Biodegradation of Pesticides Using Fungi, Bacteria And Algae

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Abstract- *A pesticide is any substance used to kill, repel, or control certain forms of plant or animal life that are considered to be pests. Pesticides include herbicides for destroying weeds and other unwanted vegetation, insecticides for controlling a wide variety of insects, fungicides used to prevent the growth of molds and mildew, disinfectants for preventing the spread of bacteria, and compounds used to control mice and rats. Because of the widespread use of agricultural chemicals in food production, people are exposed to low levels of pesticide residues through their diets. Scientists do not yet have a clear understanding of the health effects of these pesticide residues. The Agricultural Health Study, an ongoing study of pesticide exposures in farm families, also posts results online. Other evidence suggests that children are particularly susceptible to adverse effects from exposure to pesticides, including neuro developmental effects. People may also be exposed to pesticides used in a variety of settings including homes, schools, hospitals, and workplaces. Biodegradation processes can be employed for the pesticide degradation using microbes. Microbial degradation processes applied for bioremediation involves use of variety of different microbes including bacteria, fungi and actinomycetes.*

I. INTRODUCTION

Biodegradation is defined as the biologically catalyzed reduction in complexity of chemical compounds . Indeed, biodegradation is the process by which organic substances are broken down into smaller compounds by living microbial organisms. When biodegradation is complete, the process is called "mineralization". However, in most cases the term biodegradation is generally used to describe almost any biologically mediated change in a substrate.So, understanding the process of biodegradation requires an understanding of the microorganisms that make the process work. The microbial organisms transform the substance through metabolic or enzymatic processes. It is based on two processes: growth and cometabolism. In growth, an organic pollutant is used as sole source of carbon and energy. This process results in a complete degradation (mineralization) of organic pollutants. Cometabolism is defined as the metabolism of an organic compound in the presence of a growth substrate that is used as the primary carbon and energy source [4]. Several microorganisms, including fungi, bacteria and yeasts are involved in biodegradation process. Algae and protozoa reports are scanty regarding their involvement in biodegradation [5]. Biodegradation processes vary greatly, but frequently the final product of the degradation is carbon dioxide [6]. Organic material can be degraded aerobically, with oxygen, or anaerobically, without oxygen [4, 7].

Biodegradable matter is generally organic material such as plant and animal matter and other substances originating from living organisms, or artificial materials that are similar enough to plant and animal matter to be put to use by microorganisms. Some microorganisms have the astonishing, naturally occurring, microbial catabolic diversity to degrade, transform or accumulate a huge range of compounds including hydrocarbons (e.g. oil), polychlorinated biphenyls (PCBs), polyaromatic hydrocarbons (PAHs), radionuclides and metals [1,2,3,8].

It is not unusual that pesticides are formulated and thus added as mixtures of two active compounds. For instance, the two herbicides diuron and dichlobenil may be applied alone or in mixtures with each other or alternative compounds . Diuron belongs to the phenylurea herbicides while dichlobenil is a benzonitrile herbicide, and the properties of these two compounds are rather different. [9,10]

Biodegradation by fungi is also known as mycodegradation. Likewise, bioremediation in which fungi are employed is sometimes called mycoremediation. Fungi are ubiquitous in the environment, and the literature on fungal ecology is vast. Despite this, the reports of fungi in bioremediation are under-represented and as such represent the untapped potentials in fungal bioremediation. Moreover, the biology and ecology of mycoremediation have rarely been examined [11,12]

Saprotrophic fungi produce a wide range of extracellular enzymes which are essential for degradation of plant materials [13,14] these enzymes may also enable fungal degradation of organic pollutants. White-rot fungi have been considered as top fungal candidates for bioremediation purposes for many years due to their potent enzymatic arsenal . However there are a number of drawbacks for this group of organisms, for instance most white rot fungi require strict growth conditions (e.g. high temperatures) and therefore have low competitive capabilities against indigenous organisms in the environment [15,16] Furthermore, it has been shown that a number of white-rot fungi have negative effects on soil bacteria e.g. inhibiting growth of indigenous bacteria. For bioremediation of certain compounds fungi from the zygo- or ascomycetes might therefore be a superior choice. However, the effect on native bacteria will probably be strain dependent.

The degradation of pesticides in situ is usually achieved by a consortium of microbes rather than a single species. Pure culture studies do, however, allow the mechanisms by which the pesticide is metabolized to be elucidated. The mechanisms for transport of the pesticide into the cell, degradation pathways and induction and regulation of degradative pathways can be studied. Degradation products are isolated and identified. Pure culture studies also allow the location of genes involved in degradation of the pesticide; this can lead to the location of the genes involved in pesticide degradation and the development of specific gene probes for detection of these organisms in situ, precluding the need for prior cultivation [17]

II. DISCUSSION

Traditional isolation methods, involving enrichment culture and plating techniques, have been used to isolate many of the microbes that are able to degrade pesticides in pure culture.The methods used are reviewed by Bartha Bacterial Degradation of Pesticides (1990). Sources of inocula for the enrichment cultures are generally soils that have a previous history of treatment with pesticides [13] other sources include cattle dip and the fleece-rot lesions of sheep which have also experienced a pre-exposure to the pesticide. One of the major difficulties in isolating bacteria that are able to degrade pesticides is the chemical structure of the pesticide which can often limit biodegradability. Bacteria utilize available organic compounds. Therefore, by increasing the solubility of hydrophobic substrates by the use of surfactants, or solvents in biphasic cultures or by dissolving the pesticide as its salt (for carboxylic acids and phenols), the isolation of bacteria able to degrade these hydrophobic compounds can be enhanced. Once isolated in pure culture and presumptively identified, the ability of the bacteria to either utilize the pesticide as sole carbon source or, in some cases as sole nitrogen source, or alternatively to co-metabolize it, is confirmed. Bacterial transformation of DDT has been known to occur under anaerobic conditions, and numerous bacteria able to co-metabolically metabolize DDT by dechlorination to DDD under anaerobic conditions have been reported [15] Recently, an aerobic bacterium, Alcaligenes eutrophus A5, isolated for its ability to grow on 4-chlorobiphenyl as sole carbon source, was shown to partially metabolize low levels (1 ppm) of both the o,pt- and p,pt-DDT isomers when incubated at high cell-density in resting cell cultures [11]. The mechanism for attack on DDT by this bacterium appears to be analogous to the 4-chlorobiphenyl degradation pathway, and probably results from the actions of the enzymes specific for 4-chlorobiphenyl degradation. DDT appears to be oxidized by a dioxygenase to yield a dihydroxy derivative that undergoes meta cleavage, ultimately yielding 4-chlorobenzoic acid. The dihydroxy-DDT intermediate and 4-chlorobenzoic acid were isolated as intermediates from resting cell incubations. This is the first report of aerobic metabolism of DDT by a bacterium.

Bioremediation technology allows the biological-specific decomposition of wastewater to provide complete degradation at low cost and without energy consumption, among other advantages10. In natural near-shore marine systems, microorganisms, plants and algae have the ability to purify water bodies contaminated with organic substances. As primary producers, microalgae play a vital role in aquatic ecosystems, and many species can degrade organic compounds. Microalgae have the advantages of adsorption capacity, a high surface area:volume ratio, wide distribution range, rapid metabolism, low cost, and abundant availability11,12,13. In a water body, microalgae directly contact and interact with pollutants, but some toxic pollutants can inhibit their growth14 and affect their physiological ecology15. Microalgae can also biodegrade or biotransform organic pollutants via metabolic action, and the mechanisms for removal include accumulation and degradation, which includes both transformation and mineralization16. Hendrik studied the degradation of the pesticide endosulfan by blue-green algae and found that the algae exhibited strong biodegradability. Another researcher studied the adsorption, uptake and degradation effects of *Scenedesmus obliquus*on NP and octylphenol (OP) in water and reported that more than 89% of NP and 58% of octylphenol (OP) in the medium were removed by the microalgae after 5 days of incubation, and the highest removal efficiency was close to 100%18. In addition, studies of the adsorption, biotransformation and degradation of NP, bisphenol-A (BPA) and other environmental hormones have been reported in the microalgae of the genera *Chlorella*, *Scenedesmus*, and *Fibrea* as well as other species19. Microalgae can also absorb and biologically accumulate certain pollutants, which can then be transmitted up the food chain via biological amplification20.*Cladophora glomerata* can exert a bio-enrichment effect on NP so that the concentration in the organism is 10,000 times higher than the concentration in the environment21, and *Isochrysis galbana* can enrich soil NP at an initial concentration of 100 μg/L by 6490-fold, while 77% of the compound can be adsorbed and absorbed in one hour. In microalgae used as feed, the high enrichment of NP can impact organisms at higher trophic levels such as rotifers and zebrafish20. The above findings have led to research on the selection of microalgae species that are highly capable of degrading organic pollutants, and the use of microalgae for the bioremediation of contaminated water has been proposed as a beneficial strategy when implementing environmental bio-refineries10. However, there have been limited studies of the application of marine microalgae to degrade NP. The four microalgae *Phaeocystis globosa*, *Nannochloropsis oculata*, *Dunaliella salina* and *Platymonas subcordiformis*, are common and widely distributed species in aquatic ecosystems.

III. CONCLUSION

Recent studies have provided clues to the evolution of degradative pathways and the organization of catabolic genes, thus making it much easier to develop genetically engineered microbes for the purpose of decontamination. Genetic manipulation offers a way of engineering microorganisms to deal with a pollutant, including pesticides that may be present in the contaminated sites. The simplest approach is to extend the degradative capabilities of existing metabolic pathways within an organism either by introducing additional enzymes from other organisms or by modifying the specificity of the catabolic genes already present. Continuous efforts are required in this direction, and at present several bacteria capable of degrading pesticides have been isolated from the natural environment. Catabolic genes responsible for the degradation of several xenobiotics, including pesticides, have been identified, isolated, and cloned into various other organisms such as Streptomyces, algae, fungi, etc. In addition, recombinant DNA studies have made it possible to develop DNA probes that are being used to identify microbes from diverse environmental communities with an unique ability to degrade pesticides [20,21].

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