www.journalworlds.com
AGRI JOURNAL WORLD
VOLUME 2 ISSUE 5 MAY, 2022

PESTICIDE SORPTION IN SOIL: MECHANISM AND FACTORS

Kailash Pati Tripathi, Parshant Kaushik, Neethu Narayanan, Sameer Ranjan Mishra and Rakesh Kumar

Division of Agricultural Chemicals, ICAR-Indian Agricultural Research Institute, New Delhi

**Corresponding author email: parshantagrico@gmail.com*

ABSTRACT

In last six decades the food production increased exponentially in the India from fifty million tonnes to two hundred eighty-four million tonnes. With increases in production the pesticides per capita consumption also increased from 0 to 0.6 kg ha^{-1}. The major dilemma in using pesticides occurs when they are applied to the crop immobilized through sorption via different methods. Soil organic matter (SOM) and clay minerals are the main reasons that sorption. Pesticide in the either remain in free or bound (adsorbed) form. The sorbed state of pesticides do not subjected to microbial degradation, while free form remains in drive along with water. This drive of pesticides in soil creates hindrance in control of the targeted pests and the contamination of environmental components. Pesticide sorption creates a greater threat of pesticide residue in food commodities and danger to health effects but knowing the sorption mechanism and other properties of pesticides and soil will help us minimize the side effect.

INTRODUCTION

In India for production of cotton, rice, grain, millets and oilseeds approximately eighty thousand tonnes of pesticides get consumed. The prominent states which use pesticides includes Haryana, Punjab and Uttar Pradesh that have the most considerable pesticide utilization, utilizing 45,000 tons of (specialized grade) pesticides in 2000–01. This improved utilization has prompted the exhaustion of soil fruitfulness and a decrease in manageable yield production.

In last six decades the food production increased exponentially in the India from fifty million tonnes to two hundred eighty-four million tonnes. In India, pests and diseases, on average, eat away around 20–25% of the total food produced. With increases in production the pesticides per capita consumption also increased from 0 to 0.6 kg ha^{-1}. In comparison to other countries, we are using a very less amount of

pesticides. Pesticides are applied to crops immobilized through sorption via different methods and factors. (Tiryaki and Temur, 2010).

PESTICIDES APPLICATION IN SOIL

- **Deliberate application**
- **Accidental**
    i. Spray drift
    ii. Burial of container
    iii. Equipment washing
    iv. Washing from the plant surface
    v. Pesticide vapours dissolved in rain
    vi. Plant residue

Pesticides in soil occur in two forms:

1. Free

i. Adsorption
ii. Degradation
iii. Transport :(Soil to air – Volatilization) (Soil to water – Runoff and leaching) (Soil to biota –Uptake) (Movement in soil –Diffusion and mass flow)

2. Bound

ADSORPTION

Adsorption can be described as surface phenomenon which divides of pesticide molecules in the solid form and liquid form. It decreases via volatility and plant uptake, microbial degradation, dispersion in groundwater and adsorption increases through transport by erosion/runoff.

PESTICIDE SORPTION

Active accumulation of pesticides needs some attraction between solute and sorbent. Soil colloids may have a partial or complete charge, which may be temporary or permanent. Similarly, pesticide molecules may be ionic or may dissociate in soil to give an ionic compound or have partial charges. The pesticides sorption may occurs either through physical adsorption by dipole-dipole interaction or through chemical adsorption by bond formation in adsorbent and adsorbate atom.

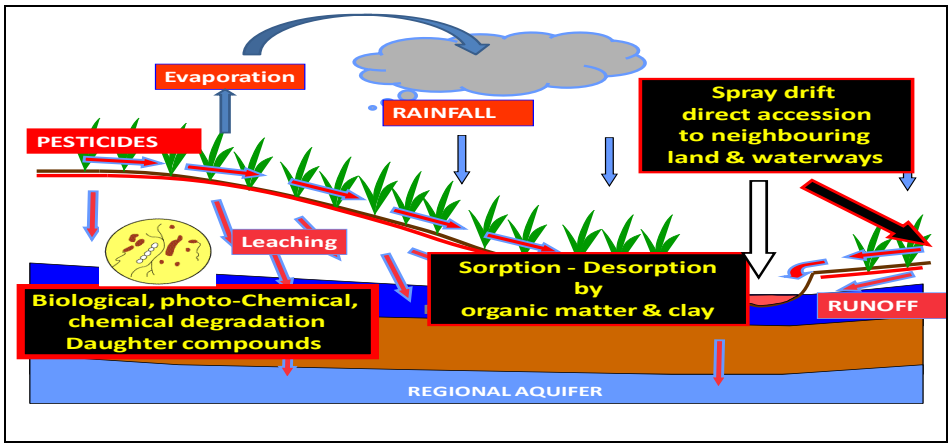

Fig.1 Pesticides in soil

MECHANISM INVOLVED IN PESTICIDE SORPTION

1. Van-der waal attraction
2. Hydrogen bonding
3. Hydrophobic bonding
4. Charge transfer
5. Ion exchange
6. Ligand exchange

FACTORS AFFECTING SORPTION

- **Properties of soil:** The different soil chemical properties which includes soil organic matter, clay content, soil moisture, soil reaction, soil temperature etc.
- **Properties of pesticide:** Properties of the pesticide such as acidity (pKa), basicity (pKb), solubility, charge distribution, the polarity of the molecule, molecular size and its concentration in the solvent.

PROPERTIES OF SOIL

1. SOIL ORGANIC MATTER:

- It contains polar groups like acid, amine, amide, phenol etc. It also has hydrophobic fractions like lipid. Thus, it can be the site for adsorption of ionic and non-ionic compounds as several sorption mechanisms are possible, thereby it play a significant role in sorption of pesticides.
- In general, the sorption of pesticides is directly proportional to the soil organic matter or organic carbon content. However, recent studies have shown that it is not the total organic carbon content but the chemical nature of the organic carbon which can significantly affect the pesticide adsorption.

2. CLAYS:

The clay fraction of soil, especially in soil having low organic carbon content, significantly affects pesticide adsorption. Three-layer minerals show higher adsorption potential than two-layer minerals.

3. METAL OXIDES AND HYDROXIDES:

They behave like clays and affect adsorption. Iron oxides in laterite soils greatly affect pesticide adsorption.

4. *p*H:

Soil pH greatly affects the active centers in soil. It also affects pesticide molecule ionization or polarization. Adsorption of triazine, amide, sulfonylureas, urea group of pesticide is pH dependent. Above the pH greater than pKa, the molecule exists as a negative ion while below pKa, it exists as a positive ion.

5. TYPE OF EXCHANGE CATIONS:

The type and nature of exchangeable metal cation on clay surface significantly controls the complex formation of the EDA (electron donor-acceptor). The high surface density of strongly hydrated cations (Na^+, Ca^{2+}, Al^{3+}) reduces the accessibility of siloxane sites for pesticides, while small and weakly hydrated cations (K^+ and NH_4^+) allow better EDA complex formation.

PROPERTIES OF PESTICIDES

1. Functional groups: Functional groups in pesticides like carbonyl, carboxylic, ester, amide, phenol etc., affect sorption as they can get ionized or polarized. Further, electro-negativity or electro-positivity of a group adjacent to a function can affect ionization and polarization.
2. The dissociation constant: Pesticide's dissociation constant (pka and pKb) affect their ionization. Pesticides which generate ions in the soil, depending on the pH, have different operative mechanisms. Cationic pesticides are more sorbed in soil.

MOVEMENT/TRANSPORT OF PESTICIDES

Pesticide in the soil is in a free and adsorbed form. The sorbed state of pesticides do not subjected to microbial degradation, while free form remains in drive along with water. This drive of pesticides in soil creates hindrance in control of the targeted pests and the contamination of environmental components.

CONCLUSION

Pesticides' status in the ecosystem is largely determined by how they behave in soils and their adsorption and microbial and abiotic breakdown. The amount of these processes is determined by pesticide Physico-chemical qualities and soil characteristics. Environmental factors such as relative humidity,

temperature, and water content are also heavily influenced by environmental factors. To increase our understanding of pesticide fate in soils, we need to consider the heterogeneity and unpredictability of soils. In studies, major integrative dynamics significant to the topsoil structure and surface properties at different water contents must be considered. In ascending order, integrative limitations depend on the scale: Organic matter hydrophobic structures, wettability. Lastly, the wet and dry cycle effect on pesticides is not known or poorly known and must be studied in these vulnerable and critical climate change circumstances.

REFERENCE

Tiryaki, O. and Temur, C. 2010. The fate of pesticides in the environment. *Journal of Biological and Environmental Sciences* 4: 29–38.

******