

## BIOREMEDIATION OF PESTICIDES IN SOILS

*Itamar Soares de Melo – Embrapa Environment, Jaguariúna, SP, Brazil.*

*E-mail: [itamar@cnpma.embrapa.br](mailto:itamar@cnpma.embrapa.br)*

Pesticides are chemical substances manufactured by the chemical industry. Such chemically synthesized organic compounds, not previously present on Earth, are termed xenobiotic compounds. They are used to protect humans against the insect vectors of disease-causing pathogens, to protect crop plants from competition from abundant but unwanted plants (i. e. weeds), insects and diseases caused by fungi. Pesticides can be classified on the basis of their intended pest targets, such as: fungicides, herbicides, insecticides, acaricides, molluscicides, rodenticides, avicides and antibiotics. Herbicides are the most used pesticides in the world. Those most used globally are: alachlor, a amide herbicide; atrazine, a triazine herbicide; 2,4-D, a phenoxy herbicide; metolachlor, an amide herbicide; trifluralin, a dinitroaniline herbicide; cyanazine, a triazine herbicide; and metribuzin, an organophosphate insecticide.

Because of the problems associated with some persistent xenobiotic compounds, only readily degraded pesticides are now permitted for use in many countries. Most of these break down through microbial activity in a period of days or weeks following application. Many of these substances are deliberately or inadvertently released into soils and water.

An organic chemical introduced into a terrestrial ecosystem may be subjected to non enzymatic or enzymatic reactions brought about by the inhabitants of the environment. Microorganisms are the major scavengers in nature, responsible for recycling most natural waste materials into harmless compounds. Most of these pesticides are subject to extensive mineralization within the time span of one growing season or less. Microorganisms convert many synthetic organic chemicals to inorganic products. Other compounds are transformed only by cometabolism. These microbial processes may lead to environment detoxication, the formation of new toxicants, or the biosynthesis of persistent compounds. Cometabolism is the phenomenon that occurs when a compound is transformed by a microorganism, yet the organism is unable to grow on the compound and does not derive energy, carbon or any other nutrient from the transformation.

The catabolism process often results in the mineralization (complete biodegradation) of some portion of an organic compound via enzymatic pathways to simple products of universal currency ( $\text{CO}_2$ ,  $\text{NH}_3$ ). In some cases, one portion of the molecule may be mineralized and another portion may accumulate in soil. Therefore, catabolism should not be equated with complete destruction of a pesticide.

Bioremediation can be accomplished *in situ* or by methods that require recovery and aboveground treatment. According to Bollag and Bollag (1995) four basic techniques may be used: 1) stimulation of the activity of indigenous microorganisms; 2) inoculation of the site with microorganisms of specific biotransforming abilities; 3) application of immobilized enzymes; and 4) use of plants to remove, contain, or transform pollutants. Several specific strategies have been used for bioremediation of contaminated soils. These include composting, land farming, above-ground bioreactors and soils-phase.

*In situ* treatment involves adding nutrients or microbes. Nutrients include sources of nitrogen, phosphores, and/or an alternate energy source. This augmentation encourages the growth of the indigenous microbes that can catabolize the target pollutants. *In situ* bioremediation also involve the use of microorganisms. Often, these organisms are indigenous to the area and may even be adapted for growth on the chemical contaminant in that particular environment.

One technology that has been used for remediation involves the use of higher plants (phytoremediation). This approach includes processes that may involve uptake of the contamination by the plant or biodegradation by microorganisms colonizing the roots or the soil immediately influenced by the roots (rhizosphere). The greater density and diversity of mi-

Microorganisms commonly observed in the rhizosphere often result in greater rates of xenobiotic metabolism. The microbial degradation in the root zone suggests that a diverse and synergistic microbial community, rather than a single microbial strain, is responsible for the enhanced biodegradation of xenobiotics in the rhizosphere compared with nonvegetated soils (Anderson *et al.*, 1993). Collectively, the microbial community provides the spectrum of degradative enzymes, each of which may be required for mineralization but may not all be present in a microbial strain (Bordelean and Bartha, 1968). In addition to their uptake and transformation of organics, plants bioaccumulate metals and radionuclides. Hyperaccumulation of heavy metals (up to 1% dry weight) is common for plants that have adapted to soils with high concentrations of Co, Cu, Cr, Pb, Ni and Zn (Baker and Brooks, 1989).

Bacteria which establish positive interactions with plant roots, are termed plant growth-promoting rhizobacteria (PGPR) and they play a key role in agricultural environments and are promising for their potential in the maintenance of soil fertility.

Rhizobacteria are the primary degraders of many herbicides in soil with *Pseudomonas*, *Arthrobacter*, *Acinetobacter* and *Bacillus* being the most active species.

Some strains of rhizobacteria, when applied to seeds of many crops, protect the growing plants from phytotoxicity of many herbicides in the soil. In our laboratory, we have reported the use of *Pseudomonas putida* strains to protect rice seedlings sown in soil contaminated with propanil and *Acinetobacter baumannii* to protect corn plants against the effect of diuron. These bacteria are effective in degrading these herbicides and also in producing indole-3-acetic acid, a phytohormone responsible for the plant growth.

The use of rhizobacteria as inoculants depends on their ability to colonize the root system and to compete with the indigenous microflora. Thus, we have selected herbicide-degrading bacteria able to establish upon inoculation in the rhizosphere of crop plants. The release of such bacteria in soil is being studied through an optimized process for manufacturing a crop inoculant. The process involves the entrapment of living cells in alginate beads and dehydration. All these approaches will be discussed.

Researches on microbial transformations of organic compounds in the rhizosphere have also focused on industrial chemicals, such as oil residues (Rasolomanana and Balandrean, 1987), trichloroethylene (Walton and Anderson, 1990), polycyclic aromatic hydrocarbons (Aprill and Sim, 1990), and pentachlorophenol (Ferro *et al.*, 1994).

## References

- Anderson, T.A.; Guthrie, E.A. and Walton, B.T. Bioremediation in the rhizosphere. *Environ. Sci. Technol.* 27:2630-2636. 1993.
- Aprill, W. and Sims R. C. Evaluation of the use of prairie grasses for stimulating polycyclic aromatic hydrocarbon treatment in soil. *Chemosphere* 20:253 – 266, 1990.
- Baker, A.J.M. and Brooks, R.R. Terrestrial higher plants which hyper-accumulate metallic elements – a review of their distribution, ecology and phytochemistry. *Biorecovery* 1:81-126. 1989.
- Bollag, J.M.; Bollag, W.B. Soil Contamination and the Feasibility of Biological Remediation. *Bioremediation Science and Applications*, 1995.
- Ferro, A.M.; Sims, R.C. and Bugbee, B. Hycrest crested wheatgrass accelerates the degradation of pentachlorophenol in soil. *J. Environ. Qual.* 23:272-279. 1994.
- Walton, B.T. and Anderson, T.A. Microbial degradation of trichloroethylene in the rhizosphere: Potential application to biological remediation of waste sites. *Appl. Environ. Microbiol.* 56:1012-1016. 1990.