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Pesticide Degradation through Microbial Interaction for Improvement of Productivity and Soil Health

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Biodegradation is a natural process, where the degradation of a xenobiotic chemical or pesticide by an organism is primarily strategy for their own survival. Most of these microbes work in natural environment but some modifications can be brought about to encourage the organisms to degrade the pesticide at a faster rate in a limited time frame.

Importance of Pesticides Biodegradation

Biodegradation that involves the capabilities of microorganism in the removal of pollutants is the most promising, relatively efficient and cost-effective technology. Biodegradation is a process that involves the complete rupture of an organic compound in its inorganic constituents.

Degradation of pesticides is very essential for controlling these problems.
Biodegradation is a process by which a pesticide is transformed into a benign substance that is environmentally compatible with the site to which it was applied. The degradation or breakdown of pesticides can occur in plants, animals, and in the soil and water. However the most common type of degradation is carried out in the soil by microorganisms, especially fungi and bacteria that use pesticides as food source. The soil fumigant methyl bromide, the herbicide dalapon, and the fungicide chloroneb are examples of pesticides which are degraded by microorganisms (Al-Rajab, 2014).

Criteria for Biodegradation

For successful biodegradation of pesticide in soil, following aspects must be taken into consideration.

- Organisms must have necessary catabolic activity required for degradation of contaminant at fast rate to bring down the concentration of contaminant.
- The target contaminant must be bioavailability.
- Soil conditions must be congenial for microbial /plant growth and enzymatic activity.
- Cost of bioremediation must be less than other technologies of removal of contaminants.

Strategies for Biodegradation

For the successful biodegradation / bioremediation of a given contaminant following strategies are needed.

- **Passive/ intrinsic Bioremediation:** It is the natural bioremediation of contaminant by tile indigenous microorganisms and the rate of degradation is very slow.

- **Biostimulation:** Practice of addition of nitrogen and phosphorus to stimulate indigenous microorganisms in soil.
- **Bioventing:** Process of Biostimulation by which gases stimulants like oxygen and methane are added or forced into soil to stimulate microbial activity.
- **Bioaugmentation:** It is the inoculation/introduction of microorganisms in the contaminated site/soil to facilitate biodegradation.

Composting

Piles of contaminated soils are constructed and treated with aerobic thermophilic microorganisms to degrade contaminants. Periodic physical mixing and moistening of piles are done to promote microbial activity.

- Phytoremediation: Can be achieved directly by planting plants which hyper accumulate heavy metals or indirectly by plants stimulating microorganisms in the rhizosphere.
- **Bioremediation:** Process of detoxification of toxic/unwanted chemicals / contaminants in the soil and other environment by using microorganisms.
- **Mineralization:** Complete conversion of an organic contaminant to its inorganic constituent by a species or group of microorganisms.

Different Approaches for Biodegradation

Although a number of techniques are available for biodegradation, the ones of utmost importance (Abdelhafid et.al 2000)

1. **Bacterial degradation:** Most bacterial species degrade pesticides. Most of the pesticides undergo partial degradation leading to the formation and accumulation of metabolites.
2. **Fungal degradation:** Fungi degrade pesticides by introducing minor structural changes to the pesticides rendering it non toxic and are released to soil, where it is susceptible to further biodegradation by bacteria.
3. **Enzymatic degradation:** Enzymes have a great potentiality to effectively transform and detoxify polluting substances because they have been recognized to be able to transform pollutants at a detectable rate and are potentially suitable to restore polluted environments.

Chemical Reactions Leading to Biodegradation: The biodegradation of pesticides, is often complex and involves a series of biochemical reactions:

1. **Detoxification:** Conversion of the pesticide molecule to a non- toxic compound. A single chance in the side chain of a complex molecule may render the chemical non-toxic.
2. **Degradation:** The breaking down / transformation of a complex substrate into simpler products leading finally to mineralization. e. g. Thirum (fungicide) is degraded by a strain of Pseudomonas and the degradation products are dimethlamine, proteins, sulpholipaids, etc.
3. **Conjugation:** In which an organism make the substrate more complex or combines the pesticide with cell metabolites. Conjugation is accomplished by those organisms catalyzing the reaction of addition of an amino acid, organic acid or methyl crown to the substrate, for e.g., in the microbial metabolism of sodium dimethly dithiocarbamate, the organism combines the fungicide with an amino acid molecule normally present in the cell and thereby inactivate the pesticides/chemical.

Advantages

- Often less expensive and site disruption is minimal.
- It eliminates waste permanently.
- Eliminates long-term liability.
- It can be coupled with other physical or chemical treatment methods.

Disadvantages

- Treatment time is typically longer.
- Range of contaminants that can be effectively treated is limited to compounds that are biodegradable.
- The process is sensitive to the level of toxicity and environmental conditions in the ground.
- If the process is not controlled it is possible the organic contaminants may not be broken down fully resulting in toxic by-products that could be more mobile than the initial contamination.

References

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