Biodegradation of Pesticides

Degradation of pesticide

Pesticide degradation is the breaking down of toxic pesticides into a nontoxic compounds and, in some cases,

down to the original elements from which they were derived.

In general there are three ways to degrade pesticides:

1. Physical
2. Chemical
3. Biological (microbial degradation)

Biodegradation of pesticides

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 biodegradation 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.

Among the various practice to decrease the load of pesticides in soil and water, the degradation by micro-organisms has given sufficient encouragement . Bollag (1974)

Suggested four major possibilities for transformation of inactivation pesticides by microorganisms they are:

- The pesticides is used as substrate and energy.
- The pesticides undergo co-metabolism i.e. organism transform it but cannot derive energy for growth from it.
- The entire pesticide molecules or its intermediate can be conjugated with naturally occurring compounds.
- The pesticides is incorporated and accumulated with in the organisms.

Factors affecting Biodegradation

1. Chemical structure of the compound
2. The capability of the individual microorganisms
3. Nutrient and O_2 supply
4. Temperature and pH

Microorganism

Many micro organisms belonging to diverse groups i.e. bacteria, actinomycetes, fungi are found to degrade different pesticides they metabolic diversity of the micro organisms enable them to degrade this chemical different pesticides .

It is interesting to note that two taxonomically microorganism may degrade the same pesticide in similar pathway .

Examples: Achromobacter , agrobacterium, Enterobacter, aspergillus, candida....etc

Microorganism involved in biodegradation o f pesticides

BACTERIA	PESTICIDE	FUNGI	PESTICIDE
Achromobacter	DDT,2,4, -D Carbaryl	Pyricularia oryzae	Pyrazophos, Hinson
A. Aerogenes	Dieldrin, Endrin	Aspergills sp.	Atrazine, simagine
Agrobacterium	Chlorophan	Penicillium chrysogenum	Parathion, dieldrin
Enterobacter	DDT	Candida tropical	Phenols
Micrococcus	Aldrin, Dieldrin	Phanerochaeta	DDT
Pseudomonas sp.	Endrin, 2,3-D Aldrin	Saccharomyces sp.	Thiocarbonates
Nocardia	Phenolic	Trichoderma viride	Malathion

Mode of microbial metabolism of pesticides

There are two modes :

1. ENZAYMATIC TYPE
2. NON-ENZYMATIC TYPE

1. ENZYMATIC TYPE

This divided into three phases

a) Incidental metabolism of pesticides which cannot serve as energy source.

b) Catabolism insecticides serve as energy source.

c) Detoxification serving as resistance mechanism.

2. NON-ENZYMATIC TYPE

a) Photosynthetic breakdown

b) Contribution via PH change

c) Production of organic and inorganic reactants

d) Production of cofactors

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 hyperaccumulate 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.

Chemical Reactions Leading to Biodegradation

The biodegradation of pesticides, is often complex and involves a series of biochemical reactions:

- **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.
- **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 dimethylamine, proteins, sulpholipaids, etc.
- **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 dimethyl dithiocarbonate, the organism combines the fungicide with an amino acid molecule normally present in the cell and thereby inactivate the pesticides/chemical.

- **Activation:** It is the conversion of non-toxic substrate into a toxic molecule, for e.g. Herbicide, 4-butyric acid (2, 4-D B) and the insecticide Pharate are transformed and activated microbiologically in soil to give metabolites that are toxic to weeds and insects.
- **Changing the spectrum of toxicity:** Some fungicides/pesticides are designed to control one particular group of organisms / pests, but they are metabolized to yield products inhibitory to entirely dissimilar groups of organisms, for e.g. the fungicide PCNB fungicide is converted in soil to chlorinated benzoic acids that kill pests.
- **Leaching:** Since many of the pesticides can be solubilized, they are removed by leaching.

Metabolism of pesticides by MO

Metabolism of pesticides may involve a three-phase process:

- Phase I
- Phase II
- Phase III

Phase I- In Phase I metabolism, the initial properties of a parent compound are transformed through oxidation, reduction, or hydrolysis to generally produce a more water-soluble and usually a less toxic product than the parent.

Phase II- The second phase involves conjugation of a pesticide or pesticide metabolite to a sugar or amino acid, which increases the water solubility and reduces toxicity compared with the parent pesticide.

Phase III- The third phase involves conversion of Phase II metabolites into secondary conjugates, which are also non-toxic. In these processes fungi and bacteria are involved producing intracellular or extra cellular enzymes including hydrolytic enzymes, peroxidases, oxygenases, etc.