BIOREMEDIATION AND ITS APPLICATIONS

***G. Bindu Madhavi, S. Bharathi and K. Gurava Reddy,**
RARS, Lam, ANGRAU, Guntur.
***Corresponding author: Email: bindugopireddy@gmail.com**

1. INTRODUCTION

Increased population, industrialization and urbanization are responsible for environmental Contamination. However, in this genomic era development of science and technology facilitates the use of the potential of biological diversity for pollution abatement which is termed as Bioremediation. This is the emerging, efficient and innovative tool for management of a wide array of contaminants. This technology includes phytoremediation (plants) and rhizoremediation (plant and microbe interaction). Most evolved process of bioremediation is Rhizoremediation, which involves the removal of specific contaminants from contaminated sites by mutual interaction of plant roots and suitable microbial flora. Bioremediation is applied to contain contaminants in soil, groundwater, surface water, and sediments including air. These technologies have become sustainable alternatives to conventional cleanup technologies due to relatively low capital costs and easiness in handling

1.1. Advantages of bioremediation

- *In situ* , Passive , Solar driven Costs 10% to 20% of mechanical treatments
- Transfer is faster than natural attenuation
- High public acceptance
- Fewer air and water emissions
- Generate less secondary wastes
- Soils remain in place and are usable following treatment
- Phytovolatilized contaminants could be transformed to less toxic forms (e.g. elemental mercury and dimethyl selenite s)
- phytovolatilization accelerates degradation processes.

1.2. Applications

- Transgenic plants engineered for the transformation of explosives and metabolic pathway engineering for degradation of xenobiotics are in progress (Abhilash *et al* 2009, Van Aken, 2009).
- Herbicide phytoremediation using transgenics is one of the most successful examples.
- Phytoremediation involves the use of certain plants to cleanup soil and water contaminated with inorganics and/or organics.
- Biotechnology and systems biology approaches are also implicated in bioremediation and are gaining considerable importance in fostering bioremediation(De Lorenzo, 2008; Van Aken, 2009)

1.3. Inorganic pollutants

Inorganic pollutants which contaminate land and water bodies include heavy metals, metalloids fluoride and cyanide etc. For healthy functioning of biota low concentrations of some trace elements e.g. Cu, Cr, Mo, Ni, Se and Zn etc. are essential. However, higher concentrations of all essential elements can also cause toxicity. Some trace elements are also nonessential e.g. As, Cd, Hg, and Pb etc. are extremely toxic to biota even at very low concentrations.

Arsenic (As) : It is one of the most toxic elements present in soils and water. Over the years, arsenic has been widely used in agriculture and industrial practices such as pesticides, fertilizers, wood preservatives, smelter wastes and coal combustion ash, which are of great environmental concern, apart from the natural sources. Arsenic contamination affects biological activities as a teratogen, carcinogen and mutagen as well as having detrimental effects on the immune system. The most common manifestations are skin melanosis and keratosis.

2. Strategies for arsenic phytoremediation:

1. The first known arsenic hyperaccumulating plant is *Pteris vittata*. Also known as Chinese brake fern,it was discovered from an arsenic-contaminated site that was contaminated from pressure-treating lumber using chromated-copper-arsenate (CCA). *P. vittata* is reported to accumulate 23 g kg-1 of arsenic in its fronds .In addition to *P. vittata* and *P. cretica*, several other plants have been reported recently including *Pityrogramma calomelanos* and *Pteris longifolia* and *Pteris umbros*
2. Phosphate fertilization of arsenic contaminated soils seems to be one of the feasible strategies for successful phytoremediation using as hyperaccumulating fern viz. *Pteris vittata.*
3. The movement of root exudates in the photosphere mobilization of soil nutrients, have yielded significant results.
4. Prospects of arbuscular mycorrhizal fungi: It has been observed that the Arbuscular mycorrhizal fungus *Glomus mosseae* formed a stable association with Chinese brake fern (*P. vittata* L.) and possessed substantial resistance to arsenic toxicity. Mycorrhizal colonization increased plant biomass and consequently increased the quantity of arsenic removed from the soil by the hyperaccumulator.
5. Grasses as ideal plants for remediation of arsenic contaminated in soil: Poaceae members (grasses) such as *Agrostis castellana, A. delicatula,* and *Holcus lanatus* have played a significant role in revegetation of the arsenic contaminated

soil in SW Europe. Vetiver is a perennial grass with strong ecological adaptability, large biomass and is easy to manage and grow in different soil conditions.

2.1. Mercury: Contamination of mercury is reported to be widespread in India. Genetic strategies, transgenic approaches including the use of microbes will fetch phytoremediation lab and field applications. Elemental mercury, Hg (0), can be a problem because it is oxidized to Hg2+ by biological systems and subsequently is leached into wetlands, waterways, and estuaries. Additionally, mercury can accumulate in animals as methyl mercury (CH3-Hg+), dimethylmercury (CH3)2-Hg) or other organomercury salt. Certain bacteria are capable of pumping metals out of their cell, and/or oxidizing, reducing, or modifying the metal ions to less toxic species. One example is the mer operon. The mer operon contains genes that sense mercury (merB), transport mercury (merT), sequester mercury to the periplasmic space (merP), and reduce mercury (merA). MerB is a subset of the mer operon and is capable of catalyzing the breakdown of various forms of organic mercury to Hg2+ (Heaton *et al* 1998; Pilon-Smits 2000; Rugh *et al* 1996).

2.2. Chromium: Phytoextraction refers to the use of metal accumulating plants that translocate and concentrate metals from the soil in roots and above ground shoots or leaves. Tree species in association with mycorrhizae have shown promising prospects for phytoremediation of Cr contaminated lands in and around tannery industrial areas.

2.3. Fluoride: Excess fluoride in drinking water causes harmful effects such as dental fluorosis and skeletal fluorosis. The high fluoride levels in drinking water and its impact on human health in many parts of India have increased the importance of defl uoridation studies. The fluoride -bearing minerals or fluoride-rich minerals in the rocks and soils are the cause of high fluoride content in the groundwater, is the main source of drinking water in India. Adsorption technique using naturally available adsorbents, especially clays which contain oxides of iron, aluminium and silicon are appropriate for removal of fluoride. Nayagarh district of Orissa, Nalgonda and Mahaboobnagar districts of Andhra Pradesh are some of the the hot spots of fluoride contamination in ground water in India.

3. PESTICIDES:

Research in examining the fate and degradation of pesticides in agricultural soils started over 50 yearsago. In view of the wide range of catabolic reactions mediated by bacterial enzymes. the capacity of bacteria and fungi to degrade xenobiotics is impressive. Options for decontamination of pesticides are: a) Chemical treatment: very expensive b) Incineration: very expensive, c) Landfills: not a permanent solution and d) Bioremediation: is a low cost feasible solution HCH degradation by *Sphingomonas paucimobilis* and endosulfan degrading microbes have been reported. The widespread use of organophosphates (OPs) in agriculture as pesticides has led to serious environmental pollution by these extremely toxic compounds. OPs are the ester forms of phosphoric acid and most widely used insecticides including paraoxon, parathion, or methyl parathion. Naturally occurring soil bacteria have evolved the ability to degrade OPs with the help of an enzyme called organophosphate hydrolase (OPH or phosphotriesterase). OPH catalyzes the hydrolysis of P-O linkage releasing p-nitrophenol as a leaving group. Since the toxicity of OPs is significantly reduced by hydrolysis of phosphoester bonds, many researchers have focused on the initial hydrolysis by OPH. Both the isomers, α-endosulfan and β-endosulfan, are degraded by attack at the sulphite group via either oxidation to form the toxic metabolite endosulfan sulfate, or by hydrolysis to form the nontoxic metabolite, endosulfan diol. Endosulfan sulfate is produced only through biological transformation, whereas, under alkaline conditions endosulfan is converted to diol. *Klebsiella oxytoca , Bacillus spp. Pandoraea sp. and Micrococcus* sp. are the bacteria reported to degrade endosulfan in solutions and soils. Many fungi viz., *Aspergillus niger, A,. terreus, Cladosporium oxysporum, Mucor thermo-hyalospora, Fusarium ventricosum , Phanerochaete chrysosporium Trichoderma harzianum* and algae such as *Anabaena sp. Chlorococcum sp., and Scenedesmus* sp. are implicated in endosulfan degradation.

4. REFERENCES.

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