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Research and Prospect of Soil Microplastic Pollution in Farmland

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Abstract

With the continuous deepening of research on microplastics pollution in water and atmospheric environments, research on the occurrence and environmental effects of microplastics in soil environments has become increasingly mature. Based on existing research results, this article summarizes the current sources and pollution status of soil microplastics in farmland, analyzes the research methods of microplastics in soil, and analyzes the potential contribution rate of different pollution sources to microplastics pollution, as well as the impact on agricultural production, agricultural product safety and soil Quality impacts and challenges. Finally, a prevention strategy for microplastics pollution is proposed, and the focus of future research on farmland microplastics pollution is prospected.

Keywords

Farmland Soil; Microplastics; Pollution; Ecological Effect.

1. Introduction

Environmental endocrine disruptors (EDCs), per-fluorinated compounds and other persistent organic pollutants, antibiotics and microplastics are the main new environmental pollutants. Among them, microplastics are small particles of plastics such as plastic fibers, fragments, and particles with a particle size less than 5 mm that are widely present in the environment. The high chemical stability, strong plasticity, and general environmental pollution problems have attracted attention from all walks of life. Studies have reported that the microplastics contained in the soil are about 4 to 23 times more than that in the ocean [1]. Studies have shown that microplastic pollution of farmland in terrestrial ecosystems is closely related to human activities. In the process of agricultural production, sewage irrigation, the use of agricultural film, the application of biological sludge and organic fertilizer and the atmospheric dry and wet sedimentation make farmland a variety of plastic waste and microplastic is a major pollution sink, but there is still insufficient research on pollution source analysis and contribution ratio [2]. Microplastics enter the farmland soil, move forward continuously under the action of rainfall, farming, and organisms, and generate ecological risks through the accumulation of bio-accumulation. In addition, high-concentration microplastics have varying degrees of impact on soil structure, physical and chemical properties, soil plant growth, etc., and further affect human health and water ecological environment through the accumulation of the food chain [3].

Microplastics will exist for a long time when entering the soil, and it is difficult for microorganisms to decompose and mineralize, and it is also difficult to remove. As the soil medium contains complex components such as organic matter and soil minerals, it is difficult to separate and detect microplastics. Therefore, the necessity and feasibility of remediation of microplastic contaminated farmland soil remains to be explored. Based on previous research,

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a method system including sample pretreatment, separation, purification and detection of microplastics has been initially formed [4]. This article summarizes the research progress of microplastics in farmland soils, especially the research results on the sources and environmental effects of microplastics in farmland soils, and looks forward to future research directions, and proposes from the perspective of plastic waste management Strategies for the prevention and control of microplastic pollution in farmland.

2. Sources of Microplastics in Farmland Soils

2.1. Agricultural Mulch

The polyethylene film commonly used in agricultural production has the functions of wolf howling for heat preservation, water retention, and moisture retention, which is beneficial to increase the yield of crops and is widely used in many countries and regions. The use of mulch film has made a great contribution to the increase in agricultural production. According to statistics, the use of agricultural mulch film in my country reached 1.404 million tons in 2017, accounting for about 70% of the world's total, covering an area of nearly 1.77×10^7 hm^2. Since the implementation of the Action Plan for the Prevention and Control of Soil Pollution in 2016, the use and recycling process of agricultural mulch film has been strengthened, and the amount of mulch film used has been continuously reduced. At the same time, serious "white pollution" has also been produced. Due to the lack of effective recovery mechanisms and small thickness, the recovery rate of agricultural film in China is less than 60%, and the residual amount of agricultural film is generally 60-90 $kg\cdot hm^{-2}$, the highest can reach 165 $kg\cdot hm^{-2}$, and it will increase with the service life [5]. Studies have shown that there is a significant positive correlation between the concentration of microplastics in the soil and the use intensity and age of agricultural film. A large amount of residual mulch film has caused many adverse effects on the farmland ecosystem and surrounding environment.

2.2. Agricultural Plastic Waste

As a large agricultural country, the application of chemical fertilizers and pesticides in my country is much higher than the world average. The maximum peak of pesticide application in 2014 reached 1.81 million tons. Chemical fertilizers and pesticide plastic packaging waste are one of the important sources of microplastics in farmland soil. At present, the main packaging of pesticides and fertilizers is mainly made of plastic materials, which are difficult to be effectively recycled due to the wide and scattered distribution in time and space during use, and then remain in the farmland soil or nearby waters. According to statistics, my country used 5.65 million tons of chemical fertilizers in 2018, and its polypropylene and polyvinyl chloride waste packaging bags were about 150,000 tons.

2.3. Rural Domestic Waste

With the development of the rural economy and the continuous improvement of residents' living standards, the ecological environment problems caused by the discharge of rural domestic garbage and sewage are becoming more and more serious. In particular, the amount of rural domestic garbage generated is large and growing rapidly. At present, the annual output of rural domestic waste in my country exceeds 2.8×1010 t, of which plastic waste accounts for 8.78%, and there are obvious regional and temporal differences [6]. In order to promote the construction of rural ecological civilization and strengthen rural ecological environmental protection, the domestic garbage and centralized collection and transportation are now covered by more than 90% of the administrative villages [7]. However, there are a large number of rural areas across the country, especially in remote and underdeveloped areas. The collection, transportation and proper disposal of rural domestic waste still require continuous exploration

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and implementation. Domestic waste that is randomly inverted continues to enter farmland with precipitation.

2.4. Sewage Irrigation

Due to the shortage of water resources and uneven spatial distribution, sewage irrigation is an important agricultural irrigation method in arid and semi-arid areas, and it is also one of the important ways for pollutants such as microplastics to enter farmland soil. It is estimated that the world's farmland sewage irrigation area exceeds 2.0×107 hm^2, accounting for about 10% of the total irrigated area; the annual sewage discharge exceeds 330 km^3, theoretically it may be used directly or after treatment for the irrigation water of 4.0×10^7 hm^2 farmland [8]. Sewage irrigation can alleviate the water crisis to a large extent, but at the same time, a variety of pollutants contained in the sewage will enter the soil during the irrigation process. In untreated sewage, the concentration of microplastics can reach 1 000-627 000 ind·m^{-3}, and the content of microplastics in the effluent after secondary treatment is generally 100·m-3, and some are as high as 125 000 ind·m^{-3}, which can be reduced to 0-50 ind·m^{-3} after being filtered by an ultrafiltration membrane.

2.5. Sludge Fertilization

Sludge is often used in fertilizers and soil amendments. In Europe and North America, the application rate of sludge in farmland exceeds 50%. In 2017-2018, my country's sludge output was 5.5 million tons, and most of the sludge treatment was landfill, and the agricultural utilization rate was about 20% [9]. 90% of the microplastics in the sewage are concentrated in the remaining sludge. The concentration of the microplastics is 1500-24000 ind·kg^{-1}. The common ones are Polyethylene (PE), Polypropylene (PP), Polyvinyl chloride (PVC), Polyethylene terephthalate (PET), Polystyrene (PS) [10]. The study of sludge from 28 sewage treatment plants in 11 provinces of our institute indicated that the content of microplastics in the sludge ranges from 1 600 to 56 000 ind·kg^{-1}, with a median value of 22,700 ind·kg^{-1}.

2.6. Biocompost

Biological composting has important applications in solid waste treatment and agricultural production due to its green and economical nature. Industry reports show that China's organic fertilizer production rose to 1.381×107t in 2018[11]. The solid waste used for composting often contains some plastic waste. These plastic products will form microplastics during the processing processes such as crushing, mechanical screening and turning over. An investigation found that the content of plastics in compost products reached 2.38-80 mg·kg^{-1}, and that of microplastics was 895 ind·kg^{-1}. Therefore, the application of organic compost is another potential way for microplastics to enter the soil.

3. Environmental Risk and Ecological Impact of Microplastics in Farmland Soil

Microplastics are cracked under the influence of environmental factors, the particle size becomes smaller, the specific surface area, surface functional groups, and the octanol/water partition coefficient increase. High-concentration microplastics will act as a foreign component and affect other physical and chemical properties of the soil. Microplastics will affect soil bulk density, water holding capacity, particle size classification of water-stable aggregates, and function with microorganisms. Relationship etc. Probably because the structural integrity of the soil was destroyed, dry cracking was observed on the surface of the soil treated with large-size microplastics. On the other hand, long-term use of PE mulch can increase soil moisture content and change pH, which is beneficial to crops, but residual plastic waste will cause problems. These results will affect the circulation of soil water and the transport and absorption of soil nutrients, which will adversely affect crop growth.

The impact of microplastics on soil microbial communities is mainly through changing the physical and chemical properties of the soil to change the living environment of microorganisms, and stress the microorganisms; microplastics themselves provide attachment carriers for microorganisms, or release of plasticizers Affect its growth and so on [12]. Soil animals are an important part of soil ecology. They play an important role in improving soil structure, promoting the circulation of nutrient elements and other substances, and also affect the biomass of soil microorganisms and soil enzyme activities. In farmland ecosystems, earthworms and other soil animals are of great significance in maintaining soil health, improving soil quality in arable land, and promoting crop growth.

In addition, the impact of microplastics on plant growth is, on the one hand, damage to soil ecology, such as negative effects on soil physical and chemical properties, microbial communities, and soil animals. On the other hand, due to the physical obstruction of the plant seed hole and root surface layer by the microplastics, the germination rate may be reduced or the root growth and development may be hindered.

4. Strategies for the Prevention and Control of Farmland Soil Microplastic Pollution

4.1. Control of Pollution Sources

The primary task of preventing and controlling microplastic pollution in farmland soil is to control the source and reduce the amount of plastic entering the environment. Natural and artificially enhanced biological or microbial remediation may be more effective. In recent years, there have been many new discoveries in the microbial degradation of petroleum-based plastics, and it is possible to develop new degradation and resource recovery technologies. For example, microorganisms isolated from soil, earthworms and insect intestines can degrade microplastics, which provides the possibility for the risk control of microplastic pollution in farmland or in-situ bioremediation [13]. At present, there are many methods for extracting and detecting microplastics in the soil, but they are basically still in the laboratory stage and cannot be applied on a large scale, and there is a lack of effective technology for cleaning microplastics in the soil.

4.2. Development of Biodegradable Plastic Products

At present, there are two basic types of biodegradable plastics. One type is derived from agricultural products such as corn and other renewable raw materials. Its representative products are polylactic acid PLA, PHA, and starch plastics. Another type of biodegradable plastics derived from petrochemical products, plastics obtained by polymerizing petrochemical monomers by chemical synthesis, such as PCL, PBAT, PBS, PBSA, PPC, etc. Biodegradable plastic products are used in agricultural production, which can effectively reduce soil microplastic pollution. At the same time, there are disadvantages such as high price and low efficiency. In addition, after large-scale use of biodegradable plastics, the impact on soil ecology, waste recycling, and biodegradation capacity needs further in-depth research.

5. Conclusion and Foresight

The pollution of farmland soil by microplastics has become an important environmental problem. Microplastics pollute farmland through a variety of ways, including agricultural mulch, rural garbage, sewage irrigation, sludge, and compost. The large-scale use and low recycling rate of plastic products, especially agricultural mulch, lead to a large number of residues of

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plastic waste in farmland. Plastic waste produces a large amount of microplastics under the action of environmental factors such as ultraviolet radiation, weathering, and microbial degradation. It is the main source of microplastics in farmland. One of the main sources. Therefore, strengthening the management and control of agricultural plastic products and waste, and establishing a sound rural domestic waste treatment and disposal mechanism is the key to realizing the source control of micro-plastic pollution in farmland.

Regarding the persistence and ecological risks of microplastics in the environment, many studies have put forward suggestions for the prevention and control of microplastics pollution in the environment. The current main starting point is source control. Many countries in the world have formulated corresponding measures and regulations to control the pollution of plastic waste and microplastics. However, there is no effective farmland pollution cleaning and repairing technology.

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