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THE IMPACT OF MICROPLASTICS ON AGRICULTURAL SOILS

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Agricultural soils that have been contaminated with microplastics have the potential to endanger food safety and human health. Microplastics are a growing environmental concern around the world. The main sources of microplastics entering agricultural soils were outlined in this review paper with an emphasis on their various characterizations and environmental fate. The transformation and movement of microplastics within agricultural soil systems were examined, with a focus on the impacts of UV radiation and mechanical abrasion from soil life and agricultural operations. In addition, a summary of microplastics' direct and indirect effects on soil flora and fauna in agricultural soils was provided. Finally, future research directions were suggested based on the knowledge gaps in three areas: standardization techniques for different types of microplastics, interactions between microplastics and other pollutants, and the long-term effects of microplastics in agricultural soils on human health risks.

Recent news states that the amount of plastic made around the world has reached 368 million tonnes. Many plastics get into the environment because they are not thrown away properly, and 79 percent of all plastic waste ends up in landfills. Plastics stay in the environment because they are strong and don't break down easily. Plastics can break up into microplastics (particles smaller than 5 mm) because of photo degradation, mechanical abrasion, and bioturbation. Also, cosmetics and products made in factories can directly release microplastics. Researchers have looked at where microplastics come from, where they end up, what happens to them, and what effects they have on living things. Concerns about microplastic pollution in land systems have been growing recently. There are rumours that the amount of microplastics on land could be 4-23 times higher than in the ocean. As the source of food, the agroecosystem is the basis of human life. Microplastics are likely to pollute it because people use it so much. Soil pollution from microplastics in agricultural areas can't be ignored. Microplastics in farm soils could have effects on farm ecosystems and food security that we don't yet know about. Due to the risks that microplastics pose to the ecosystem through the food chain, it is important to know how they behave in agricultural soil systems. This review will help us learn more about how microplastics behave in the environment by summarising studies on their sources, effects, and what happens to them in agricultural soil systems.

What are the Sources of Microplastic Pollution in Agricultural Soils?

Plastic products were widely used in agricultural techniques, such as cultivation, fertilization, and plastic mulching, as modern agricultural systems developed. These polymers provided a significant amount of microplastics to soils and even accumulated in crops when they degraded in agricultural soils. Plastic mulch films make up a significant fraction of those sources and are frequently utilized in arid and cold climates to maintain the proper temperature and increase crop output. They broke up into microplastics after being exposed to light and mechanical forces like tillage procedures, and they then migrated into agricultural soils, especially in regions with a poor rate of mulch film recovery. Consumption of mulching films and microplastic concentrations are positively correlated. Although it has been disregarded for the past few years, atmospheric deposition is another possible route for the contamination of terrestrial systems with microplastics. The weather has an impact on the inputs of microplastics from atmospheric deposition. The fallout of microplastics from the atmosphere to soil systems may be considerably influenced by precipitation and snowfall, as described in earlier research, and wind/atmosphere circulation significantly influenced the remote transport to various places (Mohajerani and Karabatak, 2020). Agricultural soils and human health may be at risk from airborne microplastics from cities that travel to rural areas and deposit on fields and even plant leaves, even if the direct negative effects of these particles on agricultural soils have not been well-documented. Compost is also frequently used to increase soil fertility, in addition to mulch films. A significant channel for microplastics entering agricultural soils was suggested by the high proportion of plastics found in the compost. The rapid fragmentation of larger plastics into smaller pieces and the microbial activity that occurs during the composting processes accelerate the concentration of microplastics added to agricultural soils. According to Yang et al.,3.50 ± 1.71million

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particles/ha/year could be the typical rate of microplastic deposition in agricultural soils with long-term, repetitive application of organic mature. Additionally, microplastics have been discovered by Weithmann *et al.*, in a variety of commercial bio wastes from household, energy crops, mature compost, and nonmatured fertilizer. These compost-derived organic fertilizers are underutilized sources of microplastics in farmland soil. The microplastics in sludge and wastewater are primarily obtained from the effluent of residential washing machines and discharged from personal care items, synthetic textile fibres, and microbeads, in contrast to the input from plastic usage inside agricultural systems. Due to the varying compositions, characteristics, and additions of these microplastics, there may be a variety of ecological threats to both agricultural soils and human life (Lwanga*et al.*, 2016).

The degradation, transport, and consequent ecological consequences of these microplastics from various sources are directly influenced by their form, type, and additive content in agricultural soils. Future research should focus on the dangers of microplastics made from various sources because those dangers have not yet been fully understood. Agricultural soils have been discovered to include all of the common polymer types PE, polypropylene, polystyrene, and polyvinyl chloride with varying detection frequencies in various sampling locations. Additionally, various additives were added into various types of plastic products for various purposes. Plasticizers were added to soften plastics, primarily in polyvinyl chloride, flame retardants were widely used in consumer products ranging from household items to polystyrene insulation foams, and antioxidants were used in many polymers, including PE and polypropylene, to stop the ageing process in outdoor settings (Tian*et al.*, 2022).

Microplastics' Transformation and Movement in Agricultural Soils

Plastics are transformed in the environment by chemical, physical, and biological processes, including fragmentation and degradation. The chemical degradation caused by ultraviolet (UV) radiation is the most important and frequently predominates the early degradation processes of plastic waste among these three forms of transformation. Due to UV exposure at an appropriate temperature and oxygen usage, microplastics in topsoil undergo phototransformation. Chemical reactions such chain scission, cross-linking, the creation of functional groups containing oxygen, and even mineralization into CO2 are all involved in the phototransformation of microplastics. Smaller microplastics and even Nano plastics may be produced during these processes. Additionally, the fragmentation of microplastics is accelerated by the combined impacts of UV radiation and mechanical abrasion caused by the turbulence of agricultural operations and soil organisms. Microplastics tend to aggregate with soil particles by electrostatic forces, which were facilitated by root exudates in the rhizosphere or during feeding and excretion by soil animals, in contrast to the way that microplastics break down into smaller particles. Aggregates may contain microplastics that are resistant to UV radiation and other types of mechanical abrasion. Microplastics in soil may not completely degrade, which could lead to an accumulation of plastic at the submicron scale and unknown environmental concerns.

In addition to degrading, the movement of microplastics through the soil's porous matrix alters their distribution. According to studies, the transport of microplastics in saturated porous media, such as soils, may be improved by the reduction in size and increase in surface functional groups of microplastics. Additionally, soil characteristics like ionic strength and cation type, as well as heterogeneity, soil organic matter, and surface coating, had an impact on the mobility of microplastics in soils. Through borrowing, ingestion, and egestion as well as epidermal adherence, soil organisms, notably earthworms, considerably facilitated the transport of microplastics in soil. This resulted in the transport of microplastics from the topsoil to deeper soil and finally to the groundwater (Kumar and Sharma, 2021).

The Effects of Microplastics on Agricultural Soil Systems

There are a number of factors that contribute to the effects of microplastics on agricultural soil systems. According to a number of studies, ingesting microplastics may slow down earthworm growth and induce weight loss, reduce nematode survival and body length, and slow down collembolan growth. The potential causes may be attributed to digestive tract obstructions created by microplastics in faunal guts that reduced food intake and nutrient absorption, or even injuries to the skin and digestive system brought on by some sharp microplastics. While other studies have reported a variety of effects of microplastics on soil fauna, the results have shown a decrease in nematode reproduction rates, an increase in the diversity of gut bacteria in collembolan, and no appreciable effects on the reproduction of epigeic earthworms. Although the causes of these variations have not yet been determined, it has been hypothesized that they may be linked to animal dietary preferences as well as the characteristics and microplastic exposure concentration. Additionally, researchershave provided evidence that microplastics may migrate along with a terrestrial food chain, going from soil through earthworm casts and chicken faeces (with increased microplastic concentration.

Recent studies have documented how microplastics affect terrestrial plants in addition to soil animals. Wheat plants have reportedly experienced severe detrimental impacts from microplastic PE residues both throughout the vegetative and reproductive growth phases. Additionally, PS microplastics of various sizes could reduce the photosynthetic rate while increasing the weight of Chinese cabbage by changing the microbial metabolism and the relationships between microorganisms. Spring onion leaves and overall plant biomass may grow substantially more quickly when PA microbeads are used. Additionally, microplastics may build up by the roots of wheat and lettuce plants before moving to the shoots and leaves and in the roots of cucumber plants before moving to the leaves, flowers, and fruits. The consequences of microplastics varied depending on the plant species and degree of contamination, and they included changes to soil structure, water holding capacity, nutritional content, and microbial population (Kumar *et al.*, 2020).

Microplastics can alter soil parameters, such as soil bulk density, soil aggregate size fraction, and evapotranspiration, in addition to their direct effects on soil animals and crops. These changes can then have an indirect impact on plant performance. By expanding the routes for water movement, microplastics may hasten soil water evaporation and alter the soil microbial population, especially with regard to root colonization microorganisms. Additionally, microplastics have been shown to lessen the detrimental effects of sulfamethazine on plant growth by modifying microbial populations. Microplastics interact with other pollutants such polycyclic aromatic hydrocarbons, organochlorine insecticides, and heavy metals (Cd, Zn, and Pb) in agricultural soil due to their large specific surface area, which in turn affects their environmental consequences. Microplastics may cause the adsorption and attachment of sorbed organic contaminants as they move vertically through the soil profile via bioturbation, surface runoff, and water penetration, or through irrigation canals, overland runoff, and even into the atmosphere. Microplastics and their co-existing contaminants provide significant environmental dangers in agricultural soil systems and act as vectors for other contaminants. These risks need to be thoroughly researched.

Crops and Plants Can Be Affected By Microplastic Pollution

Sludge from sewage and wastewater treatment plants has been discovered to contain microplastics. According to reports, around 50% of sewage sludge in developed countries was eventually applied to farmlands as commercial fertilizers, resulting in up to 870 tonnes of microplastics per million inhabitants entering European agricultural soils. The figure could be greater in places where plastic is widely used. When agricultural plastic films are used for mulching, microplastics are released into the soil when the films disintegrate. There is currently very few research on the effects of microplastics on crops. According to one study, fluorescent polystyrene nanobeads (100 nm) entered tobacco cells via endocytosis. Li et al. revealed that crop tissue cultures can ingest and store polystyrene microplastics (0.2 m), implying that the microplastics could be transferred to humans via the food chain. Moving beyond the cellular level, it has been found that biodegradable and polyethylene microplastics can interfere with wheat growth, with biodegradable microplastics having a greater negative impact. The presence of earthworms partially mitigated the harmful effects of biodegradable microplastics on fruit biomass, according to the study. This study raised a new worry about biodegradable polymers, which have been promoted as a replacement for conventional plastics in order to reduce environmental microplastics. Knowing that microplastics modify soil biophysical properties, researchers hypothesized that by lowering soil bulk density, microplastics could promote plant root penetration, soil aeration, and root growth. On the other hand, experimentally added plastic film pieces to soil created channels that promoted water movement and evaporation, resulting in water loss from soil that could impact plant health. Plant health is also influenced by changes in soil microbial populations caused by microplastics, and the impact is likely to be detrimental if root symbionts like mycorrhiza and nitrogen fixers are harmed. The slow breakdown of microplastics has been connected to microbial immobilization, while empirical proof for immobilization is currently lacking. Furthermore, microplastics may act as a medium for the introduction of phytotoxic chemicals into soil, thereby damaging plant roots and health (Tang, 2020).

Conclusions and Potential Outcomes

Agricultural soil systems serve as major microplastics reservoirs and are exposed to them in a variety of ways. Different environmental conditions may have an impact on how these microplastics behave. Agriculture methods, input from irrigation and fertilizer, and atmospheric deposition are the main causes. Microplastics are fragmented and degraded in agricultural soils by photo-oxidation, mechanical abrasion, and UV irradiation, with UV irradiation dominating the early phases of the process. Because of the nature of the soil, agricultural practises, and the qualities of the microplastics, microplastics may also move through soil systems in physical and biological ways. Through direct consumption or accumulation by organisms as well as indirect changes to soil characteristics or the soil microbial population, microplastics have a variety of effects on agricultural soils.

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