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Agwu, A., Kalu A. U.

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Bioremediation and Environmental Sustainability in Nigeria

Agwu, A
Department of Chemistry, Abia State Polytechnic, Aba. Abia State, Nigeria

Kalu A. U.
Department of Mathematics, Abia State Polytechnic, Aba, Abia State, Nigeria
Email: ugwason@yahoo.com

Abstract
Bioremediation is the use of microorganism metabolism to degrade or remove waste materials contaminants (sewage, domestic and industrial effluents) into non-toxic or less toxic materials by natural biological processes. The issue of environmental degradation through the disposal of domestic and industrial waste materials is assuming an alarming proportion in Nigeria. Wastes are dumped indiscriminately without considering the health and environmental implications. The present waste disposal and treatment method does not seem to solve the problem of environmental degradation the state is experiencing. There is need to seek alternative means of treating the contaminants. Bioremediation seems the best option. It is less costly and an environmentally friendly way of addressing the environmental issues arising from current waste treatment methods. This paper reviews some bioremediation technologies and their applications.
Keywords: Bioremediation, Contaminant, Environment, Biological Processes

Introduction

The incessant quest of man for better standard of living has resulted in the exploitation and poor management of natural resources and the consequent environmental pollution arising from such exploitations. Environmental issues such as climate change, land degradation, air and water pollution have become of major concern all over the world. In Nigeria, environmental degradation through the indiscriminate disposal of domestic, agricultural and industrial waste without considering the health and environmental implications is alarming. And the present treatment method does not seem to solve the environmental problems arising from it however, present advances and scientific researches in science are developing more environmentally friendly treatment method of pollutants in the environment (US EPA, 2006).

An emerging method of treatment that is less costly and environmental friendly than the tradition methods is Bioremediation. Bioremediation is the use of microorganisms and plants to degrade contaminants in sewage, domestic, agricultural and industrial effluents into less toxic or non-toxic materials by natural biological processes (ELC, 2008). There exist two different technologies for bioremediation namely: *in- situ and ex- situ.* In in-situ, the contaminants are treated on the sites where they occur, while in ex-situ the contaminants are removed and transported to sites where they would be acted upon (Tom, 1998).

Hazardous contaminants are harmful to man and other living organisms like cattle, livestock and plants in general. An advantage of the in- situ method is reduced exposure risks for clearing personnel and under exposure as a result of transportation accidents. Naturally microorganism degrades contaminants through their metabolic processes and this property of microbes has been exploited in bioremediation technology. Micro-organism can also degrade hazardous organic waste such an polycyclic aromatic hydrocarbons (PAH) pesticides, polychlorinated biphenyls (PCBs) metals, nitrogen compounds, halogenated organic solvents and compounds, non-chlorinated pesticides and herbicides, and radio nuclides. But they cannot degrade metals, they are converted to less bioavailable organic compound or transformed to oxidation states that increase their bioavailability to metal hyper accumulating plants (higher plants) (EPA, 2001). In bioremediation, microbes utilizes chemical contaminants in the soil as energy source, and through oxidation- reduction reactions metabolizes the contaminants into useable energy for microbes ,and other by- products which are less or non-toxic are released into the environment. The success of a bioremediation process depends on factors such as:

(i) the type and microbial population needed to degrade the contaminants
(ii) The availability of contaminants for the microbes to act on.
(iii) Soil characteristic, such as soil type temperature, PH, available oxygen and other nutrients (Mecutucheon et al., 2008; & Eneh et al., 2008).

Environmental sustainability is defined as meeting human needs without undermining the capacity of the environment to provide for those needs and support life over the long term. The aims of environmental sustainability are to;

- Encourage the sustainable use of finite renewable resources,
- Discourage the over burdening of the ecosystem and hence sustain its ability to absorb or break down waste,
- Protect natural processes and climatic systems,
- Maximize the recycling of waste and hence reducing the wastage of natural resources
- Discourage the use of non-renewable resources (Eneh et al., 2008).

To ensure environmental sustainability through the proper treatment of waste materials especially toxic contaminants, bioremediation seems the most viable option since it utilizes natural processes that will not negatively impact on the environment, and also economically it is presumed to be less expensive and the hazards associated with the transportation of

contaminants to treatment sites will be minimized if the in-situ method is applied. This paper reviews some of Bioremediation methods applicable to contaminated sites.

Methods of Bioremediation

The methods of bioremediation include: Mycoremediation, Phytoremediation and Bacteria Bioremediation

Mycoremediation

This method makes use of fungi to remove chemical contaminants from the soil. It is one of the more modern methods. In this method, the fungus makes use of certain enzymes and acids that it naturally secretes to decompose the hazardous chemicals into less or non toxic compounds (Barry et al., 1994)

This process utilizes very specific fungi for specific contaminant, therefore making it a difficult method to some extent. But it is a very environmentally friendly method. The use of mycoremediation in the removal of diesel, zinc and chemicals from contaminated soil has been reported (Eneh et al., 2008; Tom, 1998; USGS, 2006). The diesel is biodegraded to Carbon (IV) Oxide and water after the fungi has acted on it. The removal of zinc from soil polluted by effluents from textile industries was studied using two fungi strands *Ahspergillus Fumigatus* RH05 and *Aspergillus Flavus* RH07. The result indicates that by varying the conditions of pH and temperature, the two strands were very effective at removing zinc from the effluent.

Phytoremediation

This method uses plants to control and remove pollutants from the soil, air, and water. Organic and inorganic waste such as metals, sewage, sludge, salts, leachates, metalloids and xenobiotic contaminants can be removed by this method (Eneh et al., 2008). There are three ways by which plants can remove pollutants. They are through phytoextraction, phytostabilization and phytotransformation.

i **Phytoextraction-**these methods utilize the natural ability of plants to absorb certain toxins and poisonous heavy metals. The toxins and heavy metals are absorbed through the roots and stored in the roots, stems or leaves of the plant, after which the plant is harvested and is incinerated in a controlled environment.. The plant must be harvested after the extraction is complete to prevent the toxin from being reintroduced into the soil. Interest, scientist is looking for ways this absorbed metals can be extracted and recycled for further use. This would help to reduce the number of strip mines.

ii Phytostabilization-In phytostabilization the pollutants is attracted close to the roots of plants but are not absorbed. They are rather concentrated or stored in soils that are close to the roots of the plants. This serves to prevent the spread of the toxin and limits its exposure. After stabilization, the soil is then removed and treated with traditional methods. The process is easy and less drastic to the environment.

iii Phytotransformation (or phytodegradation)-This involves the use of plants to decompose or biodegrade organic based pollutants. The plant achieves the degradation by its natural metabolic process or by the use of enzymes produced by the plant. The organic pollutants are degraded into simpler non-toxic compounds that are used as food by the plants. The phytoremediation process is time consuming because the plant has to be planted, grow, reap and be destroyed. This might take years especially with trees. But the benefits quite outweigh this time factor. Phytoremediation is more environmentally friendly because it uses natural organism to clean up the environment, and it is a cheaper and easier process since it relies on sunlight and recycling of nutrients (Eneh, 2008). It is reported to be a more thoroughly way of cleaning up oil spills. The key to environmental sustainability using phytoremediation is the knowledge of the genetic and proteomic diversity necessary to select plants and other organism with optimal activities to transform or accumulate pollutants (Barry et al., 1994).

Bacteria Bioremediation

This method makes use of bacteria to clean up environmental contaminants such as oil spills, mine effluents and even human waste through its natural metabolic process.

Bacteria bioremediation may be achieved in any of the follow methods:

(A) Ex-Situ Methods

Bioreactor-A slurry or sludge of the contaminated soil is placed with microorganisms in a vessel. The bioreactor provides a controlled, optimal environment for metabolic activity and degradation of contaminants.

Land Farming-which involves spreading of contaminated soil over an area and either apply specialized bacteria or allowing indigenous bacteria to metabolize the contaminants (US EPA, 2006)

Biocell Treatment-which is similar to land farming except that the contaminated soil is placed in a pile with alternates vent layers to provide oxygen needed for bacteria growth.

Composting-Here the contaminated soil is mixed with other organic materials and left in a pile for the microorganism to act on the contaminant.

(B) Insitu Methods

Biostimulation-involves the management of a naturally occurring microbial population to monitor or provide an environment that optimizes the growth and activity of microbes. Methods of biostmulation include biorenting, air sparging, nutrient addition and oxygenation.

Bioaugmentation-This involves the introduction of specific microorganisms that targets specific chemical compounds or a range of compounds. The microbe has been developed to biodegrade common organic contaminate such polychlorinated biphenyls (Pbp), solvents and petroleum (Ojum et al., 2005).

This method is used when indigenous microbe cannot metabolize the contaminant or where the contaminants are toxic to the naturally occurring bacteria.

A specific bacterium is need for each type of contaminant. Bacteria are easily obtained, this method does not require additional clean up, since the bacteria after degrading the pollutant (which serves as food to it) cease or due to absence of food. Hence the method is a self-clearing process ensuring environmental sustainability and availing their spread adverse effect on the ecosystem if they had lived after the process. The use of bacteria in clearing up of soil contaminated with explosives (Yucheng et al., 2007; Boopathy, 2000) petroleum and hazardous wastes (Yucheng et al., 2007; Ojum, 2005), sewage chlorinated solvents, pesticides, agricultural chemicals (Ojum et al., 2005) has been reported.

Conclusion

From the bioremediation methods highlighted above, bioremediation seems the most promising, efficient, and environmentally friendly way of cleaning up the environment of contaminants all over the world. With the incessant spilling of petroleum and its allied product in the country; explosive blowing up here and there; and the careless dumping of domestic, agricultural and industrial wastes and the resultant environmental degradation which have been difficult to remediate, Nigeria should adopt some of these bioremediation techniques in combination with traditional technologies to ensure a cleaner and sustainable environment.

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