Effects of Microplastics in Plants

The fact that plastics can be used in many areas in daily life has led to an increasing demand. In parallel with the increasing use of plastic, an intense plastic pollution also occurs. It has been stated by different researchers that plastics, which take many years to decompose, cause significant problems in both aquatic and terrestrial ecosystems. Microplastics are defined as plastic pollutants with a particle size of less than 5 mm. Microplastics found in the soil are potential risk factors for the plants growing on it by changing the soil structure. In this mini review, the effects of microplastics on soil and plants and the possible damages they cause are summarized in line with the studies carried out by various researchers.

Keywords: *microplastic, pollutant, environment, plant, soil*

Introduction

In recent years, plastics have become one of the indispensable materials of daily life. Researchers estimate that global plastic production will reach 33 billion tons by 2050 (Huang et al., 2023). Plastics are synthesized from petroleum-derived products such as low or high density polyethylene (PE), polyethylene terephthalate (PET), polypropylene (PP), polystyrene (PS) and polyvinyl chloride (PVC) (Hu et al., 2022). Plastic waste is now an important environmental problem. It is estimated that approximately 12000 million metric tons of plastic waste will go to waste or mix into the natural environment by 2050, if the current production and waste management method regarding plastics continues (Geyer et al., 2017). Plastic waste is degraded by various factors such as ultraviolet radiation, wind or water erosion and becomes smaller plastic waste (He et al., 2018).

Microplastics are generally defined as plastic pollutants with a particle size of less than 5 mm and nanoplastics are particles smaller than one micrometer (Zhu et al., 2019; Peller et al., 2022). Microplastic pollution has become a growing environmental problem. While microplastics first emerged with the pollution they caused in the oceans and aquatic ecosystems, today the presence of microplastics in many terrestrial areas (agriculture, city, industrial areas, etc.) is known. Although the decomposition rate of microplastics in the soil in various ways is not known clearly, it is estimated that their presence in the soil is permanent (Rilling et al., 2019). Microplastics mixed into the soil threaten various organisms and affect human health by infiltrating storage, displacement, erosion, degradation and groundwater (Hurley and Nizzetto, 2018). In this mini review, the effects of microplastics on soil and plants and the possible damages they cause are summarized in line with the studies carried out by various researchers.

Effects of Microplastics on Soil and Plant

Microplastics are considered as a soil physical pollutant, and it is stated that plastic films create channels for water movement in the soil, increasing water evaporation and leading to soil drying (Wan et al., 2019). Microplastics also cause changes in soil microbial composition, which may affect plant growth by affecting plant root microbial (mycorrhiza, N-fixer etc.) activity (Rilling et al., 2019). Microplastics can be of different types with certain densities and show different effects in soil. They generally have lower densities than soil particles of their own size and tend to lower soil bulk density (Khalid et al., 2020). It is stated that the carbon content of the plastics is high, and since there is no rapid decomposition in the environment, an increase in the C:N ratio will occur and cause microbial immobilization (Rilling et al., 2019). Depending on the type and amount of microplastics in the soil, it greatly changes the flow of C throughout the plant-soil system and adversely affects C-dependent soil functions (Zang et al., 2020). Microplastics can add a surface with different properties in the soil, contaminants can remain on these particles for a long time, and phytotoxic substances on microplastics can be transported to the soil together (Rilling et al., 2019). De Souza Machado et al. (2019) determined that microplastics change plant biomass, tissue elemental composition, root properties and soil microbial activities in green onions.

Agricultural crops are directly exposed to microplastics as a result of plastic mulch, sludge fertilization and organic fertilizers (Khalid et al 2020). Since microplastics stay in the environment for a long time, they can have direct and indirect effects on plants (Khalid et al., 2020).

Microplastics interact with various heavy metals (arsenic, chromium, copper, cadmium and lead, etc.) and metalloids in the soil, causing harmful effects on soil structure and soil microbial activity, ultimately affecting plant and human health (Kumar et al., 2022). Microplastics can increase phytotoxicity in plants by absorbing heavy metals (Kumar et al., 2022). In another study, high-dose HDPE (10%) caused Cd phytotoxicity, polystyrene (PS) adversely affected plant growth and increased phytotoxicity in the presence of Cd. Also, it was determined that both HDPE and PS increased the concentrations of extractable Cd with soil diethylenetriaminepenta acetic acid (DTPA) and increased pH in soil containing Cd. Thus, microplastics changed Cd bioavailability, plant performance and soil properties (Wang et al., 2020). Microplastics have a large surface area and can act as a vector for other pollutants in the soil. Huang et al. (2023) stated that microplastics significantly increased Cd accumulation in plant shoots and roots and supported plant Cd uptake, especially polyethylene was more effective on Cd accumulation. Researchers stated that plant Cd uptake is supported as a result of a small decrease in soil pH and an increase in the amount of available Cd by microplastics. Microplastics can affect biomass, chlorophyll content, photosynthetic activity, shoot and root development length in plants through apoplastic and symplastic pathways (Kumar et al., 2022).

Although the effect of microplastics on plants varies depending on the dose in the studies, there are more studies with negative effects in general. The long-term effects of microplastics are still an important question. Similarly, it was stated that the negative effects of microplastics on both above-ground and sub-soil growth in plants varied depending on the dose (Zang et al., 2020). Yang et al. (2021) investigated the effect of non-degradable high–density polyethylene (HDPE) and biodegradable polylactic acid (PLA) and they determined that HDPE and low dose PLA stimulated plant growth but high-dose PLA reduced shoot and root biomass of maize. It has been determined that soil can affect plant growth because it changes nutrient content and microbial structure (Kumar et al., 2022). It has been determined that plastics with small particles can be taken up by plant roots and affect the uptake and transport of mineral elements by roots (Li et al., 2020; Xu et al., 2021). While both HDPE and PLA further increased Zn concentrations in roots, they reduced Zn translocation to above-ground parts of maize plants (Yang et al., 2021). Furthermore, microplastics can also accumulate in the pores of the seed capsule, and as a result of clogged pores with microplastics, water uptake is prevented and there may be a problem in the germination of seeds (Zhang et al. 2021). Bosker et al. (2019) pointed out that there was a 78% decrease in germination of seeds of *Lepidium sativum* exposed to plastic particles of different sizes, and this was due to the physical blocking of the seed pores by microplastics.

In the study examining the effects of 100 nm and 5 µm polystyrene microplastics (PS-MPs) in wheat; PS-MPs at high concentrations (200 mg L^{-1}) inhibited the elongation of wheat roots and stems and 5 µm PS-MPs showed a greater toxicity effect (Liao e al., 2019). It was determined that polylactic acid (PLAMP) microplastics significantly reduced root length in soybean (Lian et al., 2022).

In addition, PS-MPs damaged photosynthetic activity in wheat leaves, inhibited protein synthesis and caused oxidative stress by changing antioxidant enzyme activity (Liao et al., 2019). Indeed, microplastics decreased peroxidase (POD) activity and increased catalase (CAT) activity in soybean leaves. In this study, it was stated that the metabolic pathway most affected by microplastics in soybean is amino acid metabolism (Lian et al., 2022). Huang et al. (2023) decelerated that microplastics create physiological toxicity risks for plants by inhibiting photosynthesis and increasing oxidative damage in plants, and synergistic toxicity risks may occur in plants, especially if microplastics are present in combination with Cd.

In recent years, studies on the environmental effects of microplastics have gained intensity, and only a few of their effects on plants have been mentioned above. It is seen that the various materials we use contain factors that may cause significant harm to the environment. In this study, the effects of these on agricultural products have been emphasized, and it is thought that more studies should be done in this sense.

Conclusion

Microplastics reduce soil fertility, disrupt soil structure, and thus adversely affect plant growth and development. Therefore, microplastics are as important a threat to terrestrial ecosystems as other pollutants. Also, the use of these plants in the food chain poses a great risk for human health. It will be important to clearly determine the effect of microplastics on soil-plant systems and to carry out agricultural production in a healthy and sustainable way.

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