Study of Bioremediation on Hospital Plastic Waste Management

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Abstract

This work highlights the importance of bioremediation on hospital waste. In bioremediation microorganisms cultured under certain environmental conditions are used to degrade the wastes without producing any harmful by-products. The hospital wastes are degraded using different processes like incineration, landfill, etc. The bioremediation process does not leave any harmful by-products and is also eco-friendly. The degradation of plastic takes time and it pollutes the environment. This research work concentrates on plastic wastes produced in hospitals and its bioremediation procedure.

Keywords: Bioremediation, solid waste, waste management, incineration, landfill

1. Introduction

Solid waste is defined as any wastes that are being discharged from residences, hospitals, industries, factories, agricultural activities, etc. which contains garbage, food wastes, yard wastes, construction wastes, biomedical wastes, electronic wastes, sewage sludge, etc. that is in solid nature [1]. The practices of handling and disposing of these wastes vary in different regions and in India the practice depends on the type of wastes that have been classified into municipal and hazardous solid wastes. The current methods that are being used in solid waste disposal are landfill, incineration, segregation, and disposal and composting [2]. Solid waste is generally classified as household waste as municipal waste, industrial waste as hazardous wastes, and biomedical waste as infectious wastes [3]. Hospital wastes like sharps, disposals, solid wastes, anatomic wastes etc. are generated during various activities taking place in the hospitals including immunization, research activities. These generated wastes are roughly infectious and can be a threat to human health if not managed in a proper manner [4]. The survey report states that, out of 4kg of waste generated in a hospital, 1kg of it would be infected.

2. Bioremediation

Bioremediation is the process that is used to treat polluted water, soil, and other subsurface materials by changing the environmental conditions to activate the growth of microorganisms and to degrade certain pollutants. Bioremediation is less expensive and more suitable method than any other methods that are currently being used. A pure culture of microorganisms represents a population derived from an individual cell. A pure culture must be axenic (stranger) i.e. free of contaminating organisms. Pure cultures are the basis for laboratory studies with respect to morphology, physiology, metabolism, genetics etc. this applies to bacteria, fungi, protozoa, microscopic algae etc. The culture of aerobic bacteria is as follows; on solid media, the oxygen supply is optimal. Culture on solid media is usually performed in a covered glass or plastic dishes i.e. petri dishes. The growth of aerobic bacteria is liquid media is largely influenced by the oxygen available for respiration. The amount of oxygen dissolved in a nutrient solution usually is insufficient to, meet the respiratory potential of a growing population. Therefore, aeration is necessary to achieve good growth.

The culture of anaerobic bacteria is as follows; With respect to the tolerance towards molecular oxygen, there are two types of anaerobes. Moderate anaerobes tolerate transient exposure to air whereas strict anaerobes are unable to tolerate oxygen and are killed by oxygen contact. The method of cultivation of anaerobic bacteria is specifically directed towards the exclusion of molecular oxygen.

3. Characteristics of Bacteria used in bioremediation

Bacteria are mainly a unicellular organism, which multiplies rapidly in favorable condition. The characteristics of bacteria are entirely different from other organisms living in this world. Some of the bacteria are very useful or essential for nature, as well as life on earth and others, are harmful which causes severe diseases. The main classification of bacteria is, most of them are of prokaryotic which doesn't have a nucleus. The bacteria lack chlorophyll and are seen as colonies.

The bacteria were first observed by a Dutch merchant named Anton Van Leeuwenhoek. The bacteria reproduce through the process called binary fission. Each bacterium survives according to a specific temperature and pH value, which differ for different bacteria's. The prokaryotes belong to the kingdom Monera. The certain bacteria which is seen in an organism's digestive system helps in the breaking down of food particles for easy digestion. These bacteria serve an essential role in waste decomposers. For the growth of bacteria, pH value plays an important role. The pH value of bacteria should range between 6.5 to 7.5. The bacteria have different shapes and are seen in different sizes. They may be in spherical shape, rod like shape, corkscrew in shape. The bacteria classified according to their shape and they are; Coccus which are round or spherical in shape, Bacillus which are rod shaped, Spirillum which is spiral or curve in shape. By the bacteria cell shape, they can be classified as Capsule, Lipopolysaccharide, Fimbriae or Pili, Flagella, Slime, Spores.

4. Related Works on Bioremediation

In [5], biotechnological applications like Bioleaching, biosorption, phytoextraction, and phytostabilisationetcetra are described that helps in the recovering of metals. The reactive and hazardous compounds are removed by a new peroxide based enzymatic method, harmful heavy metals and toxic chemicals were degraded easily by this method. Bioremediation has its role in the treatment of oil wastes from the oil industry and Oil and Natural Gas Corporation (ONGC) is doing innovative research work develop microbes which reduce hydrocarbon content from oil waste [6]. The biological methods play a vital role in e-waste management for the treatment of wastes. The e-waste disposal is a global issue and is mainly due to the toxicity of substances if not properly processed [7].

The microorganisms coupled with genetic engineering techniques gains importance in waste management; the radioactive waste uranium can be removed by bacteria called geobactermetallireducens [8]. In [9], the microorganism is used for the removal of heavy metals from waste water, effluent, and soil by the action of pseudomonas spp., which is good absorbent. The major limitation is that several microorganisms have no ability to break toxic metals into harmless metabolites. Modification should be done genetically in these micro-organisms in order to improve their characteristics or abilities for bioremediation. Bioremediation was found to be cost effective and eliminates the risks in the traditional remediation methods [10]. The method of removal of inorganic contaminants from soil by washing is called landfill burial, but this produces a residue which contains high metal and it requires further treatments. These metals get interacted with enzymes or cellular proteins which causes toxicity than interaction with membranes.

The work [11] discussed how to isolate the microbes which are capable of degrading organic molecules. The characteristics of microbes and the enzymes used for the purpose

of bioremediation and the ways to avoid potential side effects are also analyzed. The roles of age-related diseases and the benefits of their removal were surveyed and identified. There are many differences between researches about age-related diseases and bioremediation make this goal as challenging scientifically. Hospital wastes have hazardous and infectious properties so it has distinct apart from all other wastes [12]. Research is going on all over the world for reducing and disintegrating the generated waste, due to this research, a survey conducted to evaluate the conditions of hospital waste disposal.

The solid waste management sector in India faces a lot of problems, especially the increasing urban population [13]. The general principles and techniques of bioremediation used in laboratories and food industry are described in [14]. The main aim is to identify the lowest pollution level. The bioremediation process also helps to convert the contaminates such as pesticides, herbicides, and cleaning chemicals into nontoxic substances. The bioremediation and remediation technologies which are using naturally occurring or genetically modified microorganism are discussed in [15]. The main purpose is to clean the residues and the contaminated area from toxic organics, providing an important technology to solve the hard pollutants. Through the biochemical test and gram staining reaction, the bacterial strain will be identified. The antiseptics and disinfectants from biomedical waste kill the viruses and various type of toxin infectious bacterial strain [16]. The enormous increase in solid waste results in the environmental impact. The solid waste degradation technique produces a minimum impact on the environment [17].

The municipal solid waste is a serious issue in the surrounding environment and public health, mainly because of unscientific disposal and not properly handling and recycling of leachate. The testing of biosorption of Cd2+ was done by applying the fungal isolate. The waste containing cytotoxin compound can be applied only the use of microalga technology [18]. The presence of recalcitrant cytotoxin drug in the aquatic environment pose a significant and harmful effect of the ecosystem and human health. Flutamide is a biosorption of anticancer drug, performed by the living and dead biomass of Chlorella vulgaris. The living micro algae have a better performance for the removal of drugs. Higher the dead biomass higher will be the absorption capacity of microalgae [19].

Bioremediation is a promising technology for the treatment of soil and ground water contamination. It is very effective to deal with petroleum hydrocarbon contamination and are disposed of by biological treatment [20]. The high potential of microbe which is ecofriendly and financially reasonable is used for the recovery of metal from waste stream [21]. The mobilization and immobilization also depend on organisms involved in physio chemical condition. For determining the metal mobility, the microbiological process is used and having the application of bioremediation in metal pollution [22]. Metal chromium is a major environmental pollutant. When comparing chemical reduction and microbiological reduction there is friendly and cheaper way to decrease the bacterial strain. The activity of chromate reduction by the bacteria is not related to enzyme [23]. In [24], a detailed study has been done on the microbial degradation of plastic. Though there are several reports regarding the potential of plastic degrading microbes, none of this has been used practically.

The processes of bioremediation on soil environment which is contaminated by petroleum hydrocarbons, limitations of both in-situ and ex-situ bioremediation are explained in [25]. Waste water has to be treated before being dumped into sensitive areas. The usage of Chlorella vulgaris algae was used for the treatment of waste water and the results show that it is a new option and the residue can be used for biofuel production [26]. The biodegradable plastics and the degradation of plastics by microorganisms are discussed in [27]. The additives like starch and pro oxidants are added to make plastics degradable. The fungus and microalgae are grown together, which is referred to as “mycoalgae” biofilm, which takes up the nutrient pollutants in the water and leaves the

purified water as the end product of the chemical process. The intensive aquaculture can be sustained through nutrient recycling into highly nutritious sustainable feed [28]

The potential of Capra aegagrushircus manure for bioremediation on soils contaminated with petroleum hydrocarbons was studied under certain conditions [29]. The bioremediation of soil contaminated crude oil by agaricomycetes was studied and the results showed that they had higher bioremediation ability and they can reduce soil toxicity in a very short period of time [30]. The experimental work done for the isolation of cadmium bioremediating microorganisms was analyzed in [31], the results show that any bacteria that show merely resistant to heavy metals have the potential for heavy metal removal. The work [32] deals with the isolation, identification, and screening of polythene degrading microbes, Bacillus sp. has greater potential for degrading polythene compared to other microbes.

An experimental study was conducted on the usage of some bacteria for biodegrading of waste water [33]. The consortium of Bacillus subtilis, Nitrosomonas, Bacillus circulans, and Bacillus pumilus resulted in an effective lowering of BOD, COD and TSS levels in waste water. The conducted studies reveal that some specified microorganisms which are already present in the Long Beach soil and by increasing their abundance, the diesel oil can be degraded, the specialized microorganism selected from their own environment can degrade diesel oil from the soil [34]. The bioremediation of the domestic wastewater runoff using vermi-biofilteration is done, the result shows that through this process, better water quality is obtained when compared to another filtration system [35]. The hydrocarbon, as well as heavy metals, have to be treated before it is being dumped. Bioremediation method was found to be effective, the results show that some bacteria are been identified from the wastewater sample such as Bacillus subtilis, Micrococcus luteus, Staphylococcus aureus, and Staphylococcus epidermidis can degrade hydrocarbon. The Bacillus subtilis and Micrococcus luteus are also able of reducing heavy metals [36].

The article [37] explains the bioremediation of liquid waste oil through the bioreactor. The test is done by taking a sample from liquid waste petroleum oil and gas companies prabumulih south Sumatra, Indonesia. The result shows that, if the process contains 10litres isolate and 6ml/sec air discharge, then it can reduce the final weight of waste, pH, Specific gravity and BOD level. A microorganism is a tool of bioremediation technology for cleaning environment. For removing toxic waste from the environment, the biological agents are used, as well as to manage the polluted environment and recovering of the contaminated soil [38]. The study reveals that the majority of the waste can be degraded using the bioremediation process. The work [39] explains the perspectives of bioremediation through mushroom cultivation. The industrial waste was found to be a substrate for mushroom cultivation and through bioremediation process, these wastes can be converted as spent mushroom compost. The spent mushroom compost is recently proposed to call “post mushroom substrate” because it is actually not a spent but used for many useful purposes.

Even though, the chromium is released to the soil and water resources in a large amount, which causes pollution [40]. The chromium, are treated using some physical and chemical methods, though these methods are available, this cause secondary pollution. The microbes are found to be effective for the treatment of contaminants. In [41], the enzymes of the plant in Rhizosphere degrading toxic compounds was discussed. The Rhizosphere microorganism leads in increasing availability of hydrophobic compounds and hence results in degradation and which may be overcome to enhance the remediation of a contaminated environment. Table 1 and 2 depicts the characteristics of classical waste management techniques in terms of the characteristic parameters.

Table 1. Characteristics of classical waste disposal techniques (Eco friendliness, temperature, efficiency)

SL.NO	Methods	Eco friendliness	Temperature	Efficiency
1	Incineration	Not ecofriendly as high heat is being used.	High temperature is being used for the process	High efficiency with disadvantages
2	Land fill	Not ecofriendly as leachate is generated	Very low temperature	Medium efficiency with disadvantages
3	Chemical disinfection	Not so ecofriendly as intense chemicals are being used	Temperature depends on the type of chemical used	Medium efficiency
4	Autoclaving	Not so ecofriendly as high heat is liberated	High temperature	Medium efficiency
5	Microwave irradiation	Not ecofriendly	High temperature in a controlled environment	Low efficiency

Table 2. Characteristics of classical waste disposal techniques (expense, toxicity, byproducts)

SL. NO	Methods	Expense	Toxicity	Byproducts
1	Incineration	High installation cost	High toxic material is being liberated	Gaseous emissions, Carbon dioxide, Nitrogen oxides
2	Land fill	Low installation cost	Toxicity relies on the landfill material	Leachate, metals, glass piece, carbon dioxide
3	Chemical disinfection	Not expensive	High toxicity chemicals are being used	Plastic bags, chemical oxides

4	Autoclaving	Very expensive	Low toxicity	Harmful byproducts
5	Microwave irradiation	Less expensive	Less toxicity	Ashes, poisonous gas,

5. Conclusion

This research work proposes various bioremediation techniques for waste disposal. The disposal of hospital waste is really a challenging task and required many improved technologies. A comparative analysis has also been performed on the classical waste disposal methodologies. The outcome of this work will be an aid for researchers working on bioremediation techniques.

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