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Impact of Bioplastics on the Environment of the Soil

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Abstract

The contribution of plastic waste that is disposed of improperly is estimated to be 30% worldwide, and these wastes pose a particular threat to all living things. As a result, in recent years, the evaluation of the potential effects of plastic particles on the biotic component of ecosystems has grown in importance. Consequently, since 2018, the number of publications on this topic has increased. The purpose of this paper is to review recent research on the effects of bioplastic particles and plastics derived from petroleum, also known as (bio) plastics, on the terrestrial ecosystem, particularly soil biota. This is the first review to examine the potential effects of bioplastics and plastics derived from petroleum on the soil compartment. Petroleum-derived plastics were studied more frequently than bioplastics, and 18% of the papers analyzed dealt with bioplastics. Bioplastics were found to have no effect on seed germination. However, they might make the process of germination take longer to complete. Root and stem growth was subjected to effects that were both inhibitory and stimulating. The biochemical activity of nitrifiers and the transformation of carbon compounds were unaffected by bioplastic microparticles. Earthworms were the primary organisms used to examine the effects of petroleum-derived plastics on soil biota, but data on bioplastics are scarce. Microplastics derived from petroleum that can be found in soil at concentrations of up to 1000 mg kg1 typically do not affect earthworm reproduction or cause earthworm mortality. Petroleum-derived plastics may accumulate in the intestine of earthworms and travel up the food chain as micro- and nanoparticles. In conclusion, the final evaluation of bioplastics' ecotoxicity is hampered by the high variability of results and the apparent lack of dose-dependence relationships, necessitating the development of ecotoxicological studies on bioplastics, particularly those on the effects of bioplastics on soil animals.

Keywords: Terrestrial ecosystem • Ecotoxicological • Microparticles

Introduction

One of the major environmental issues that affects ecosystems and humans alike is the contamination of the environment with plastic debris. Plastics are typically polymeric hydrocarbons that have been enhanced with additives to improve specific properties. In the 1940s and 1950s, massive production of (bio)plastics began, and it will reach almost 368 million tons worldwide in 2019. Bio-based plastics accounted for nearly 1% (or 2 million tons) of this production in 2019. Polymers that are made from renewable resources like starch, sugar, natural fibers, or other organic components of varying compositions are known as bio-based plastics. One of the materials industries that is expected to grow at the fastest rate is the production of polymers from renewable resources. By 2025, bio-based plastics are expected to make up about 2% of all plastics on the market worldwide. It is not necessary for biobased plastics to be biodegradable. According to European Bioplastics, 2020, it was estimated that nearly half of bio-based polymers were not susceptible to biological decomposition in the environment. Bioplastics include plastics that are biodegradable and biobased. European Bioplastics' definition states that "a bioplastic is either bio-based, biodegradable, or features both of these properties" [1-5].

Description

The physicochemical properties of the pure polymers of petroleum-derived plastics and bioplastics that are introduced into the market typically contain additives and/or modifiers. The additives improve the final product's pliability, resistance to ultraviolet light, and flammability, among other desirable physical properties. Plasticizers, dyes, pigments, antioxidants, light and UV stabilizers, and others fall into this category. During any stage of polymerization or processing, additives or modifiers can be incorporated into a polymer in any proportion. Not only do these compounds alter the physicochemical properties of polymers, but they also alter the biological properties of those polymers, such as their biodegradability and toxicity. Bioplastics and plastics derived from petroleum eventually become waste that must be properly managed. Around 250 million tons of plastic waste were produced worldwide in 2018. About 70% of them were collected and sent to managed landfills, recycling facilities, or energy recovery units. About 30% of the remaining plastic waste was improperly disposed of. In practice, they entered the ecosystem directly, whether it was aquatic or terrestrial. It should not come as a surprise that plastic particles are regarded as the most prevalent kind of debris encountered in the environment given how much plastic waste is produced.

It was estimated that continental systems could store up to 32% of all plastics produced, and agricultural soil could store even more microplastics than oceanic basins. Clearly, it poses a significant threat to terrestrial ecosystems. In addition, soil is an essential and biologically active component of the environment that contributes to the carbon and other elemental cycling through global ecosystems and provides water and nutrients to living things.

Plastics derived from petroleum and bioplastics that enter soils undergo numerous biological, chemical, and physical processes. Earthworm activity, bioturbation by plant roots, and microbiological decomposition are all major contributors to biological transformations. Adsorption, desorption, sedimentation, incorporation into soil aggregates, chemical interactions with water, humic-like compounds, and other soil components are all examples of physicochemical processes. Plastics are broken up into macroplastic (150 mm), microplastic (5 mm), and nanoplastic (100 nm) particles as a result of these various transformations and weathering processes (such as UV radiation and rainfall). Secondary plastics are frequently referred to as plastics that have disintegrated and/or degraded. Primary plastics, on the

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other hand, are the raw material that is directly utilized in industry, medicine, and other human activities [4,5].

Conclusion

The bioplastic and petroleum-derived plastic particles, especially the smaller ones (micro- and nanoparticles), are easily transported vertically and horizontally within the soil matrix, and some of them may reach the aquifer, thereby contaminating groundwater. Plastic particles are widely dispersed as a result of transportation, and they can be found not only in industrial areas but also in non-urban areas and even on the shorelines of the most remote islands. Researchers in Switzerland analyzed soil samples from 26 floodplain sites and found that microplastics were present in 90% of the soil. The annual input of microplastics to farmlands in Europe ranges from 63,000–430,000 tons, while the annual input to farmlands in North America ranges from 44,000–300,000. It is mostly brought on by the application of sewage sludge, wastewater-based irrigation on farmland, or degradation of plastic mulch on semiarid agricultural lands. The number of plastic particles in sewage sludge ranges from 1,000 to more than 20,000 per kilogram of dry mass.

Acknowledgement

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Conflict of Interest

None.

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