Pollution of Microplastics in Coastal Plain of the Huangshui River Basin

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Abstract. Marine microplastic pollution is one of the hot spots in current marine environment research. The coastal zone has unique micro-plastic pollution characteristics at the junction of land and sea, and the micro-plastic pollution in the coastal zone soil is still unclear. In this study, Huangshui river basin was selected as the research area in Laizhou Bay, China. Soil samples were collected from the depth of 0-3, 3-6 and 6-9 cm at each location. Microplastics were separated by flotation. Microplastic characteristics were investigated and analyzed by Nile red staining and Fourier infrared spectrometer. The results showed that there was slight microplastic pollution in the coastal plain. 92.9% of the detected microplastics were granular, 6.1% were fibers, and only 1.0% were films. Microplastics with a particle size of 20-100 μm accounted for 57.9% of the total, particles with the size of 100-1000 μm accounted for 38.6%, and particles with the size of 1000-5000 μm accounted for 3.5%. The presence of film-like PE was detected, indicating that microplastic contamination in the soil was likely to come from the utilization and mulching of agricultural mulch. The amount of microplastics in soil was related to the size of microplastics. Abundance of microplastics in soil increased with decreasing of the size of soil. In addition, the microplastic content in soil decreased, and particles with a smaller size occupied a larger proportion, with the increasing of the depth of soil.

1. Introduction

The extensive use of plastics has led to the widespread of microplastic pollution in the soil [1] and the ocean [2], which has a serious impact on the environment. A large number of microplastics enter the ocean from land under the transportation of wind, rivers and lakes[3]. Therefore, the characteristics of microplastic pollution in the soil of the coastal area is an important basis for investigating the migration of microplastics from land to ocean. Human production, life and industrial and agricultural activities are the main sources of microplastic pollution in the soil [4], and the source and pollution pathways can be traced from the type and form of microplastic pollution in the soil in coastal areas. The types and forms of microplastics in soil usually have typical patterns and characteristics, which are related to the type and the usage of the soil. For example, in the soil of the Sydney industrial area [5], the main types of microplastic pollution are polyvinyl chloride (PVC), polyethylene (PE) and
polystyrene (PS), which are related to industrial production. The pollution of microplastics in the soil of coastal areas also has its own unique pattern and characteristics. Microplastic pollution is widespread in many coastal areas in the world, such as the Bohai Sea and Yellow Sea Beach in Shandong [6], the beaches in Mexico [7], and the beaches in Slovenia [8] and the Arabian Gulf beaches [9]. However, microplastic pollution in the coastal plain area of the Huangshui river basin is still unclear. Therefore, the purpose of this study is to investigate the characteristics and spatial distribution of microplastic of the Huangshui river basin in Laizhou Bay.

2. Methods and materials

2.1. Soil samples
From four sampling points in Longkou City, Yantai, China (Figure 1) (N 120°33'36" and E 37°41'4", N 120°33'6" and E 37°40'28.81", N 120°36'52" and E 37°40'23.31", N 120°33'13" and E 37°40'26") soil samples were collected and stored in aluminum boxes. The sampling points covered agricultural soil such as farmland orchards. Three samples were collected from the depth of 0-3, 3-6 and 6-9 cm at each location. Respectively, a total of 12 soil samples were collected.

![Figure 1. Sampling location: N 1, N 2, N 3, N 4](image)

2.2. Separation and detection of microplastics
Dry the soil samples, pick out impurities and visible plastic through a 2 mm sieve. Then wash the plastic and store in a Petri dish. Add 30% H₂O₂ to the sieved soil, and stand at 60 °C for 1 h to fully oxidize and digest the organic matter of the soil. Transfer the treated soil solution to a small glass bottle, add the NaCl solution, treat it with a sonicator for 5 min and stir it with a magnetic stirrer for 4-5 min. After 24 h, transfer the supernatant to a beaker and repeat the above operation. After 4-5 times, the collected supernatant is collected by filtration with a 0.45 μm PC membrane. 2-3 drops of Nile red-methanol solution are dripped into the entire filter membrane, and incubated in the dark for 0.5 h to fully stain. Put the filter on a glass slide, observe it with green fluorescence under a fluorescence microscope, and use the camera of the fluorescence microscope to capture and record all the fluorescent particles in the view. The size of the particles detected by the fluorescence microscope is calculated according to the square root of the particle area [10]. The area is analyzed and measured in ImageJ on the fluorescent microscope photo of the particles. Macros of automatic particle recognition and quantification based on fluorescence images are performed in ImageJ software. The micro plastic particles are detected by Fourier infrared spectrometer. The infrared spectrum is compared with the standard spectrum of the plastic to identify the type of micro plastic.
3. Results and discussion

3.1. Analysis of microplastic morphology, abundance and particle size

The results of fluorescence microscopy on the size and morphology of microplastics in soil samples are shown in Figure 2. The main forms of microplastics were granular (92.9%), and a few were fibers (6.1%) and films (1.0%). At the same time, in a total of 3352 microplastic particles in 12 samples, 57.9% of the particles were located at 20-100 μm, 38.6% of the particles were located at 100-1000 μm, and only 3.50% of the particles were larger than 1000 μm, indicating that the microplastic pollution mainly originated from small-sized particles. The particle size distribution of microplastics in each soil sample (Figure 3) also showed that the abundance of microplastic pollution was related to the size, and the abundance increased as the size decreased.

![Figure 2. The percentage of particle size (a) and morphology (b) of microplastics in soil samples](image)

![Figure 3. Particle size distribution of microplastics in each soil sample](image)
3.2. Analysis of microplastic types

Fourier infrared spectrometer has size requirements for microplastics. Only larger microplastics could be selected for testing to judge the type by comparing the spectrogram with the standard spectrogram. The spectrum of the samples (Figure 4) were obtained and compared with the PE standard spectrum. The sample's spectrum was found to have an absorption peak at 2918 cm\(^{-1}\) representing the \(-\text{CH}_2-\) asymmetric stretching vibration, an absorption peak at 2850 cm\(^{-1}\) representing the \(-\text{CH}_2-\) asymmetric stretching vibration, an absorption peak at 1471 cm\(^{-1}\) representing the \(-\text{CH}_2-\) bending vibration and an absorption peak at 719 cm\(^{-1}\) representing the \(-\text{CH}_2-\) \(_n\) (\(n \geq 4\)) in-plane rocking vibration. The above characteristic peak was consistent with the characteristic peak on the standard spectrum of PE, so it was judged that the sample belonged to PE. Combined with the film-like morphology of microplastics, it was judged that the microplastics originate from the pollution of PE film in the soil, considering that the sampling point belonged to agricultural soil.

3.3. Analysis of micro plastic spatial distribution

Due to the interception of the microplastic particles by the pores of soil, microplastics in soil layers of different depths have different spatial distribution of pollution abundance (Figure 5). However, due to human activities, there may be some differences in the characteristics of microplastic pollution in soil layers of different depths. At N 2 and N 3, the amount of microplastics in the top of soil was greater than the amount of microplastics in the deep of soil; at N 1 and N 4, the amount of microplastics increased as the soil layer deepened. Considering that the sampling point was located in agricultural soil such as farmland and orchard, this difference was most likely caused by man-made earth digging. But overall, as the depth increased, the amount of microplastics tended to decrease, the proportion of large-size particles decreased, and the proportion of small-size particles increased.
4. Conclusions
There was slight microplastic pollution in the coastal plain area of the Huangshui river basin. 92.9% of the detected microplastics were granulars, 6.1% were fibers, and only 1.0% were films. Microplastics with a particle size of 20-100 μm accounted for 57.9% of the total, particles with the size of 100-1000 μm accounted for 38.6%, and particles with the size of 1000-5000 μm accounted for 3.5%. The presence of film-like PE was detected, indicating that microplastic contamination in the soil was likely to come from the utilization and mulching of agricultural mulch. The pollution degree of microplastics in soil was related to the size of microplastics. Abundance of microplastics in soil increased with decreasing of the size of soil. In addition, the microplastic content in soil decreased, and particles with a smaller size occupied a larger proportion with the increasing of the depth of soil.

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