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PESTICIDES: INTRODUCTION, TYPES AND TOXICITY

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Abstract

In the modern system of agriculture, the use of pesticide has become a necessity in order to enhance crop productivity and output. The present scenario of the demand for the production of pesticides has increased from a few million tonnes to thousand million tonnes. Pesticides are classified in a number of ways depending upon their chemical structure, target pest species, mode of action, toxicity level etc. The excessive use of pesticides has threatened the environment and human health and the situation demands for urgent measures to restrict overuse and management of already applied formulations. Reconsidering their recalcitrant nature and long shelf life urgent measures are needed based on biological interventions. There are various mechanisms for the clean-up of pesticides in different environmental matrices soil, such as volatilization, incineration chemical treatment, etc.
Keywords: Pesticides, classes, toxicity, degradation.

Introduction

Utilization of pesticides to increase high yield and quality of food grains lifts various environmental issues resulting in the unbalancing of the ecological system (Singh *et al.*, 2020a). They overall deteriorate the ecosystem resulting in the destruction of biodiversity, including microflora and microfauna Singh *et al.* (2020b). The present scenario of the demand for the production of pesticides has increased from a few million tonnes to thousand million tonnes (Singh *et al.*, 2019a,b,c). Most of the pesticides are potent inhibitors of various enzymes such as acetylcholine esterase which lead to several diseases like nausea, headache, slow heartbeat, breathing difficulty teratogenic, mutagenic, and carcinogenic effects (Singh *et al.*, 2019d,e,f). Pesticides also induce DNA damage, malfunction of tumour suppressor genes (p53), cat genes and apaf-1 (Kumar *et al.*, 2019a,b). The various spectroscopic, voltammetric, chromatographic technique has been employed till date for the detection of pesticides in various environmental samples having a high recovery rate. Biodegradation offers us an inexpensive and reliable method to remove pesticides and their intermediate metabolites from the environment. We review here the different classes of pesticides, their environmental hazards and their detection in various biological samples.

Pesticide Classification

Pesticides may be classified in a number of ways depending upon their chemical structure, target pest species, mode of action, toxicity level etc. (Kumar *et al.*, 2019c,d). The classification given by the U.S. EPA is based on the chemically related structure of pesticides which includes Organophosphates, Carbamates, Organochlorine, Pyrethoid, Sulphonylurea etc. WHO classifies pesticides on the basis of GHS acute toxicity hazard categories for acute dermal or oral toxicity (rats) and are summarized in table 1.

Table 1: Diverse classes of pesticides with specific groups, structure and general application.

Classes	Groups	Structure	Uses
Based on the chemical-related structure	**Organophosphates**	Esters of phosphoric acid The fundamental structure of Organophosphates contains terminal oxygen linked to phosphorus via a double bond, and a halide group.	Active against mosquitoe, crop pests, mites, flies of cattle's, and aphids etc.
	Carbamates	The general formula for carbamates is $R_1NHC(O)OR_2$, in which R_1 and R_2 are aliphatic and/or aromatic moieties. It was first used in 1956.	It is used to kill or incapacitate the target organism being derived from carbamic acid
	Organochlorine pesticides	These are the organic compounds having one covalently bond of a chlorine atom.	It is extensively used in agriculture to control pests like mosquito, aphids etc.
	Pyrethoid	These are the compounds extracted from *Chrysanthemum* flower It is a single pesticide active ingredient; contain six components	It is used till 1st Century and is largely used in agriculture, mosquito control, lawn etc.

		cinerin 1, cinerin 2, pyrethrin 1, pyrethrin 2, jasmolin 1, and jasmolin 2 that have anti-insecticidal activity	
Target pest species	Algicides or algaecides	The formulation contains the active ingredient sodium carbonate peroxyhydrate along with some of these salts copper chelates copper sulfate, triethanolamine, copper gluconate/citrat)	Control of Algae
	Avicides	Usually contains 4-aminopyridine or alphachloralose or fenthion compound	Control of Birds
	Bactericides	Certain antibiotics, essential oils, biological agents were used as bactericides	Control of Bacteria
	Fungicides	a formulated product consisting of an active ingredient plus inert ingredients commonly used fungicides includes aerosols, essential oils, chemical compounds etc.	Control of Fungi and Oomycetes
	Herbicides	Contains Phenoxy compounds, Phenyl acetic acid, Benzoic acid, Pthalic acid and many other nitrogen derivatives.	Control of Weeds
	Insecticides	Natural insecticides include nicotine, pyrethrum, rotenone. Synthetic includes OP's Organochlorine, Carbamates etc.	Control of Insects and Aphids
	Miticides	Commonly used miticides include	Control of Mites
	Molluscicides	Metaldehyde, Methiocarb, Ach inhibitors and metal salts such as Fe(III) phosphate and aluminium sulphate	Control of Slugs and Snails
	Nematicides	aldicarb, carbofuran, phorate, fensulfothion, DBCP essential oils etc. were used as nematicides, and chemical composition differs from compound to compound	Control of Nematodes
	Rodenticides	Anticoagulants, metal phosphides, hypercalcemis and others like arsenic, barium, sodium flouroacetate etc.	Control of Rodents
	Virucides	Commonly used virucides include H_2O_2, hypochlorites, ferric ions ethanol, lipids azodicarbonamide, curdline sulphate, disulfate benzamides, benziothiazolones etc	Control of Viruses
Based on work	**Contact pesticides**	These pesticides are sprayed directly and kill a pest when it comes in contact with that.	For the control of insects, weeds and usually used as herbicides
	Systemic pesticides	These pesticides are absorbed by plants or other organism and move to untreated tissues.	They are used as pest controller not only in plants but also in animals to control lice, grubs etc.
	Fumigants	These pesticides are used as solid or liquid which finally converts into a toxic gas.	For the control of flies, bees, mosquito in the fields or household to impede their mode on infection

Effect of pesticides on plant growth and hormonal dysfunction

Pesticides protect plants by protecting from harmful pathogens and in turn disrupts the production of various plant hormones like gibberellins, cytokinins, auxins, nitrogen fixation, siderophore production, phosphate solubilization, and uptake of essential major and micronutrients (Kapoor *et al*., 2019; Kumar *et al*., 2019e,f,g). The abatement in microflora and soil fertility due to regular use of pesticides has an adverse effect on PGPR activities of the rhizobacteria (Sidhu *et al*., 2019). A recent study reveals that the higher dose of pesticides decreases the potential of PGPR strains to induce the growth-promoting mechanical and production of enzymes and also results in the generation of reactive oxygen species (Kumar *et al*., 2018a,b). The pesticide also affects the plant growth by inhibiting various enzymes which are essential for the growth of plants. The permeability of the plant cell and trans-cuticular diffusion is affected by the spraying of pesticides on them (Kumar *et al*., 2018c,d). Many studies on the effect of pesticides on plant growth emphasize its effect on delay in seed germination experiments.

Effect of pesticides on Endocrine system

In the endocrine system, pesticides can disrupt the function of hormone receptors by binding with nuclear receptors either directly or indirectly (Kumar *et al*., 2018e; Datta *et al*., 2018; Singh *et al*., 2018; Dhanjal *et al*., 2018). In direct mechanism, the nuclear receptors, which regulate gene transcription binds with pesticides and releases unsuitable signals causing conformational changes, and in an indirect mechanism, pesticides bind to steroid transport proteins resulting in the inhibition of Steroidogenic enzymes (Singh *et al*., 2017; Kaur *et al*., 2017; Kumar *et al*., 2017)

Effect on pesticides on Reproductive System

Pesticides induce various oxidative stress by forming ROS species resulting in sperm dysfunction, poor semen quality, and male infertility (Singh *et al*., 2017; Mishra *et al*., 2016). In females, disrupts and imbalances estrogen hormones and intervene estrogen and androgen receptors for irregularities in instinctive abortion, ovarian cycles, improper function, developmental births defects etc. (Wani *et al*., 2016; Kumar *et al*., 2016; Sharma *et al*., 2016))

Route of Exposure of pesticides in humans

Pesticides enter the human body via three main routes skin (dermal), incapacitation via food (ingestion) and via breathing (Inhalation) (Kumar *et al*., 2015a,b). Pesticides enter skin either with sweat glands or damaged skin when the liquid mixtures of pesticides are sprayed (Pramanik *et al*., 2015). The outer layer epidermis of the different parts of the body acts for the absorption of pesticides. The entry of the pesticides via inhalation occurs for volatile pesticides and Oral ingestion, simply intake of the pesticides to the digestive tract via mouth during spraying.

Degradation of pesticides

The pesticides are degraded into various by-products by various processes such as biodegradation, hydrolysis, oxidation, biotransformation photolysis, and metabolic reactions. There are various mechanisms for the clean-up of pesticides in different environmental matrices soil, such as volatilization, incineration chemical treatment, etc. Chemical methods and volatilization is feasible but is challenging as large volumes of alkali and acids are generated that must be disposed off. Incineration has met serious public opposition because of high economic costs its and potentially toxic emissions. Overall all of these methods are costly and unproductive because these methods include ex-situ treatment (Singh *et al*., 2019a). Several biological techniques have been developed for biodegradation of pesticides. Biodegradation is an eco-friendly technique using naturally occurring plants and microorganism to degrade, digest and convert organic compound into harmless bio-products. Microbial metabolism is the simplest degradative process of pesticides in which soils, as the degrading microorganism obtains carbon, Nitrogen, phosphorous or energy from the pesticide molecules. Due to their long persistence in nature, they are toxic to plants, microflora and mammals. Bacterial and fungal strains can degrade carbamates and utilize pesticides as their sole carbon or energy source (Singh *et al*., 2020a).

Conclusion

Pesticide poisoning leads to disruptions of the various metabolic process not only in humans but also in microbes, plants and animals. Imbalancement of various metabolic process in a living organism including hypersensitivity, giddiness, allergies, dermal abrasions, double vision, headache Acetylcholine esterase activity, damaged to the central and peripheral nervous system, bone cancers, sarcoma, leukaemia, lymphomas, soft tissue sarcomas, brain, stomach cancers, reproductive disorders, sexual hormones birth defects, improper function of intervene androgenic or estrogenic receptors, instinctive abortion, irregularities of ovarian cycles, developmental birth defects, bone cancers, sarcoma, leukaemia, lymphomas, soft tissue sarcomas, brain, stomach cancers, reproductive disorders, birth defects, disruption of the immune system and damage to central and peripheral nervous system etc. The complexation of metal ions with pesticides shows a positive sign for increasing degradation processes in soil. Interaction of pesticides with humic substances increases not only the degradation effect of pesticides but also a positive sign for the growth of beneficial soil microflora. Humic substances are highly chemically reactive. Humic substances either bind with the active site of the results of the pesticide in the neutralization or might be having a role in the degradation of pesticides. Our future study will address the bio-degradation behaviour of pesticides with metals ions and humates.

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