Mycoremediation: Current State and Perspectives

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Mycoremediation (also called *fungal treatment* or *fungal-based technology*) is the application of fungi in remediation of polluted soils and aqueous effluents. The fungi mostly used are wood-rot Basidiomycetes capable of degrading lignin (ligninolytic fungi). Most of these fungi cause white rot of wood, and so they are often called white-rot fungi (WRF). The ability of WRF to degrade lignin is due to a complex of extracellular enzymes—namely, lignin peroxidase, manganese dependent peroxidase, hydrogen peroxide generating oxidases, and phenol oxidases such as laccase. The lignin peroxidases were first discovered in the basidiomycete *Phanerochaete chrysosporium* Burds., and in the 1980s this fungus was the main experimental model in lignin degradation research. Due to the nonspecific character of radical-mediated reactions of ligninolytic enzymes, the degradation of a wide variety of xenobiotic compounds, having an aromatic structure like lignin, has become a subject of extensive research.

BIODEGRADING CAPABILITY OF WRF

In 1985 it was demonstrated that *Ph. chrysosporium* was able to degrade, besides lignin macromolecules, many types of organopollutants such as polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls and dioxins, chlorophenols and chlorolignins, nitroaromatics, synthetic dyes, and different pesticides. Logically, the degrading ability of other species of WRF was tested as well very soon after. Several powerful degraders—e.g., *Phanerochaete sordida* (P.Karst.)J.Erikss., *Pleurotus ostreatus* (Jacq.:Fr.)P.Kumm., *Trametes versicolor* (L.:Fr.) Lloyd, *Nematoloma frowardii* (Speg.)E.Horak, and *Irpex lacteus* (Fr.)Fr.—were selected; however, the screening was mostly performed using liquid culture media.

BIODEGRADATION IN SOIL

In soil conditions the fungal degrading potential of WRE is only one prerequisite. Other factors, such as the ability of fungal mycelium to colonize soil matrix, its resistance to autochthonous soil microflora and to the toxic compounds present in polluted soils, as well as the effect of physicochemical parameters of the respective soil, will be discussed in the lecture. Step-by-step selection of a fungal degrader will be demonstrated using the model fungus *Irpex lacteus.* Provided that the respective fungal strain significantly decreased the content of the respective pollutant in the soil under laboratory conditions and, simultaneously, that applied ecotoxicological tests also documented the decrease in soil toxicity, the process can be scaled up.

SCALE-UP AND FIELD APPLICATIONS

Large-scale production of fungal inoculum does not represent a special problem; the inoculum (i.e., lignocellulosic material such as straw, sawdust, and wood chips colonized with fungal mycelium) can be produced using facilities of a local oyster mushroom (*Pleurotus* spp.) or shiitake (*Lentinus edodes*) farm. In case of a long distance between a mushroom farm and the decontamination site, a solid-state fermentor can be used; for a very long distances the inoculum in the form of alginate-gel pellets can be prepared. Landfarming, biopiling, or treatment in containers are frequently used techniques in soil remediation. All the approaches are based on the same principle—mixg the contaminated soil with lignocellulosic substrate colonized with fungal mycelium and allowing it to work for several weeks or months under proper environmental conditions. Experience in large-scale soil mycoremediation gained in the Czech Republic, the USA, and Germany will be evaluated in the lecture.

PROBLEMS, ADVANTAGES, AND PERSPECTIVES

Mycoremediation, similar to most of other bioremediation approaches, has some drawbacks: the process is usually slow, and the removal of contaminants is rarely close to 100%. The soil matrix and bioavailability of the respective pollutant influence the final result of the treatment. However, compared to physical or chemical treatments, bioremediation is environment friendly and is a cost-effective approach. On one hand, specific features of mycoremediation are that no special equipment is needed for inoculum production (sometimes even a spent oyster mushroom substrate can be used as inoculum), and for the soil treatment, standard agricultural machinery can be used. The other advantage of mycoremediation is that the soil treated with this procedure is biologically sound and active; fungal mycelium and its career (straw, wood chips) is converted to humus, and after the decomposition of the substrate, the introduced ligninolytic fungus is not able to compete with the newly revived soil microflora and dies off naturally. On the other hand, in several cases, the degradation can be unsuccessful, and thus the process has not yet become a reliable environmental biotechnology.

In conclusion, the future success of mycoremediation depends on more intensive research into bioremediation generally and more extensive research into the biodegrading potential, physiological properties, and ecology of a large number of white rot and litter-decomposing fungi.

AKNOWLEDGMENT

The support by grant No. 206/03/P078 and 203/03/0508 of the Grant Agency of the Czech Republic is highly appreciated.