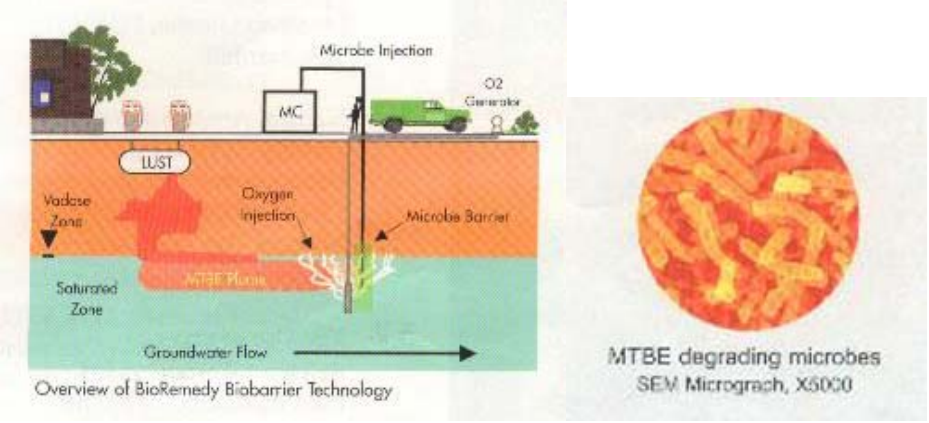
BIOREMEDIATION

Bioremediation is a remediation technology using biological systems to cope pollution problems. "Bioremediation is an ecologically sound and state-of-the-art technique that employs contaminants"(Dr. Barware All). "Bioremediation is the process of using bacteria and other biological enhancements under controlled conditions to control pollution caused by different components of gasoline and fuel oxygenates in the contaminated land and groundwater"(David Laughlin and Randy Mueller).

Biological enhancements to degrade gasoline and fuel oxygenates developed so far are enzyme-catalyzed Dissolved Oxygen In Situ Treatment (DO-IT), Iso-Gen Technology, Cl-out microbes (patented pseudomonas species) and MC-100/ SC-100 a mixed consortium of organisms/ a single culture of organisms used for in-situ MTBE degradation. Phytoremediation using living green plants to clean-up or remediate sites by removing pollutants from soil and water has recently been successfully demonstrated. The invention of EM Technology has unfolded its tremendous success to eliminate and detoxify harmful pollutants carried by sewage and industrial wastes.

DO-IT technology includes a unique equipment platform, the Super-Ox, which contains a specialized pure-oxygen mixing process that generates high dissolved oxygen water at concentrations of approximately 40 ppm. The DO is very stable and results in faster complete contaminant degradation. The Super-Ox injects the oxygenated biologically enhanced water into the subsurface to support continuous microbial activity. The DO-IT system has successfully degraded the dissolved-phase of MTBE (methyl tertiary-butyl ether) and reduced over 90% of benzene. The DO-IT technology optimizes in-situ degradation of organic compounds, including a range of petroleum contaminants, BTEX (benzene, toluene, ethyl benzene & xylene as well as difficult compounds like MTBE.
[-*http://www.teri.res.in/teriin/news/terivsn/issue7/newsbrk.htm*
- *David Laughlin and Randy Mueller: Contaminated Soil Sediment & Water, a magazine of environmental assessment and remediation, Nov-Dec 2002*].

In-situ bioremediation of MTBE (BioRemedy Biobarrier Technology) degradation occurs in the ground and eliminates the need for extracting groundwater, above ground treatment and disposal. An overview of BioRemedy Biobarrier Technology is given for ready reference.



(Contaminated Soil Sediment & Water: The magazine of environmental assessment & remediation, spring 2001.)

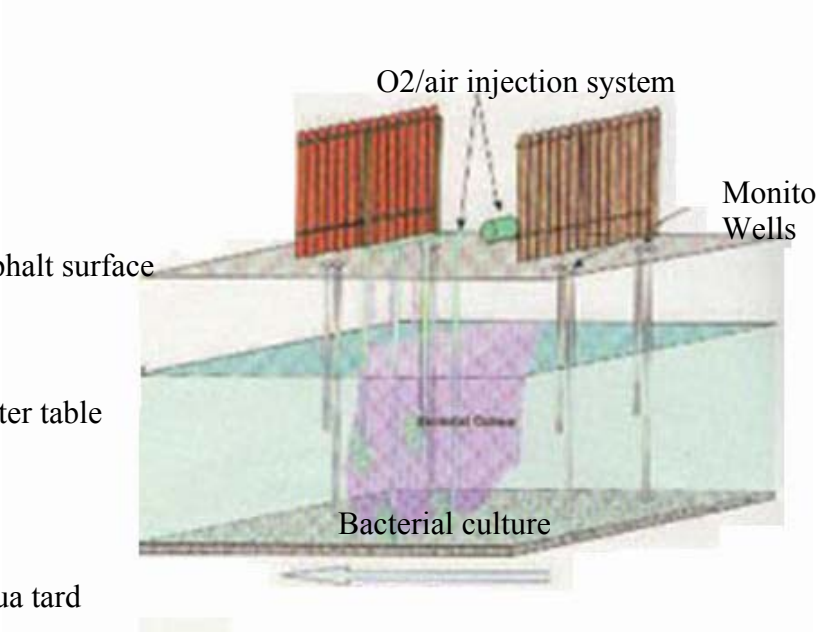
Iso-Gen Technology is also effective in reducing concentrations of MTBE and petroleum hydrocarbons in groundwater at a fuel storage terminal in San Jose, California, USA. Iso-Gen technology consists of: an Iso-Gen controller with an AC voltage rectifier/transformer unit, and an Iso-Gen Downhole Unit consisting primarily of an electrolysis cell, circulation pump, and diffuser tube. The system is capable of producing high levels of dissolved oxygen (10-15 ppm) and affects an area of 12 ft in radius. Iso-Gen technology from H_2O Technologies Limited uses electrolysis to disassociate water into hydrogen and oxygen generating a particular stable-in-solution form of dissolved oxygen (DO). The stable DO is available for microbes to utilize and degrade MTBE and other petroleum hydrocarbons and additives.

Cl-out is comprised of patented pseudomonas species, which have the ability to reduce chlorinated organic contaminants such as tetra-chloro-ethylene (PCE) and try chloroethene (TCE) under aerobic conditions. These are broken down completely under aerobic conditions without harmful byproduct. Cl-out oxidizes chlorinated chemicals using a co-metabolic metabolism, which requires the addition of dextrose to trigger the reactions. A dehalogenating enzyme first removes one chlorine atom from PCE, which has four chlorine atoms, to produce TCE. This allows oxygenases enzymes, probably monooxygenases (MMO), to oxidize TCE forming an epoxide, which is further oxidized to 1,2-didhydroxy-TCE. Then 1,2-didhydroxy-TCE is oxidized completely to carbon dioxide, fatty acids and water. Cl-out bioremediation can be implemented in conjunction with airsparging and groundwater recirculation to accelerate the groundwater remediation by increasing the circulation of Cl-out microbes in the subsurface and augmenting the microbial activity by boosting the dissolved oxygen concentration in the groundwater.

[- *Contaminated Soil Sediment & Water: The magazine of environmental assessment & remediation, June/July 2001*]

MC-100, a mixed microbial culture, and MS-100, a single culture of organisms, developed by Equilon Enterprises, LLC, from the activated sludge at a chemical refinery waste water treatment plant using conventional enrichment practices was used to clean-up dissolved MTBE groundwater plumes. During full scale demonstration a biobarrier was established down gradient in the BTEX/MTBE source zone in order to force the flow of groundwater containing dissolved MTBE to and through the biobarrier as shown in the figure. The biobarrier microorganisms (MC-100 & MS-100) use the MTBE as a fuel source, breaking it down to water and carbon dioxide. The system has the provision for the supply of oxygen to augment bioremediation.

MTBE biobarrier illustration



[- *Contaminated Soil Sediment & Water: The magazine of environmental assessment & remediation, Spring 2001*]

PHYTOREMEDIATION has been successfully deployed to cleaning up groundwater pollution and soil contaminants using different species of living green plants. Growing and harvesting plants on a contaminated site as a remediation method is aesthetically pleasing, solar-energy given, passive techniques that can be used to clean-up sites particularly with shallow, low to moderate levels of contamination.

Plants can breakdown or degrade organic pollutants or contain and stabilize metal contaminant by acting as filters or traps. The plants can uptake and translocate metal contaminants of the soil/groundwater by roots in the above ground portions. The hyper-accumulators plants absorb large amounts of metals in comparison to other plants (phyto-extraction). Certain plant species are able to immobilize contaminants in the soil/groundwater through absorption and accumulation/adsorption/precipitation in the rhizosphere, thus reducing the mobility/migration to the groundwater and air. Phytoremediation is low cost, environmental friendly and effective for a wide range of chemical such as pesticides, solvents, crude oil, polyaromatic hydrocarbons and metals as well.

Man, the most exalted creature, having polluted the environments with sewage, industrial effluent and wastes and gasoline with MTBE and BTEX etc to ensure his own survival has sought the help of invisible scavenger force of Nature i.e. microorganisms (bacteria, actinomycetes and fungi) to control environmental pollution by reducing/eliminating/detoxifying hazardous and harmful pollutants.

EM TECHNOLOGY invented by Prof. Dr. Teruo Higa, Okinawa, Japan, has shown beneficial effects in the field of agriculture, animal husbandry, fisheries and livestock but in particular has brought a revolution in the field of environmental pollution control. Besides success stories of EM Technology in USA, Japan, Germany, Brazil and etc, the use of EM Technology in Pakistan in the filed of tanning and petroleum industry has completely eliminated the obnoxious odor of tanning industry, has converted the solid waste (sludge) of leather industry and petroleum into useful byproduct (biofertilizer). EM treated petroleum sludge was applied to onion crop and produced comparatively larger onions with no residual effect of heavy metals. In case of EM treated tannery's effluent and sludge the concentration of most harmful Cr was reduced from 50,000 ppm to 320 ppm besides minimizing the concentration of heavy metals considerably.

Mechanism of microorganisms in control of environmental pollution is still being explored. However, it is argued that organisms during bioremediation either eat-up/gobble the contaminants especially organic compounds or assimilate heavy metals themselves, thus effectively degrading specific contaminants/ harmful compounds and converting them to non-toxic useable byproducts. Bioremediation of sewage, industrial effluent and solid waste using EM Technology is cost effective, easy practicable and harmless. The byproduct obtained is applicable in floriculture, horticulture and as soil amendment to ameliorate saline-sodic soils.