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Pesticides Pollution in Agroecosystems and Their Social and Ecological Consequences

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Abstract
Numerous biological and cultural methods have been used to manage pests since the dawn of agriculture. But as the population grew, it became necessary to discover quick fixes for these pests. Pest-toxic chemicals turned out to be a practical tool for pest management. Given the rising need for agricultural products, the use of agrochemicals in agriculture has become unavoidable. Agrochemical production, marketing, and use have expanded many times since the start of the green revolution. In addition to having detrimental effects on non-target species, the chemical-based agriculture production system has societal and ecological repercussions, including contaminating food, rivers, soils, and bottom sediments. The detrimental effects of agrochemicals on the environment and human health were only discovered in the latter part of the nineteenth century. Agrochemical toxicity to humans and other environmental components was evaluated once the negative effects of excessive use were recognized. The effects of these agrochemicals, particularly pesticides, were examined at various trophic levels of the agroecosystem, influencing the main environmental elements like soil, water, and air. The effects of pesticide residues were discussed in this article along with potential remedies to lessen their effects.

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INTRODUCTION

A "pest" is defined as any organism that disrupts human wellbeing or activity in any way. In agriculture, over 600 insect species, 1800 plant species, and several nematode and microbe species are classified as significant pests. If not regulated, they would drastically affect crop output (Dunwell, 2003). These pests have been controlled through a range of cultural and biological methods for thousands of years, dating back to the commencement of agriculture.

However, as the population increased, need was felt to find fast-acting means for managing these pests. Chemicals toxic to pests proved to be a convenient weapon for dealing with pests. The chemicals synthesized expressly for the long of unwanted species are called chemical pesticides (Chapman and Reiss, 1999, Wong *et al.,* 2023). The pesticides may be divided into various categories like herbicides, insecticides and fungicides etc.

Pesticides were originally described approximately 2500 B.C., when Sumerians utilized sulfur compounds as insecticides to control insects and mites (WHO/UNEP, 1989). The Chinese are credited with developing insecticides for crop treatment and fumigation as early as 1200 B.C. They utilized chalk and wood ash to combat indoor and storage pests. There are additional references of using mercury and arsenic compounds to control body lice and other pests (Gipps, 1990; Rasool et al., 2022). The Chinese also applied white arsenic to rice roots to protect them from pest infestations, while sulfur and copper were employed to combat lice (Michael, 1987).

In Greece and Italy, fumigants, oil sprays, and sulphur ointments were all used. Inorganic compounds have actually been used since classical Greece and Rome. While Hormer recognized Sulphur's fumigant value, Pliny the Elder mentioned arsenic and soda's insecticidal properties.

DISCOVERY AND TYPES OF PESTICIDES

The nineteenth century saw a shift toward a systematic, scientific approach to the use of chemicals for plant pest management. In 1867, Paris Green was used in a crude form consisting of copper arsenate, iron sulphate, and lead arsenate (Dudani, 1999). Millardet (1885) discovered the Bordeaux mixture (lime plus copper sulphate), which produced excellent effects against grape downy mildew. Bordeaux mixture originated as a highly effective fungicide and is still chosen in a number of instances. Another milestone was the discovery of organomercury dressings in Germany in 1913. This can be viewed as the age of first-generation pesticides, followed by second-generation pesticides (Dudani 1999).

In 1934, P. H. Mueller discovered the insecticidal potential of DDT (dichlorodiphenyl trichloroethane), which was successfully employed in 1939 and 1942 to reduce potato beetle and lice (Wright, 1992). Tisdale and Williams created the first dithiocarbamate fungicide (thiram) in 1934, which led to the invention of several effective and commonly used fungicides such as ferbam, zineb, and maneb. A wide range of chemical substances are now accessible for plant disease treatment. These include antibiotics, phenols, heterocyclic nitrogen compounds, and quinones. Figure 1 also displayed the temporal progression of pesticides.

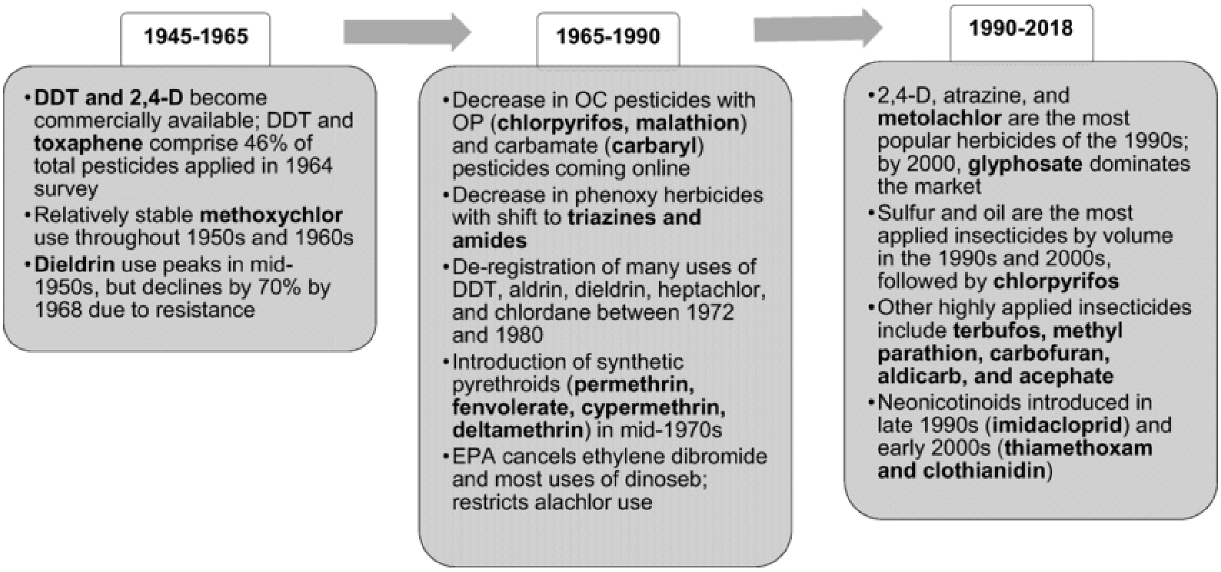

Figure 1: Pesticides development and uses

Copper sulfate and calcium hydroxide (hydrated lime) react to form the Bordeaux combination, which gets its name from the Bordeaux region of France where it was created and used to combat grape downy mildew. This copper fungicide was the first to be created and is still the most popular one worldwide (Agrios, 2005). Blight, anthracnoses, downy mildew, cankers, and other bacterial and fungal leaf spots are all under its control. The only component of the Bordeaux mixture that is harmful to diseases and occasionally to plants is copper.

One of the most significant, adaptable, and extensively utilized classes of contemporary fungicides are organic sulfur compounds. These consist of maneb, zineb, nabam, thiram, ferbam, and mancozeb. They are all dithiocarbamic acid derivatives. The zinc ion maneb, also known as mancozeb (and marketed under the name Dithane M-45), is used to prevent fruit and foliage diseases of a variety of vegetables, including vine, tomato, and potato crops. Because dithiocarbamates are converted to the isothiocyanate radical, which inactivates the sulfhydryl group (-SH) in amino acids and enzymes within pathogen cells, dithiocarbamates are thought to be poisonous to fungi mostly because they prevent the synthesis and activity of these substances (Agrios, 2005).

A pesticide should ideally be deadly to the intended pest but not to humans or other non-target species. Sadly, this isn't the case (Fig. 2). As a result, the issue of pesticide misuse and use has come up (Burtling et al., 2024). Low crop production, devastation of soil life, and undesired buildup on food crops are a few adverse outcomes of excessive pesticide use (Edwards, 1986).

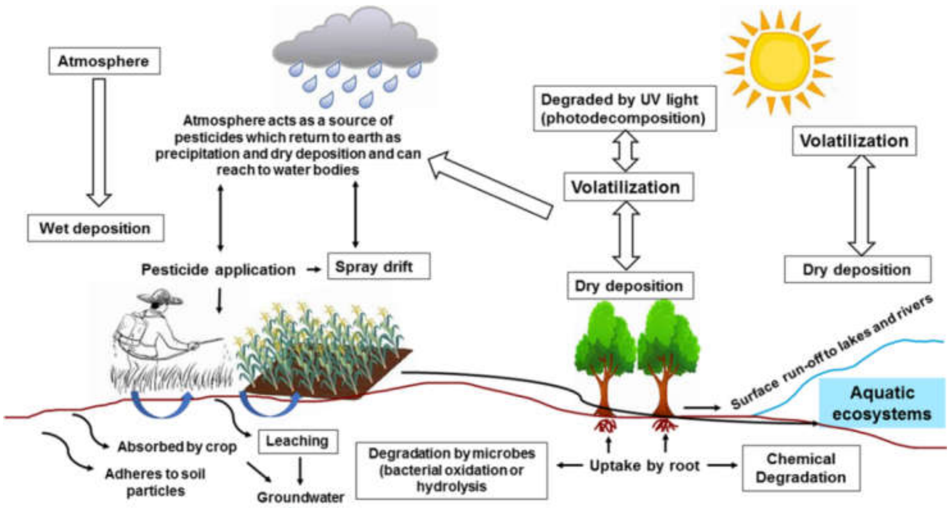

Figure 2: Pesticide contamination in agro-ecosystems: toxicity, impacts, and bio-based management (Umesh Pravin Dhuldhaj *et al.*, 2023).

In 1962, American scientist Carson noted in her book "Silent Spring" that indiscriminate DDT spraying was the cause of birds' abrupt deaths. Since then, the detrimental effects of pesticides on people, animals, plants, and soil microbes have been acknowledged globally. This sparked public concern about pesticides. There have been numerous reviews and publications discussing various facets of pesticides. Navarro et al. (2007), Akhtar et al. (2009), Yaashikaa et al. (2022), Sharma et al. (2023), Kaur et al. (2024), and Pimentel (2005) are a few of these.

CONCLUSION

The continuous rise in pesticide use in agroecosystems to ensure food supply for the world's growing population puts human health and the environment at greater risk. The properties of the soil and the kind of pesticides employed affect the fate and movement of pesticides when they are introduced into the agroecosystem, in addition to the bacteria, animals, and plants that inhabit the soil. The accumulation of pesticides in animal products, feeds, and plant-based diets is linked to careless use. To assess the hazards posed by agrochemicals and understand their environmental impacts, bio-monitoring research is crucial.

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