The World Food Price Global Youth Institute

Impact and Prevention of Soil Microplastic Pollution

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Abstract

This paper summarizes the research results of microplastic pollution in soil environment at home and abroad, introduces the present situation and source of microplastic pollution at home and abroad, discusses the research status and the latest progress of the main detection technologies of microplastic pollution in soil at home and abroad, and puts forward feasible suggestions to the shortcomings of the current research on soil microplastic pollution

Key words: farmland soil; microplastic pollution

Microplastics refers to plastic particles with a diameter of less than 5 mm. With large specific surface area, strong adsorption force and other characteristics, Microplastics is not only a new environmental pollutant but also an important carrier of soil pollution. Microplastic pollution has been listed as the second largest scientific problem in the field of environment and ecology[1].

With the unreasonable discharge of solid waste, the global soil pollution situation is not optimistic, and soil microplastic pollution has become a major issue that needs to be solved. In the past ten years, the research on microplastic pollution mainly focuses on the Marine environment, and in recent years, soil microplastic pollution has gradually received attention.

1. Research status

In recent years, scholars at home and abroad have carried out a lot of research on the analysis of microplastic pollution in the environment and its ecological impact. With "microplastics" and "soil; microplastics" as key words, the publications of research papers of China National Knowledge Network database in the field of microplastics and soil microplastics in the past 13 years from 2010 to 2022 are collected, as shown in Table1

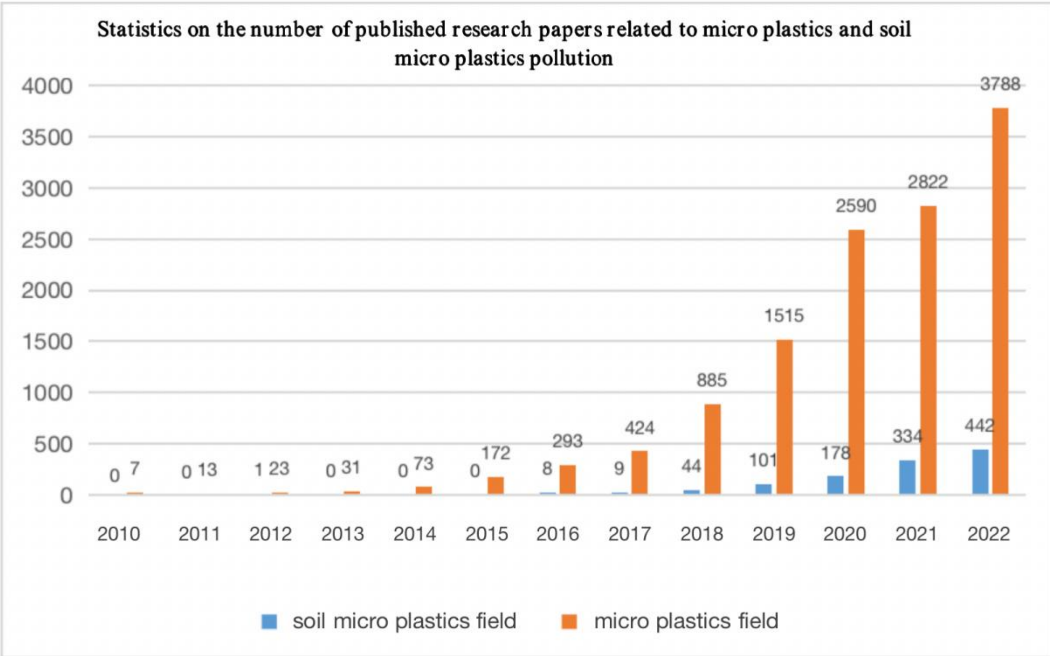
1. 

Table 1

According to table 1, research works related to microplastic pollution present the trend of rapid growth, becoming a hot spot in the field of environmental research. However, It was not until around 2016 that scholars conducted a series of studies on the sources and distribution of microplastics pollution in various types of soil and the effects of microplastics on soil biomes. In 2020,2021 and 2022, the number of papers published on the study of soil microplastics were 178, 334 and 442 respectively, accounting for 7%, 12% and 12% of the total number of papers published in the field of microplastics in the same year, indicating that the problem of microplastics pollution in soil has gradually received scholars' attention.

2. Classification and source

Due to the complex structure and the difficulty to degrade, microplastics exist in the soil environment for a long time and accumulate continuously. When the cumulative concentration reaches a certain degree, it will become a serious pollutant to the soil.

According to the sources, microplastics can be classified into primary microplastics and secondary microplastics. Primary microplastics are small particle size plastic fragments or particles generated by production activities, while secondary microplastics are smaller particle size plastic fragments formed by long-term weathering, crushing and degradation of primary microplastics. Secondary microplastics are more likely to cause damage to soil ecosystem than primary microplastics[2]. According to their morphology, microplastics can also be divided into spherical particles, films, fragments and fibers. Due to the small particle size of microplastics, their chemical properties are stable, their natural degradation rate is slow, and they are extremely easy to accumulate in the food chain. [3]

Microplastic pollution in soil is mainly caused by human production activities, and the sources and ways are very extensive. According to the research of Yang Qingfeng et al[4], microplastics are widely distributed in soils in soils around the world. Although there is a lack of unified standards for the detection and analysis of soil microplastic, and there are differences in sampling and analysis methods, it is not difficult to see that farmland soil in various parts of the world has been polluted to varying degrees through the research and analysis of soil microplastic pollution in some typical countries and regions of the world. Table 2 presents the pollution status of soil microplastics in some countries and regions of the world.

Soil microplastic pollution in China

region	sampling site	form	type	size	abundance(/kg)
Liaohe region	watershed soil	Debris, film, foam, fiber	PE、PP、PS、PA、POA、RY、PODC	500 ~ 1 000 μm	273.33±327.65
Shandong	tidal flat soil	Fibers, fragments, particles, films	PE、polyester resin、PP	1 540±1 020 μm	31.2 ~ 1 246.8
Rongcheng, Shandong	tidal flat soil	Foam,sponge, fiber, debris		<5 mm	
Shanxi	farmland soil	Fibers, particles	PS、PE、PP、HDPE、PVC、PET	0 ~ 0.49 mm	1 430 ~ 3 410
Shanghai	farmland soil	Fibers,fragments, films	PP、PE	<1 mm	78.00 ± 12.91
Xinjiang	cotton fields	Fibers, films			61.9±20.3 ~ 102.9±69.4
Yunnan	vegetable plot	Fiber, debris, film, rope		50 ~ 100 μm 95%; >100 μm 5%	18 760 N/kg

Table 2

Based on Table 2 and relevant existing studies, it can be found that the content of microplastics in soil all over the worlds is relatively high, which mainly comes from plastic waste generated in human daily life and production. At present, the global soil microplastics pollution situation is serious. Microplastics are widely found in industrial, tidal flats, sludge, greenhouse cultivation, mulched farmland and cultivated land and other types of soil, and there are great differences in the abundance and distribution of microplastics in different regions.

According to whether the pollution has a fixed pollution discharge point or not, the classification of microplastic pollution sources includes non-point source pollution caused by farmland mulch, greenhouse cultivation and landfill, as well as point source pollution caused by sewage discharge, wastewater irrigation and sludge utilization.

Based on the different ways of soil microplastic pollution generation, the sources of soil microplastic pollution can be divided into three categories:

(1)Industrial and agricultural production activities directly discharge microplastic particles into the soil (land) environment. Nlzzetto calculated the total microplastics imported from agricultural land in European and American countries through sludge use and the results showed that the total amount of microplastics was 63,000 ~ 430,000 t in Europe and 44,000 ~ 300,000 t in North America, which confirmed that sludge application is one of the important ways for microplastics to enter the soil. Weithmann et al. investigated the distribution of microplastic particles in organic fertilizers and found that the maximum number was 895 particles/kg, indicating that the application of organic fertilizers has also become an important way for microplastics to enter the soil.

(2) Microplastics transported from other environmental media such as water and atmosphere into the soil.

(3) Microplastics or even nano-plastics formed by large plastic particles or wastes that enter the soil environment through a variety of ways, mainly including plastic products and wastes from agricultural mulching film and municipal waste landfill. residual plastic accumulated in the soil through long-term plastic film mulching , plastic film will be broken into smaller pieces or microplastic.after natural weathering or artificial influence (farming, plastic film recycling, etc.), In recent years, there have also been some international reports showing that long-term agricultural film residue can lead to the problem of microplastic pollution in the soil.

3. The impacts of farmland microplastic pollution on soil ecosystems

(1) The influences on soil fertility (physical and chemical properties)

The microplastics in the soil release various substances (such as heavy metals, organic substances and toxic substances) adsorbed on the surface into the soil environment, thus changing the physical and chemical properties of the soil. 引用 For example, Liu et al. had found through the study of loess in China that the interaction of glyphosate and other pesticide components with microplastics in farmland soil would lead to the loss of dissolved organic carbon and organophosphorus quality in soil, thus changing the physical and chemical properties of soil, reducing the content of soil nutrients and affecting the growth and development of crops. Therefore, the entry of microplastics into the soil environment will directly or indirectly change the stability of soil physical and chemical properties. In particular, secondary microplastics have significant effects on soil physicochemical properties, thus affecting soil fertility and the ordered life activities of microbial communities.

(2) The impacts on plants

Microplastics can be adsorbed on the seed epidermis and the surface layer of the root and whiskers, blocking the seed capsule holes or cell wall holes, thus inhibiting seed germination and root growth and development. Liu Zhanli et al [5] had found that the high density polyethylene (HDPE) with small particle size and high concentration can be easily adsorbed on the root surface of mung bean, hindering the absorption ofwater and nutrients inthe soil, and then leading to the reduction of the germination rate and growth rate of mung bean.

(3) The effects on soil microbiota

Soil microbiota plays a key regulatory role in maintaining the dynamic balance of soil ecosystem. The healthy growth of animals and plants and the benign cycle of soil nutrients are inseparable from microbial regulation. Microplastics have strong adsorption characteristics, and the microplastics discharged into the soil environment in various ways may carry some harmful substances or viruses, which are harmful to the animals, plants and microbial communities in the soil environment. This is evident in the case of Huang et al., who have found that microplastics could significantly improve the soil catalase and urease activities and change the soil bacterial community composition[6]. Additionally, it is also exemplified in the work undertaken by Hu Xiaojing et al., who have showed that adding microplastics may accelerate the succession rate of soil microbial communities and change the structure of soil bacterial communities[7].

(4) Compound contamination of soil microplastics

At present, heavy metals, persistent organic pollutants and antibiotics have been detected on the surface of microplastics. As the carrier of these pollutants, microplastics have a certain compound effect on the soil ecological environment. Most studies suggest that there are multiple interactions between microplastics and contaminant molecules (Huffer et al., 2016) , and adsorption mainly depends on the affinity between polymer and chemical substances, that is, through intermolecular forces such as van der Waals force, dispersion force and induced force (Chu Xianxian et al., 2021). However, due to the late start of soil microplastics research, the interaction and migration between microplastics and other pollutants in the soil environment have not been deeply explored, and the ecological risks brought by their combined pollution effects have also been controversial.

4. Detection and separation measures of microplastic pollution in farmland

(1)Detecting methods

a.Visual inspection method

Eye inspection is one of the main methods for identification of microplastics based on the shape, color, particle size and so on. When the microplastic size is in 1 ~ 5 mm, microplastics can be classified by direct observation with the naked eye; when the size is less than 1 mm, it is necessary to use a microscope for observation and identification. The texture and structure of the surface of microplastics can be clearly observed with a microscope, and the general optical microscope can identify microplastics with a size of more than 100 μm. This method is economical and simple, but the accuracy is slightly poor, and dyeing is needed to assist. When the size of microplastics is <100 μ m, the scanning electron microscope (SEM) needs to be used for observation. ERIKSEN et al. [8] found that SEM-EDS (Scanning Electron Microscope-Energy Dispersive Spectroscopy) technology can be used to observe and analyze the composition and characteristics of microplastics. However, microplastics are insulators and need to be sprayed with metal before scanning electron microscopy, which is relatively complicated and not economical.

b.Power-spectral method

Raman spectrum and infrared spectrum are two commonly used detection methods. Both methods are one of the best detection methods available today and can be used in conjunction with each otherHowever,, the organic matter of the sample has great interference to the detection, so it is necessary to deal with the organic matter.. . Also, the two method has the disadvantages of long time and high cost.

c. Mass spectrometry

Gas chromatography-mass spectrometry (GC-MS) can be accurately used in the qualitative analysis of microplastics, and pyrolysis-gas chromatography-mass spectrum (PGC-MS), thermal gravetry-mass spectrum (TG-MS) and thermal extraction-desorption-gas chromatography-mass spectrometry can be used for qualitative and quantitative analysis of microplastics. All methods require pyrolysis, which is suitable for qualitative and quantitative analysis of microplastics, but the detection process will destroy the sample, thus the physical characteristics of the shape and particle size of the microplastics can not be analyzed .

(2) Separation method

a.Manual separation.

Manual separation includes sieving and manual sorting with the help of microscopes, tweezers, etc., which is often used as a preprocessing step for the subsequent efficient separation process. It is easy to operate and can separate macroscopic plastic particles and larger sized microplastics from soil samples ; however, the effective identification and accuracy are low, and it is time-consuming and laborious.

b.Electrostatic separation.

Soil minerals and other particles are conductive, while plastics do not, and using this difference in electrostatic properties, the two can be separated under an applied electric field. Electrostatic separation operation is simple and fast, and has high separation efficiency for microplastics in some types of soil. However, the application of the technology is affected by the properties of soil organic matter and microplastics; besides, the samples should be dispersed and dried before separation, and the small-size microplastic particles cannot be effectively separated.

c.Density separation.

It is one of the most commonly used ways to separate microplastics from environmental media. The method is to add the sample into a high-density saturated salt solution after pretreatment, and make use of the difference in the density of the plastic and the mineral components of the soil, so that the components with less density such as microplastics float on the upper layer and can be further separated. Its advantages include high separation efficiency for a certain density of microplastics, simple operation, and low costs. However, the deficiency is that it cannot meet the separation of dense microplastics and can be time-consuming.

d. Other separation techniques.

Other separation techniques include pressurized fluid extraction, panning, magnetic sorting, etc.

5. The inadequacy of microplastic pollution control and feasible suggestions

In recent years, the pollution of microplastics in soil has been paid great attention by the international community, and a lot of investigations and studies have been carried out on the pollution of microplastics in soil at home and abroad. At present, there are some differences in the pollution levels and pollution characteristics of microplastics in soil in different countries, which are mainly related to different land use and pollution sources, and are also related to different analysis methods that they used. Therefore, it can be found that the comparability of survey data between different studies is insufficient. Various analysis methods have some limitations in wider applicability and effectiveness, as well as problems such as high labor cost and narrow scope of application. In terms of the combined pollution of soil microplastics, there is a lack of in-depth research, and there is a certain controversy about the ecological risk caused by their combined pollution effect. There is a lack of appropriate management practices for microplastic emissions and the disposal of plastic waste (such as the treatment and recycling of waste agricultural mulch).

Based on the current status of microplastic pollution and detection technology, the following key research directions are proposed:

（1） Strengthen the research on microplastic pollution in farmland in China, find out the pollution bottom number, carry out pollution traceability, and evaluate the pollution risk of microplastic pollution in soil to the quality and safety of agricultural products, crop growth or soil ecological environment, so as to provide a scientific basis for the prevention and control of microplastic pollution in soil and risk management.

(2) At present, there is no unified technical means and standards for the detection and separation of microplastics in the soil environment. Therefore, it is necessary to study the identification methods with strong operability, low cost, automation, efficiency and convenience according to different soil environments, so as to standardize the standards for the detection and identification of microplastics in the soil environment.

(3) Promote the in-depth research on the combined pollution effects of microplastics, and provide scientific basis for the risk control of soil combined pollution.

(4) Further implement relevant laws, regulations and standards on the control of plastic wastes and microplastic pollution. Strengthen the control and treatment of waste agricultural mulch recycling and plastic wastes, and control the generation of microplastic pollution from the source by developing scientific and reasonable management measures.

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