ISBN: 978-81-968830-8-9

14. Bioremediation

Monika V. Mankar

Department of Chemistry,
School of Pharmaceutical Sciences,
Raigad College of Pharmacy Mohopre,
Raigad, India.

Dr. Viraj H Mankar

Department of Chemistry,
School of Pharmaceutical Sciences,
Raigad College of Pharmacy Mohopre,
Raigad, Maharashtra, India.

Abstract:

Bioremediation is a treatment process that uses biological microorganisms (yeast, fungi, or bacteria) to naturally break down (digest/biodegrade) hazardous substances into less toxic/harmless products. It is a cost effective and natural process, commonly used to treat organics, fuels or solvents. (Organic compounds are those containing carbon and hydrogen atoms). Bioremediation requires optimum level of water, oxygen, heat and nutrients, for healthy bacteria (Microorganisms) growth. This chapter will provide the basics of bioremediation and its benefits and techniques. This will provide the sustainable solutions for green environment.

Keywords:

Bioremediation, pollution, pollutants, effect of bioremediation, solutions on pollution, composts.

14.1 Introduction:

The Explosion rise of global population has led to the increased exploitation of natural resources and sources to respond to the high demands of the population for food, energy and all other requirements. Industrial revolution was a response to those requirements; however, it has been realized in the production of huge number of various organic and inorganic chemicals that have directly and indirectly led to the prolonged pollution to the habitants.

The duration of the contamination is regarded to be because of their difficulty in biodegradability. The trend of environmental pollution is so fast that the detectable rates of contamination are encountered deep in ocean waters. Based on the estimations made by the environmental protection agency (EPA), only around 10% of wastes were safely disposed of.

In addition to the pollutants and toxicants increased from industries that continuously affect the environment and lead to serious occurrence of environmental disasters such as the union-carbide Bhopal disaster and large-scale contamination of the Rhine River the progressive issue.

Furthermore, this reveals the deterioration of the aquatic habitats and conifer forests in the northeast, US, Canada and some parts of Europe. The release of radioactive material in the Chernobyl accident and mostly recently the crises resulted from crude oil pollution. Pollution in Mexican Gulf water and the leakage of the radioactive materials from Fukushima reactor in Japan, these contaminations is known as to be biologically degraded by using microorganisms called Bioremediation.

Bioremediation have been Categorized into five groups, these includes (a) Halogenated aromatic hydrocarbons.(b) munitions wastes (c) organic Solvents (d)pesticides (e) polyatomic hydrocarbons (PAH) (creosote any wastes) PAH pentachlorophenol (pep) polychlorinated biphenyls (PCB) trichloro- bis (4- Chlorophenyl) ethane (DOT) 2- benzene, toluene, ethylbenzene and xylene (BTEX) and trinitrotoluene (TNI) are persistent pollutants in the environment known to exert carcinogenic and mutagenic impacts and have been classified as priority pollutants by EPA.

It has a cost around one trillion USD, to decontaminate toxic waste from states sites in the USA using traditional waste disposal methods, such as incineration and land drilling. Bioremediation is regarded to be an effective and, in the meantime, an economic method for the decontamination of environment.

A. Advantages of Bioremediation:

- Possible to completely breakdown organic contaminants into other nontoxic chemicals
- Equipment requirements are minimal compared to other remediation technologies.
- Can be implemented as an *in-situ* or *Ex-situ* method depending on conditions.
- low cost of treatment per unit Volume of soil or ground water compared to other remediation technologies
- Low technology equipment is required from really available equipment e.g. pumps well drilling equipment's etc.
- Bioremediation is perceived positively by the public because it is a natural process.
- Complete breakdown of pollutants in to nontoxic compounds is possible because the process does not involve transferring of containment to another environmental medium.

B. Disadvantages of Bioremediation:

- If the process of is not Controlled, it is possible the organic contaminants may not be broken down fully resulting in toxic by-products that could be more mobile than the initial contamination.
- The process is sensitivity to the level of toxicity and environment conditions in the ground the conditions must be conducive to microbial activity etc need to consider temperature, pH etc.

14.2 Bioremediation Methods & Techniques:

A. Bioventing: introduction of oxygen in to the soil using forced air to encourage microbial activity nutrients such as nitrogen and phosphorous to be added to the soil to increase the growth rate of microorganisms-

B. Injection of Pumping of ORC's: ORCS (oxygen release compound) are introduced into the soil to encourage microbial activity (similar to bioventing). This method is only used when the ground water is already contaminated because ORCS are in liquid form.

C. Slurry Phase Lagoon Aeration:

Air and soil are combined in a lagoon to encourage microbial activity

a. Contained or Biopires: Soil is excavated and mixed with necessary amendments pies are placed in enclosed buildings and aerated using bowlers and pumps.

b. Composting: Soil is excavated and combined with amendments woods chips to bulk out the soil organic amendments such as hay or manure are also added which increase microbial activity and the process takes places in enclosures called windrows. Open windrow systems stack the compost in entangled pieces and aerate it by treating down and rebuilding piles static windrow. Systems aerate the compost piles by a forced air system shows a diagram of a typical Composting method.

c. Land Farming: Soil excavated and spread in lined treatment beds amendments are sometimes added to the soil is tilled to aerate to as necessary to encourage microbial activity treatment and is enhanced from photoxidation from the sun.

d. Slurry Phase Treatment: A aqueous mixture of soil and water is mixed with amendments stored in tanks and the mixture is continuously stirred to keep Solids suspended to maximize contact area between contaminated soil and microorganisms

D. Ground Water Treatment:

a. Bioasparging:- Air is injected into the groundwater to encourage aerobic biodegradation.

b. Aerobic treatment - Amendments introduced by injection or water recirculating systems into groundwater can include ORC or H_20_2 organic components can convert contaminants to carbon dioxide and water by aerobic treatment which is faster than anaerobic and therefore it is preferred.

c. Anaerobic treatment: Carbon sources such as molasses or hydrogen releasing compounds (HRC) are introduced such as dioxide and traces of hydrogen.

Ex-Situ treatment is decreasing in popularity compared to in situ treatment. In 1991, 35% of treatment work at superfund sites was in-situ compared to 55% in 1999 (USE PA, 2001 a). This is likely due to increasing effectiveness or *in-situ* methods and a desire to avoid

exposing the contaminated soil at the surface where likelihood of human Contamination is increased the most popular and *Ex-Situ* and *in-situ* methods are Bioventing and land forming respectively. An interesting use of Bioremediation is the treatment of acid mine drainage using passive wetlands and surface reducing bacteria.

In aerobic degradation successful bioremediation can be monitored by measuring carbon dioxide and oxygen levels, decreases in oxygen concentration and increases in carbon dioxide concentration signify increased bioactivity.

Bioremediation can be complemented with other technologies Such as Soil vapors extraction and soil washing.

14.3 Types of Bioremediations:

They are three types of Bioremediations and all are used to remove toxic Substances and contaminants from the environment whether they are rivers or crude oils.

A. Biostimulation: Biostimulation is the method in which bacteria are motivated to start the process of bioremediation. In this method, first the experts release nutrients and other important substance in the soil, where there is need or removing the contaminants. They are in the form of grass gas or liquid, which increases the growth of microbes in that area. As a result, bacteria and other microorganisms remove the contaminants quickly and efficiently.

B. Bioaugmentation: In some processes of bioremediation there are some special sites where microorganisms are needed to remove the contaminants for example municipal waste water bioaugmentation is used for that purpose. However, unfortunately this process is not very successful as it is difficult in counter the growth of microorganisms to remove the particular contaminants.

C. Intrinsic Bioremediation: The process of intrinsic bioremediation takes place in soil and water, because these two places are always full of contaminants and toxins. This process is also called as natural attenuation and it also measures of the microorganisms to remove the harmful substances from soil and water. Especially those sites are treated with this method which is underground, for example underground petroleum tanks. It is difficult to know if there is a leakage in the petroleum pipes, containments and toxins find their way to enter in these sites and create harmful effects on the petrol therefore only microorganisms can destroy toxins damage to the human health.

D. Composting Bioremediation Technology: Composting has been used widely for remediation of organic contaminants as it accelerates destruction of containments with proper aeration of water CN ratio and duration composting can degraded various organic compound present in feedlot reported a decomposition of organophosphate and carbamate pesticides during composting. However, organochlorin insecticides are resistant to degradation so organochlorin insecticides have been banned in most countries. Composting may release metals from organic combination through organometallic complexes degradation and increasing metals addition to compost and increases in pH of compost could help reduce the availability of metals.

E. Compositions of Compost: Compost compositions will determine its quality and addition of compost should not lead to Soil pollution. According to World Bank (1997) compost must be of high quality, such that no leaching of heavy metal uptake by plants can occur even under acidic soil conditions. Compost should be directed to develop and maintain soil structure and also improve physical structures properties of soil.

Decreases soil -Susceptibility to erosion encouraging microbial activity as well as providing potentially available plants nutrients. Compost quality is a major factor that could affect both social acceptability and economic value of compost in various developed nations of the world.

F. Environmental Benefit of Composting: A properly managed compost operation promotes clean and readily marketable finished products and also minimises nuisance potential. It is simple to operate and also reduction in land fill space where composting is operated as waste management technique. Reduced surface area and groundwater containment will be phenomenon in landfill. According to WHO 100 million people experiences diarrhoea or contact diseases such as typhoid and cholera through contaminated water, that will be eliminated because of compost formation.

G. Innovative uses of Compost: Each year agricultural effluents, industrial residues and industrial accidents spread contaminants in water, soil, air, streams and reservoirs. A new compost technology known as compost bioremediation is currently being used to restore contaminated soils, manage stream water, control odours, and degrade volatile organic compounds (vocs). Compost bioremediation refers to the use of a biological system of microorganisms in mature, cured compost to sea water to break down contaminants in water. Soil microorganisms consume contaminants in soil, ground and surfaces water and air. The containments are digested metabolized and transformed into humus and inert by-products such as carbon dioxide, water and salts. Compost bioremediation has proven selective in degrading or alternative many types' containments such as chlorinated and non-chlorinated hydrocarbons, wood preserving chemicals, Solvents, heavy metals, pesticides, and petroleum products. Compost used in that is especially made to treat specific contaminants at specific sites.

The ultimate goal in any remediation project is to return the site to its pre-contamination condition which often includes revegetation to stabilize the treated soil. In addition to reducing contaminant levers compost advances this goal by facilitating plant growth. In the role compost provides soil conditioning and also provides nutrients to a wide variety of vegetation.

H. Organic Contaminants: Dr Michael cole, an expert in the degradation of organic contaminants in soil says remediation soil containing 3000 parts per million (ppm) of Dicamba herbicide to non-detectable levels in 50 days. Core mixed wood chips and mature compost make the combined substrate to 10 percent compost and wood chips and 90 Dicamba can eventually degrade in non-amended soil, however that process requires years to degrade. In additional to speeding up the Bioremediation process uses of compost can be also saving money. Traditional remediation by land filling and incineration cost up to five times more than bioremediation by composting technology.

I. Compost Software Fillers: Compost Software fritter (CSF) one type of bioremediatory where cement box with three baffles to allow water to flow. Inside the CSF is designed to remove floating debris, chemical contaminated surface scum and sediment from stormwater by allowing it to pass through layers of specially tailored compost. The porous structure of the compost fritters the physically debris while it degrades the chemical contaminants, scum baffies along the side of the unit trap large flouting debris and surface films.

14.4 Conclusion:

The foremost step to a successful bioremediation is site characterization which helps establish the most suitable and feasible bioremediation technique. *Ex-situ* Bioremediation techniques tend to be more expensive due to additional costs attributed to excavation and transportation; nonetheless they can be used to treat wide range of pollutants in a controlled manner. In contract *in-situ* techniques have no additional cost attributed to excavation, however cost of on-site installation of equipment coupled within inability to effectively visualize and control the substance of polluted site. Some *in-situ* Bioremediation techniques are inefficient. Consequently, cost of remediation apparently is not the major factor that could determine the bioremediation technique to be applied to any polluted site. Geological characterize of polluted sites including soil type, pollutant depth and type site location relative to human habitation and Performance characteristics of each bioremediation technique, they should be incorporated in deciding the most suitable and efficient method to effectively treat polluted sites.

14.5 References:

1. *Yuvraj (2022). "Microalgal Bioremediation: A Clean and Sustainable Approach for Controlling Environmental Pollution". Innovations in Environmental Biotechnology. Vol. 1. Singapore: Springer Singapore. pp. 305–318.*
2. *Singh N, Kumar A, Sharma B (2019). "Role of Fungal Enzymes for Bioremediation of Hazardous Chemicals". Recent Advancement in White Biotechnology Through Fungi. Fungal Biology. Vol. 3. Cham: Springer International Publishing. pp. 237–256*
3. Cole Max liu and I. Rang, 1995; Effect of compost addition on pesticide degradation in planted soils in bioremediation of recalcitrant organics Edited by R.E Hinchee, O.B Anderson and R.E Hoeppel Columbus Battele press.
4. Chaney, R L, and Ryan, J A. 1994. "Risk based standards for arsenic, lead and cadmium in urban soils. Summary of information and methods developed to estimate standards for Cd, Pb and as in urban soils." Germany.
5. Chaney R. Etc 1994, Phytoremediation Potential of Thlaspi Caerulescens and Bladder Campion for Zinc- and Cadmium-Contaminated, Soil *Journal of Environmental Quality, 23(6.)*
6. Fordham Wayne 1995-yard trimmings composting in the Air force Biocycle *Journal of composting and recycling*
7. Gerrand GA TA Grist and RE Green 1995 The com- post story: From soil enrichment to pollution remedia- tion. Biocycle. *36: 53-56. Schroeder*, Philip D. 1997.
8. Schroder philip D. 1997 Restoration of prime farm land they distributed by mineral Soil mining in the upper Costal plants of Viginia master's Thesis viginia tech.