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## Microbial Remediation of Soil Contaminated with Pesticides and other Hazardous Chemicals-Present and Future

A. A. M. KUHI AND H. K. MANONMANI

Department of Food Microbiology, Central Food Technological Research Institute, Mysore 570 013. India.

For the last several decades our environment has been continuously exposed to toxic petrochemicals, synthetic pesticides, heavy metals, solvents, radionuclides and many other organic and inorganic pollutants. The persistence of several anthropogenic chemicals, their biomagnification in the food chain and eventual entry in to human body have been a matter of grave concern. In recent years attempts are being made world over to clean up the contaminated ecosystems. Among the few options available for this purpose microbial bioremediation is the most promising one. As microbes can utilize organic chemicals as carbon and energy sources the pollutant chemicals are completely mineralized and hence is the preferred method. Microbes are also endowed with the ability to adapt themselves and proliferate even in inhospitable environments. Microbial remediation is safer, effective and less expensive.

Organochlorine pesticides such as BHC, DDT, heptachlor, aldrin and a dieldrin etc. are major contaminants in food, and hence, are found in high concentrations in human adipose tissue. Elimination of these toxic chemicals from the environment is the only option available for obtaining safer food. There are several reports of bioremediation of soils contaminated with some of these pesticides residues. Aerobic degradation of  $\alpha$ -HCH in heavily contaminated soil slurry by native microorganisms has been reported (2). Wade et. al. (14) have reported rapid degradation of  $\gamma$ -HCH in upland soil after multiple applications of the compound. Accelerated degradation of  $\gamma$ -HCH in flooded and upland soils after pretreatment of the soils with HCH was observed (4). Sahu et. al. (13) have shown the degradation of soil applied and  $\alpha$ -andy-isomers of HCH on inoculation with a *Pseudomonas* sp. A microbial consortium that can degrade  $\alpha$ -, $\beta$ -, $\gamma$ -and -isomers of HCH has been developed in our laboratory which has indicated its ability to degrade soil-bound HCH isomers too. We also have shown that *Pseudomonas aeruginosa* strain DT-Ct-2 isolated from soil effectively bioremediated DDT-contaminated soil. Complete mineralization of 15  $\mu\text{g}$  DDT  $\text{g}^{-1}$  soil occurred within 96 h. The organism was effective even in

native soil containing organic matter.

A number of herbicides and their catabolites have been shown to deleteriously affect the germination of seeds as well as young seedlings of certain crop plants. Seedlings of peas and soybean are highly susceptible to even low concentrations of dicamba (3, 6-dichloro-2-methoxybenzoic acid) and inoculation of soil with dicamba-degrading bacteria protects the seedlings from the deleterious effects. Similarly 3-chloro- and 4-chlorobenzoates (3-CBA and 4-CBA) and 2,4,5-trichlorophenoxyacetic acid (2, 4, 5-T) inhibit germinations of seeds of tomato, tobacco, egg plant (brinjal) and other *Solanaceae* members. Treatment of soil by chlorobenzoate degrading *Pseudomonas aeruginosa* 3mT and 2, 4, 5-T-degrading *Burkholderia cepacia* AC 1100 eliminated the toxic effects of chlorobenzoates and 2, 4, 5-T, respectively. Bioremediation of 3-CBA-contaminated soil by inoculating with *Pseudomonas alcaligenes* C-O has been reported has also been shown (6). Degradation of chlorobenzoates in soil slurry. Soil degradation of 2, 4-dichlorophenoxy-acetic acid (24-D) was demonstrated<sup>9</sup>. Rapid mineralization of atrazine in soil slurry and moist soil by a *pseudomonas* sp. and the dependence on inoculum density and soil moisture have been reported (5). Bioremediation of pentachlorophenol-contaminated soils by straw compost and bioremediated soil inocula (11), by bioaugmentation using activated soil (3) and by solid substrate cultures of the "shiitake" mushroom, *Lentinula edodes* LE2 (12) have been shown. Efficient biodegradation of chloroanilines and chlorobenzenes in soil slurries by specialized organisms has been demonstrated (5).

Bioremediation technologies are gaining popularity and are here to stay. However, there is a need to isolate more and potent microbes and develop them to be able to withstand, thrive and remediate specific contaminated sites. Mixed cultures have been proved to be more efficient in bioremediation processes. But the success will lie on the judicious selection and formulation of microbial consortia to suit the given situation. Caution however, has to be taken to evaluate the

impact of the inoculated organisms on the ecosystem.

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