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Bioremediation Potential of Mushrooms

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Abstract- Potential of Mushroom to work as Bio-remediating agent has made a significant remark in the field of Environment Management. Ability of mushrooms to grow on agro-industrial waste has made researchers to ponder over the new and better possibilities to clean the environment. There are certain things which are yet to be explored like oil is a mixture of a number of toxic derivatives. Can mushrooms eradicate or detoxify all of them? Secondly, Can the edible species of mushroom involved in bioremediation, be declared safe to use? Restoration of polluted land can be used to grow food crops or not? So, there is a lot to explore yet. Although, this practice has a lot of future prospects, carrying forward the economic concept of Mushroom Cultivation Technique & its role in Bioremediation.

Keywords- Bioremediation, Mushroom, fungi

I. INTRODUCTION

With ever increasing commercialization, Industries have flourished all over the world like mushrooms which results in pollution of air, water and soil by toxic chemicals in addition with overuse of harmful pesticides and insecticides in agriculture. Toxic pollutants like hydrocarbons enter the environment through oil spill, tank leakages or wastewater disposal. The enormous quantity of pollutants, their persistence and mobility in natural environments and their frequent toxicity, create a need to understand their behavior in natural environments and devising means of bringing about their reduction or total eradication [1]. To overcome the problem, scientists are striving hard. The practice to remove pollutants from environment with the use of biological processes, termed as **bioremediation**. There had been significant researches in this field with the use of bacteria like *Pseudomonas putida*, having ability to degrade oil spills. Ability of fungi to degrade the hydrocarbons and the toxic pollutants has become a matter of interest to various environmental researchers.

II. REASONS OF OIL POLLUTION & ITS CONSEQUENCES

There may be several sources of oil pollution like accidental discharge, pipeline leakage [2] Saboteurs, who cut pipelines to steal crude oil or refined premium motor spirit or kerosene [3]. Of importance is the industrial activity resulting from the operations in the refining of petroleum products and gas glaring. Some of the major pollutants emitted are ammonia, chromium, organic acid and sulfides etc are discharged into the environment and causes contamination of in the environment.

Major consequences of oil pollution are:-

1) Generally the addition of oil to the soil decreases the water holding capacity of the soil [4]. Soil factors affected by oil pollution on land includes soil atmosphere (air in the soil), soil water availability and retention, exchangeable Mn, Fe, total N, available P, No3 and the sulphur status of the soil [5].
2) The oil in the soil renders the soil hydrophobic thus reducing the presence and availability of water in the soil [6]. Oil pollution in the soil leads to plant nutrients deficiency symptoms'[7], resulting from droughty conditions as well as unavailability of plant growth resources.
3) Oil in the soil affect microbes, oxygen contents of the soil and plant roots [8]. Crude oil pollution of the soil leads to nutrient availability that are toxic to plants, like manganese [2].
4) Pollution of crude oil containing heavy metals in the soil leads to barrenness' of the soil [8]. These metals result in nutrient imbalance, toxicity of the soils and unfavourable growth (if any) of plants in the ecosystem. However, some heavy metals stimulate growth. Vanadium was reported by [9], to stimulate the growth of lettuce.

Mycoremediation (Bioremediation using Fungi)
The term Mycoremediation was coined by **Paul Stamets** to represent the process of using fungi to degrade contaminants in the environment. Basically fungi are Heterotroph, obtaining their nutrition by absorption.

Exoenzymes, powerful hydrolytic enzymes secreted by the fungus, break down food outside its body into simpler compounds that the fungus can absorb and use. Fungal hyphae have a small volume but large surface area, enhancing the fungal absorptive capacity. The ability of fungi to decompose organic materials to form extended mycelia network and the low specificity of their catabolic enzymes confer their ability to use pollutants as a growth substrate. It means that they are suited to a wide variety of remediation contexts, including some in association with plants. Edible and/or medicinal fungi also play a role as natural environmental remediator's [10], as do aquatic fungi[11].

One of the clear roles that fungi have played early on in mycoremediation studies is that some fungi do an excellent job in supporting other organisms into remediation activity, just as they often seem to support those same organisms into living healthily in native ecosystems. It is as though the enzymes secreted by many fungi actually stimulate aggressive toxin degradation by other microbes present in the soil as well as plants. Research findings support the concept that some fungi can degrade complex toxins such as 4-5 ring PAH's into simpler toxins more bio-available to other organisms, just as they often do with complex plant materials.

III. MYCORESTORATION

Usage of mushrooms to decrease pollution level in given area is the process of Mycorestoration. Mycorestoration by enhancing the inherent flora of contaminated site or seeding with degradative one ought to be a suitable way along with the use of spent mushroom compost [12,13]. Saprotrophic, endophytic, mycorrhizal, or even parasitic fungi/mushrooms can be used in mycorestoration, which can be performed in four different ways:

- **Mycofiltration** (using mycelia to filter water)
- **Mycoforestry** (using mycelia to restore forests),
- **Mycoremediation** (using mycelia to eliminate toxic waste, and
- **Mycopesticides** (using mycelia to control insect pests).

These methods represent the potential to create the clean ecosystem, where no damage will be left after fungal implementation [14].

Mushrooms as Bio-remediating agent

Most of the fungi body is mycelium, bunch of hyphae, which constitute vegetative part of fungus. But it is the fruiting bodies which result from sexual reproduction that are visible as mushrooms and other fungi. Earlier mushrooms have been used as food & medicine. With the knowledge of other useful properties of mushrooms like compost used as animal feed, biofertilizer & biogas, here comes a new environment friendly aspect of them i.e. Bioremediation. The present work is to familiar the reader about the contributing researches in the same context.

White rot fungi is a physiological grouping of fungi that can degrade lignin (and lignin-like substances). Four main genera of white rot fungi have shown potential for bioremediation: *Phanerochaete, Trametes, Bjerkandera*, and *Pleurotus* [15]. One of the most important aspects of *Pleurotus* spp is related to the use of their ligninolytic system for the bioconversion of agricultural wastes into valuable products for animal feed and other food products and the use of their ligninolytic enzymes for the biodegradation of organopollutants, xenobiotics and industrial contaminants [16]. Stamen [17] that mycelial mats are used for bioremediation because mycelia produce extra cellular enzymes and acids that break down recalcitrant molecules such as; lignin and cellulose and that lignin peroxidases dismantle the long chains of hydrogen and carbon making them effective at breaking apart hydro carbon the base structure common to oils, petroleum products, pesticides, PCBS and many other pollutants.

Studies reveal that White-rot fungi have been used in bioremediation of polluted soils and accumulation of heavy metals. They have also been found to be involved in mineralization, bio-deterioration, biodegradation, transformation and co-metabolism [18]. Isikhuemhen *et al*. [19] eported that white-rot fungi are increasingly being investigated and used in bioremediation because of their ability to degrade an extremely diverse range of very persistent or toxic environmental pollutants.

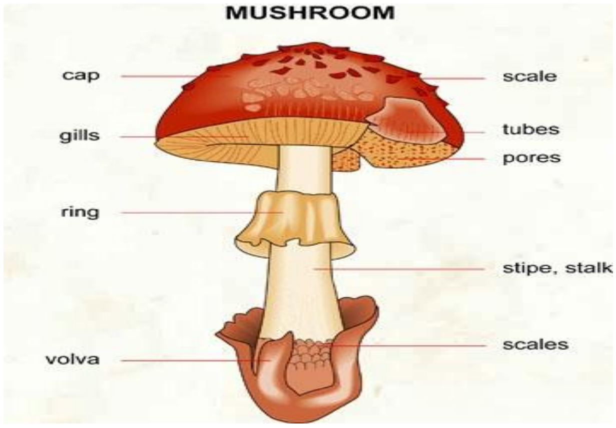

Fig. 1

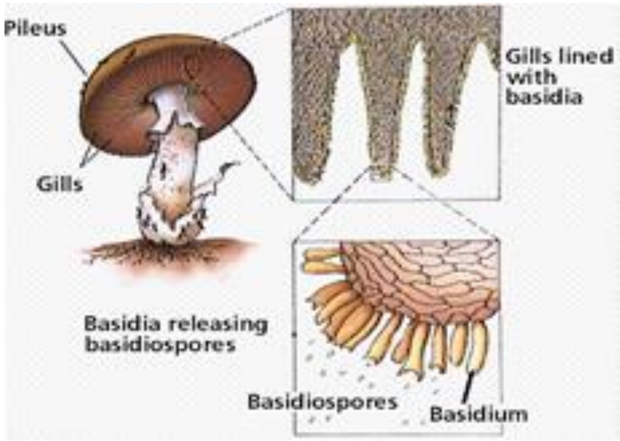

Fig. 2

Fig. 3 Oyster Mushrooms on oily straw

Fig. 4 Mushroom on wood

IV. MECHANISM OF ACTION

Mushroom forming fungi (mostly basidiomycetes), are amongst nature's most powerful decomposers, secreting strong extra cellular enzymes due to their aggressive growth and biomass production. These enzymes include **lignin peroxidases** (LiP), **manganese peroxidase** (MnP), H_2O_2 producing enzyme [16] , and **laccase**, etc. Thus, carbon sources such as sawdust, straw and corn cob can be used to enhance degradation rates by these organisms at polluted sites. White rot fungi have been used for biotransformation of pesticides, degradation of petroleum hydrocarbons and lignocellulolytic wastes in the pulp and paper industry. Studies based on concept of zero waste discharges from cardboard & handmade paper industries revealed the exploitation of solid sludge & effluent by *Pleurotus florida* with no morphological dissimilarity and non toxicity [21].

Polycyclic Aromatic Hydrocarbons (PAH) constituted of two or more fused aromatic rings and part of crude oil are major pollutants found in soil and sediments. Most of the restoration of PAH contaminated sites depends on the activity of bacteria. Whereas low molecular weights PAH are usually readily degraded, high molecular weights PAH resist extensive bacteria degradation in soil and sediment media [22] .

According to Hamman [23], the mechanism of biodegradation depends in part, on the compound being degraded, but there are some consistent steps in the process regardless of the substrate. The ligninolytic enzymes in white rot fungi catalyze the degradation of pollutants by using a **non-specific free radical mechanism** [20]. So they are able to mineralize a wide range of highly recalcitrant organopollutants that is structurally similar to lignin [24]. When an electron is added or removed from the ground state of a chemical it becomes highly reactive, allowing it to give or take electrons from other chemicals.

The main reactions that are catalyzed by the ligninolytic enzymes include **depolymerization, demethoxylation, decarboxylation, hydroxylation and aromatic ring opening**. Many of these reactions result in oxygen activation, creating radicals that perpetuate oxidation of the organopollutants [24,25]. Once the peroxides have opened the aromatic ring structures by way of introducing oxygen, other more common species of fungi and bacteria can mineralize the products intracellularly into products such as CO_2 and other benign compounds.

It has been demonstrated that a lot of species belonging to the group of white-rot fungi are able to degrade lignin, which is a naturally occurring polymer [20]. This capacity is assumed to result from the activities of extracellular oxidases and laccases [23]. These enzymes are nonspecific; they oxidize a wide range of xenobiotics [16,18].

Phanerochaete chrysosporium, *Agaricus bisporus*, *Trametes versicolor* and *Pleurotus ostreatus* amongst many mushrooms have been reported in the decontamination of polluted sites. In Nigeria, *Lentinus squarrosulus*, *Pleurotus tuber-regium*, *P. ostreatus* and *P. pulmonarius* have been employed in bioremediation of contaminated soils both *in-situ* and *ex-situ*.

White-rot fungi have been proposed for the biodegradation of polluted sites containing complex mixtures of PAH's such as occurring in creosote, coal tar and crude oil [21]. Isikhuemhen *et al*. [19] carried out a solid state fermentation (SSF) experiment with *Lentinus squarrosulus* (strain MBFBL 201) on cornstalks and evaluated lignocellulolytic enzymes activity. The results showed that *L. squarrosulus* was able to degrade cornstalks significantly after 30 days. Maximum lignocellulolytic enzyme activities were obtained on day 6 of cultivation and are a good producer of exopolysaccharides. The very fast good rate of *L. squarrosulus* makes it an ideal candidate for application in industrial pretreatment and biodelignification of lignocellulosic biomass.

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