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BIOTECHNOLOGY FOR SOLID WASTE MANAGEMENT – A CRITICAL REVIEW

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Abstract: **Solid waste management has been a challenge for certain decades in metropolitan cities, where tons of wastes are generated from several sources. These wastes produced don't have proper disposal methods, but nowadays the research has been carried out for proper disposal and removal of chemicals from industrial waste also municipal solid waste. As of today the solid waste is usually disposed by dumping method which requires large area and it contains toxic substances which are harmful to the environment. This can be substituted by biotechnological methods such as composting, biodegradation of xenobiotic compounds and bioremediation. In this review the above mentioned methods are explained which are effective. Significant research has been carried out for several years to find the efficient method for solid waste management. Composting which is a method of decomposition of organic matter by microbes under controlled condition has been efficient bio technique for many municipalities. Xenobiotic compounds are artificially developed compounds such as benzopyrene and explosive oils etc. These compounds enhance the microbial activity. These are advancements in disposal of solid waste using biotechnological methods.**

Keywords *– Composting, Biodegradation, Xenobiotic, Benzopyrene, Explosive oils.*

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I INTRODUCTION

Since from 1970 the new technologies have appeared in that the biotechnology attracted more attention. Biotechnology in solid waste management may defined as the technique that involves living organism to complete the decomposition process and it is more effective to control the environment from the solid waste. The waste generated by India is itself around 100000 metric tons per day and the waste produced by the large metropolis cities such as Delhi and Mumbai is around 8300 and 9000 metric tons per day. Now the MSW generation is about 1.5 billion tons per annum, if the generation of MSW rate increases continuously then the rate of waste generation is projected to be 2.5billion tons per year in the coming years. Also, the increase in per capita waste generation range would be from 1.2 to 1.42 kg per person per day by 2025. The reason behind the increase in solid waste in India is due to inefficient and insufficient waste infrastructure development. Solid waste management is the process of managing and disposing various wastes like household waste, industrial waste, E waste and waste water etc. The management method must aid sustainability and convert the solid waste to a resource. The proper management of solid waste can be achieved with the help of biotechnology and it results in generating more wealth and have impact on vital sector of the economy. In this review the proper management of the solid waste by biotechnology is explained in deep and with some examples to treatment of solid waste

II OBJECTIVES

The main objective of this paper is to review the various biotechnology process used in solid waste management. And also, to identify the efficiency of the various biotechnological process used in solid waste management. An attempt has been made to study the suitable and innovative bio-technologies for the fluctuating solid waste generation rate.

III BIOLOGICAL TECHNIQUES

Biotechnology in solid waste management is the process of application of science and technology to the living and non-living materials for the treatment and disposal of solid waste and waste water in controlled condition without disturbing the eco- system. This paper reviews the most

common and efficient methods adopted at various level of solid waste disposals.

Composting is a biological method majorly used by municipalities to manage the organic solid waste. Biodegradation is bio-technique suitable for xenobiotic compounds. Bioremediation is a natural process which uses microorganisms to treat the pollutants from water or soil.

Composting:

Among the available technologies, composting is the fundamental method that suits various scales of application, from individual level to community level. The process of the decomposition of waste and treatment of waste water in controlled conditions with the help of micro-organism and Flea present in the nature.it is small scale decomposition process, in which the controlled parameters are moisture, pH, and temperature and C/N ratio.

The common materials which are composted easily are leaves, grass, animal food, old herbs & spices, newspapers, vegetable, bread, cereals & organic waste etc. The materials to avoid for composting are plastic, bones, meat, synthetic chemicals, diseased plants and animals etc. Additional materials such as saw dust and fibre powder can be used for quicker breaking of organic compounds.

This process involves the following easy steps to complete its process:

- Preparation of site for the compacting
- Selection of type of composting
- Separation of the waste (food and vegetable waste)
- Collection of dry organic matter (saw dust, sludge)
- Addition of the of waste layer by layer
- Covering the container with plastic cover to maintain required moisture content and temperature.

In this process the organic matter is converted to humus like substance, the final product looks like soil, which is rich in carbon and nitrogen and it is optimum medium to grow the plants. After the composting process the end product produced which increases the soil sensibility to hold water and makes soil easier to cultivate. Vermi-composting lately has become more efficient as the breaking of solid waste occurs in the presence of worms and increases the richness of the nutrients in compost. These process are time consuming and it requires human monitoring. Hence, rapid composting was introduced in the recent years.

The rapid composting increases the rate of degradation of chemicals or waste with keeping the nutrient content high. The main aim to go for this process is to maintain the all vital parameters in optimum condition and increase the composting rate.

Rapid composting solid waste by addition of chemicals is a method in which the chemicals like bauxite, phosphogysum and residues are added to increase the amount of biodegradation of waste. The addition of bauxite increases the temp, pH and acts as a catalyst for aeration of the composting mixture. Addition of glucose as instant carbon also increases the rate of decomposition of composting mixture.

Another method- Berkley rapid composting (BRC) process involves frequent turning and shredding of composting material. This method is suitable for the composting material is between ½ to 1 ½ inches in size. This method takes the time around 2 to 3 weeks.

Biodegradation of xenobiotic compounds:

The xenobiotic compounds are those which are not naturally available but are man- made compounds with high concentration. The microorganism which have the natural capacity of degrade the maximum xenobiotic compounds but not able to degrade some other compounds are used. The xenobiotic compound which have the resistance power for biodegradation and remain in nature it is called as Repulsive compound. The following are some xenobiotic compounds and there Degrading microbes:

Table 1 List of Common Microorganism for Xenobiotic Compounds

Xenobiotic compounds	**Microorganisms degrading xenobiotic compound**
Petroleum hydrocarbons	Bacillus sp. S6 and S35
Pesticides Glyphosate	Pseudomonas putida, P. aeruginosa and Acinetobacter faecalis
Organochlorine – DDT	Morganella morganii, stenotrophomonas maltophilia, Actinomycetes
Tetrachlorvinphos	Proteusvulgaris, stenotrophomonas maltophilia
Chlorpyrifos	Bacterial strains
Atrazine	Providencia spp, Enterobacter spp

Application of the microorganism for the process of degradation is in two modes:

Aerobic degradation:

The xenobiotic compounds like chlorinated aliphatic, petroleum hydrocarbons, benzene, fluorine, phenol and toluene are rapidly and potentially degrading by the aerobic degradation. Many bacteria have the capacity of grow on these chemicals and they produce the enzymes which convert toxic compound to non-toxic compound by degradation. The chemical reaction is – Xenobiotic compound + O_2 ⟶ CO_2 + water + biomass + residue

The method of conversion of biodegradable material to gases like carbon dioxide, methane and nitrogen compounds is called the mineralization. The process is said to be complete mineralization when the full present biomass is consumed and the complete carbon is converted to carbon dioxide.

Anaerobic degradation process:

Some of the pollutants are not degradable by aerobic degradation they are some pesticides like DDT and chlorinated dioxins. The waste from the pesticides have the bad effect on the environment and it is important to degrade the pesticides waste.

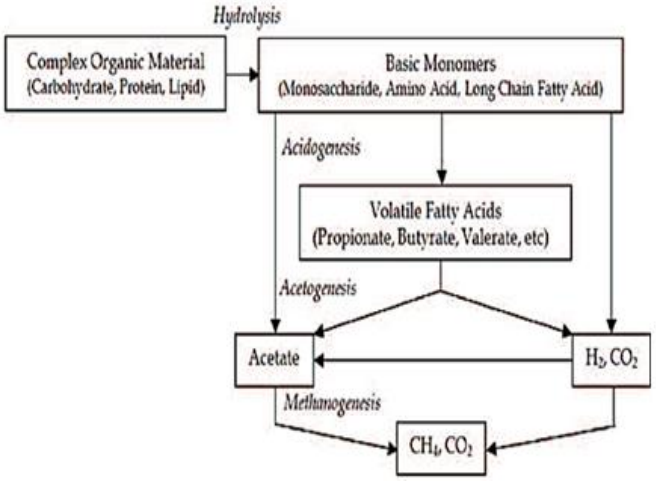

Figure 1 Process of Anaerobic Biodegradation of xenobiotic compounds

Bioremediation:

It is the natural process which makes the use of microorganism to remove waste or pollutant from the water and soil. This method is environment friendly as it involves eco-friendly microbes in treating the solid waste.

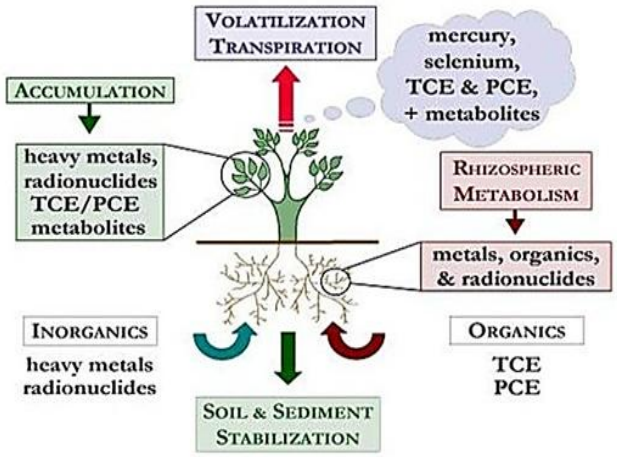

Figure 2 Concept of Bioremediation

Bioremediation can be grouped in to two categories:

1) In-situ bioremediation:

It is the process in which treatment of contaminated soil or water takes place without excavation and transport of containments. Biological treatment on surface of the waste is carried out by bacteria. The contaminated spots are in the form of aqueous solution from which the bacteria develop further and result in degradation of organic compounds. It is the alternative method of treatment of soil and ground water. This method is economical and makes the use of non-toxics microbes for the treatment of chemicals.

The in-situ bioremediation is dividing into 3 types:

a) Biosparging:

Is the process of treatment of waste used where the sites having petroleum products like diesel, gasoline, lubricating oil. In this method the concentration of oxygen is increased by injecting the air below ground water under pressure. The proper control of air pressure has to avoid the liberation of volatile particles to atmosphere, in turn causing air pollution.

b) Bioventing:

This is the process of degradation of waste compounds which are degradable by aerobically. Solid wastes generated from oil reservoirs during extraction of gasoline and petroleum are treated using bioventing. The waste treatment rate varies from site to site, as the different composition of hydrocarbons and difference soil texture, and in this process the contaminated site is injected by oxygen and nutrients like phosphorus and nitrogen to increase the rate of removal process.

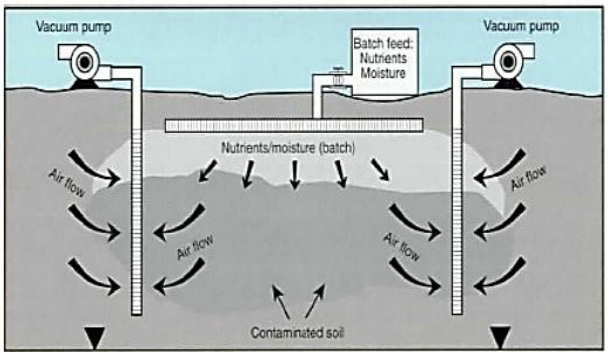

Figure 3 Bioventing

c) Bio augmentation:

The process of enhancing the degradation of waste takes place at the contaminated site by introducing the microorganism which having the specific metabolic capacity. This process ensures that the in situ microorganisms also degrade contaminates present in the ground water and soil to non- toxic compound like chloride and ethylene.

2) Ex-situ bioremediation:

In this bio technique, the soil contaminated by waste is sampled & excavated, transferred to another place for treatment. The following are the types of ex situ bioremediation:

i) Composting: Is the process of degradation of waste by controlled conditions the temperature should be around 55-65.

ii) Bio piling: The hybrid process of land forming and composting is biopiling and it is used where the cleaning of the surface contaminated by the petroleum hydrocarbons. This process takes a time around 2 to 3 months.

iii) Land forming: The process in which the excavation of contaminated soil and spreading it periodically tilled on a prepared surface till it degrades.

Bioremediation of other solid wastes:

Bioremediation of heavy metals:

The heavy metals are those which having the high density and atomic weight as compared to other elements. The few heavy metals like silver (Ag), cupper (Cu), cadmium (Cd), lead (Pd), zinc (Zn), chromium (Cr), these are considered as heavy metals because of their toxicity property. The major problem among the all is the contamination of soil through heavy metals in environment, these not only contaminate the soil, but also pollutes the ground water through the process of leaching. The decontamination of heavy metals if critical as, toxic metals may enter the food chain through water causing adverse effect on the human body. Biological members like bacteria, algae, fungi act as a bio-absorbents in degradation of the metals.

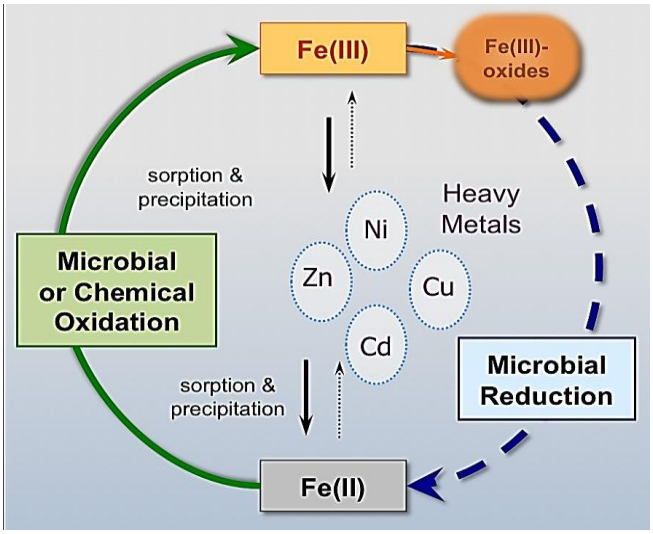

Figure 4 Bioremediation of heavy metals Bioremediation of agricultural waste:

The waste generated by the agricultural field is about 35 billion metric tons of waste per year in world wide. Presently, conversion of these organic wastes in value added products such as organic fertilizers has helped in restoring the soil nutrients. Vermicomposting has been effective in agricultural lands in northern India. The treatment of agricultural waste is important in order to increase the fertility of the soil and to control the adverse effect on human beings.

Bioremediation of Rubber waste:

Rubber is a synthetic material which neither degrades easily nor is recycled easily due to its physical composition. Around 12% of the global solid waste is rubber waste. Automobile tires are made up of high grade of carbon and complex polymer. Unscientific method of disposing rubber is by burning it. Burning rubber produces large number of toxic elements with carbon monoxide.

With the increase in vehicular production, use of rubber contributes to 65% in automobile industry. It consists of fatal chemical like zinc oxides which inhibit the growth of naturally occurring bacteria, resulting in reduction of degradation process. It is significant to remove toxic component of rubber using fungi such as Recinicium bicolour. Later, devulcanization can be carried out by oxidizing bacteria or sulphur. This results in reducing bacteria such as Thiobacillus ferroxidase and Pyro coccus furious in to simpler compounds. This rubber after devulcanization can be recycled easily. The calorific value of the rubber is equal to that of coal, so controlled combustion of rubber is an advantageous waste management method, as the heat generated (thermal energy) can be used for production of energy.

IV CONCLUSION

Generation of solid wastes is increasing exponentially across the globe. Biotechnologies are recommended as efficient techniques to dispose solid waste in sustainable way. Composting method is most suited for simple organic waste scaling from individual level to community level. Bioremediation is a method most suited for various categories of solid waste, ranging from agricultural waste to heavy metals in industries. It also poses future potential research in converting applying bioremediation for chemical and petroleum industrial solid wastes.

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