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Microplastics in Agricultural Soils

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Abstract

Microplastics have been a major source of pollution, a problem for the environment worldwide They can endanger human health and food security once they get into agricultural soils. Large quantities of plastic fragments are left behind after crop cultivation. The leftover plastic waste eventually breaks down into microscopic pieces, that will have a diameter of less than 5mm. Numerous alterations in the physico-chemical properties of the soil, such as porosity, enzymatic and microbiological activity, plant growth, and yield, are caused by microplastics. By altering their properties, microplastics can modify a number of important soil biogeochemical processes, which can have a variety of implications on the functions and activities of soil microorganisms.

1. Introduction

Microplastics are <5 mm in size, made up of diverse chemical components, and come from multiple sources. Microplastics have become a global environmental issue and have sparked significant concern about their possible ecological consequences due to their ubiquitous use and inappropriate disposal. The world's plastic manufacturing is hovering around 368 million tones (Mendoza et al., 2018). A significant amount of plastic garbage ends up in landfills, accounting for 79% of all plastic debris that enters the environment improperly (Horton et al., 2017). Plastics survive longer in the environment due to their exceptional resilience and resistance to biodegradation. Plastics can fragment into microplastics (particle sizes less than 5 mm) due to photodegradation, mechanical abrasion, and bioturbation. According to reports, the terrestrial system may contain 4-23 times more microplastics overall than the ocean does (Nizzetto et al., 2016).

2. Sources of Microplastics in Agriculture

2.1. Sludge products

A lot of MPs are found in sludge, which are frequently added to soil as an amendment (Weithmann et al., 2018). This causes a lot of MPs to enter the soil environment.

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2.2. Plastic film mulching

Plastic films are widely utilized because they have the ability to control soil temperature and improve the efficiency of water consumption, both of which support and enhance crop quality and growth. MP pollution is caused by plastic film residues that break down into small fragments due to weathering, UV radiation, and mechanical farming practices. These particles then find their way into the soil ecosystem. Compared to non-mulched soils, mulched soils have more plastic films. Because of its extensive use, lack of plastic waste leftovers, and improper handling, plastic film mulching is thought to be a major source of microplastics in terrestrial ecosystems.

2.3. Sewage irrigation

The amount of MPs in untreated sewage is high. 1% of MPs in sewage still make their way into the environment after treatment. Textile fibres from residential washing machines and personal hygiene items like face washes, toothpaste, and soap are the primary sources of these MPs.

3. Effects of Microplastic(s)

3.1. Effects of microplastic(s) on agricultural ecosystems

Extensive distribution of microplastics (MPs) in agricultural soils can impact several soil features, including physicochemical qualities, soil fertility and soil microbial population, ultimately influencing soil quality and nutrient cycling. To enhance the performance and applications of plastic goods, a range of additives, including stabilizers, flame retardants, and plasticizers, are used during the manufacturing and processing stages. These compounds are gradually released into soils during extended contact to the natural environment, which has a negative impact on the diversity and functions of soil microorganisms. MPs can also absorb a variety of pollutants including heavy metals, Per-and Polyfluorinated substances (PFAS), Polychlorinted biphenyls (PCBs), Dichloco diphenyl trichloroethane (DDT), Hexachlorocyclo hexane (HCH), Polypropylene Copolymer (PPCPs) and Polycyclic aromatic hydrocarbons (PAHs) and act as carriers for their migration in the environment affecting soil ecosystem.Numerous investigations have demonstrated that ingesting microplastics may reduce nematode survival rates and body length as well as slow earthworm growth and weight loss. By affecting the pH, soil structure, soil fertility and nutrients, soil microorganisms, and water-stable aggregates, microplastics can have an impact on the biophysical characteristics of the soil. Different degrees of microplastic integration will occur over time in soil aggregates: more tightly in fibre types and more loosely in fragment types. The bulk density of the soil is low when microplastics are present, which will have entirely different indirect consequences on the overall soil system.

3.2. Effects of microplastic(s) on soil properties

Plant performance is largely influenced by the characteristics, diversity, and biological community of the soil. MPs alter the microbial populations and physicochemical characteristics of the soil, which may have an indirect impact on plants by altering the rhizosphere, growth conditions, and nutrient availability. According to Qi et al. (2018), the accumulation of residual MPs in field soil can cause negative impacts on crop production because they: (1) destroy the soil structure, alter the physico-chemical properties of soil, and affect nutrients mobility and moisture diffusion in soil; (2) reduce the availability of nutrients, alter microbial activities, affect crop development and growth, reduce seed germination (3) slow down development of roots during germination; and (4) influence greenhouse gas emissions . MPs dramatically speed up the pace at which soil water evaporates, which could cause the soil to dry out and perhaps have a detrimental effect on plant health. MPs have the potential to lower soil fertility and promote loss of plant nutrient. Furthermore, MPs have the potential to lower the diversity of soil microbes by lowering the abundance of rhizosphere fungal symbionts or soil microbial diversity. Microbial activity is impacted differently by varying soil MP concentrations. Soil microbial activity is increased by high concentrations of MPs and decreased by low concentrations of MPs. The length of exposure determines how MPs affect soil microbes. MPs impact soil microbial populations in two major ways. On the one hand, modifications to the physicochemical qualities of soil impact the microbial population *via* modifying the living habitat of microorganisms. Conversely, MPs provide unique ecological environments for bacteria, or their growth is impacted by plasticizer release.Plant growth and performance can be impacted by microplastics in three different ways: 1) direct toxicity to plants, primarily to nanoplastics; 2) indirect effects on plant growth through modifications to soil properties and microbial communities; and 3) direct toxicity of contaminants present in MPs, such as plasticizers, flame retardants, antioxidants, colorings, and so forth. MPs have the ability to cling to plant roots and alter their characteristics, making it more difficult for plants to absorb nutrients and water. Large-scale MPs in the soil reduce irrigation and rainfall infiltration, which has a detrimental impact on the soil's ability to store water and may even result in anoxia. Plant health is also impacted by changes in soil microbial communities brought on by microplastics, and if root symbionts like mycorrhiza and nitrogen fixers are disturbed, this impact is probably going to be detrimental.

4. Strategies Against Microplastic Pollution on Soil

4.1. Use of the biological mulches

Plastic mulches, common in horticulture, can be substituted with environmentally-friendly alternatives like paddy straw, wheat straw, and certain long grasses, effectively eradicating the need for plastic in agricultural settings. By embracing natural mulching options, farmers can mitigate plastic usage while promoting sustainable farming practices.Top of Form

4.2. Proper check of the entry in the field of sludge

Using sewage sludge as fertilizer and irrigation for crops is a significant contributor to microplastic pollution, mitigatable through rigorous entry checks and recommended testing methods. Implementing these measures is crucial for potentially reducing field contamination.Top of Form

4.3. Promotion of natural and organic farming

Promoting natural farming could decrease reliance on coated fertilizers and synthetic products containing microplastics. Embracing solely farm-based organic products offers a pathway to eliminating the use of such substances altogether.

4.4. Use of bioremediation by biological means

Bioremediation is key to improving soil health by enabling microbes to metabolize chemical pollutants and microplastic derivatives, thereby addressing soil ailments effectively.

4.5. Use the cemented and biodegradable pipes for irrigation channel

Modern irrigation channels, predominantly composed of plastic tubes and pipes, pose a risk of microplastic pollution due to potential particle shedding during irrigation. Transitioning to cemented and biodegradable pipes offers a solution to mitigate this pollution source.

5. Conclusion

The presence of microplastics in agricultural soils demands urgent attention and action. By raising awareness, conducting further research, and implementing effective mitigation strategies, we can work towards preserving soil health, ensuring food safety, and protecting the environment for current and future generations.

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