Insecticide Persistence and Health Implications

Aditya Kumar Sharma*, Rajnish Kumar, Shailendra Kumar Mishra and Ankit Kumar

Department of Ag. Entomology, Baba Raghav Das Post Graduate College, Deoria - 274 001, Uttar Pradesh, India

Corresponding Author
Aditya Kumar Sharma
Email: adisharmajmd098@ gamil.com

OPEN ACCESS

Keywords

Insecticide persistence; Agro ecosystem; Residues; Organochlorine insecticides; Bioaccumulation; Ecotoxicology

How to cite this article:

Sharma, A. K., Kumar, R., Mishra, S. K. and Kumar, A. 2026. Insecticide Persistence and Health Implications. *Vigyan Varta* 7 (02): 35-40.

ABSTRACT

Insecticides are essential for enhancing agricultural productivity; however, their persistence in agro ecosystems poses significant environmental and human health risks. Persistence refers to the prolonged presence of insecticidal residues in soil, water, air and biota, commonly expressed through half-life values. Based on persistence, insecticides are classified as non-persistent, moderately persistent and highly persistent, with organochlorine insecticides exhibiting extreme stability, bioaccumulation and biomagnification. Environmental processes such as leaching, volatilization and adsorption redistribute insecticides rather than eliminate them, resulting in long-term ecological contamination. Persistent residues adversely affect soil organisms, aquatic life, wildlife and beneficial insects, while chronic human exposure is linked to neurological disorders, reproductive toxicity and developmental abnormalities. Past incidents, including the Endosulfan tragedy and Bhopal gas disaster, underscore the urgent need for safer pest management strategies and stricter regulatory control.

INTRODUCTION

Insecticides are those chemical substances that prevent, destroy and kill the insect; another insecticides persistence is the ability of insecticides to remain present and active for a long time in soil, air and water **(Mishra *et al.*, 2023)**. Provide for long term pest control but may harm sensitive plant and animal. May lead to illegal or unessential residue on rotational crop. Insecticide persistence often is expressed in term of half-life. This is the length of time required for one half of the original quality to breakdown. Insecticides persistence is also known as Insecticide residue. The insecticide after being sprayed in the field or being used in godowns to control the insect pests faces biological and physical factors operating in the environment. The ultimate fate of insecticidal residues in the environment depends on these factors. They may be adsorbed/absorbed by soils, may get leached through rainwater, may be picked up by plants and animals, may get evaporated directly or with water vapours, may be drifted to different places by wind and so on. All these processes are responsible in reducing the level of insecticide at the site of application. But when we consider the environment as a whole, these processes do not reduce the total amount of insecticide within the environment.

The present study embodies those factors which are responsible for degradation of insecticides in the environment. Before coming to actual topic it is necessary to explain certain terms which are commonly used in residue studies. In nature the disappearance of residue takes place in two steps. The first step is the initial phase in which the disappearance of the residue is fast, this phase is called 'dissipation'. The second phase in which there is a slow decrease in the amount of residue is known as 'persistence'. Dissipation follows the law of 'first-order kinetics and the rate of disappearance is related to the amount of insecticidal deposit. The persistence does not follow the law of first order kinetics because of the storage of translocated insecticides and degradation at various rates. Insecticides are vital in agricultural growth because they may minimize agricultural product losses and increase affordable production and food quality **(Aktar *et al*. 2009; Fenik *et al*., 2011; Strassemeyer *et al*., 2017).** Without a parallel growth in food supply, the world's population would have surged in the twenty-first century. There would be a 78 per cent loss of fruit output, a 54 percent loss of vegetable production and a 32 per cent loss of cereal production if pesticides were not used **(Tudi *et al*., 2021).**

Type of Insecticide Persistence:

On the basis of residual analysis or half-life it is three types

1. **Non-persistence Insecticides:** Are those insecticides that chemical persisting in the soil less than 30 days. e.g – Malathion.
2. **Moderately persistence insecticides:** Are those insecticides that chemical persisting in the soil between 30 to 100 days after spraying of the insecticides.
3. **Persistence insecticides:** Are those insecticides that chemical persisting in the soil more 100 days. e.g: Organochlorine insecticides.

Persistence in soil may vary greatly with respect due to degradation influenced by several factors determined by specific local conditions. Ultimately the degradation products water, co2 and minerals however the intermediate degradation products of some insecticides are concern for health or environmental reasons. In these cases half-life value should be determined for the intermediate products. Degradation of insecticide residue in the environment depends on a number of factors out of which the most important is the chemical nature of the insecticide itself. If the insecticide is labile it can be degraded easily by physical and biological factors but the degradation of persistent insecticide residue is very difficult.

Vigyan Varta
www.vigyanvarta.in

Vigyan Varta an International E-Magazine for Science Enthusiasts

Vol. 7, Issue 2

E-ISSN: 2582-9467
Popular Article
Sharma et al. (2026)

Insecticides disappear from the soil in three steps.

1. Acclimation Phase.
2. Dissipation Phase.
3. Persistence Phase

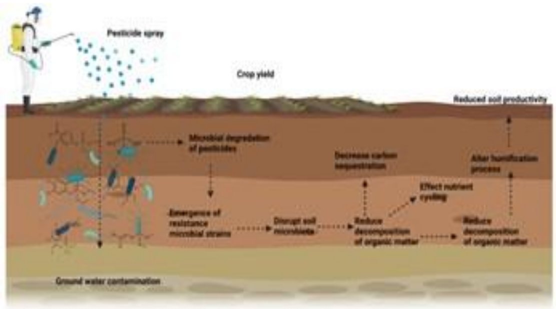

Fig:1 Schematic representation of insecticide disappearance in soil showing three distinct phases: acclimation, dissipation and persistence. Initially, during the acclimation phase, insecticides exhibit minimal detectable loss as soil microorganisms adapt to the chemical presence. This is followed by the dissipation phase, characterized by rapid reduction in residue concentration governed primarily by first-order kinetics. Finally, the persistence phase involves a slow and prolonged decline in residues due to adsorption, limited bioavailability and formation of stable metabolites, leading to long-term environmental contamination.

1. **Acclimation Phase:** Prior to the degradation, a period is noticed in which no disappearance on the compound is evident. Sometimes it is adaptation or long period length of time between the addition or entry of the insecticides into the soil and evidence of its detectable loss.

2. **Dissipation Phase:** No change in concentration is noted but then the disappearance become evident and the rate of loss often become quickly.

3. **Persistence Phase:** Which is longer and is expressed in units of time; hours, days, weeks, month and even years.

Several breakdown products of the insecticides are stable and create as many problems as the original compound. These breakdown products are called – Terminal Residue. Here the example of persistent insecticides *viz.*, Organochlorine insecticides (OCs) are chemical compounds that were previously used in agriculture but are now banned due to their environmental persistence and potential for causing toxicosis in animals. These compounds are known for their high toxicity, slow degradation and bioaccumulation. They accumulate in fat and can be detected in milk, with clinical signs of poisoning including hypersensitivity, twitching and convulsions.

Organochlorine – Toxicity & Persistence

S.N.	Chemical Name	Toxicity LD^{50} for rat mg/kg	Use	Persistence in Environment	Hazardous
1.	Dichloro diphenyl trichloroethane (DDT) $C_{14}H_9Cl_5$	Oral: 113-130 Dermal: 2510	Acaricide/ Insecticide	High Persistence Half life is 2-15 Years	Moderately
2.	1,1-dicholoro-2, 2bis(p-chlorophenyl) ethane (DDD)	Oral: 4000	Insecticide	High Persistence Half life is 5-10 Years	Acute
3.	Dichloro diphenyl dichloroethane (DDE)	Oral: 800 - 1240	Insecticide	High Persistence Half life is 10 Years	Slightly
4.	Dicofol $C_{14}H_9C_{13}O$	Oral: 684-1495	Acaricide	Moderately Persistence Half life is 60 Days	Moderately
5.	Endrin $C_{12}H_8C_{16}O$	Oral: 3 Dermal: 15	Avicide Insecticide	Moderately Persistence Half life is 1 Days to 12 Year	Highly
6.	Dieldrin $C_{12}H_8C_{16}O$	Oral: 46 Dermal:50-120	Insecticide	Highly Persistence Half life is 9 Month	Highly
7.	Methoxychlor $C_{16}H_{15}C_{13}O_2$	Oral: 5000-6000	Insecticide	Highly Persistence Half life is <120 Days	Acute
8.	Chlordane $C_{10}H_6Cl_8$	Oral: 200-700 Dermal: 530-690	Insecticide	Highly Persistence Half life is 10 Year	Moderately
9.	Heptachlor $C_{10}H_5Cl_7$	Oral: 40-220 Dermal: 119-320	Insecticide	Highly Persistence Half Year is 2 Year	Highly and Moderately

Toxicity of Insecticides on environment

Insecticides exert their toxic effects through various biochemical mechanisms that target specific physiological processes in organisms. Organophosphate and carbamate insecticides inhibit acetylcholinesterase, an essential enzyme in nerve signal transmission, leading to continuous nerve stimulation and eventual paralysis in target insects. However, this mechanism also affects non-target organisms with similar nervous systems, including vertebrates and beneficial arthropods.

Organochlorine pesticides such as DDT disrupt sodium channel function in nerve membranes, causing prolonged nerve excitation and tremors, while also interfering with calcium metabolism in birds, leading to eggshell thinning. Neonicotinoid insecticides have been implicated in bee population declines, affecting navigation, foraging behaviour and colony survival even at sublethal exposure levels **(Kadam and Ghutke, 2022).**

Aquatic ecosystems are particularly vulnerable to pesticide contamination through surface runoff, groundwater infiltration and direct application. Organophosphate insecticides can cause acute toxicity in fish, amphibians and aquatic invertebrates at concentrations commonly detected in agricultural watersheds **(Gerhards and Oebel, 2006)**

Human exposure of chronic low-level exposure has been associated with neurological disorders, reproductive problems and certain cancers, with children being particularly susceptible due to their developing organ systems and higher relative intake rates. Epidemiological studies have linked pesticide exposure to increased risks of Parkinson's disease, Alzheimer's disease and developmental disorders in children **(Ghutke *et al.*, 2023)**. Here the some example of Kerala Endosulfan Tragedy and Bhopal gas tragedy.

The UNO classify Endosulfan as highly dangerous insecticides killer and banned in 62 countries. Endosulfan a highly toxic Organochlorine insecticide was sprayed in the cashew plantations in Kasaragod District since 1976, till 2001 regularly three times every year. The aerial spraying of Endosulfan was allegedly undertaken to contain the menace of the tea mosquito bug (*Helopeltis antonii*). By 1990s health disorders of very serious nature among the human population came to the lime light. Children were found to be the worst affected with congenital anomalies, mental retardation, physical deformities, cerebral palsy, epilepsy etc.

Bhopal Gas Tragedy; Bhopal's pesticide plant was built in 1969 to manufacture Sevin insecticides to kill beetles, weevils and worms The plant was operated by Union Carbide India, Limited, but an American company, Union Carbide Corporation, held > ½ of the stock The leak began on December 2, 1984, when water entered a tank that was used to store methyl isocyanate, a toxic gas and a key ingredient in Sevin. The water reacted with the gas, causing extreme pressure and heat that possibly caused the tank to explode. The tank spewed 40 tons of poisonous gas into the air. The toxic cloud was mostly methyl isocyanate, a compound that can irritate the throat and eyes, cause chest pain and shortness of breath and, in large doses trigger convulsions, lung failure and cardiac arrest.

List of Banned Insecticides and their Year

S.N.	**Insecticides Name**	**Banned Year**
1.	Aldein	2001
2.	BHC (Benzene Hexachloride)	2001
3.	Chlordane	2001
4.	Dieldrin	2001
5.	DDT (Dichloro diphenyl trichloroethane)	2001
6.	Endrin	2001
7.	Heptachlor	2001
8.	Lindane	2001
9.	Organo Mercury Compound	2001
10.	Mirex	2001
11.	Phosphamidon	2001
12.	Toxaphene	2001
13.	Methyl Parathion	2001
14.	Monocrotophos	2007
15.	Endosulfan	2012
16.	Phorate	2015
17.	Benomyl	December 2020
18.	Carbofuran	December 2020
19.	Triazophos	December 2020
20.	Dichlorvus	December 2020
21.	Carbaryl	December 2020
22.	Carbosulfuron	August 2021
23.	Dicofol	August

		2021
24.	Aluminium phosphide 3 g	August 2021

Toxicity of Insecticides on Human Health/Health hazards

Unintentional poisonings kill an estimated 355,000 individuals worldwide each year, according to reports and these poisonings are closely linked to excessive exposure and inappropriate usage of harmful substance. The use of various synthetic pesticides on a regular basis can result in a number of issues. This usage has been linked to a variety of human illnesses and problems, including malignancies, respiratory disorders, diabetes, Parkinson's disease, Leukemia, mental disorders and neurological disorders, to name a few **(Kim *et al*. 2017).**

It effect direct and indirect on human health like

Direct effect-

1. Dermal (Skin)
2. Oral (mouth)
3. Inhalation (Lungus)
4. Eyes

Indirect effect

1. Air
2. Water
3. Food chain
4. Ingestion

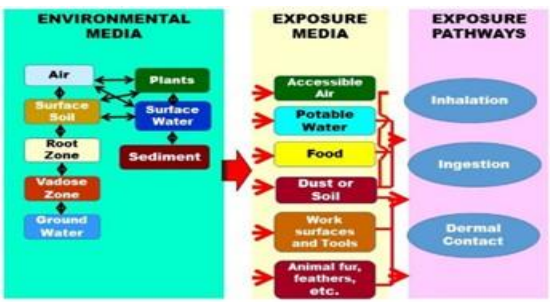

Fig: 2 Conceptual illustration showing direct and indirect pathways of insecticide exposure in humans. Direct exposure occurs through dermal contact, oral intake, inhalation and ocular absorption during handling or application. Indirect exposure results from environmental contamination of air, water bodies and the food chain, leading to chronic ingestion and long-term health risks.

Part of the body absorbed insecticides at different rate. The head is 4 times more absorbent then the head. Genital area is 11 time more absorbent. Pesticides can enter the body through inhalation of aerosols, dust and vapour that contain insecticides. Enter through oral exposure by consuming food and water. Skin exposure by direct contact. The effects of insecticides on human health depend on toxicity of the chemical, length & magnitude of exposure

CONCLUSION

Insecticide persistence in agro-ecosystems leads to long-term contamination of soil, water, air and the food chain, posing serious risks to the environment and human health. Persistent residues, especially from organochlorine insecticides, bioaccumulate and bio magnify, affecting non-target organisms and causing chronic health disorders through direct and indirect exposure. Despite regulatory bans, residual contamination persists, highlighting the need for safer insecticides, strict regulation, continuous residue monitoring and adoption of sustainable pest management practices.

REFERENCES

Aktar, M., Paramasivam, M., Sengupta, D., Purkait, S., Ganguly, M. & Banerjee, S. (2009). Impact assessment of pesticide residues in fish of Ganga River around Kolkata in West Bengal. *Environmental Monitoring and Assessment*, *157*(1), 97–104. https://doi.org/10.1007/s10661-008-0518-9

Fenik, J., Tankiewicz, M. & Biziuk, M. (2011). Properties and determination of pesticides in fruits and vegetables. *TrAC Trends in Analytical Chemistry*, *30*(6), 814–826. https://doi.org/10.1016/j.trac.2011.02.008

Gerhards, R. & Oebel, H. (2006). Practical experiences with a system for site-specific weed control in arable crops using real-time image analysis and GPS-controlled patch spraying. *Weed Research*, *46*(3), 185–193.

Ghutke, T. D., Kadam, R. G. & Vineeth, M. (2023). Impact of organic additives on enzymatic antioxidant activities in *Lentinus edodes* (Shiitake mushroom). *Environmental Reports: An International Journal*, *5*(1), 13–16. https://doi.org/10.51470/ER.2023.5.1.13

Kadam, R. G. & Ghutke, T. D. (2022). Impact of organic additives on non-enzymatic antioxidant activity in *Lentinus edodes* (Berk.). *Environmental Reports: An International Journal*, *4*(1), 9–13. https://doi.org/10.51470/ER.2022.4.1.09

Kim, K. H., Kabir, E. & Jahan, S. A. (2017). Exposure to pesticides and the associated human health effects. *Science of the Total Environment*, *575*, 525–535. https://doi.org/10.1016/j.scitotenv.2016.09.009

Mishra, M. K., Mishra, S. K., Pandey, L. & Pandey, R. (2023). Agrochemicals and their impact on environment. In *Recent Trends in Plant Protection* (pp. 47–56). NIPA Publisher.

Strassemeyer, J., Daehmlow, D., Dominic, A. R., Lorenz, S. & Golla, B. (2017). SYNOPS-WEB: An online tool for environmental risk assessment to evaluate pesticide strategies at field level. *Crop Protection*, *97*, 28–44. https://doi.org/10.1016/j.cropro.2016.11.036

Tudi, M., Ruan, H. D., Wang, L., Lyu, J., Sadler, R., Connell, D., Chu, C. & Phung, D. T. (2021). Agriculture development, pesticide application and its impact on the environment. *International Journal of Environmental Research and Public Health*, *18*(3), 1112. https://doi.org/10.3390/ijerph18031112.