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Review Article



A comprehensive review on microplastic impacts on plant and terrestrial food chain

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Abstract

Growing evidence points to microplastics as a serious environmental contaminant that affects terrestrial food chains and plants. Their presence in the soil can change its composition, influencing its porosity, water retention, and microbial activity, which can lower fertility and impede plant development. Microplastics can hinder the growth of both roots and shoots, as well as hinder the development of roots and seed germination rates. Furthermore, they have the ability to concentrate and absorb dangerous contaminants like pesticides and heavy metals, which can be absorbed by the plants and result in phytotoxicity and other health problems. Additionally, microplastics interrupt the cycle of nutrients by interfering with ability of organic matter to decompose. Microplastics can be consumed by soil-dwelling species in the terrestrial food chain, such as nematodes, earthworms, and insects. This can cause physical obstructions, decreased eating, and problems with development and reproduction. The ecosystem may experience a domino effect if these creatures disappear since they are essential to the health of the soil and the cycling of nutrients. As microplastics and their related poisons move up the food chain and perhaps reach higher trophic levels, such as birds and mammals, they have the potential to bioaccumulate and biomagnify. By direct consumption or contamination of pollen and nectar, microplastics can harm pollinators like bees and reduce their pollination effectiveness, which in turn affects agricultural yields and plant reproduction. In the end, eating infected plants or animals can expose humans to microplastics, which poses risks for toxicity, inflammation, and the spread of dangerous substances. With an emphasis on long-term pollution effects and techniques to identify and measure microplastics in soil and biota, ongoing research attempts to clarify the routes and processes of microplastic impacts on terrestrial ecosystems. Enhancing waste management, cutting back on single-use plastics, creating biodegradable substitutes, and raising public awareness of plastic pollution are examples of mitigation techniques. To preserve ecosystem health and guarantee food security, it is imperative to address the effects of microplastics on plants and terrestrial food chains.

Keywords: Microplastics, Soil Health, Plant Growth, Terrestrial Food Chain, Bioaccumulation, Pollutants, Ecosystem Impact.

Introduction

The transport of objects from primary production to final consumers is a complicated system known as the terrestrial food chain, which is impacted by social, economic, and environmental variables (Hövelmann et al., 2006). Terrestrial food webs are made up of diverse species assemblages, with

plants and insects having important roles in feeding relationships (Hale et al., 2023). Furthermore, Berman et al., (2023) examine the distinct paleobiological characteristics of the Bromacker vertebrate fossil collection, emphasizing the higher the incidence and multiplicity of terrestrial herbivorous species within a particular paleoenvironment, indicating an initial stage in the development of the contemporary terrestrial

trophic structure. The complexity of terrestrial food chains and the need to understand these systems for ecosystem management and assessing human health are highlighted by this body of research.

Humans are at the end of the food chain and the human gut microbiota is "the end of the food chain and the start of good health" (Gibson, 2002). This arrangement represents the relationship between our gut bacteria, the food we eat, and our general health. According to Richard Manning's description of the food chain, all species, including humans, depend on plants for energy, highlighting the essential role that plants play in maintaining life (Guerzoni, 2010). There are many facets to the complex interaction that exists between humans and agricultural food crops in the food chain, including ecological, economic, and nutritional aspects. Humans primarily obtain their nutrition from agricultural crops, which offer the vital nutrients and energy needed for both survival and good health (Caldwell & Wang, 2020). Human behaviors, such as selecting for desired features that can increase productivity and resilience against pests and diseases, have an impact on the cultivation of these crops (Jasper et al., 2019). Moreover, since agricultural systems frequently form the backbone of rural economies, the economic aspects of crop production have a major impact on food security and livelihoods (Vanisree et al., 2022). This relationship is not without difficulties, though; an over reliance on monocultures can result in a loss of biodiversity and a greater susceptibility to climate change (Bourdeau, 2010). Therefore, even if agricultural food crops are necessary for human nutrition, maintaining this interdependent relationship and ensuring long-term food security require sustainable methods. Microplastics are plastic particles that are smaller than 5 mm. They can be produced as tiny particles for different applications or they can come from the breakdown of bigger plastic trash. Their diverse shapes, sizes, and chemical compositions are among their qualities, which might affect how they behave in the environment and how dangerous they are.

Typically, microplastics are divided into two categories: primary microplastics, which are produced on purpose, and secondary microplastics, which are produced when bigger plastic objects break down (Fox et al., 2023). Microplastics' aberration patterns describe how they disperse and accumulate in different settings, such as land and aquatic ecosystems. Studies reveal that microplastics may display geographical variability, impacted by elements including river flows, sedimentation procedures, and human endeavors (Liqi et al., 2017). Furthermore, their ecological impact may be worsened by their interactions with other contaminants, which could result in bioaccumulation in food webs (Bianco V et al., 2019; Liu X et al., 2024). Comprehending these patterns is crucial in evaluating the ecological hazards linked to microplastics and formulating efficacious measures for their mitigation. Numerous ways allow microplastics to infiltrate the food chain, which has a major negative influence on ecosystems

and human health. One main route of entrance is through aquatic ecosystems, where marine organisms—such as fish and shellfish—ingest microplastics, which are then consumed by humans (Sharma, 2024). Furthermore, microplastics can enter the soil from terrestrial sources such as agricultural runoff, where crops may absorb them (Liaqat et al., 2024). Studies show that atmospheric deposition is especially important because microplastics can travel through the atmosphere, land on land, and contaminate water and food supplies (Cverenkárová et al., 2021). Moreover, microplastics are more common in terrestrial and marine food webs as a result of bigger plastic trash breaking down into microplastics through environmental weathering processes (Singh et al., 2023). Finally, as microplastics can enter into food products, the use of plastic packaging during the production and processing of food might directly cause contamination (Chain, 2024). When taken as a whole, these routes demonstrate the complex character of microplastic pollution in the food chain. This review's primary objective is to provide an overview of the presence of microplastics in the human food chain, with a focus on the materials function as carriers of different organic micropollutants and microbes. We'll also talk about the negative effects eating microplastics has on your health.

Effect of Microplastic on Soil properties and fertility

Effect of MP on soil physical properties: MPs have a beneficial impact on soil aeration. The largest effect that MPs have on soil is a change in bulk density, which often leads to increased aeration, lower root penetration resistance, and increased water holding capacity—all of which are beneficial to plant growth (Leifheit et al., 2021; Islam et al., 2023). According to (Zhang et al., 2019), polyester microfibrils significantly enhanced the volume of holes larger than 30 μm while reducing the volume of pores smaller than 30 μm .

Adding MPs to soil usually results in a decrease in bulk density. (0.1-0.4) % polyester MP fibers increased the soil's ability to retain water while decreasing the bulk density of the soil in Albic Luvisol (Ingraffia et al., 2022). MP fibers influenced soil aggregate durability consistently, regardless of polymer or concentration. High concentrations of polyethylene MPs (2%) alter soil texture and reduce the soil's ability to retain water (Wang et al., 2022). Micro plastics tend to decrease contact angle and saturated hydraulic conductivity while increasing bulk density and water-holding capacity (Table 01); aggregate stability is unaffected. Polyester fibers have a bigger influence on the physical characteristics of soil than polypropylene granules because their form is very different from that of soil particles (Yu et al., 2023). Physical properties that affect soil quality and functions, such as infiltration, porosity, erodibility, and the soil's capacity to transmit gases and liquids, can all be strongly impacted by the stability of soil aggregates. It was discovered that soil aggregate creation and stability had a significant impact on the complex interactions among soil organic carbon, fine mineral particles, and the microbial population (Zhang et al., 2019).

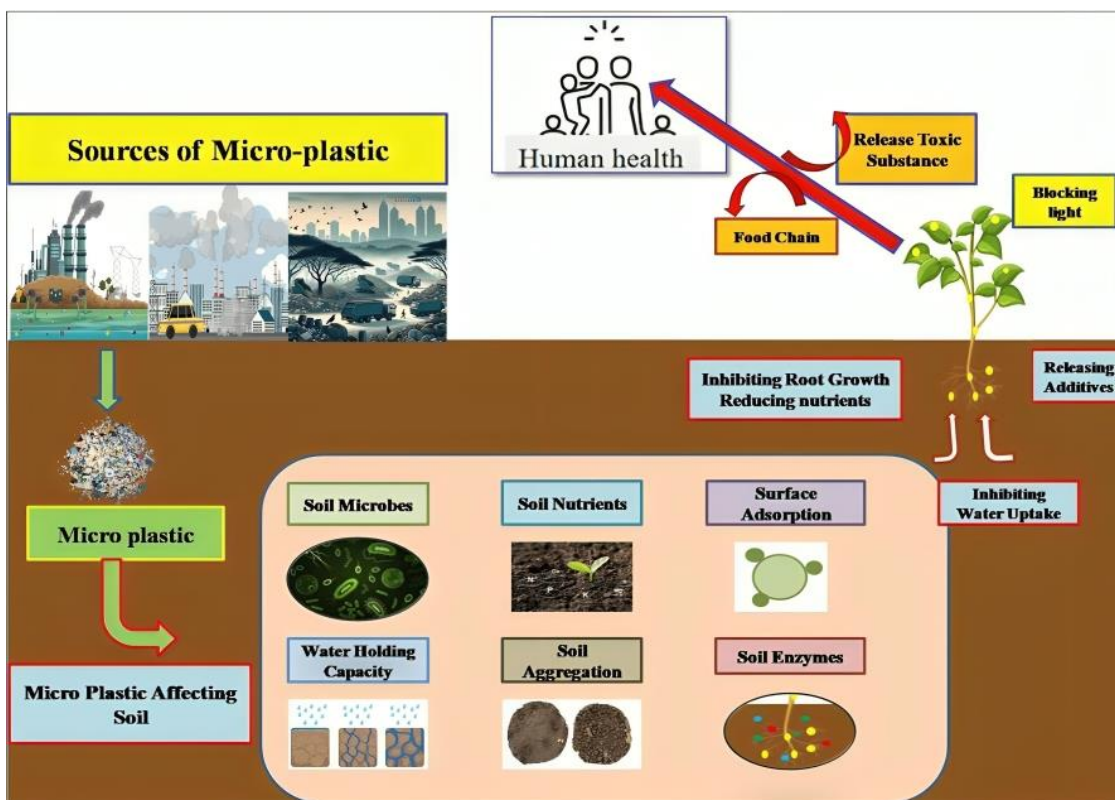


Fig. 1 Source and ingestion of micro plastics in ecosystem and food chain

Table 1. Impacts of polyester microplastic on the physical and hydrological characteristics of soil

S.N.	Distinct Types of Agricultural Soil	Formation of Aggregates	Erosion of Soil	Water-Retentive Capacity	The Bulk Density	Reference
1.	Vertisol	Macro aggregation	No change	Decrease	Decrease	Javier (2023)
2.	Alfisol	recently established	More erodible	Increase	No change	Zhang et al. (2023)
3.	Entisol	Decrease	More corrosive	Increase	Decrease	Ingraffia et al. (2022)a
4.	Albic Luvisol	Decrease	-	Increase	slightly less	Ingraffia et al. (2022)b

Table 2. Impacts of microplastics (MPs) on soil physical properties

S. N.	Soil physical properties	Effect of microplastics (MPs)	References
1.	Soil Aeration	Through lower bulk density, MPs improve soil aeration.	Leifheit EF et al. (2021)
2.	Bulk Density	MPs boost water retention and lower bulk density.	Ingraffia et al. (2022)
3.	Pore Size	Polyester microplastics enlarge bigger pores (>30 μm) and diminish smaller pores (<30 μm).	Zhang et al. (2019)
4.	Soil texture	2% polyethylene MPs change soil texture and minimize water retention.	Wang et al. (2022)

Effect of MP on soil chemical properties: overestimates of soil organic carbon (SOC), a crucial metric for assessing soil quality and the global carbon cycle, caused by microplastic pollution (Chia et al., 2021). MPs can potentially affect the soil nutrient cycle through modifying organic matter and available nutrients. MPs age as a result of long-term enrichment and emission migration, changing in size, shape, and surface characteristics. Additionally, MPs have the ability to absorb or desorb additional contaminants during these processes, such as organic pollutants and toxic chemicals, which hurt the soil organisms. MPs have different environmental implications for ecosystems than larger plastic waste. MPs provide home for a range of microbial species in the environment and can be accidentally ingested by some animals. After being exposed to the environment, MPs will degrade and may become more susceptible to absorbing pollutants. MPs are prone to accumulating toxic compounds and diseases, which puts the ecosystem at risk through the food web and food chain in addition to the potential for physical injury to species (Wen et al., 2022).

MPs' Impact on the Biological Properties of Soil

The impact of microplastics (MPs) on the biological characteristics of soil encompasses their potential to have diverse impacts on different plant species within a community and influence plant development. According to recent studies, MP either extended fine roots or reduced root diameter. The features of fine roots differ significantly across different types of plants. For example, according to McCormack et al. (2015), the average proportion of absorptive fine roots in woody plants is 33%, whereas in herbaceous plants it is 81%. The impact is mostly influenced by the host-symbiont interaction in question as well as the MP parameters (concentration, type, form, and

additives). With a plant host that is heavily reliant on MP, the MP may have a greater effect on the mycorrhizal symbiosis (Leifheit et al., 2021). MPs can occasionally inhibit plant development.

Effect of microplastic on soil borne diseases

Due to the disruption of microbial communities and soil processes caused by microplastics (MPs), the effect of MPs on soil-borne organisms is becoming increasingly critical. Studies reveal that MPs have the potential to modify soil health, impact nutrient cycle, and change microbial diversity, all of which have important ecological ramifications. In polluted soils, MPs have been demonstrated to decrease microbial diversity, forming a unique "plastisphere" that supports microbes that break down plastic while reducing nitrifiers and ammonia oxidizers (Vijay et al., 2024). According to certain research, biodegradable MPs like PBAT (poly butylene adipate-co-terephthalate) can drastically change the bacterial community in the rhizosphere by promoting some bacterial populations and suppressing plant growth (Jiaxi et al., 2024). In some soil types, the presence of MPs may increase the quantity of bacteria that fix nitrogen and phosphorus and hence increase the amount of nutrients that are bioavailable (Vijay et al., 2024). On the other hand, especially in flooded settings, MPs can cause soil structure and water retention to be disrupted, which can have a detrimental effect on microbial-mediated processes such sulphur transformations (Weiwen, 2024). Through a variety of ways, including direct toxicity from their surface features and indirect impacts on the physicochemical qualities of the soil, MPs interact with soil organisms (Kun et al., 2023). To fully comprehend the long-term effects on soil ecosystems, further fieldwork is required due to the intricacy of these interactions (Vijay et al., 2024).

Table 3. Effects of microplastics (MPs) on microbial diversity and soil health

S.N.	Soil ecosystems	Microbial and soil health aspects	Effect of microplastics	References
1.	Polluted soil	Microbial activity	Reduces microbial diversity, resulting in the formation of a "plastisphere"	Vijay et al. (2024)
2.	Rhizosphere soil	Bacterial population	Biodegradable MPs like PBAT disrupts bacterial populations in plant roots	Jiaxi et al. (2024)
3.	Organic soil	Nutrient Availability	Augmentation of nitrogen- and phosphorus-fixing bacteria, hence enhancing the availability of bioavailable nutrients.	Vijay et al. (2024)
4.	Flooded soil	Soil Structure	Microbially mediated activities like sulphur conversions may suffer as a result of MPs' disruption of soil structure and water retention.	Weiwen (2024)
5.	Upper crust soil	Soil toxicity	Either direct toxicity from their surface characteristics or indirect effects on the soil's physicochemical properties.	Kun et al. (2023)

Even though MPs clearly have a negative impact on soil organisms, recent research indicates that some microbial communities may be able to adapt to them, suggesting that soil

ecosystems may be resilient. To completely understand these processes and their consequences for soil health and agriculture, more study is necessary.

Effect of microplastic on nutrient recycling

The transport and interconversion of various nutrients within and between biotic and abiotic organisms in the global environment is known as nutrient cycling. Inorganic ions (NH_4^+ , NO_3^- , SO_4^{2-} , H_2PO_4^-), gases (N_2 , CO_2), minerals (apatite, the major P-containing mineral), and organics (bound into diverse C-based compounds in living or dead organisms or their products) are some of the numerous forms that nutrients may appear in (Lavelle et al., 2005). Macronutrients, particularly carbon, nitrogen, and phosphorus, are constant in natural ecosystems. But alterations to natural ecosystems can have a significant impact on the equilibrium of nutrients. For instance, lowering the soil C pool leads to an imbalance in the soil C:N ratios, which in turn influences the amount of phosphorus that is accessible to microorganisms and the availability of phosphorus in the soil (Huang et al., 2019). The main emphasis of this section is on nutrient cycles that have been significantly impacted by MP pollution.

Soil Nitrogen Cycling

The nitrogen cycle is a recurring set of chemical reactions that transform nitrogen as it travels through the atmosphere and both marine and terrestrial ecosystems. According to McNeill & Unkovich (2007), the nitrogen cycle in soil consists of five major stages: nitrogen fixation, mineralization, immobilization, nitrification, and denitrification. N fixation is the process by which industrial or biological activities transform atmospheric N_2 into reactive forms of N. Reactive nitrogen (reactive N) is nitrogen that is bound to carbon (organic N), hydrogen (NH_3 , NH_4^+), or oxygen (NO^x , NO_3^- , N_2O) and is accessible for biological transformation or absorption. Available mineral N for plant and microbial absorption is provided by the biggest N pool in the plant root zone or by the breakdown of organic materials in the soil. However, the organic matter decomposition process, which is mostly handled by soil fauna and microorganisms, can liberate (mineralize) this organic N to generate mineral N (NH_4^+). While N is returned to the soil by plant or microbial mortality, or by grazing animals' dung or urine, it is made accessible for uptake by plants and microorganisms through the decomposition of organic materials in the soil. Mineralization-immobilization turnover, or MIT, is the interconversion of mineral N into organic N or vice versa (Jansson & Persson, 1982). In the fifth stage of the nitrogen cycle, denitrification occurs when bacteria reduce the ionic nitrogen oxides (NO_3^- and NO_2^-) to the N_2 via gaseous oxides (NO and N_2O). During nitrification, ammonium in soil is oxidized by nitrite (NO_2^-) to NO_3^- (Knowles, 1982).

Soil Carbon Cycling

One major non-plant carbon source in soils is microplastics (MPs), which are mostly made of carbon (Rillig & Lehmann, 2020). Once in the soil, MPs frequently become immobilized within organic compounds and minerals, forming MP-derived aggregates that provide additional carbon sources, disrupting the natural carbon cycle and influencing plant growth,

microbial growth, and decomposition processes (Rillig et al., 2021; Zhou et al., 2021b). According to Chen et al., (2020a) and Liu et al., (2017), MPs can increase MP-derived dissolved organic carbon (DOC) and SOM but limit the storage of native soil organic matter (SOM). Different MP types have different effects on native SOM breakdown. For example, biodegradable MPs speed up decomposition by giving microorganisms carbon, but they may also have a negative priming effect because of increased DOC (Zhou et al., 2021a; Rillig et al., 2021).

MPs have a dose-dependent effect on carbon flow both above and below the soil, affecting CO_2 uptake and emission. For instance, whilst 1-5% PVC powder enhanced carbon assimilation into the soil, 10% polythene and PVC powder changed the distribution of carbon between roots and soil (Zang et al., 2020). Furthermore, MPs have an indirect influence on carbon cycle activities including rhizo deposition and organic carbon sequestration by influencing the colonization rates of arbuscular mycorrhizal fungi (Zhou et al., 2020b, 2021b). SOM breakdown rates are strongly influenced by the quantity of MPs present in the soil; low dosages of polyethylene (0.01% w/w) increased SOM decomposition, but large doses (1% w/w) decreased microbial activity and carbon consumption (Xiao et al., 2021). In paddy soil, however, MPs had very little influence on the mineralization of external carbon substrates (Xiao et al., 2021).

Soil Phosphorous Content

MPs have a direct impact on the soil's overall phosphorus level. For example, MPs made from PS and PVC considerably decreased the overall phosphorus level (Yu et al., 2021a). On the other hand, in acidic red soil, the presence of plasticized PVC MPs enhanced the available P content, promoting soil P cycling (Yan et al., 2021). The available P content in soil is increased by the processes of inorganic P mineralization and inorganic P solubilization (Qu et al., 2020).

Micronutrient and Trace Element Availability in Soil

Microplastics (MPs) have a high surface area-to-volume ratio and are hydrophobic, making them effective vectors for soil pollutants. This influences the micronutrients' bioavailability and stoichiometry in the soil by enabling them to adsorb and mobilize B, Cl, Cu, Fe, Mn, Mo, and Zn (Liu et al., 2019a; Tang et al., 2021; Feng et al., 2022). These interactions can affect microbial diversity, plant development, and soil fertility. Surface complexation, Van der Waals forces, and electrostatic forces (Cao et al., 2021) aid them. Micronutrient availability can have a detrimental impact on crop health as they are necessary for balanced crop fertilization (Shukla et al., 2019). The hydrophobicity of MPs is decreased by dissolved organic matter (DOM) and biofilms on MPs, which improve micronutrient adsorption (Tang et al., 2021; Li et al., 2022). MPs' binding affinity for micronutrients is further enhanced by weathering caused by oxygen and UV exposure. Studies on MPs' ability to adsorb micronutrients are still in their infancy.

MPs can change the availability of some minerals, such as zinc, but their desorption in soil is low and increases in the stomachs of earthworms, endangering soil organisms (Hodson et al., 2017; Feng et al., 2022). By changing its soil movement and raising its organic-bound portion, MPs also have an impact on Cu availability (Li et al., 2021c; Yu et al., 2020b). Additionally, boron adsorbs onto MPs, which may have an impact on the soil stoichiometry (Wang et al., 2021a).

Additionally, MPs can change the quantities of micronutrients in the soil by releasing metals like Cu, Zn, and Mn that are utilized as plastic additives back into the soil (Meng et al., 2021). Therefore, MPs in soil have a major impact on the composition and bioavailability of trace elements and micronutrients, which in turn affects the general health of the soil and ecosystem function.

Table 4. Impact of microplastics (MPs) on soil nutrients cycling

S.N.	Nutrient Cycling and other aspects	Impact of microplastics (MPs)	References
1.	Nitrogen Cycling	Reduces the reactive nitrogen availability by slowing down the fixation, mineralization, immobilization, nitrification, and denitrification processes.	McNeill & Unkovich (2007)
2.	Macronutrients	Changes the Soil carbon ratio	Huang et al. (2019)
3.	Carbon Cycling	Influence carbon transport, microbial activity in soil and organic matter decomposition in soil	Rillig et al. (2021)
4.	Soil Carbon content	Effect the SOM storage and increase in MP-derived dissolved organic carbon	Chen et al. (2020a)
5.	Phosphorus Content	Increase or decrease soil phosphorus levels based on mineralization	Yan et al. (2021)
6.	Hydrophobicity and Adsorption	Hydrophobic nature of MPs can be altered by dissolved organic matter, affecting micronutrient adsorption	Li et al. (2022)
7.	Micronutrient Availability	Either increase or decrease the availability of vital micronutrients.	Tang et al. (2021)
8.	Release of Additives	Discharge harmful metals (Cu, Zn, Mn) into the soil affecting trace element composition	Meng et al. (2021)

Effect of microplastic on plant growth and development /agricultural System

Microplastics (MPs) have a substantial effect on agricultural systems and plant growth, influencing a number of physiological and ecological functions. These can lower the crop output by preventing root elongation, seed germination, and general plant health. Microplastics effect the plant growth in various ways. For instance, in rice plant, particular polyethylene (PET), can lower fresh weight (12-37%), reduce

root length (15-20%) and shoot height (15-30%) (Iswahyudi et al., 2024). Also, exposure to microplastic pollutants (MPs) can result in reductions in chlorophyll content. Plant growth depends on microbial habitats and nutrient availability, which are influenced by soil bulk density and pH, which can be changed by microplastics (MPs) (Chen et al., 2024). Plant nutrient intake can be impacted by MPs' disruption of the carbon, nitrogen, and phosphorus (C: N: P) ratios in soil (Palansooriya & An, 2024).

Table 5. Effects of microplastics (MPs) on plant growth

S.N.	Plant growth parameters	Effect of microplastics	References
1.	Fresh Weight of Plant	Decreased by 12–37%	Iswahyudi et al. (2024)
2.	Root Length	Reduced by 15–20%	Iswahyudi et al. (2024)
3.	Shoot Height	Decreased by 15–30%	Iswahyudi et al. (2024)
4.	Chlorophyll a & Chlorophyll b	Reduced by 43% & 41%	Chen et al. (2024)
5.	Soil Bulk Density and pH	Altered by MPs, affecting microbial habitats and nutrient availability	Chen et al. (2024)
6.	Nutrient Intake	Changes the C: N: P ratios effecting plant nutrient uptake	Palansooriya & An (2024)

Even though MPs clearly have a negative impact on plant development, some research indicates that they may also improve the availability of nutrients in the soil, which might be

advantageous for particular agricultural techniques (Liava & Golia, 2024). Nonetheless, there is still broad agreement that MPs seriously jeopardize sustainable agriculture systems.

Effect of microplastic on Human health

Microplastics might potentially affect human health and are primarily introduced into the human food chain through contaminated foods. Another way that the human body might become contaminated is through inhalation of microplastics (Karbalaee et al., 2018). Skin contact is a small source of microplastics in the human body (Campanale et al., 2020).

After ingestion, the impact of microplastics on the human gastrointestinal system is mostly unknown. Following ingestion, the majority of micro- and nanoplastics are thought to be eliminated in feces (>90%). Given that microplastics up to 150 µm in size were found in the lymph in investigations on mammals, absorption of microplastics by the intestinal epithelium most likely only happens with particles smaller than this. Larger microplastics can only affect the immune system locally, such as intestinal inflammation, whereas exposure to these microplastics results in systemic exposure. Deep organ penetration is possible for the tiniest fraction of microplastics (<1.5 µm) (CONTAM, 2016). Because of their size, nanoplastics are more dangerous since they can pass through the blood-brain barrier, the placenta, and M-cells in Peyer's patches in the small intestine to reach the blood and lymphatic system, where they can infect the liver and gallbladder (Smith et al., 2018). The first evidence of microplastics in the human placenta was found in a study published in 2021. Twelve pieces, ranging in size from 5 to 10 µm, were found in four placentas. It is yet unknown how they enter the placenta and whether they have any impact on pregnancy or the developing fetus (Ragusa et al., 2021). However, microplastics' long-term consequences on human health are largely unknown (Kontrick, 2018). Their harmful effects on the body could include the production of reactive oxygen species during the inflammatory response, which could induce oxidative stress and have cytotoxic effects. Consuming microplastics can interfere with metabolism, immune system function, and energy balance (Prata et al., 2020).

Microbial attachment to the surface of microplastics is another concern linked to eating food containing them. It has been established that the surface of microplastics contains a variety of harmful species, and eating seafood exposes people to more of these microbes. Microplastics can leach toxic substances into food, including BFRs, PCBs, PAHs, bisphenol A, and antibiotics. These substances can then cause cancer, mutagenic reactions, and endocrine disruption (De-la-Torre, 2020). Nonetheless, certain research indicates that ingesting persistent organic pollutants along with microplastics constitutes a minimal cause of contamination for people. The projected daily intake of bisphenol A from a typical diet would be 40 million times higher than that of contaminated seafood (Rist et al., 2018).

Using protective masks was one of the first steps taken to stop the COVID-19 epidemic from spreading over the world. They are frequently made of man-made polymers. Disposable masks, however, soon turned into garbage that might emit

fibrous microplastics and contaminated the environment (Fadare & Okoffo, 2020). Furthermore, because the SARS-CoV-2 virus can persist on surfaces for up to five days, researchers are starting to anticipate the transmission of COVID-19 via microplastics emitted by discarded masks. This possibility of spreading the infection has not yet been proven or disproven (Liu & Schauer, 2021; Enyoh et al., 2020).

Effect of microplastic on Biodiversity / Ecosystem Balance

In a variety of settings, microplastics (MPs) represent serious risks to ecological balance and biodiversity. Their widespread presence has a negative impact on flora and wildlife by upsetting terrestrial and aquatic ecosystems.

Aquatic Ecosystem Impact

Many aquatic species, such as fish and zooplankton, consume MPs. This can cause bioaccumulation and biomagnification in food chains, which can eventually have an impact on human health and food safety (Dhiman et al., 2023). According to Isaac & Kandasubramanian (2021), they serve as carriers of dangerous contaminants, impairing physiological processes and changing species interactions in aquatic environments.

Impacts on Ecosystems on Land

MPs have the potential to disrupt the equilibrium in the plant-soil-microbial system in terrestrial contexts by adversely affecting soil functions and concurrently improving some plant functions. Reduced microbial activity, which is essential for nutrient cycling and soil health, might result from the presence of MPs (Jia et al., 2024).

Ways to reduce the microplastic contamination: Ecosystem perspective

Microplastic pollution is a growing environmental problem that requires a multimodal strategy for mitigation because of the complex relationships that exist within ecosystems (Samuel et al., 2024). Microplastics, which are plastic particles smaller than five millimeters, come from a variety of sources, such as tire wear and tear from vehicles, micro beads in personal care items, and the fragmentation of bigger plastic waste. These particles are extremely common in freshwater, marine, and terrestrial ecosystems, and their widespread existence has detrimental effects on the health of the environment (Pallavi & Raut, 2024).

Enhancing waste management procedures is a vital tactic for lowering the pollution caused by microplastics (Mathew, 2024). Microplastic contamination is largely caused by inadequate waste management and disposal systems. Microplastics can be released into the environment, for example, by burning plastic trash, open dumping, and poorly managed landfills. Reducing the quantity of plastic trash that breaks down into microplastics can be achieved by putting in place efficient waste management methods, such as cutting-edge recycling technology. The amount of plastics entering

ecosystems can also be decreased by promoting the use of biodegradable substitutes and supporting the reduction of single-use plastics through laws like levies or prohibitions (Gary et al., 2024). The decrease of microplastic emissions at the source is another important strategy. Plastics-producing and -using industries should use best practices and technology that reduce microplastic creation. For instance, producers of textiles may look at natural fiber substitutes or create sophisticated filtering mechanisms that collect microfibrils while being washed. In a similar vein, the auto sector may fund research to develop tires that are less likely to leak microplastic particles and are more resilient. Manufacturers of personal hygiene products can replace microbeads with natural, biodegradable alternatives in their formulas (Yu & Flury, 2024). Combating the pollution of microplastics necessitates preservation and restoration of natural ecosystems. As natural filters, riparian zones, mangroves, and wetlands catch microplastics before they get to bigger bodies of water. Better organic matter content and soil structure in healthy soils can help bind microplastics and stop them from moving (Liang et al., 2021).

In order to deal with microplastic pollution, innovative research and monitoring are also essential. Creating efficient mitigation plans requires a thorough understanding of the origins, movements, and ultimate destination of microplastics. In addition, studies on the ecological effects of microplastics, particularly their capacity to bioaccumulate and disturb food webs, are required to guide conservation and policy initiatives (Lusher et al., 2021).

Preventing microplastic contamination requires both public awareness campaigns and educational initiatives. The demand for plastic items is mostly driven by consumers, therefore altering public perception of the harm that microplastics do to the environment can result in a decrease in the use of plastic. Campaigns to reduce plastic use and beach clean-ups are examples of community-based projects that can increase awareness and encourage cooperation. Furthermore, including instruction on microplastics in school curricula might encourage the following generation to adopt sustainable lifestyles (Garcia-Vazquez & Garcia-Ael, 2021). In general, a comprehensive ecosystem approach that incorporates waste management, source reduction, habitat conservation, research, and public involvement is needed to reduce the pollution caused by microplastics. Mitigating the environmental and ecological implications of microplastics can be achieved by addressing the issue at different levels, ranging from individual consumer decisions to global industrial practices. We can strive for a cleaner, healthier Earth for coming generations by taking a holistic strategy.

Conclusion

Microplastics pose a significant threat to terrestrial ecosystems, impacting soil health, plant growth, and food chains. By altering soil properties, hindering nutrient cycling, and interfering with plant development, microplastics disrupt essential ecological processes. These tiny particles can be

ingested by soil organisms, causing physical damage and affecting their reproductive capabilities. As microplastics move up the food chain, they can bioaccumulate and biomagnify, potentially harming higher trophic levels, including humans. To mitigate these risks, it is crucial to implement effective waste management practices, reduce single-use plastic consumption, promote biodegradable alternatives, and raise public awareness about the dangers of plastic pollution. By addressing these issues, we can protect our environment, ensure food security, and safeguard human health.

Future Perspective

In the future, combating the problem of microplastic contamination will need international cooperation. Plastic pollution primarily originates in suburban and urban areas, and most of it ends up in lakes, rivers, oceans, and seas. MPs contaminate water sources and spread hazardous materials like DDT and hexachlorobenzene up the food chain, hurting marine life and eventually people. Long-term dietary exposure to MPs may change the chromosomal sequences of humans, resulting in major health hazards such as obesity, cancer, and infertility (Laskar & Kumar, 2019). PE MPs particles are found in common goods such as makeup, face wash, hand sanitizers, toothpaste, and dental care items (Sharma & Chatterjee, 2017). Prolonged use of these products can lead to serious health risks, including tissue absorption that damages skin. Governments must adopt tough anti-plastic policies, impose zero tolerance for their usage, and enact local legislation and fines to reduce plastic pollution in order to meet this problem. The manufacture of traditional, non-biodegradable plastics should be stopped by authorities, and biodegradable plastics should be promoted and brought to market at the lowest feasible cost. Since people's behavior directly affects the effectiveness of pollution control techniques, environmental health education and general public awareness are essential.

Conflict of Interests

Authors declare no conflict of interests.

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Not Applicable

Authors' Contribution

Conceptualization: DP and SD; Data collection: SB, SG, AB, SK and DP; Preparation of tables and figures: SB, AB, SK and DP; Writing the first draft: SG, DP, SB; Editing and proofreading: all the authors.

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