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Review Article

Fate and Effect of Selected Insecticides on Soil

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A B S T R A C T

The production and utilization of insecticides is increasing worldwide day by day. It is important to know that when insecticides are applied to field, only small portion reaches to its target and remaining large part reaches the environment. As much as 50 per cent of the insecticides applied on a crop reaches soil either as spray drift or runoff or from leaves fallen on soil (Khan, 1980). It has also been reported that only less than 0.3 per cent of the pesticide reaches the target leaving the remaining 99.7 per cent in the environment (Pimentel 1995). That may lead to some problems, such as toxicity to non-target organisms, leaching, adsorption, desorption, volatilization, runoff in soils and their absorption and accumulation in plants. Polluted soil, surface and ground waters involve risk to the environment and also to human health due to possible direct or indirect exposures. Soil is the repository of all types of agricultural inputs including insecticides which directly or indirectly influence soil productivity and agro-ecosystem quality. The metabolic fate of insecticides is dependent on environmental conditions, microbial community, plant species, insecticides characteristics and biological and chemical reactions. Data on the rate of insecticide degradation are extremely important to predict the potential risk associated with exposure. Such studies are, therefore, the foundation for understanding the fate and behaviour of an insecticide and any subsequent risk assessment.

Keywords

Insecticide, Risk assessment, Pesticide, Agro-ecosystem quality

Introduction

Insecticides

Insecticides are pesticides that are kill harm, repel, or mitigate one or more species of insect.

The term insecticide has been defined under the act to include any substance or such other substance or preparations intended for the purpose of preventing, destroying, repelling or mitigating any insect, rodents.

Classification of insecticides

1. Botanical insecticides

Eg: Pyrethrum, Marigold, Nicotine, Azadirachtin etc…

2. Synthetic insecticides

Eg: Organochlorines - HCH, Aldrin, etc…

Organophosphates – phorate,
Carbamates - cabofuran, carbaryl

Pyrethroids – felvenarate,

Neonicotinoids – imidacloprid

3. Biorational Formulations

Eg: Growth regulators

Pheromones

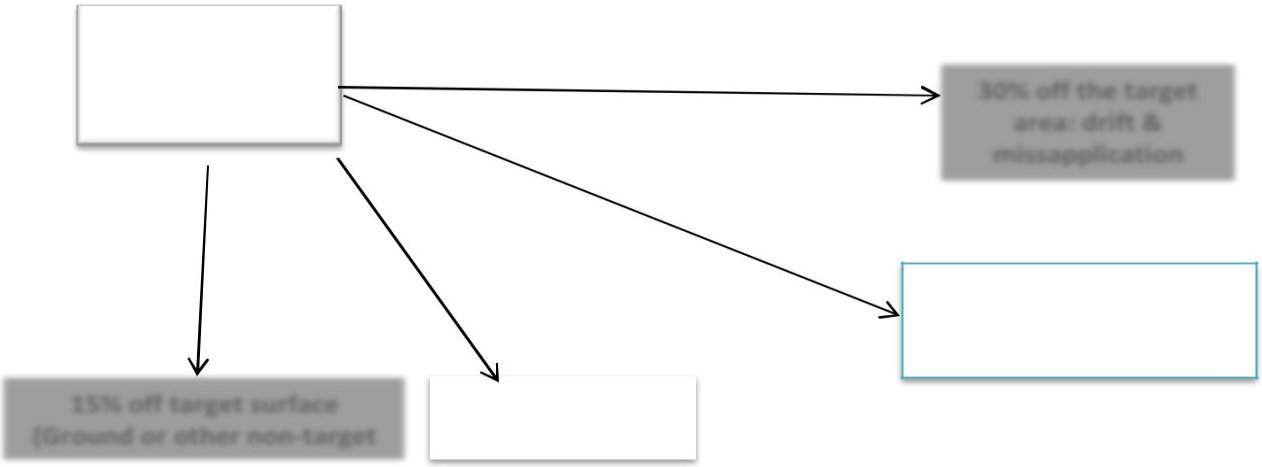
Microbial formulation

Consumption of insecticides in World and India

Among the different agrochemical the insecticides are having consumption rate followed by herbicides in both world and India. In world among pesticides highest consumption by insecticides about 44 % and 76 % and in world as well as India respectively.

Andhrapradesh and Telegana, Punjab, Maharashtra lead in consumption of crop protection chemicals followed by other states. Madhya Pradesh has been benefited a lot by proper crop protection usage and emerging as one of the important Soybean producing region not only in the country but globally. A rise in the usage of agrochemicals has also been observed in West Bengal where the purchasing power of farmers had been low. In India state wise percent consumption of pesticides was highest in Andrapradesh and Telangana state about 24 %, followed by Maharashtra 13 %, Punjab 11 %, MP and Chhattisgarh 8 % and Karnataka 7 % and least in West Bengal 5%.

Distribution of insecticides on target or non-target area



Fate of insecticides in different environments

Transfer processes

Adsorption
Volatilization
Spray Drift
Runoff
Leaching
Absorption

Microbial breakdown
Photo degradation

Chemical degradation

Das and Mukherjee (2010) conducted experiment on soil application of insecticides influences microorganisms populations. Reported that the application of insecticides *viz.*, HCH, phorate, fenvalerate and carbofuran significantly increased the population of bacteria, actinomycetes and fungi in soil. Population sizes of bacteria were greatest 30 days (122.6, 134.8, 101.2 and 112.3 c.f.u x 10^{5} g^{-1}) and fungi (22.8, 21.2, 19.9 and 15.7 c.f.u x 10^{4} g^{-1}) and 45 days actinomycete (72.5, 55.2, 54.5 and 50.6 c.f.u x 10^{5} g^{-1}) in hexachlorocyclohexane (HCH) application followed by phorate, fenvalerate and least in carbofuran respectively.

Fig.1 Consumption pattern in pesticides in World and India

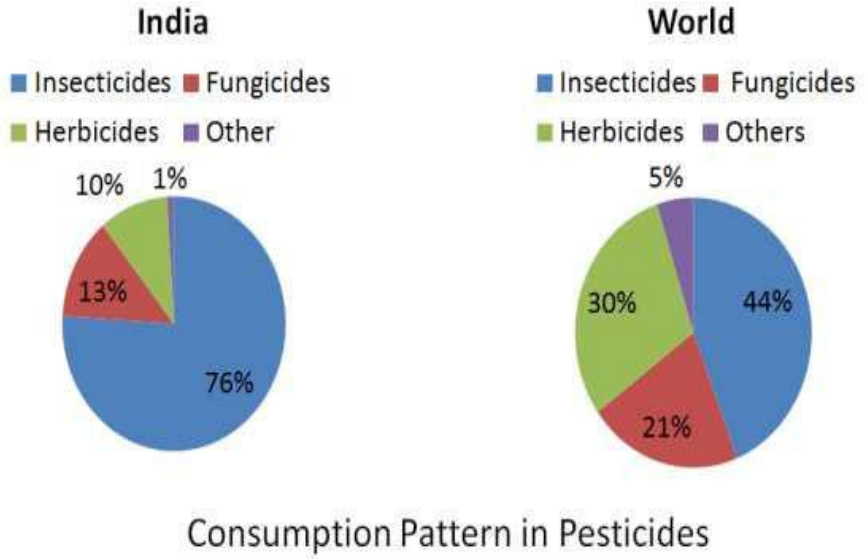


Fig.2 State wise per cent consumption of pesticides in india

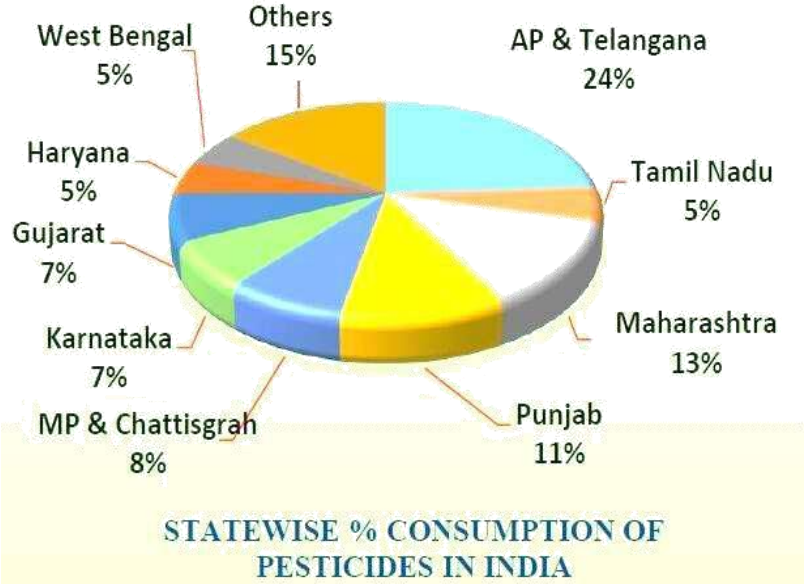
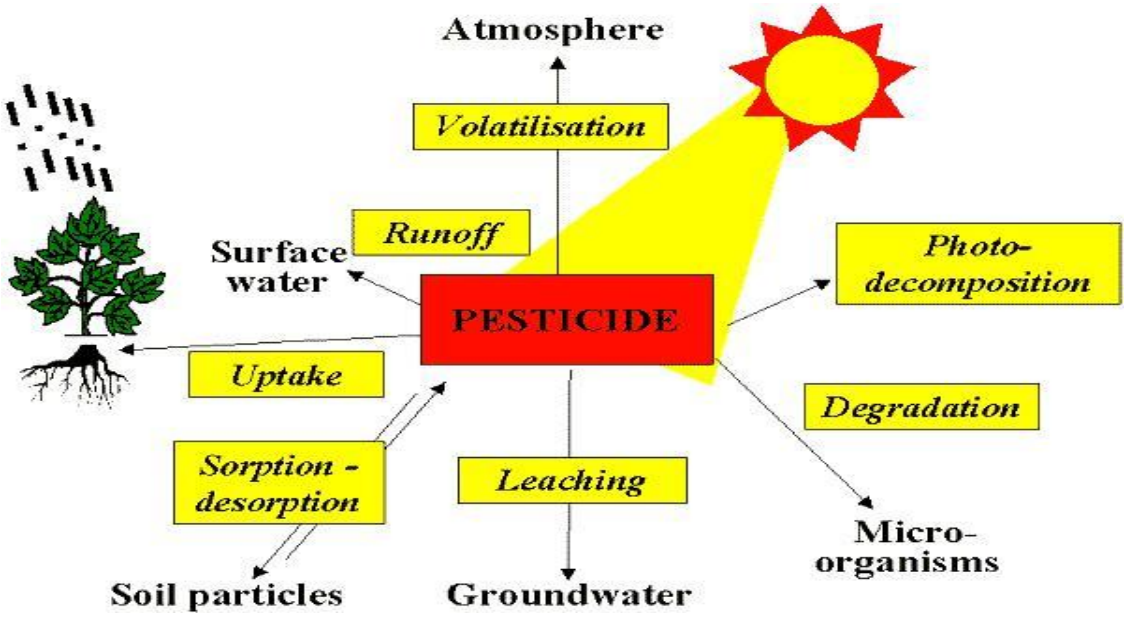


Fig.3 A schematic view of the fate of a chemical in the environments



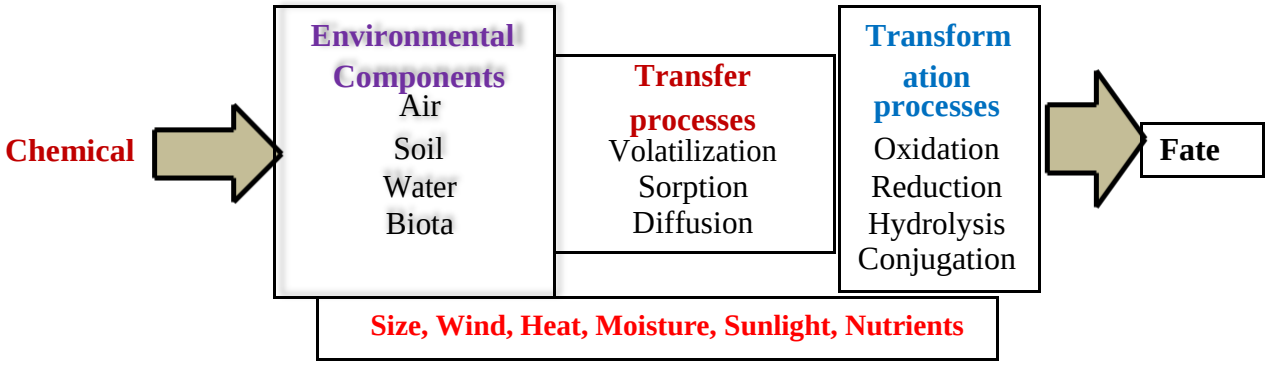


Fig.4 Disappearance of residues take place in two

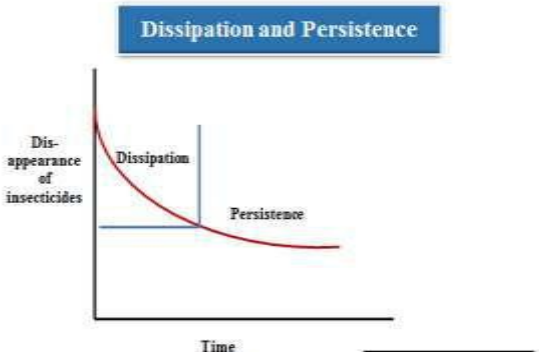


Table.1 Properties that influence degradability of insecticides

Property	Degradability	
	More easily	Less easily
Solubility in water	Soluble in water	Insoluble in water
Size	Relatively small	Relatively large
Functional group substitution	Fewer functional group	Many functional group
Compound more oxidized	In reduced environment	In oxidized environment
Compound more reduced	In oxidized environment	In reduced environment
Created	Biologically	Chemically by man

Aliphatic	Aliphatic up to 10C-chains, Straight chains, Aromatic compound with one or two nuclei	High molecular weight alkanes, branched chain, polyaromatic hydrocarbon
Substitution on aromatic ring	OH, COOH,CHO, CO, OCH_3, CH_3	F, Cl, NO_2, CF_3, SO_3H, NH_2
Substitution position	p- position o- or p-Disubstituted phenols	m- or o- position m-Disubstituted phenols

Processes that govern the behavior and fate of insecticides

Three types:

Transport types: Which move it away from its initial point of introduction to the environment and throughout the surface water system (leaching, runoff etc.)

Transfer types: Way of insecticides distribution b/w solid & liquid (soil and soil water) or between soild and gases (soil and soil air). (sorption, desorption etc.)

Transformation types: biological and chemical processes that change the structure of insecticides or completely degrade. (biodegradation, decomposition etc.).

Dissipation and Persistence

Disappearance of residues take place in two steps:

Dissipation

Persistence

Insecticide persistence in soil

Continuous existence of insecticides in soil for long time called as insecticide persistence

Insecticide persistence expressed in terms of half-life

Persistence degrees	**Typical soil half-life**
Non-persistent	**<30 days**
Moderately persistent	**30 - 100 days**
Persistent insecticides	**>100 days**

Samnani *et al.* (2013) studied the persistence of imidacloprid in different soils under laboratory conditions. The result found that the initial deposits of imidacloprid varied from 0.81 to 0.87 µg g^{-1} in sandy loam soil, clay soil, black and red soils at 1.0 mg kg^{-1}. The initial deposits of imidacloprid varied from 1.69 to 1.74 µg g^{-1} and 3.39 to 3.45 µg g^{-1} in sandy loam soil, clay soil, black and red soils at 2.0 and 4.0 µg g^{-1} respectively. The per cent dissipation of imidacloprid in/on soil treated at 1.0 mg kg^{-1} was 30.59, 39.29, 39.51 and 39.80 per cent after 15 days of application in sandy loam, clay, black and red soils respectively and the corresponding value at 2.0 and 4.0 µg g^{-1} were 26.4, 38.95, 37.85, 33.91 per cent and 25.66, 35.88, 35.10 and 32.75 per cent respectively.

Sharma and Singh (2016) conducted an experiment on the persistence and behavior of imidacloprid and its metabolites in soil under sugarcane. Results found that in soil the total imidacloprid residues were mainly constituted by the parent compound followed by 6-chloronicotinic acid, nitrosimine and imidacloprid-NTG (nicotinylnitroguanidine) metabolites. Maximum residues of imidacloprid and its metabolites were 4.29 and 7.81 mg kg^{-1} in soil samples collected seven days after the application of imidacloprid at 20 and 80 g a.i. ha^{-1} respectively.

Adsorption/ desorption of pesticides

- Interaction between insecticides & soil.
- A insecticide's tendency to be adsorbed by soil is expressed by its adsorption (partition) coefficient (K_{oc})

K_{oc} = Conc. adsorbed / Conc. dissolved

- High value of K_{oc} indicate a tendency for the insecticide to be adsorbed by soil particles rather than remain in the soil solution.

Adsorption	Partition coefficient	
Weakly adsorbed	< 50	May be leached
Moderately adsorbed	50 – 5000	High potential of runoff
Strongly adsorbed	> 5000	Runoff loss with sediments

Insecticides adsorption mechanisms

The different bonding mechanism that occur between insecticides and the soil

Physical bonding due to Vander walls forces (pyrethroids)
Electrostatic bonding by ion exchange and protonation (Carbamates and Organophosphates)
Hydrogen bonding (Organochlorides)
Covalent bonding or ligand exchange (Organophosphates)

Ramakrishna and Philip (2018) studied the adsorption and desorption characteristics of lindane, carbofuran and methyl parathion on various Indian soils. The order adsorption of pesticides on soils was: lindane >methyl parathion >carbofuran. Compost soil showed maximum adsorption capacity. The order of adsorption capacity of various soils was compost soil > clayey soil > red soil >sandy soil. Adsorption isotherms were better fitted to Freundlich model and values increased with increase in organic matter content of the soils.

Water solubility of insecticides

Determines the tendency of insecticides to move or transfer from water to soil, air and organisms

Solubility	mg/L (parts per million)
Low solubility	<50
Moderately soluble	50-500
Highly soluble	>500

Volatilization of insecticides

It a process of conversion of solid and liquid insecticides into a gas determines its movement with air current away from the treated surface.

Volatilzation potential to volatilized is depends on its Henry's law constant (H).

H = Vapor pressure / Solubility

A high value of H indicates a tendency for the insecticide to volatilize & be lost to the atmosphere.

Volatility	H
Low volatility	< 1x 10^{-8}
Moderately volatile	1x10^{-8} to 1x10^{-3}
Highly volatile	> 1x10^{-3}

Source: Gavrilescu, 2005

Leaching of insecticides

Leaching is the movement of insecticides through the soil rather than on surface. Two kind of phenomena are associated with leaching:

Preferential flow

Allows insecticide molecule to move rapidly through soil profile section.

Water flows rapidly through worm holes, root channels cracks & large structural voids in soil.

Matrix flow

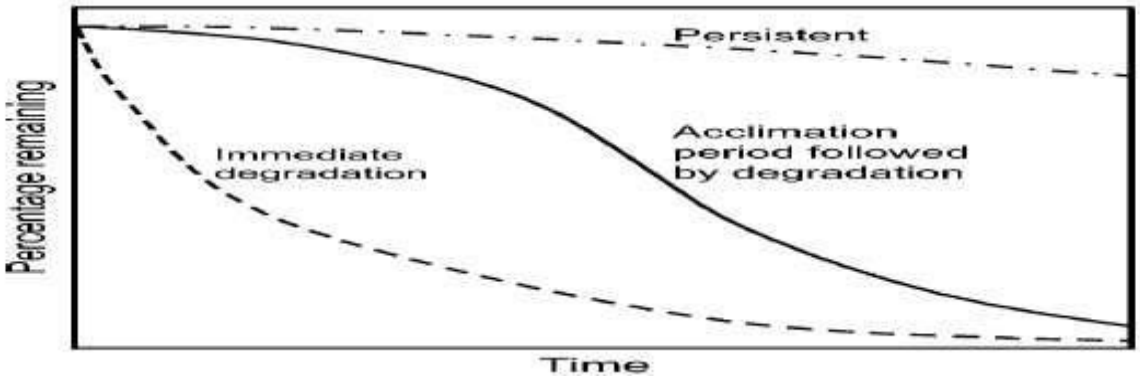
Slower migration of water & insecticides through the soil structure.

The insecticides move slowly with water into small pores in soil & has more time to contact soil particles.

Factors influencing insecticide degradation in soil

Insecticide structure
Insecticide concentration
Insecticide solubility
Soil types
Soil moisture
Temperature
Soil pH
Soil salinity
Soil organic matter

Time taken for insecticides degradation in soil



Fate of insecticides in soil is mainly regulated by their behavior in soil where various physico-chemical and biological processes control their dissipation and movement towards other environmental compartments like air, water and biota. The mobility of an insecticide in soil is determined by the extent and strength of sorption, which is influenced by various soil physico-chemical properties. Sorption is one

of the most important processes that affects the fate of insecticides in soil and determines their distribution in the soil/water environment. Adsorption is one of the most important processes which controls their movement, persistence and degradation and determines the fate of insecticides in soil.

References

Das, A. C. and Mukherjee, D., 2010, Soil application of insecticides influences microorganisms and plant nutrients. *Appl. Soil Ecol.*, 14: 55–62.

Gavrilescu, M., 2005, Fate of pesticides in the environment and it's bioremediation, *Eng. Life Sci*., 5(6): 497-526.

Khan, S. U., 1980, Occurrence and persistence of pesticide residues in soil. In: Pesticides in the soil environment. *Amsterdam: Elsevier*, 240.

Pimentel, D., 1995, Amounts of pesticides reaching target pests: environmental impacts andethics. *J. Agric. Environ. Ethics.*, 8: 17–29.

Rama Krishna, K. and Philip, L . , 2018, Studied adsorption and desorption characteristics of lindane, carbofuran and methyl parathion on various Indian soils. *J. Hazardous Materials*., 160: 559-567.

Samnani, P., Kamlesh, V. and Pandey, S. Y., 2013, Persistence study of Imidacloprid in different soils under laboratory conditions. *Int. J. Environ. Sci*., 4(2): 151-157.

Sharma, S. and Singh, B., 2016, Persistence behavior of imidacloprid and its metabolites in soil under sugarcane. *Environ. Monit. Assess*., 186(6): 2281-2288.