the elemental cycle moving in a dynamic balance.

The social strife among microbial communities is revealing. It leads to interactions between prokaryotes and eukaryotes, as in symbiotic gut microorganisms, and among prokaryotes, as expressed in quorum sensing and biofilms. Thus, they are equally efficient in existing singly as in well as exercising division of labour, which was earlier thought to be the domain of multicellular organisms alone.

- (I) Biofilms : The role of biofilms in the pathogenesis of some chronic bacterial infections is now widely accepted. Biofilm

formation capacity is greatly influenced by environmental stress conditions like reduced water availability, affecting dynamics, development, and ultrastructural properties. This has been demonstrated with *Pseudomonas putida* and *Pseudomonas aeruginosa*.

- (ii) Pathogenesis and virulence of bacteria are often realised as acquired characters. Although Archaea have not been described as pathogens, recent molecular studies reveal that genetic mutations and processes like horizontal gene transfer might have been actually responsible in contributing to bacterial virulence from archaeal genes.
- (iii) Symbiosis : There is a growing realisation that a mutualistic relationship has evolved from pathogenesis as these phenomena involve similar means of infecting the hosts. Symbiosis between bacteria and primitive organisms was an absolute necessity for the diversity and evolution of multicellular organisms.

In the microscopic examination of thermophilic archaeon *Ignioccus* spp., *Nanoarchaea equitans*, a tiny archeon, was recognized as an attached symbiont. This symbiotic pair was isolated from a hot submarine vent in the Kolbeinsey Ridge, north of Iceland. *N. equitans* was later classified as a novel phylum of archaea, the nanoarchaeota. Some bacteria, particularly sulphate reducing forms, generally associate themselves syntrophically with others and thus synergize many biogeochemical reactions.

Taxonomic diversity

The metabolic diversity of microbes is matched by taxonomic diversity. Owing to limitation in traditional detection techniques, which requires growth of organisms, less than one per cent of all bacterial species have been described to date.

Although culture-based studies have limited ability to estimate bacterial diversity, they have demonstrated the wide variety of metabolic modes in bacteria, routes of energy conversion and ranges of substrates used. In some instances, culturable methods have reaped considerably large orders of bacterial genera while molecular methods failed to detect the whole lineage of the same. Recent biomarker based techniques such as DNA analysis have, however, enabled the detection of non-culturable species, and have allowed a more complete detailed picture of bacterial communities to be developed. Current culture independent estimates of the number of prokaryotic species in a gram of soil range from several hundred to nearly nine thousand orders of magnitude greater than the estimates based on culture-dependent approaches.



Fig.2: The red of these volcanic rocks is produced by *Sulfolobus solfataricus*, extremophilic micro-organisms that thrive in the Solfatara volcanic area near Naples, Italy.

Source: http://science.nasa.gov/current/event/ast30a/pr99_1.htm

Traditionally, microbiologists believed that microbes, especially bacteria, had high dispersal rates and that there is a general absence of biogeographic pattern for free-living micro-organisms. Recent studies, however, show that bacterial endemism does exist, and at least a few taxa can exhibit biogeographic patterns. The strongest evidence to date for biological pattern in prokaryotic organisms comes from recent studies of the hot spring archaeon *Sulfolobus* from five geographically distinct regions: a significant correlation was found between genetic distance and geographical distance.

Evolution and exobiology

It is estimated that there could be 10 billion species of bacteria on earth and they represent a very significant proportion of the Earth's evolutionary diversity. Evolution is no longer believed to be hierarchical but reticulate. It therefore appears that, apart from the phylogenetic lineage formation from the universal common ancestor, horizontal gene transfer plays an important role in passing of information across unrelated groups.

Ubiquity of microbes is not restricted to the normal world occupied by the rest of the life forms. Microbes are known to inhabit the extreme limits on the Living Planet in which existence of life was difficult to imagine earlier. New questions therefore arise about the appearance of life on Earth. For example, protective effect of salt on extreme halophiles helped them to survive very long periods of dormancy. Scientists now dare to imagine that such unusual properties might have actually helped in seeding life on Earth from extra-terrestrial sources. Thus, while meteorites and cosmic dusts might have 'inoculated' our planet with life, the presence of frozen methane in the satellite Triton might actually have possibilities of harbouring methane forming and methane utilizing microorganisms.

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