Microbes to the rescue

The sea reacts to an oil spill like a living thing in distress, says s ananthanarayanan

AN animal reacts to injury or sickness by diverting resources to tissue repair or overcoming infection. Other energy-consuming processes may be placed on hold till the urgent demands are met and resumed when the emergency is over. It is found that in the sea, too, when an oil spill occurs, an insignificant number of oil-digesting microbes that are present multiply a billionfold, till the oil that spread over and dispersed in the water is significantly reduced.

The *Environmental Science & Technology* journal carries as its cover story a paper on microbial activity at the sites of the two worst oil spills in US history authored by Terry Hazen, microbial ecologist with the Lawrence Berkeley National Laboratory, and Ron Atlas, professor at the University of Louisville.

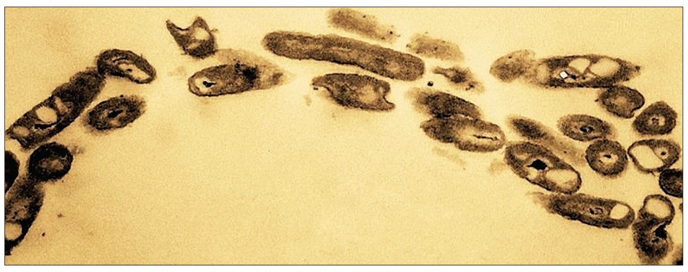
Environmental disasters happen when a large quantity of mineral oil is released at sea, usually through damage to an oil-carrying ocean liner or an accident at an oilrig.

Millions of litres of oil spread over hundreds of kilometres of sea surface and cause huge losses of fish and bird populations, including seals and large whales. Oil in the feathers and fur of birds or animals alters their temperature regulation systems, renders them easy prey to predators and also acts to poison them. The oil on the water surface reflects sunlight, limiting underwater photosynthesis and affecting plant life and, thereby, the whole food chain. The oil slick can float on to beaches and shores and clog them with a thick layer, affecting life and navigation. The oil cover is also a fire hazard for ships and personnel engaged in controlling the spread of the spill.

Major oil spill events include the Kuwaiti oil fires spills during the Gulf War and the more recent BP Deepwater Horizon oil spill in the Gulf of Mexico. The last case, of April 2010, arose from a blown oil well that pumped out nearly a million tonnes of mineral oil for three months.


Gulf of Mexico oil spill


Victims of BP oil spill


Alcanivorax borkumensis is a rod-shaped bacteria that relies on oil to provide it with energy. Relatively rare in unpolluted seas, it quickly comes to dominate the marine microbial ecosystem after an oil spill and it can be found throughout the oceans.

The damage to sea life was unprecedented and nearly 800 km of coastline stayed contaminated as late as July 2011. Closer home, though not of the same scale, are the ONGC pipeline burst at Uran in January 2011 and the recent oil-carrier, *MV Rak*, which sank off the coast of Mumbai.

Oil contamination of the sea, of course, needs to be eliminated, finally, only by microbial degradation, over months. The physical measures taken are only for containment of damage and risks and pollution of beaches. Chemical sprays that herd the oil into globules and accelerate biodegradation are used to help the natural process. When conditions are right, limited areas of oil spread may be destroyed by burning. Chemical agents can be used to thin and spread the spill so that it disperses, but this can also lead to an undesirable spread or even contamination due to the chemicals. Sometimes, physical booms or floating dams prevent the spread to sensitive areas.

Contamination itself is also limited by physically skimming off the surface oil or sucking it up with vacuum cleaners. Water channels may need dredging and shores and beaches often need to be cleaned using mechanical shovels and earthmovers.

Biological agents

The paper of Terry Hazen and Ron Atlas emphasises the role of micro-organisms that rush into action when the environment is struck by pollution of oil spills. They have studied two major disasters — the Exxon Valdez spill of 1989, where an oil tanker struck a reef and spilled about 100,000 tonnes of crude oil off the coast of Alaska, and the recent BP accident in the Gulf of Mexico. Despite the differences in time and circumstances of the two cases, the team found that microbial degradation played the significant role.

"Responders to future oil spills would do well to mobilise as rapidly as possible to determine both natural and enhanced microbial degradation and what the best possible approach will be to minimise the risk and impact of the spill on the environment," says Hazen. "The fate of all oil spills will depend upon a unique set of circumstances that will govern risk and impacts, including the volume of oil spilled, the chemical nature of the oil, and the ecosystems with their specific environmental conditions impacted by the spilled oil," he says. "However, the one common denominator is the cosmopolitan nature of oil-degrading microbes."

Petroleum hydrocarbons in crude oils are basically derived from vegetable matter, including aquatic algae, buried below the seas more than 100 million years ago. These hydrocarbons thus regularly leak out of underground reservoirs, especially at the sea floor, and in the sea a host of micro-organisms have evolved to use this as food and energy sources. The organisms are found everywhere, but not in any significant numbers, as petroleum hydrocarbons, some 250 million litres a year worldwide, form only a small component of any ecosystem. But come an oil spill and micro-organisms in the region discover not only an unlimited food source but also the reduction of competing life forms, including predators. Micro-organisms have very fast reproduction rates – e-coli, for instance, undergoes cell division every 20 minutes. The result is that unhampered growth of oil-degrading organisms leads to vast forces being generated very early and the mobilisation by the sea itself dwarfs the physical efforts of coastal and state agencies.

While the physical removal of oil soon becomes impractical, especially of what has moved below the surface, the active solution is to facilitate the action of microbial oil scrubbers. The addition of nitrogen fertiliser and also agents to spread the oil and increase the surface area for microbes to act has been found to speed up the action of microbes. "Field tests showed that the addition of fertiliser could help attain petroleum-hydrocarbon losses as high as 1.2 per cent per day," says Hazen.

The oil slick deposited on the shoreline in the Exxon Valdez case was reduced by 30 per cent within weeks. The case of the BP Deepwater Horizon spill was 10 times larger and needed a different strategy to control. With the focus on preventing the oil from reaching the shoreline, burns, skimming, siphoning, containment booms, shoreline beams and beach sand mixing, all were employed. In addition, chemical dispersion agents were employed, even if mainly for the safety of relief operation directly around the well.

But it was found that in the highly dispersed cloud, the microbial action was more intense than elsewhere. Hazen and his team found that the species of microbes native to the region, as well as one newly discovered species, "degraded the oil plume to virtually undetectable levels within a few weeks".

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Throwback to the first life forms

steve connor **reports on the discovery of the oldest known fossils that prove life began more than 3.4 billion years ago**

THE fossilised remains of the oldest known lifeforms on earth have been discovered in samples of rock collected near a remote watering hole in the middle of the Australian Outback. Scientists said the microscopic fossils belonged to primitive bacteria that lived more than 3.4 billion years ago, when the earth had emerged from a period when it was probably too hostile for life. These primitive microbes used sulphur instead of oxygen to generate energy from food and, the scientists said, they may be the closest that science will ever get to the mysterious origin of life on our planet.

The fossils were found in rocks that were originally formed in shallow seas near a coastline and suggest that beaches may have been the key habitat where the earth's first lifeforms thrived, said David Wacey of the University of Western Australia. "The environment in which the microfossils were found is important – it extends the record of life in shoreline or beach-like environments by about 200 million years. This suggests that beaches could have been the setting for the origin of life itself. The discovery gives good solid evidence for life over 3.4 billion years ago. It confirms there were bacteria at this time, living without oxygen."

Earth is estimated to be about 4.5 billion years old but the planet' hostile, meteorite-bombarded environment is thought to have been too inhospitable for life to get going until about 3.8 billion years ago. Previous studies have indicated the presence of similar microfossils in 3.5 billion-year-old rocks but these claims have been disputed. The latest microfossils have been subjected to an exhaustive series of tests that confirmed that they were once living cells, not merely the product of non-living chemical reactions. They were discovered in rock that was sandwiched between layers from two well-dated volcanic eruptions, which narrowed the fossils'date of origin to within a few tens of millions of years.

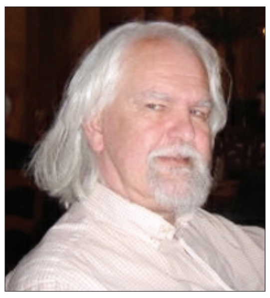
"That's very accurate when the rocks are 3.4 billion years old," said Professor Martin Brasier of the University of Oxford, co-leader of the study, published in the journal *Nature Geoscience*. "At last we have good solid evidence for life over 3.4 billion years ago. It confirms there were bacteria at this time, living without oxygen. Such bacteria are still common today. Sulphur bacteria are found in smelly ditches, soil, hot springs, hydrothermal vents – anywhere where there's little free oxygen and they can live off organic matter."

Oxygen appeared in significant quantities in the atmosphere only after the evolution many millions of years later of plant-like microbes which could use sunlight for photosynthesis, producing oxygen as a byproduct. Until that point, life on earth had to make do with sulphur, which can be metabolised in a similar way to obtain energy from food. "I believe we are as close as we have ever been to the very first microbes here... The problem we now have is that there are very few rocks older on earth in which to search for anything more primitive," Dr Wacey said.

The microfossils were in the Pilbara, a remote region of Western Australia with a harsh environment of spiky vegetation and red dust.

The Independent, London


Dr David Wacey


Professor Martin Brasier


This landscape in Western Australia is home to these very ancient fossil cells.

Use value

Modern equipment and techniques of application have enhanced the power of fungicides, writes tapan kumar maitra

FUNGICIDES used during vegetation protect different parts of plants against fungi and bacteria.

With respect to the nature of their action, their behaviour in plants and their properties, they can be divided into several groups:

- Contact formulations with a protective action effective against pathogen such as downy mildew (grape mildew, late blight of potatoes and tomatoes, blue mould of tobacco and sugar beets, etc.) This group includes inorganic copper compounds, derivatives of dithiocarbamic and phthalic acids and dithianon.
- Contact formulations with a protective and curative action effective against diseases caused by powdery mildew. These fungi have an external mycelium and can be suppressed (oidium of grapes, American powdery mildew of gooseberries, powdery mildew of apples, cucumbers, etc.) This group includes compounds of inorganic sulphur, nitro-derivatives of phenol as well as formulations of other groups of chemical structure — FDN and quinomethionate. All these substances, characterised by an acaricidal action, are effective in controlling scab and blight. EPTC is a fungicide with a broad spectrum of action and is also effective in controlling gray mould and grape mildew. The fungicides dodine and anilat are narrowly specialised: the former is used to control apple scab, and the latter, the rust of grain crops.
- Systemic formulations relating in their chemical structure to different groups. The greatest favour in practical work has been found by benzimidazole derivatives — benomyl, carbendazim — and also thiaphanate methyl and pyrazophos. They are toxic to many pathogens except phycomycetes. The phosphorothioic acid derivative IBP is effective against rice pyriculiariosis.


Chemicals are extensively used to control late blight.

One of the features of using fungicides on vegetating plants is the plurality of treatments (from two to six). The reason is that most of the substances used are characterised by a low persistence, which is determined by the retaining of the toxicant on the treated surface in fungicidal doses and usually ranges from five to 25 days.


Similar symptoms in soybean: caused by sudden death syndrome (top) and tebuconazole phytotoxicity.

Consequently, to ensure reliable protection of plants in the vegetation period, fungicide treatments must be repeated every five to 25 days. A major role is played by the proper choice of the treatment time. As a rule, treatment with protective fungicides must precede the infection of plants, preventing it, or must be performed soon after infection, preventing the spreading of the disease.

The effectiveness and reliability of protection are determined by how uniformly a fungicide covers the different parts of plants. All the leaves of plants, both outside and inside the crown, must be uniformly coated with the formulation. Dripping of the working-liquid from leaves must never be tolerated

The thoroughness of treatments is achieved by the use of modern equipment, low-volume spraying and by the proper choice of the rates of use of the working liquid.

Unlike contact fungicides, the duration of whose protective effect is determined by how long they remain on the surface of foliage, systemic formulations penetrate into plants, move in and intoxicate plants, inhibiting the development of a fungus's mycelium inside a plant. They are distinguished by their persistence, more uniform distribution over a plant and their effectiveness depends to a smaller extent on the amount of atmospheric precipitation after a treatment.

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