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Application of Mushroom Fungi in Solid Waste Management

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Abstract - The implementation of increasingly stringent standards for the discharge of waste into the environment, as well as the increase in cost of habitual disposal or treatment options, has motivated the development of different processes for the treatment and disposal of wastes. Solid waste may seem to be the most ordinary forms of wastes, but they could be responsible for many problems such as spread of diseases and emission of green house gases. Over the years, solid waste disposal was a neglected issue as these wastes were simply dumped on land in the outside of the city. Unscientific disposal of solid wastes causes an adverse impact on all components of the environment and human health. Transformation of wastes and pollutants are classified as being chemical or biological in nature. Micro-organisms are the agents which bring about the conversion of these wastes into useful products like fuel gases, fuel alcohol and also compost which can be used as manure. Among different bioconversion of solid waste composting appears to be a safe form of treatment of solid waste and the reclamation of the nutrients containing in them. During the last few years, composting by mushroom fungi has gained wide acceptance as a key component of integrated solid waste management. It has been promoted as an eco-friendly and sustainable solution to urban waste management. It encourages the production of beneficial microorganism (mainly mushroom fungi) which in turn breaks down organic matter to create humus. Humus, a rich nutrient filled material, increase the nutrient content on soils and helps soil to retain moisture. Addition to this mushrooms directly utilize bioconversion of solid wastes generated from industry and agriculture into edible biomass, which could also be regarded as a functional food or as a source of drugs and pharmaceuticals.

Keywords: Environmental pollution, solid wastes, solid wastes management, biological methods, mycoremediation, mushroom fungi

I. INTRODUCTION

Biotechnology has versatile role in environmental protection. The role of biotechnology in environmental concerns is not only for pollution control but also prevents pollution and minimizes waste. Environmental biotechnology is concerned with the application of biotechnology as an emerging technology in the context of environmental protection. The rapid industrialization, urbanization and other developments have resulted in a threatened clean environment and depleted natural resources. The development of human activities (in industry, transport, agriculture, domestic space), the increase in the standard of living and higher consumer demand have amplified pollution of air (with CO_2, NO, SO_2, greenhouse gasses, particulate matters), water (with chemical and biological pollutants, nutrients, leachate, oil spills), soil (due to the disposal of hazardous waste, spreading of pesticides), the use of disposable goods or non-biodegradable materials, and the lack of proper facilities for waste (Gavrilescu and Chisti, 2005). Advanced techniques or technologies are now possible to treat waste and degrade pollutants assisted by living organisms (microbes, plants, animals).

II. SOLID WASTES

The term solid waste is defined as an “any unwanted or useless solid materials generated from combined residential, industrial and commercial activities” is known as solid wastes. Due the increased pollution, industrialization and urbanization, a trend of significant increase in solid waste generation has been recorded worldwide. Waste generation has been observed to increase annually in proportion to the rise in population and urbanization.

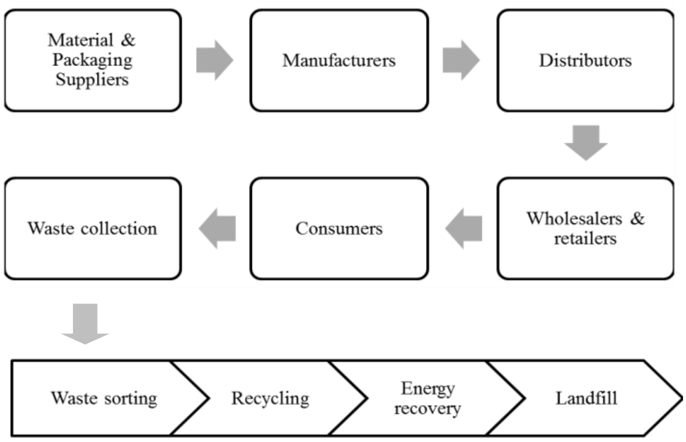

Figure 1:Flow chart of waste creates

Figure 1 emphasizes the fact that we do not consume materials; we simply use them and ultimately return them, often in an altered state to the environment. The resulting processed goods

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are sold to the users of products, who in turn have three options after use: to dispose of this material; to collect the material in sufficient quantities to either use it for energy production or to recycle it back into the industrial sector; or to reuse the material for the same or a different purpose without remanufacture and huge waste discarded in landfills (Vesilind*et al*., 2002).

2.1. Types and sourcesof solid wastes

Wastes are produced by human activities and it includes: municipal wastes, industrial wastes, and agricultural wastes. Municipal wastes are composed of wastes generated by households and wastes of similar character from commercial, institutional, open areas and treatment plant sites (Peavy*et al*., 1985). Industrial process wastes include a very wide range of materials and the actual composition of industrial wastes in a country will depend on the nature of the industrial base. The most important feature of industrial wastes is that a significant proportion is regarded as hazardous or potentially toxic, thus requiring special handling, treatment and disposal.Agriculture wastes include horticultural and forestry wastes such as, crop residues, animal manure, diseased carcasses, unwanted agrochemicals and empty containers. The different source of wastes illustrated in figure 2.The central pollution control board (CPCB) had conducted a survey of solid waste management in 299 cities and has given the data of waste generation for different cities (CPCB, 2000). The management of solid wastes is going through a critical phases, due to the unavailability of suitable facilities to treat and disposal of wastes. Unscientific disposal these wastes cause an adverse impact to the environment and human health (Rathi, 2006).

2.2. Impacts of solid wastes

The solid wastes from different sources contain a large number of chemical and toxic substances especially from industrial wastes. It is necessary to know the properties of the waste so as to assess whether its uncontrolled release to the environment would lead to toxic effects on humans or other living organism in ecosystem.

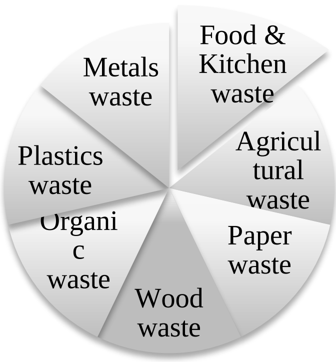

Figure 2: Sources of solid wastes

The hazardous chemicals from wastes (industries) cause dermatitis. Inhalation is the most common source of workplace exposure to chemical and most difficult to control. The air pollutants caused by these wastes can directly damage respiratory tract and causes systemic effects. Contamination of groundwater is a serious problem of immediate concern (WHO/UNEP, 1989). Ground water contamination due to leachates from refuse dumps and poorly managed landfill sites can result in ingestion of toxic chemicals from the factory. The disposal of industrial wastes, sewage sluge, and dredged spoils can have diverse harmful effects on the marine environment and direct effects on the human health. Discarded plastics are harmful to the marine environment largely because they endanger marine life. Plastic yokes from beverage containers pose a similar threat to birds and small fish. A recent study detected plastic particles in the digestive tracts of 25% of the sea bird species examined (UNEP/GESAMP, 1990).

III. SOLID WASTES MANAGEMENT

Solid waste management reduces or eliminates adverse impacts on the environment and human health and supports economic development and improved quality of life. A number of processes are involved in effectively managing waste for a municipality. These include monitoring, collection, transport, processing, recycling and disposal. Apart from physico-chemical processes there are two leading innovative mechanisms of waste disposal being adopted in India which include composting (aerobic composting and vermin-composting) and biomethanation. The concept of waste to energy for disposal of wastes is relatively new to India. Although these have been tried and tested in developed countries with significant output, these are yet to get off the ground in India because of the fact that financial viability and sustainability is still being tested (Lal, 1996; Khan, 1994).

3.1. Physico-chemical method

In many metropolitan cities, open, uncontrolled and poorly managed dumping is commonly practices, giving rise to serious environmental degradation (Mor*et al*., 2006). Solid wastes are disposed by depositing it in low-lying areas outside the city without following the principles of sanitary landfilling. Compaction and leveling of waste and final covering by earth are rarely observed practices at most disposal sites, and these low-lying disposal sites are devoid of a leachate collection system or landfill gas monitoring and collection equipment (Gupta *et al*., 1998). The main environmental problem associated with landfilling is pollution of groundwater.

Incineration is the process of control and complete combustion, for burning solid wastes. It leads to energy recovery and destruction of toxic wastes, for example, waste from hospitals. The temperature in the incinerators varies between 980 and

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2000°C. One of the most attractive features of the incineration process is that it can be used to reduce the original volume of combustible solid waste by 80–90% (Jha*et al*., 2003).Unfortunately, in Indian cities, incineration is not very much practiced. Incineration of solid waste under oxygen deficient conditions is called gasification. The objective of gasification has generally been to produce fuel gas, which would be stored and used when required. In India, there are few gasifiers in operation, but they are mostly for burning of biomass such as agro-residues, sawmill dust, and forest wastes (Ahsan, 1999). The potential effects of physico-chemical methods have been listed in Table 1.

Table 1: Potential effects of physico-chemical methods

Waste disposal method	Potential effects
Physical method	• Potential for exposure to a variety of harmful materials which may cause birth defect, asthma, respiratory diseases and cancer. • Causes soil acidification due to deposition of acid gases; increases soil metals; damage vegetation due to oxides of nitrogen and sulphur dioxide. • Contaminate ground and surface water.
Chemical treatment	• Emission of harmful organic compounds causes diseases like cancer, asthma and respiration problems. • Causes soil acidification and damage vegetation due to harmful organic compounds.

3.2. Biological method

The microbial conversion of the organics present in solid waste in the presence of air under hot and moist conditions is called composting, and the final product obtained after microbial activity is called compost (humus), which has very high agricultural value. It is used as fertilizer, and it is nonodorous and free of pathogens (Ahsan, 1999; Khan, 1994).As a result of the composting process, the waste volume can be reduced to 50–85%.The composting methods may use either manual or mechanical means and are accordingly termed as a manual or mechanical process (Ambulkar and Shekdar, 2004)

Under anaerobic condition if the organic waste is buried in pits, it will be acted upon by anaerobic microorganisms with the release of methane and carbon dioxide; the organic residue left is good manure. This process is slower than aerobic composting and occurs in fact naturally in landfills. However, thermophilic digestion for biomethanation is much faster and has been commercialized. Anaerobic digestion leads to energy recovery through biogas generation. The biogas, which has 55–60% methane, can be used directly as a fuel or for power generation (Ahsan, 1999; Khan, 1994).Several hundred species of bacteria are involved in the anaerobic digestion and biogas production.

Vermicomposting involves stabilization of organic waste through the joint action of earthworms and aerobic microorganisms. Initially, microbial decomposition of biodegradable organic matter occurs through extra cellular enzymatic activity (primary decomposition). Earthworms feed on partially decomposed matter, consuming five times their body weight of organic matter per day. The ingested food is further decomposed in the gut of the worms, resulting in particle size reduction. The worm cast is a fine, odorless and granular product (Jha*et al*., 2003).

IV. MUSHROOM FUNGI IN BIOREMEDIATION

Mushroom inclusive of fungi, are ubiquitous in the soil, and contributes to degradation of toxic materials in the soil. Mushroom grows in hydro-carbon and non-hydro-carbon contaminated soils, secretes enzymes laccase, manganese dependent peroxidase and lignin peroxidase which are used for remediation (Barr and Aust, 1994; Aust*et al*, 2003). Lau *et al,* (2003), reported the use of mushroom compost to degrade PAH contaminated soil. Mushroom exhibits extra ordinary abilities to transform recalcitrant pollutants and also degrades broad spectrum of structurally diverse toxic environmental pollutants (Reddy, 1998). Their extra cellular ability, access them to degrade non-soluable toxic compounds and non-popular compounds (Levin *et al*, 2003). Mushroom also exhibit low specificity of the enzymes produced which enables them degrades recalcitrant, anthropogenic compounds (Mendel *et al*,1998).

The presence of heavy metals and other harmfulcontaminants, which mushroom attacks extra-cellularly,digests led to increase in mushroom as opposed toinhibition of mushroom and subsequent removal of toxicmetal in the environment (Hitivaniand Mecs, 2003; Stamets, 2005). The scavenging of metalsfrom polluted sites by mushroom (Malik, 2004) are due toremediation and purifying abilities of mushrooms.Emuh (2009) reported that mushroom inoculated in locally sourced substrates showed promise in bioremediation of crude oil polluted soil.

V. ROLE OF MUSHROOM IN SOLID WASTE MANAGEMENT

Buswell*et al*., (1996) described that edible mushroom cultivation was one of the most economically-viable processes for the bioconversion of many types of agro wastes.Rajor(1996) described that the Sawdust, a bulky waste generated by wood processing industries, has very few profitable and eco friendly uses and has a problem of proper disposal. Chang(2000) described that mushroom cultivation was a direct utilization of their ecological role in the bioconversion of solid wastes generated from industry and agriculture into edible biomass, which could also be regarded asa functional food or as a source of drugs and pharmaceuticals. Spent mushroom compost, a bulky solid waste generated from the mushroom industry, however, could be exploited as a soil fertilizer and as a prospective bioremediation agent. Mushroom is a fungus, which feeds by secreting enzymes and digests food externally and absorb the

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nutrients in net like chain called hypha. The net like chain (hypha) is exposed to stimuli in their ecological niche and act as a conscious intellect and respond to stimuli. Dense and regular branching of hypha endows fungi with potentials to pervade any substrate thoroughly (Hudson, 1986). As mycelium thickness increases the rate of mechanical penetration and breaking down of substrate also gets increases. This culminates at higher the rate of digestion of substrate through the secretion of extra-cellular enzymes. This shows the potentials of bioremediation capabilities of mushroom (Hamman, 2004). This hypha/mycelium penetrates contaminated site, thus placing a mat on them and this is the process of breaking down of toxic products or pollutants. The enzymes produced by mushroom which are lignin perioxidase, manganese perioxidase and laccase penetrate, break and digest or mineralizes harmful substances in waste (Stamets, 2005). These enzymes act singly or collectively in aiding mycelium to break down nature or human made resistant materials (Stamets, 2005). Similarly, Hitivani and Mecs(2003) reported that the mycelium of mushroom exposed to heavy metals of cadmium, copper, lead, mercury and zinc increased the production of enzymes laccase, decolourized them and subsequently absorbed the heavy metals.

VI. CONCLUSION

Mycoremediation offers an efficient and cost effective way to treat different types of solid wastes. So by developing an understanding of mushroom fungi communities and their response to the natural environment and pollutants, expanding the knowledge of the genetics of the microbes to increase capabilities to degrade pollutants, conducting field trials of new mycoremediation techniques which are cost effective, and dedicating sites which are set aside for long term research purpose, these opportunities offer potential for significant advances. Thus, mycoremediation is in the process of paving a way to greener pastures.

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