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Helping the ecosystem through mycoremediation

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The sciences of mycofiltration, mycoremediation, mycoforestry and Mycorestoration are part of an emerging field of study. While fungi promise to play an invaluable role in repairing many forms of environmental damage, the parameters, techniques and time lines for implementation are still in development. Though the concept of mycoremediation is in its infancy, this evolving technology holds great promise. Fungi can be introduced into a contaminated environment relatively cheaply.

Mycoremediation is a form of bioremediation, the process of using mushrooms to return an environment (usually soil) contaminated by pollutants to a less contaminated state. The term mycoremediation was coined by Paul Stamets and refers specifically to the use of fungal mycelia in bioremediation.

Fungi are non-photosynthesising, heterotrophic organisms that derive their energy from a saprophytic or parasitic existence. They are unicellular, amoeboid, or filamentous, never having the leaves, stems, and roots characteristic of higher plants. Reproduction occurs by sexual or asexual spore formation. One of the primary roles of fungi in the ecosystem is decomposition, which is performed by the mycelium. The mycelia of fungi like roots of plants, secretes extracellular enzymes and acids that break down lignin and cellulose, the two main building blocks of plant fiber. These are organic compounds composed of long chains of carbon and hydrogen, structurally similar to many organic pollutants. The key to mycoremediation is determining the right fungal species to target a specific pollutant. Certain strains have been reported to successfully degrade the nerve gases VX and sarin.

Researchers in Britain have demonstrated that inoculating contaminated soils with fungi enhances the degradation of multiple chemicals, such as simazine, trifluralin and dieldrin. This beneficial activity occurs even at levels of soil hydration that would be hostile to plants. Impact of *Trametes versicolor* and *Phanerochaete chrysosporium* on differential breakdown of pesticide mixtures in soil microcosms at two water potentials and associated respiration and enzyme activity.

In an experiment conducted in conjunction with Thomas, a major contributor in the bioremediation industry, a plot of soil contaminated with diesel oil was inoculated with mycelia of oyster mushrooms; traditional bioremediation techniques (bacteria) were used on control plots. After four weeks, more than 95% of many of the PAH (polycyclic aromatic hydrocarbons) had been reduced to non-toxic components in the mycelial-inoculated plots. It appears that the natural microbial community participates with the fungi to break down contaminants, eventually into carbon dioxide and water. Wood-degrading fungi are particularly effective in breaking down aromatic pollutants (toxic components of petroleum), as well as chlorinated compounds (certain persistent pesticides).

Mycoremediation is being carried out in the United States by Battelle Laboratories in Washington State.

The three types of fungi; saprophytic, parasitic, and mycorrhizal species, vary in use for the type of bioremediation processes :

– Saprophytic Fungi use enzymes to decompose biologic material

– Parasitic Fungi are able to destroy bacteria and other pathogens

– Mycorrhizal Fungi remove substances from the biosphere

Saprophytic fungi are responsible for breaking down all types of organic matter. They breakdown organic matter by secreting enzymes as well as other exodates which breakdown the hydrocarbon chains that are found in all organic matter. The byproducts of these reactions are usually more readily available for the uptake and or further break down by other biologic organisms. Many fungi

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species play an important role in the recycling of complex wood debris and garden wastes. Many of them thrive in varied and complex environments. Some of these saprophytes are capable for breaking down cellulose, lignin, as well as polycyclic aromatic hydrocarbons.

Parasitic fungi excrete there own enzymes which have been found to be toxic the bacteria in the soil or substrate where they are growing. Mycelia of the mycorrhizal fungi attack disease causing pathogens (fungi, bacteria, protozoa, and nematodes) around the roots of plants, which help to protect them. Experiments by Batelle (is an international science and technology enterprise) showed that a particular fungus produced an army of crystalline entities, which advanced in front of the growing mycelium.The crystals appear to attract motile bacteria by the thousands and to stun them.The advancing mycelium then digests the bacteria, effectively removing them from the environment.

Under natural conditions plants live in close association with soil organisms called mycorrhizal fungi. These fungi colonize plant roots and extend the root system into the surrounding soil. Estimates of amounts of mycorrhizal filaments present in a cubic inch of healthy soil are up to a mile of filaments. Fungal mats are now known as the largest biological entities on the plant. The relationship between plants and fungi is beneficial to both; the plant enjoys improved nutrient and water uptake, disease resistance with superior survival and growth, the fungi receive nutrients in the form of phtosynthates and are able to grow and survive. It is believed that fungi are responsible for the world of plants being able to inhabit and evolve on land from their aquatic origin

The mycoremediation process begins with field collection of higher fungi from an area of interest. The process includes the selection, culturing, toxicity screening, preconditioning, mesocosm scale testing, and pilot scale application. The potential use of fungi for the purpose of remediation is just starting to be studied extensively in the United States. European and Asian nations are also evaluating the possible uses of fungi and its by products as a tool for remediation. Research is on going; Pacific Northwest National Laboratory (PNNL) Marine Sciences Laboratory (MSL) in Sequim, Washington, Indira Gandi Institute Development and Research in Bombay, India, as well as The Center for Soil and the Environmental Research in Aslow, Norway are but a few facilities who are or have been carrying out research on the remediation potential of fungi.

Potential applications for mycoremediation technologies include:

– Fungi have been shown to accumulate radionucliotides, metals, and even rare earth elements. They would be potentially useful in detecting the presence of and could potentially act as hyper accumulators of these harmful compounds.

– Fungi are great biodegraders and resultant compost as been proven to enhance plant growth as well as bioremediation activity. Our land fills, although contained, are only gradually returning their components to a smaller biomas with the same or greater concentrations of toxins. Why not use fungi to turn these toxic holding areas into usable biomas.

– Fungi as the ability to enhance plant growth. The eucalyptus tree is not a native to northern parts of China and attempts at raising this fast growing tree were failing, until fungi were added to the soil. The mycorrhiza enhanced the plants ability to uptake vital nutrients. Fungi when used in conjunction with plants used for phytoremediation may also enhance a plants ability to survive and take up pollutants from the soil.

– The process of paper production involves the removal of lignin from wood pulp. Current methods employ toxins for the removal of lignin and the bleaching process used to overcome the discoloring effects of the presence of small amounts of lignin in paper. Fungi have the means, *via* enzyme production to decompose just the lignin whole leaving the cellulose of wood. If fungi or its byproducts were used in paper production we would be able to eliminate a large source of pollution to the environment.

– Agricultural waste reduction.
– Creation of buffer zones.
– Nonpoint source pollution reduction in watersheds.
– Contaminated sediment cleanup.
– Reduction of material relegated to confined disposal facilities.
– Decontamination.
– Minimization of contaminants from road runoff.

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