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ACUTE TOXICITY EFFECT ON THE SOIL BIOTA IN AGROECOSYSTEM

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ABSTRACT

Pesticides have become an inextricably linked component of modern agricultural production and technology. Their constant usage presents a burden for soil and soil biota. Soil organisms are considered model organisms for assessing perturbations to the soil ecosystems as well as environmental risk assessments of chemicals. They reflect soil contamination and are highly susceptible to changes in ecological factors causing harm to the soil environment by preventing soil-dwelling micro and macro species from flourishing. They may have an adverse impact on the growth of advantageous indigenous soil microbes and their related biotransformation in the microbial community, soil biochemical processes, and soil enzymes. This paper will discuss how these chemicals affect the soil invertebrates' toxicity on soil microbes resulting in a significant loss of population and a negative impact on the fertility of the soil.

Keywords: Insecticides, pesticides, soil environment, soil invertebrates, and toxicity

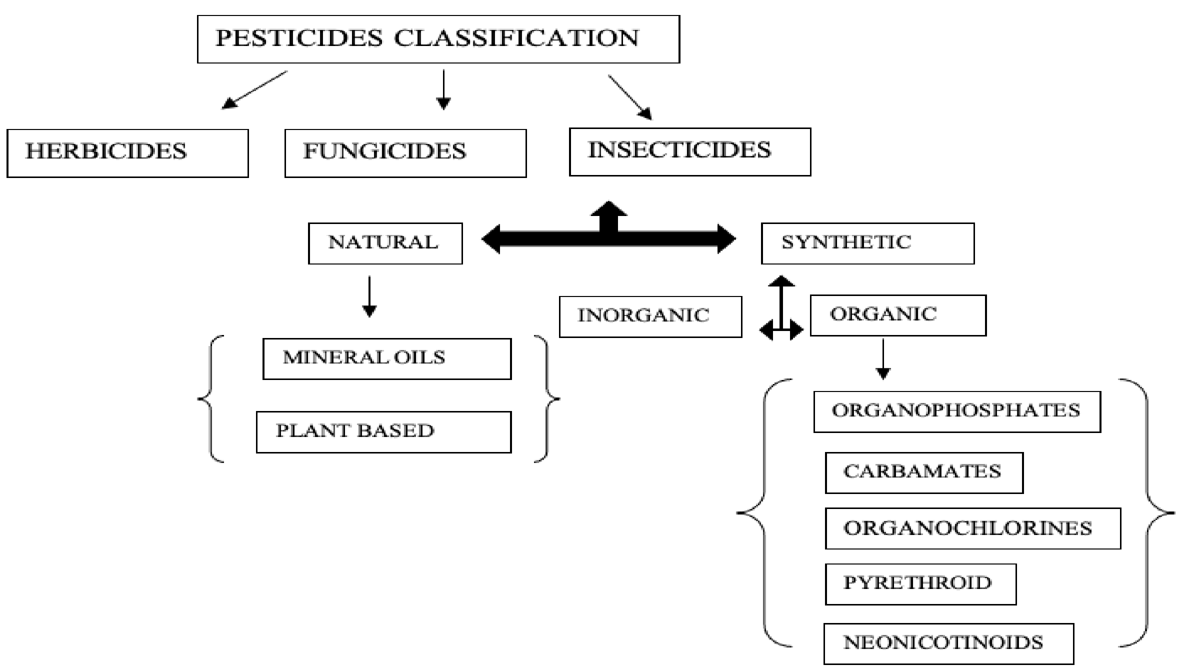
INTRODUCTION

The term "pesticide" encompasses both herbicides and insecticides (which can involve insect growth regulators, termiticides, etc.) molluscicide, nematicide, avicide, pesticide, rodenticide, animal repellent, insect repellent, bactericide, fungicide and antimicrobial. As part of pest management tactics, they are widely employed against a wide variety of crop-infesting insects. They destroy the field's and ecosystem's natural enemies, disrupting the hosts' equilibrium. Insect populations expand rapidly without natural enemies, necessitating pesticide management. Due to lesser chemical exposure, pesticide resistance among natural enemies is uncommon despite the presence of pests. Sub-lethal pesticide deposition can alter organisms' biological characteristics of low and extremely low toxicant concentrations. Since most pesticide assessments are the individual as well as population-level environmental toxins that haven't been studied, ecological pesticide evaluation generally neglects sub-lethal effects. Sub-lethal pesticide exposure alters insects' profiles.

The majority of applied pesticides contaminate the soil environment, whereas only 0.1% reach the intended organism (Carriger et al., 2006). The affect of these chemicals on microbes' genetic makeup and the activities they regulate has received more attention. The increasing use of pesticides in agro-ecosystems to ensure food supply for an ever-increasing population is causing concern for human health and the environment (Pimentel, 1995). Once pesticides enter an agro-ecosystem, their fate and transport are largely dictated by the type of pesticide and the soil characteristics, in addition to the soil-dwelling microorganisms, plants, and animals. Changes in soil microbiological actions, soil characteristics, and enzymatic activities as a result of pesticide treatments are the key components that have a significant impact on soil productivity. In soils contaminated with pesticides, phosphorus-solubilising bacteria and nitrogen-fixing are rendered inactive. Studies have shown that pesticides limit the activity of enzymes in soil, which are important markers of soil health and "biological assessment" of agricultural productivity. Many biochemical events driven by microorganisms and enzymes, such as mineralization of biological materials, redox reactions, nitrification, ammonification, denitrification, etc., may be affected by pesticides. By entering the food chain, pesticides' effects on the ecology of soil may eventually have an effect on human health. Within the agroecosystem, the interactions between soil compaction and soil biota, as well as biochemical and biophysical processes, constitute a relational web in which soil biota are an integral part of the soil and not merely its inhabitants (McGill & Spence, 1985).

Classification of pesticides

Pesticides are chemicals with varying physical, chemical, and other properties. Consequently, for classifying pesticides the chemical composition and the nature of their active binding groups, is the most common and useful method. This type of `classification sheds light on the effectiveness and physical and chemical properties of various pesticides. Understanding the chemical and physical properties of pesticides is crucial for determining the application method, precautions to be taken during the application, and application rates. Based on their chemical composition, pesticides are grouped into four major classes: organochlorines, organophosphorus, carbamates, pyrethroids and pyrethrin (Alengebawy et al., 2021). The chemical classification of pesticides is somewhat intricate. In general, contemporary insecticides are organic compounds. They include natural and synthetic pesticides. Synthetic pesticides are synthetic compounds that do not occur naturally. They are divided into numerous classes based on the requirements. Presently, the three most common classifications of pesticides are based on the pesticide's mode of entry, its function and the pest organism it kills, and its chemical composition. WHO divided pesticides into four classifications based on their toxicity: extremely dangerous, highly dangerous, moderately dangerous, and slightly risky (WHO, 1996).The three frequent approaches for implementing pesticide categorization given by Drum classification are: classification system is based on pesticides function and the pest species they eliminate; and categorization is based on the chemical composition of the pesticide.



Organochlorines: Organochlorine compounds comprised dieldrin, aldrin, endrin, endosulfan, chlordane, andheptachlor. Cyclodiens are permanent organic compounds that have adverse effects on human and wildlife health, generating concerns. DDT, DDD, DDE, heptachlor epoxide, and dieldrin were detected in a significant amount in samples of agricultural soil and water decades after their use was prohibited. Much research has demonstrated the durability of organochlorine pesticides in the environmental field (Reiser & O'Brien, 1999).

Organophosphates: Some pesticides are very toxic to nonvertebrate than chlorinated insecticides, despite being chemically unstable. The first product on the market that was efficient against a diverse range of pests was parathion. Organophosphates, such as malathion, are comparatively safe for animals and break down relatively quickly in the environment, whereas others, such as malathion, have been linked to severe toxicity and numerous deaths, particularly in developing nations. A small number of organophosphates, such as phosalone and dimethoate, are deemed nontoxic to beneficial arthropods. These insecticides are also biodegradable, less polluting, and have a sluggish resistance rate(Leamond et al., 1992).

Carbamates

Carbamates and organophosphates are related. However, their origins are distinct. Organophosphates are synthetic chemicals created from phosphoric acid, whereas carbamates are a class of molecules formed from carbamic acid. Carbamic acid is the source of carbamate insecticides. The first carbamate carbaryl, an N-methyl carbamate, eradicated several insect pests and animal ectoparasites. Carbamates, particularly N-methyl carbamates, are lethal to foraging bees and very toxic to Hymenoptera. Biodegradation of carbamate in the environment is relatively fast.

Pyrethroids

Based on the principle of naturally occurring pyrethrins, pyrethroids are created with enhanced light and air stability. Due to the fact that sunlight, heat, microbial activity, and moisture accelerate pyrethroids' decomposition, pyrethroids persist for a long time in places with minimal sunlight. After residential treatment, cypermethrin persists for roughly three months (Wightwick et al., 2010). These quickly penetrate insect nerve systems and immobilise them (Reigart, 2009).Both beneficial and harmful insects are affected due to the extreme toxicity of pyrethroids to insects.

Neonicotinoids

They have the same mechanism of action as nicotine. These pesticides are utilized globally. The majority of neonicotinoids are absorbed and transported to the plant tips. Imidacloprid is the very first insecticide of this class with relatively low toxicity to mammals. Nonetheless, it is toxic for useful arthropods, such as bees (LD50=0.008 g/bee). Imidacloprid and clothianidin seem to be much more hazardous for the bees when applied as a spray than when applied as a seed treatment field (Tennekes, 2011). Since the majority of neonicotinoids are somewhat soluble, they are transportable in the surroundings.

Herbicides

These are the most important pesticide class for weed control. The much of pesticide research on soil biota have been conducted in other countries. However, Australia's increased use of pesticides in zero-till systems has undoubtedly had an impact on soil biota. Despite a decrease in bacterial populations, glyphosate has enhanced fungus and actinomycetes populations, resulting in overall boosts in soil microorganisms(Hussain et al., 2009). Glyphosate and chlorsulfuron have both been associated with rising amounts of Pythium root rot in barley seedling(Blowes, 1987)and both herbicides have also been connected to take-all fungus (Mekwatanakarn & Sivasithamparam, 1987). Chlorsulfuron treatment increased *Rhizoctonia solani* root disease but had no influence on take-all levels(Rovira & McDonald, 1986).

Fungicides

Fungicides are chemicals that kill fungi or prevent their growth. Agriculture and industry both utilise fungicides. If a fungicide promotes crop growth by eradicating foliar or soil-borne diseases, an increase in the system's organic matter often increases the microbial population. Fungicides can have devastating effects on non-target microorganisms, especially saprophytic and symbiosis soil-borne fungi. For example, benomyl is very toxic to mycorrhizal fungi(Smith et al., 2000), which could have implications for plant nutrition. Foliar sprays that miss their target leaves and spray drift may also have unwanted effects on soil biota. The initial organic synthetic fungicides are dithiocarbamates (such as thiram, mancozeb, zineb, and maneb). Few fungicides are dangerous for aquatic species. Maneb is very dangerous for fish, while triadimefon is highly toxic to crustaceans. Dithiocarbamate-containing fungicides havevery low persistence. Triazoles (myclobutanil, flusilazole and penconazole), pirimidines (fenarimol) and carboximides (boscalid), are high-persistent fungicides (Wildermuth et al., 1997).

Risks related to pesticide usage

The risks connected with pesticide use surpass their beneficial benefits. Pesticides have devastating consequences on non-target species, biodiversity, aquatic and terrestrial food webs, and ecosystems. According to Majewski and Capel (1995), around 80–90% of sprayed pesticides can evaporate in a few days (Majewski & Capel, 1995). It is quite frequent and likely to occur when utilising sprayers. The pesticides that have been volatilized evaporate into the air and may potentially damage non-target organisms. A case in point of this is the usage of herbicides, which evaporate from treated plants and are capable of causing serious harm to other plants(Straathof, 1986).As a result of the unregulated use of pesticides, numerous terrestrial and aquatic animal and plant species have declined. In addition, they have rare species on the verge of extinction, including the osprey, bald eagle, and peregrine. (Helfrich et al., 2009). Additionally, soil, air, and water have been poisoned to dangerous levels by these pollutants.

The effects of pesticides on soil ecology may then affect human health by moving up the food chain. The extensive utilisation of pesticides creates a substantial strain on the health of the soil by destroying the soil biota vital for supporting soil processes. Numerous laboratory studies have shown a change in the soil microbial community and a reduction in microbial growth and enzymatic activity as a result of exposure to a single herbicide. Pesticides can have two types of effects: direct (immediate or short-term) effects on species that come into contact with them or indirect (environmental and/or food supply changes) effects caused by the changes the chemical causes.

There has been extensive evidence for the crucial function of soil mesofauna (e.g., mites, springtails, enchytraeids, fly larvae, etc.) in establishing the microstructure of the soil, and for the substantial contribution of soil macrofauna (e.g., termites, ants, diplopods, beetles, earthworms, etc.) to the construction of the soil macrostructure, and in humification. It is generally accepted that the role of soil mesofauna in the ingestion and subsequent transfer of mineral soil is minimal. In an experiment in which springtails were put into small cores containing both loose and compact dirt, the compact soil inhibited springtail migration and repelled the animal's (Didden, 1990). However, larger soil animals may burrow down the strata. Bulk densities up to 1.7 Mg m' had no effect on the depth of dung beetle burrows in moist, well-drained sandy soil (Brussaard & Hijdra, 1986), but at soil water potentials -50 kPa, the survival of eggs and larvae decreased.

The majority of soil macrofauna knowledge is related to earthworms. Earthworms can be categorised into three biological groups (Lavelle, 1981): (1) epigeic earthworms, which feed on and live in leaf litter; (2) anecie earthworms, which feed on leaf litter that they mix with soil of the higher strata but hide in semi-permanent vertical burrows dug into the soil; and (3) endogeic earthworms, which reside in the soil and feed on soil organic matter as well as dead and living roots. In terms of the effects of soil compaction, the following two categories are important. (Rushton, 1986) discovered a significant correlation between the length of the tunnels of the earthworm *Lumbricus terrestris* and compaction in pasture soil with a bulk density between 1.38 and 1.50 Mg m'. The variance explained, however, was fairly low: r = 0.40. There was no correlation between the soil water content, which varied between 13.9% and 16.1% (w/w), and the soil moisture content. In sandy silt and loamy silt soils, (Joschko et al., 1991)found that *L. terrestris* burrows were longer at lower bulk densities (1.06-1.12 Mg m*) than at higher bulk densities (1.41-1.60 Mg m'). According to (Brown et al., 1988), *L. terrestris* would not penetrate soil samples with a significant decrease in their abundance as a result of pesticide contamination. (Karas et al., 2018) also found that pesticides diminish the quantity of sulphur-oxidizing bacteria, which convert reduced sulphur compounds to sulphate, and have deleterious effects on the enzymes that regulate the phosphorus cycle. By converting nitrogen and sulphur into forms that may be taken by microbes and plants, both ammonia and sulphur oxidisers play a critical role in sustaining soil fertility. Herbicides disrupt earthworm enzymatic activity, increase mortality, decrease fertility, change feeding behaviour, and lower community biomass. (Yang et al., 2006)observed a clear synergistic effect on earthworms exposed to a quaternary mixture of fenobucarb, chlorpyrifos, acetochlor, and clothianidin, whereas(Van Hoesel et al., 2017) found that the effects of insecticides and fungicides on earthworm activity were amplified in the presence of herbicides. It implies that crop protection inputs, specific pesticides, may pose long-term threats to food security.

Even though pesticide pollution in soil has been shown to have adverse impacts on soil biota, it is not strictly regulated. According to a study by (Jennings & Li, 2014),only 174 of the 54 United Nations member states have specified regulatory guidance values for maximum pesticide residue levels in the soil. The guidelines for the same pesticide might vary by two to ten orders of magnitude, yet less than 30% of these nations control more than one hundred pesticides. Quantification and monitoring of large-scale pesticide residues are hampered by the absence of regulations. The majority of research has quantified only a few pesticide components, and these are limited to national- or field-scale measurements. A comprehensive review of the current state of global pesticide soil residue is necessary to communicate the urgency of adopting sustainable pesticide use, increase public awareness, and justify the need for stricter regulation, despite the fact that the absence of regulation discourages investments in monitoring campaigns. Due to the soil organisms' populations' persistence (capacity to rebound over the period), there may rarely be short-term effects but no long-term consequences(Silva et al., 2019).Reduced biological diversification affects the detritus food chain, which changes the balance or homeostasis of an ecosystem. This is caused by the application of broad-spectrum pesticides. As a result of the eradication of their natural predators, this can lead to the reintroduction of pests.

CONCLUSION

Pesticide is a generic version for numerous groups of herbicides, fungicides insecticides, rodenticides, and home disinfectants that are intended to kill or repel pests. In order to boost agricultural production in the face of a rapidly expanding population, pesticides have been widely used and have become a significant environmental concern.In order to protect crops and ensure food production, it is heavily used and exposed, which has detrimental synergistic effects on microorganisms that are crucial for soil fertility and productivity, including those that recycle nutrients from the soil, degrade organic matter, fix nitrogen, promote plant growth, and stabilise the soil, as well as those that perform other biochemical alterations like nitrification, ammonification, and phosphorus solubilisation. Negative impacts on microbial populations and activity in the soil are caused by soil fauna activity and pesticide residue deposition in the top layer of soil.Concerns have been raised concerning the safety of pesticides, due to the risks pesticides bring to the agro-ecosystem.

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