Ecofarming
e-Magazine for Agriculture and Allied Sciences
http://www.ecofarming.rdagriculture.in
e-ISSN: 2583-0791

Microplastic Pollution

Unravelling Threat to Flora and Fauna in Soil Ecosystem

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Received: November, 2023; Accepted: November, 2023; Published: January, 2024

Abstract

In recent years, pollution has become a growing concern due to its detrimental effects on the environment. While much attention has focused on microplastics in oceans and their impact on marine life, a hidden crisis is unfolding in the soil ecosystem. Microplastics, particles smaller than 5mm, are infiltrating soils globally, posing a grave threat to terrestrial flora and fauna. This article explores the issue of

microplastic pollution in soil, investigating its effects on terrestrial ecosystems' delicate balance. It's, originates from various sources, including personal care products and plastic debris breakdown, alters soil physicochemical characteristics, and may pollute underground water. The prevalence of microplastics in soil raises urgent concerns, impacting soil properties and affecting diverse environments. Understanding their impact on soil and developing strategies for mitigation is crucial for addressing this pervasive environmental issue.

Keyword: Agriculture; Microplastic; Soil; Environment; Pollution; Climate change

1. Introduction

Microplastic pollution, a growing concern in recent years and has garnered significant attention for its detrimental effects on the environment (Anbumani and Kakkar, 2018). While much focus has been on the presence of microplastics in the oceans and their impact on marine life, there is a hidden crisis occurring beneath our feet in the soil ecosystem. Microplastics, tiny plastic particles less than 5mm in size, are infiltrating soil systems worldwide, posing a grave threat to terrestrial flora and fauna (Sajjad et al., 2022). In this article, we will delve into the issue of microplastic pollution in soil and explore its effects on the delicate balance of terrestrial ecosystems. The leftover plastic debris gradually degrades into minute fragments with a diameter of less than 5mm, known as microplastics. MPs are responsible for many changes in the soil's physicochemical characteristics, including porosity, enzymatic activities, microbial activities, plant growth, and yield. Their ubiquitous nature, high specific surface area, and strong hydrophobicity MPs play an important role in the transportation of toxic chemicals such as plasticizers, polycyclic aromatic hydrocarbons (PAHs), antibiotics, and potentially toxic MP elements. maybe transported deep into the soil and can pollute underground water. The term macroplastics is used to differentiate microplastics from larger plastic waste, such as plastic bottles. Microplastics include any plastic fragments or particles that are already 5.0 mm in size or less before entering the environment. These include microfibers from clothing, microbeads, and plastic pellets (also known as nurdles) Plastic degrades slowly, often over hundreds if not thousands of years. Increases the probability of microplastics being ingested and incorporated into, and accumulated in, the bodies and tissues of many organisms. Global production of polyethylene and polypropylene (the most frequent microplastics in soil) is increasing at an annual rate of approximately 7% (1950–2012).

2. The Prevalence of Microplastics in Soil

Microplastics can originate from various sources, including the breakdown of larger plastic items, such as bottles and bags, or through the direct release of microplastics found in personal care products, like exfoliating scrubs and toothpaste (Ghosh et al., 2023). These tiny particles are so pervasive that they have infiltrated even the most remote and seemingly pristine environments. In soil, microplastics can be introduced through various means, including urban runoff, agricultural practices, and the deposition of airborne particles.

3. Types of microplastic

3.1 Primary microplastic: Primary microplastics are small pieces of plastic that are purposefully manufactured, these plastic fragments or particles that are already 5.0 mm in size or less before entering the environment. Sources include personal care products, such as toothpaste, shower gels, and fibers from laundry. and have also been produced for use in air-blasting technology. involves blasting acrylic, polyester microplastic scrubbers at machinery, engines, and boat hulls to remove rust and paint and also Washing synthetic clothing and fabrics may release microplastic a single polyester fleece jacket can release >1900 fibers per wash

3.2 Secondary microplastic: Secondary plastics are small pieces of plastic derived from the breakdown of larger plastic debris, both at sea and land, soil. Over time a culmination of physical, biological, and chemo-photo-degradation, including photo-degradation caused by sunlight exposure can reduce the structural integrity of plastic debris and cause the development of secondary plastics. Sources of secondary microplastics include water and soda bottles, fishing nets, and plastic bags.

4. Assessment of microplastics in soil

This is alarming because four-fifths of all plastics end up in the soil, turning this important and vulnerable ecosystem into a threatened sink of microplastics. Thus, realistically assessing the risk that microplastics pose to soil is of great urgency. The terrestrial environment is estimated to receive 4-23 times more plastic waste. Microplastic pollution in the soil environment has thus begun to elicit great concern. Microplastic pollution has been detected in various soils including agricultural/farmland, greenhouse, home garden, coastal, industrial, and floodplain soils. Microplastics affect soil physical and chemical properties, microbial and enzyme activities, and plant growth, and also pose adverse ecotoxicological effects to soil fauna. These effects depend on the concentration, size, and shape of microplastics, as well as soil texture.

5. Impact of microplastics in soil

Four microplastic shapes: fibers, films, foams, and fragments; Eight polymer types: polyamide (PA), polycarbonate (PC), polyethylene (PE), polyester (PES), polyethylene terephthalate (PET), polypropylene (PP), polystyrene (PS), and polyurethane (PU). fibres due to their linear shape, may destabilize soil structure once they are incorporated into soil aggregates. Chemical properties of microplastics, such as molecular chain arrangement and functional group, could impact their capacity of absorption to other chemicals like heavy metals or antibiotics. Low-density polyethylene (LDPE) films may increase soil pH, while high-density polyethylene (HDPE), may increase the Reduction in soil respiration.

6. Agricultural plastic mulching as a source of microplastics

Microplastic contamination on land maybe 4-23 times greater than that in the ocean. The global market for agricultural plastic films was 4 million tons ($10.6 million) in 2016 and is projected to grow at a rate of 5.6% per year through 2030. Approximately 20 million hectares of farmland worldwide practice plastic

mulching, with China accounting for the largest proportion (~90%). Improper disposal of agricultural plastic films may lead to the accumulation of microplastics in agricultural soils, posing a considerable threat to terrestrial wildlife.

7. Impact of microplastic on human health

Trophic-level transfers of microplastics have also been shown to occur. It has been suggested that microplastics can induce various subsequent effects on organisms, such as feeding disruption, reproductive reduction, intestinal damage, and metabolic disturbances (Yin et al., 2021). High-density polyethylene with sizes of 0-80 µm can be taken up into the cells of blue mussels, Mytilus edulis L., and induce a strong inflammatory response and food security.

8. Remediation of microplastic

Various methods, such as advanced oxidation processes, photocatalysis, microwave, and bioremediation have been employed to degrade/eliminate microplastics (MPs) from soil and water. Increasing education through recycling campaigns is another proposed solution for microplastic contamination (Prata et al., 2019). Incinerating plastics to use as energy, is known as energy recovery. Improving recycling technology to be able to reduce the production of plastic and its distribution in terrestrial as well as aquatic systems.

9. Key Challenges and Perspectives for Future Research

It is necessary to develop accurate, simple, efficient methods to assay multiple types of microplastics in soils. To understand various scenarios that can take place in real soil environments, future research should strengthen developing simulation experiments to obtain the realistic state of soil microplastics under field conditions. It largely lacks certain data about concentrations, volumes, types, and compositions of microplastics in soil environments. In future research, it is urgent to address the distribution, transport, and degradation of microplastic in terrestrial environments to reveal environmental behaviors and effects. As emerging persistent contaminants, microplastics can be taken up by soil biota. Trophic transfer and transgenerational effects are also necessary to be taken into account in the future.

10. Conclusion

In summary, global pollution concerns have predominantly centered on ocean microplastics, but a concealed crisis is emerging in soils as these particles threaten terrestrial ecosystems. The article emphasizes microplastics' diverse sources, including personal care products and plastic debris, and their impact on soil characteristics and potential water pollution. The widespread presence of microplastics in soil is alarming, necessitating an understanding of their profound effects and the development of mitigation strategies. The study underscores their pervasive nature, entering soils through urban runoff, agriculture, and airborne particles. Assessment reveals a significant influx of plastics into the soil, transforming it into a microplastic sink with critical risks. Microplastic pollution affects various soils, influencing physical and chemical properties, microbial activities, and plant growth based on concentration, size, and

shape. Different microplastic shapes and polymer types impact soil structure, with agricultural plastic mulching exacerbating the issue. Improper disposal leads to significant microplastic accumulation in agricultural soils, threatening terrestrial wildlife. Microplastics induce health risks through trophic transfers, prompting the use of remediation methods like advanced oxidation and bioremediation. Future research challenges include accurate assessment methods and addressing data gaps. Efforts are underway to understand and mitigate microplastic pollution in soil, focusing on sources, behavior, and remediation. Sustainable waste management and reduced plastic usage are crucial, along with advocating the 3 INR and concepts like REPLAN for a sustainable future.

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