ISSN: 2664-9640

Research Progress and Prospects of Soil Microplastic Pollution in Farmland

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Abstract

Microplastics (MPs) is a new type of environmental pollutant, which has a negative impact on the soil ecosystem, and it can enter crops through the soil environment, thereby threatening human health and life safety. It is one of the research hotspots of farmland soil pollution in recent years. This article elaborates on the morphological classification, source, separation and detection methods, distribution characteristics, and harm to the soil environment of microplastics in farmland soil, and summarizes its impact mechanism on soil microorganisms and crops; and look forward to the future direction and focus of the research on MPs in farmland environment, and put forward reasonable suggestions for the current problems, in order to provide a theoretical basis for future related research.

Keywords

Microplastics; pollution; farmland soil; crops; microorganisms.

1. Introduction

Microplastics refer to plastic particles with a particle size of less than 5 mm [1], which have the characteristics of easy migration, difficult degradation, and easy to cause secondary pollution to the environment. At this stage, there is a strong dependence on plastics in life and production processes. Plastics are widely used in industrial and agricultural production, daily life, infrastructure construction and other aspects [2]. Studies have shown that in recent years, the presence of microplastics has been detected in marine and terrestrial ecological environments [3-4]. Microplastics contain a lot of toxic and harmful substances, such as polybrominated diphenyl ethers (PBDEs), phthalates (PAEs), etc., and are easy to adsorb heavy metals and antibiotics in the soil to cause compound pollution [5]. Microplastics are easily absorbed by organisms and are widely distributed in soil ecosystems. They will accumulate, enrich, migrate and transform in farmland soil. Microplastics enter the food chain, accumulate and migrate along the food chain, and cause harm to microorganisms, animals, plants, and the human body [6-7].

2. Research overview of microplastics

2.1. The morphology of microplastics

The morphology of microplastics is closely related to the surrounding environment, and can be divided into fragments, films, fibers and particles [8]. Liu [9] found that the microplastics in the soil of the farmland on the lakeside of Dianchi Lake in Yunnan were mainly fibers, accounting for 92.69% of the total, while films and debris accounted for a very small proportion. Han [10]

and others showed that the microplastics in the soil of the Daliao River Basin accounted for the largest proportion of microplastics, reaching 57.36%, and the smallest proportion of particles, only 1.53%. Wang [11] and others found that there are 4 types of microplastics in farmland soil in Hetao Irrigation District of Inner Mongolia, including fragments, films, fibers and particles. Among them, the film type accounts for the highest proportion, accounting for 38.57% of the total.

2.2. The source of microplastics

The sources of microplastics in farmland soil mainly include atmospheric deposition, the use of mulch and plastic films, the application of organic fertilizers, and irrigation. Atmospheric deposition refers to the process in which microplastic particles are carried into the local soil environment by wind in remote areas [12]. At present, the existence of microplastics has been detected in the Qinghai-Tibet Plateau [13], and atmospheric deposition is the main route for the migration of microplastics to remote areas. Mulch and plastic films are widely used in agricultural production. After crops are harvested, their residues in the soil undergo physical fragmentation, chemical decomposition, and microbial degradation, and are finally converted into microplastics, which will cause serious pollution to farmland soil [14]. Studies have confirmed that the use of mulch and plastic films in China is increasing, and a large amount of microplastics are retained in farmland soil [15-16], becoming the main source of soil microplastics. In principle, the application of organic fertilizer is a green agricultural production method, but in the production process of organic fertilizer, a certain amount of microplastics is allowed. Therefore, the application of organic fertilizers is also considered to be one of the sources of soil microplastics. Organic fertilizers are widely used all over the world. China is a big country in the production and use of organic fertilizers. According to research estimates, the total amount of microplastics put into farmland soil by applying organic fertilizers in China is 52.4~26400 tons every year [17].

2.3. Separation and extraction methods of microplastics

The separation and extraction methods of microplastics in farmland soil mainly include heating method, air flotation method and density separation method [18]. Among them, the density separation method is widely used in the separation and extraction of microplastics in the soil. Before separating and extracting soil microplastics, the air-dried soil sample needs to be screened through a metal sieve, and the soil sample on the sieve is taken, and the mineral components in the soil are removed by density separation. The density of microplastics is lower than that of soil, but microplastics will be absorbed by soil aggregates [19], which reduces the extraction efficiency of microplastics. The density separation method can solve this problem. Use distilled water or a high-density extraction salt solution to separate microplastics from soil aggregates. The higher the density of the extract, the greater the density range of the microplastics that can be extracted[20].

2.4. Distribution characteristics of microplastics

Microplastics are widely found in different types of soil, such as farmland [21], vegetable plot [22], plantation [23] and mangrove soil [24]. Studies have shown that the closer to residential areas, the higher the abundance of microplastics. The abundance of microplastics in farmland in Xinjiang, China is (1075.6±346.8)/kg soil[21], and the abundance of microplastics in vegetable fields in Wuhan is (320-12560) Among the soil/kg soil, the microplastic pollution in suburban road soil is 1.8 times that of residential area soil [22]. The types of microplastics in farmland soil mainly include polyethylene, polypropylene, and terephthalic acid (PET) [25-26], which indicates that microplastic pollution is affected by the use of plastic products such as food packaging bags, mulch film, and plastic film. In general, the pollution of microplastics in

farmland soil environment is closely related to human daily life and production activities. The abundance of microplastics in areas with more frequent human activities is higher.

3. Harm of microplastic pollution

3.1. The harm caused by microplastics to the soil environment

Under natural conditions, microplastics are extremely difficult to degrade, and are easy to accumulate and migrate in the soil, which affects the soil environment of farmland, changes the physical and chemical properties of the soil, and affects the energy and material cycle of the soil system. Studies by BOOTS [27] and others have shown that microplastics can reduce soil pH, change the size and distribution characteristics of soil aggregates, and affect soil stability. Microplastics have an enveloping and nucleating effect on organic matter and minerals, which can block some pores in the soil and affect the water permeability of the soil [28]. Microplastics contain toxic and harmful additives such as plasticizers, which directly or indirectly affect the growth and development of the farmland soil environment and organisms. Microplastics have small particle size and strong hydrophobicity, which can adsorb pollutants from the environment and produce compound toxicity [29]. In addition, microplastics can also change soil moisture and porosity, change the oxygen content and flow rate in the soil, and then change the relative distribution characteristics of soil microorganisms [30]. All in all, microplastic pollution in farmland soil will affect the physical and chemical properties of the soil and soil aggregate structure, reduce soil fertility and microbial diversity, on the other hand, it will also harm plants and animals in the farmland soil environment, affect the growth of crops, and reduce food Yield and quality affect animal growth and reproduction.

3.2. The harm of microplastics to soil microorganisms and crops

Soil microorganisms include bacteria, fungi and actinomycetes, etc. Microplastics will reduce the diversity of soil microorganisms [31]. The additives contained in microplastics can inhibit the activity of soil microorganisms, affect the development of microorganisms, and are not conducive to the maintenance of soil fertility [8, 32]. Studies by ZETTLER [33] and others have shown that microorganisms can be adsorbed on the surface of microplastics for a long time, which affects the ecological functions of soil microorganisms. For example, KETTNER[34] et al. found that parasitic and saprophytic fungi on polyethylene and polystyrene particles multiply, and Campylobacter containing pathogenic bacteria can also attach to microplastics, causing potential damage to soil organisms and human health. threat.

Microplastics indirectly affect the growth of crops by affecting the ecological environment of farmland soil. The impact of microplastics on crops is mainly reflected in the following three aspects: First, it increases the transpiration of crop leaves, affects the development of crop roots, and inhibits crop growth. The second is to reduce the germination rate of crop seeds [35] and reduce crop biomass. The third is to affect the growth and development of crops. After crops absorb microplastics, they cause genotoxicity and migrate from the roots to the above-ground parts. They are distributed in the stems and leaves, which adversely affect the transportation and growth of crops.

4. Outlook

In recent years, research on soil microplastics pollution in farmland has grown rapidly, and the research direction mainly focuses on the form, source, distribution characteristics and harm to soil of soil microplastics. At present, research on the technical system for the prevention and control of soil microplastic pollution in farmland is relatively lacking. In summary, future research on the interaction between microplastics, soil microorganisms, and crops needs to be further carried out. The process of microplastics from soil to crops and the mechanism of action

on crops are explained in detail, with a view to microplastics in farmland soils. Pollution control research provides theoretical support.

Acknowledgements

The research was funded by the Scientific Research Item of Shaanxi Provincial Land and Engineering Construction Group Co., Ltd. (Program No. DJNY2020-13, DJNY2021-25, DJNY2021-26, DJNY2021-34).

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