International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Index Copernicus Value (2013): 6.14 | Impact Factor (2013): 4.438

Phytoremediation: An Analytical Technique for the Assessment of Biodegradation of Organic Xenobiotic Pollutants: A Review

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Abstract: ***Phytoremediation is an emerging environmental friendly approach for remediation of contaminated sites using plants, is the matter of great attention from the past few years. Environmental problems are caused mainly due to accumulation of industrial effluents which form xenobiotants. There is an immediate need to degrade these xenobiotic compounds in an eco-friendly way. Various techniques that have been in use are microbial remediation, phytoremediation and photoremediation. Each having its own ways of degradation, and also have some impacts on the environment. This review examines the developments in the use of transgenic plants for the degradation and phytoremediation of organic xenobiotics. From last many years, considerable progress has been made to increase the efficiency and effectiveness of phytoremediation. Still the technique is not widely in use as it could be for the treatment of contaminated sites. Present studies with transgenic plants indicate that specific degradation capabilities can be added to plants for remediation of pollutants.***

Keywords: Phytoremediation, Biodegradation, Xenobiotics, Pollutants

1. Introduction

Biodegradation is the total breakdown of the complex and toxic contaminants into non-toxic elements by the action of microorganism and plants.

Bioremediation is defined as "The use of biological mechanisms to destroy, transform, or immobilize environmental contaminants in order to protect potential sensitive receptors." (Bioremediation Discussion Group, 2006). Bioremediation is the most effective method for the removal of wide variety of organic pollutants. Many compounds that are considered to be hazardous can be converted into harmless products. This eradicates the chance of potential problems associated with treatment and disposal of contaminated material. Phytoremediation is one of the sub-classes of bioremediation.

Phytoremediation–the use of plants for cleaning up of xenobiotic compounds–has received much attention in the last few years and development of transgenic plants customized for remediation will further enhance their potential. Although plants have the inherent ability to detoxify some xenobiotic pollutants, they generally lack the catabolic pathway for complete degradation/mineralization of these compounds compared to microorganisms (Susan Eapen, 2007). Phytoremediation is the use of vegetation for in situ treatment of contaminated soils, sediments, and water. It is applicable at sites containing organic nutrients, or metal pollutants that can be accessed by the roots of plants and sequestered, degraded, immobilized, or metabolized in place. (Schnoor, 2001). Most of the recent studies are based on finding best plant for the job, pollutant transforming mechanism of plants and determining which plants can be use for phytoremediation.

Due to man-made activities and natural processes environmental problems are increasing day by day which is a result of increase in population, industrialization, and urbanization. Since the time of industrial revolution, scientific and technological developments permitted humans for the over exploitation of natural resources and create disturbance to the natural environment.

Phytoremediation is the best solution to the pollution problem. It is the most effective modern technology that uses floral systems for treatment of contaminants. This new and emerging technology is a multidisciplinary approach, and mainly depends on plants.

Phytoremediation is based on one basic principle that is the use of plant that takes the pollutant through the roots. The pollutants can be stored in the plant, volatized by the plant, and metabolized by the plant, or any combination of these techniques.

Some of the most commonly used techniques for phytoremediation are the following.

1. Phytoextraction is the uptake and storage of pollutants in the plants stem or leaves. Some plants, called hyper-accumulators, extract pollutants through the roots (Dzantor, *et al*., 2007). After the pollutants accumulate in the stem and leaves the plants are harvested. Then plants can be either burned or sold. This method is particularly useful when remediating metals.
2. Phytovolatization is the uptake and vaporization of pollutants by a plant. This mechanism takes a solid or liquid contaminant and transforms it to an airborne vapor. The pollutant can be metabolized by the plant before it is vaporized, as in the case of mercury, lead and selenium (Dzantor, *et al*., 2007).
3. Phytodegradation is the metabolization of pollutants by plants. These contaminants accumulate in plants tissues,

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where the plant then degrades the pollutant (Dzantor, *et al*., 2007).

Understanding of these processes needs an interdisciplinary approach involving chemists, biologists, soil scientists, and environmentalists.

The term xenobiotic is derived from Greek where 'xenos' means 'foreign or strange' and 'bios' means life. Xenobiotics compounds are chemicals which are alien to the biosphere. Depending on their fate in air, water, soil or sediment, Xenobiotic pollutants may become available to microorganisms in different environmental compartments. The principal means of transformation and degradation of xenobiotics compounds on earth inhabited in microorganisms (Doty et al., 2008). In natural habitats, the physiochemical properties of the environment may affect and even control biodegradation performances. Substances that are present in abnormally high concentrations can also be considered as xenobiotics. For example, the antibiotic drugs found in the human body are considered as xenobiotics as they are neither produced by human body itself nor a normal part of diet. Even a natural substance can be considered a xenobiotics if it has entered the body of another organism. But this term generally used to refer to a chemical or pollutants that are unfamiliar to almost all living organisms.

Xenobiotics in the body are removed by the process called xenobiotic metabolism. In this process these compounds are degraded by liver where enzymes by the process of oxidation, hydrolysis, reduction or hydration degrade xenobiotics and then these excreted out of the body by the usual excretion routes of urination, exhalation, sweating, and excretion (Singh & D'souza, 2007).

In early times, we had enough land and resources, but today our carelessness results in global scarcity of these resources. The speedy industrial development in the past has tremendously increased the amount of toxic waste effluents into water bodies. Environmental pollutions are caused by the release of domestic and industrial effluents mainly consist of wide range of organic and inorganic pollutants. But xenobiotics from industries are creating problems to the ecosystem, and this made environmentalists to focus more on effects of pollution and its prevention techniques.

In some cases, industrial effluent releases are well synchronized while others are accidental which may be lethal and persistent in land and aquatic environments. The potential health hazard of a xenobiotic compound is its persistency in the environment and its toxicity. The issue of xenobiotics has now been a research study area for chemists, biologists and environmentalists.

2. Materials and Methods

This review paper has been written about the phytoremediation which is an analytical technique for the assessment of biodegradation of organic xenobiotic pollutants. It consists of the review of last ten years' articles on the said topic. The researchers selected articles, sorted out the relevant information and by gathering the information of the phytoremediation this review paper has been complied.

Advantages of Phytoremediation:

Phytoremediation also have many advantages, as compared to other remediation techniques.

1. It is applicable to large contaminated sites without causing much environmental disturbance.
2. Phytoremediation is applicable for organic and inorganic hazardous pollutants which are lethal to environments.
3. It is easy to implement and maintenance cost is also low.
4. Phytoremediation does not have the destructive impact on soil fertility and structure and the presence of plants is likely to improve the overall condition of the soil, regardless of the degree of contaminant reduction (Srivastava, 2007).
5. Vegetation can also reduce or prevent erosion and fugitive dust emissions. (Srivastava, 2007).

With all advantages phytoremediation is environmentally friendly and aesthetically pleasing to the sight. Although all remediation techniques are useful and have some advantages, depends upon the type of contaminants, their presence in the natural environment and some other factors.

Disadvantages of Phytoremediation:

Phytoremediation is rapid and sustainable technique but still have some negative impact on the environment.

1. As this technique is based on plants and dependent on sunlight, natural environmental conditions like temperature, humidity, precipitation and other climatic conditions, phytoremediation is inhibited to some particular sites containing contaminants.
2. High concentration of hazardous materials can be toxic to plants.
3. Phytoremediation will likely require a large surface area of land.

3. Discussion

Remediation is the most suitable, efficient, and cheap way to deal with these so called xenobiotic compounds and to reduce the hazards associated to them. Different practices have been employed for degrading these recalcitrant. Bioremediation is probably the best available eco-friendly solution to the deal with organic pollutants. The use of flora for remediation is the sub type of bioremediation called phytoremediation.

The recent studies of last decade shows that phytoremediation has been developed in the last few years by the work done on knowing the mechanism of plants uptake and by understanding about the enzymes, enzymatic metabolism of plants and functions of those enzymes that are practiced in the degradation processes. Research on the enzymatic transformation pathways will help in determining the definitive fate of organic xenobiotants and other chemicals in phytoremediation system. Recent studies on transgenic plants and gene technology of plants show that specific degradation capabilities can be added to plant species selected for phytoremediation purposes. Advancement to increase the efficiency and effectiveness of this technique has revolutionized the whole era of environmentalism. Still this technique is not widely in use as it could be for the treatment of thousands of contaminated sites. The use of genetic engineering has especially helped to step up removal rates of hazardous pollutants.

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More research in the biological processing of xenobiotic compounds will provide thought provoking knowledge about phytotoxicity, and genetic engineering may allow plants to tolerate higher levels of organic xenobiotics. This new knowledge will allow phytoremediation to be applied more extensively and effectively.

Many hindrances are on the way of wide applications of this technology. Scientists, engineers, and environmentalists are discussing about the more widespread future use of this technology. Detailed, precise and simple information should be made easy available to the general public for their understanding, to enhance its acceptability and to make it a global, and sustainable biodegradation technology of the future. Environmental problems caused by the industrial effluents are pileup, turned into complex compounds, which in turn form a xenobiont. There is an immediate need to degrade these xenobiotic compounds in an eco-friendly way. Now a day phytoremediation technique is successfully in use in many contaminated sites of some developed countries, this technique is still in its infancy and yet to be applied commercially.

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