Microplastic Distribution in Soils from the Typical Sparsely Populated Area, Northwest China

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Abstract. In order to improve the knowledge of the microplastic pollution in the sparsely populated area, a preliminary monitoring survey was carried out in the northwest of China. Microplastics were evaluated in 28 soils collected from 6 sites by the methods of density separation and identified by microscope and Fourier infrared spectrum instrument. Microplastics were detected in all sampling points but the abundances, morphologies and polymers varied in different sampling points due to the natural conditions and anthropogenic influences. And the size of the detected microplastics is larger in comparison with other study areas. But with time, the degraded microplastics still could threat the ecology and environment. This study is helpful to get the whole pictures of microplastics around the world.

Keywords: Microplastic; distribution; soil; sparsely populated area

1. Introduction

Plastics were largely used since 1950s and made people’s life more convenient. However, plastics are chemical inertness and slow biodegraded [1]. With the improperly disposal of wasted plastics, there are many plastics accumulated in the global environment [2]. Those plastics exposed in the environment will be mechanically broken down under the wave action and photochemical processes triggered by UV-B light and then degraded into small fragment [3-5]. When the diameter of plastic debris is less than 5mm, it was regarded as microplastics [2,6]. Compared to plastics, microplastic has larger specific surface area and various organic pollutant, various heavy metals can easily adhere on the surface of microplastics [7,8]. So the transport of microplastics may lead to the redistribution of organic pollutant or heavy metals. Besides, the size of microplastics is similar to the diet of many aquatic organisms. So, microplastic may be accidentally ingested and aggregated in the stomach and gut or even gathered on the gill, liver or other organs of the aquatic organism [9-11]. After the microplastics being ingested, the behavior, survival, growth, reproduction and metabolism of the aquatic organisms maybe influenced [12-16]. Not only for aquatic organisms, earthworm has also been reported that microplastics ingestion will influence their growth and increase their mortality [17]. There are some studies also found that microplastic can uptake by plants [18-19]. Some of the aquatic organisms and plants are the main diet of our humans, so microplastic may also go into human’s body through the food chain and threaten the human health by the chemical of plastics and adhered pollutants [20,21]. So, for the public health, it is urgent to understand the distribution of microplastic around the world and the fate of microplastics.

A large number of studies have showed that microplastics distributed widely in the global environment, including beaches, estuarine and sub-tidal habitats, surface waters and bottom sediments of seas and inland lakes [22-28]. While most studies worked on the microplastics distributions in the
area with high population, less studies worked for the sparsely area [29,30]. Xinjiang located in the Northwest China, which is relatively sparse. In recent years, due to the unique geographical advantages of Xinjiang and the rapid development of economy, the industry, tourism, oil production and other industries have developed rapidly, while the environmental pollution in this area gets more serious caused by the human activities [31]. To explore the further microplastic pollution in this area, we conducted this study by collecting the soil in this area and analyzing the microplastic contaminations. 6 typical sampling points were selected including deserts, agricultural land, wasteland and sediment of the inland lake. This study can provide the basic data of microplastic pollution in the sparsely area, promote the evaluation of microplastic pollutions and may contribute to the pollution control.

2. Materials and Methods

2.1. Study Areas

The study area was in the northwest of China and the sampling of the soil was conducted around Xinjiang, where the population is 24.87 million and the area is 1.66 million square kilometers. In this study, 6 sampling points were set up and 28 soil samples were collected in August 2018, as shown in figure 1. The first site is Aton black town (AB, 38°24’ 55’’N, 90°08’ 16’’E) and 5 samples were collected there. The population density of AB is 7.2 people per square kilometer, and the land type is wasteland. The second sampling point is in Taklimakan Desert (TD, 39°47’ 30’’ N, 88°23’ 25’’ E) and 3 samples were collected. TD is the largest desert in China, with an average annual precipitation of no more than 100 mm. The whole desert is affected by the intersection of two prevailing wind directions as the northwest and the north, which accounts for the frequent sand-drift activities. The third sampling point is Bosten Lake Beach (BL, 42°03’ 43’’N, 87°9’ 15’’E) with 5 samples. BL is the largest inland fresh water lake in China and many tourists visited there annually. The fourth sampling point is also located in a desert, named Kumatago desert, where is close to a city named Shanshan (KD, 42°51’ 01’’N, 90°13’ 01’’E), there is no river in this area, and the annual precipitation is only 17.6-25.3 mm, 5 samples are collected in total. The fifth place is in Hami basin (HM, 42°48’ 6’’ N, 92°41’ 26’’ E) and there were 5 samples obtained. The north wind and northeast wind prevailed in Hami basin throughout the year, with an average annual gale of more than 8 degrees. The last sampling point is in an agricultural land of Zhangye City (ZY, 37°25’ 30’’N, 101°24’ 28’’E) with 5 samples, Zhangye belongs to temperate arid climate with an average annual precipitation of 198 mm which implies that the land in this sampling area is dry.

Figure 1. Schematic diagram of sampling points in the study areas.
2.2. Microplastic Separation

For each sampling point, 3-5 samples were collected with a distance of 1m to each other. All the samples were collected by a clean spade and stored at a 20cm×20cm×5cm squares iron box, and then sent to the laboratory by keeping away from sunlight. In order to separate the microplastic from the collected samples, the following five steps were carried out (figure 2):

1) Drying the soil in a drying oven (UN55, Memmert) for 12 hours at 50℃, and recording the total mass of each sample.

2) Sieving and weighing the soil with 4.75mm, 1mm, 0.6mm and 0.15mm diameter sieves.

3) Distinguishing microplastics from the samples that above 4.75mm by visual inspection.

4) For these samples that smaller than 4.75mm, the microplastics can be separated by density method, the specific steps include putting the dried soil into the volumetric flask, pouring the saturated salt water (ρ= 1.2g/cm³), then covering the volumetric flask, shaking, and repeating the above steps 3 to 5 times, until the soil is completely dispersed, stand upside down on the support. When the particles in the saturated brine no longer move up and down, open the plug and carefully remove the soil. Suspected microplastics are floated on the surface of brine and can be obtained after drying.

5) Put the dried suspected microplastics into ethanol (ρ= 0.8g/cm³) to remove light materials with a density of less than 0.8g/cm³.

6) Identify the suspected microplastics after drying.

![Figure 2. Schematic diagram of separation experiment.](image)

2.3. Microplastic Identification

The identification of microplastics mainly includes two steps: the primary selection under the microscope (SMZ25, Nikon Corporation, Tokyo, Japan) and the final identification by Fourier Transform Infrared Spectrometer (Nicolet iN10, Thermo Fisher, Waltham, MA). Suspected microplastics were preliminarily identified with microscope and recorded based on their shape, surface structure, color and luster. Micro Fourier infrared was used to identify these selected suspected microplastics. All particles transferred to the cardboard were photographed using a digital camera for size measurement. The types of microplastics were compared with the database and the infrared spectrum was obtained.

2.4. Quality Assurance and Quality Control

In order to reduce the possibility of plastics contamination, strict quality control was carried out through the whole experiment. The extraction and identification of microplastics were conducted in a closed room. During the experiment, the samples are covered with aluminum foil paper to prevent contamination from the air. Pure cotton experimental clothes and medical masks were worn to reduce influence of the blow and the fiber from clothes. At the same time, triplicate experiment was performed and no microplastic particles were found in the blank group, so the experiments were reliable.

2.5. Statistical Analysis

The size, shape and type of microplastics as well as the abundance of microplastics at each sampling
point were analyzed. The abundance of microplastics in this study was expressed by the number of microplastics particles per kilogram of dry mass soil (N·kg\(^{-1}\)). Results were analyzed by Microsoft Excel 2010 and SPSS 20.0 software package, and the P-value was set as 0.05.

3. Results

3.1. Abundance and Distribution of Microplastics in Soils

For different kind of soil, the components of the size varied (table 1), even for the two deserts (TD and KD), the components are different. For KD, all the size of the soil is below 0.6mm while the soil diameters in TD ranged from smaller than 0.15mm to larger than 4.75mm. For the rest sampling point, the component of soil size is also wide but the content for different size is varied. However, microplastics were found in all sampling points with different abundance. The highest abundance was in BL as 11.51±2.86 N·kg\(^{-1}\) while the lowest abundance was found in KD as 1.37±0.34 N·kg\(^{-1}\). TD is also a desert and compared to KD, the abundance is much higher as 9.55±1 N·kg\(^{-1}\). AB, as a wasteland, also has a low microplastic abundance as 2.35±0.97 N·kg\(^{-1}\). ZY, which is an agricultural land, the microplastic abundance is 6.3±0.95 N·kg\(^{-1}\). The microplastics abundance in HM is 4.79±1.19 N·kg\(^{-1}\).

| Sample sites             | Soil diameters (mm) | Abundance (mean±SD,n/kg) |
|--------------------------|---------------------|--------------------------|
|                          | >4.75               | 1.18-4.75               | 0.6-1.18     | 0.15-0.6     | <0.15        |
| Aton black town (AB)     | 21.77%              | 21.54%                  | 8.38%        | 28.73%       | 19.59%       | 2.35±0.97    |
| Taklimakan Desert (TD)   | 6.74%               | 3.14%                   | 1.34%        | 3.43%        | 85.35%       | 9.55±1       |
| Bosten Lake Beach (BL)   | 0.78%               | 0.17%                   | 0.17%        | 97.48%       | 1.41%        | 11.51±2.86   |
| Kumatago desert (KD)     | 0.00%               | 0.00%                   | 0.00%        | 55.94%       | 44.06%       | 1.37±0.34    |
| Hami basin (HM)          | 3.09%               | 19.43%                  | 14.08%       | 44.49%       | 18.92%       | 4.79±1.19    |
| Zhangye City (ZY)        | 13.88%              | 27.90%                  | 9.71%        | 39.88%       | 8.63%        | 6.3±0.95     |

The detected microplastics also has different size as showed in figure 3. In ZY, the size of the detected microplastics varied widely from smaller than 0.15mm to larger than 4.75mm. But for the two deserts (TD and KD), the size of the detected microplastics found in TD is larger than that in KD. Especially in KD, the largest microplastics size is as small as 0.6mm. Large microplastics, as the size larger than 4.75mm, were found also in AB and BL, and most of them were found in BL. In HM, except the microplastics larger than 4.75mm, the rest sizes are all included. For all the detected microplastics, 32% microplastics are in the size of 1.18-4.75mm, and followed by the size of 0.6-1.18mm as 27%. The smallest microplastics occupied least as 7%.
3.2. *Morphologies of the Detected Microplastics*

Four morphologies of microplastics were found in the sampling point including fiber, sponge, foam and film. Fibers are the main morphology as 93.3% and the proportion of foams is 4%, films and sponges are rarely found and only 1.3% of all the detected microplastics, respectively. As well, for the six sampling point, the morphologies proportions of the detected microplastics are also varied (figure 4). For KD and HM, only fibers were found. Foams was found in TD, BL and ZY, while sponge was only found in BL and Film was only found in AB.

**Figure 3.** Microplastic size soils in different sampling point.

**Figure 4.** Microplastic morphologies in different sampling point.

Different morphologies of microplastics show different physical characters (figure 5). The foaming plastic is white with no regular shape, the film was transparent, soft and thin and the sponges are light but with an aging-color as yellow. Fibers are the main distributed microplastics and they showed varied lengths and thickness.
3.3. Components of the Detected Microplastics

The polymer types of the microplastics were identified by micro infrared spectroscopy. The corresponding FTIR spectrums of the microplastics in figure 5 were shown in figure 6. Six polymers were found in the detected microplastics including PP, PE, PS, PET, EVA and EAA. PP was the most widespread that found in all the sampling point and also occupied the highest proportion as 40%. PE and PET were also with the high proportion as 33.33% and 13.33%, but they were not found in two deserts. The proportion of PS was following PET as 9.33% and not found in KD and HM. EVA and EAA were rarely seen and only occupied 2.67% and 1.33%, and EAA was only found in TD. In ZY and AB, Except EAA, the rest all kinds of polymers were found in this sampling point. While in the two deserts, PP, PS and EAA were detected in TD and only PP was detected in KD. All the components of the polymer types in different sampling point were showed in figure 7.
4. Discussions

4.1. Microplastics Distribution in Remote Areas

The abundance of microplastics is usually assumed to be related to human activities, but in our study area as located in the northwest of China, where is relatively remote with a low intensity of human activities, a certain amount of microplastics is still found. As microplastics was found in Tibet, Arctic [29,30], it indicated that the pollution of microplastics is ubiquitous in global environment. But the abundance is varied for the remote area and coastal area. In the southeastern coastline of South Africa, Belgium and France, the microplastics abundance ranges from hundreds to thousands per kilogram sediments [32,33], the abundance of the microplastics in farmland soil near Bohai sea is 634 N·kg⁻¹ [34]. The abundance of microplastics in sludge samples from seven WWTPS in Ireland has even reached 15385 N·kg⁻¹ [35]. While in our study area, the abundances of microplastics were only ranged from 1.37 to 11.51 per kilogram sediments. Furthermore, Sassolo lake, located in a remote mountainous area. Only 40 and 0 microplastics per kilogram of sediments were detected at 8 and 33 m depths, respectively [36]. Even though, due to the influence of microplastics to the plants or earthworms, we still could not ignore the influence of microplastic pollution in the remote area.
4.2. The Suspected Resources of Microplastics in Remote Areas

The sources of microplastic in the study area are different due to the characters variety of each sampling point. In the BL sampling point, the Bosten Lake is the largest inland fresh water lake in China and attracts a lot of tourists, so it is inevitable to bring in some plastic pollution. AB as a wasteland but still trucks passed by, and the tire abrasion is a major source of microplastics [37]. For ZY, as an agricultural land, microplastics can come from the plastic film, which was widely used in agricultural production [38]. Besides, those detected microplastics may also migrate from other places. The transportation ways of microplastics are diversified, such as wind and current, which can be used as the carrier of microplastic transport. As in Tibet, the microplastic abundance of river sediments is much higher than lake sediments for the current is the main force of the microplastic transport [30,39]. The existing research has also pointed out that microplastics exist in the atmosphere and even in the snow [40]. In the studied area, the wind force is comparatively strong, so the wind force plays an important role in microplastics migration. Especially in the sampling point of HM and the two deserts. In addition, the adhered bacteria or other microorganism will migrate with microplastics and may cause the invasion of alien species.

In the study area, fibers are the main microplastic morphologies that detected, which is well agreed to Tibet, where is also a remote area that fibers occupied 53.8% to 80.6% [30,39]. Besides, Liu et al [38] found that 53.3% of the microplastic detected in 20 vegetable field soils in the suburbs of Shanghai was fibers, and for the microplastics in the Yangtze estuary system, 79.1% are fibers [41]. In the wastewater that collected in the Waste Water Treatment Plants in Ireland, 75.8% of the microplastics consisted of fibers [35]. In the remote areas such as Arctic, 95% of the founded microplastics in the polar water are fibers [28]. In our study, 93.3% microplastics are fibers. However, there are some places that fragments are the main detected microplastics such as Lake Hovsgol, Mongolia, Maldives and Nansha Island in South China Sea [42-45]. So the morphologies of microplastics differed in different areas and it need more researches. In our study, PP and PE were the highest content polymers in the sampling point, which agrees well with other studies [30,39,43,45]. This is due to the widely usage of PP and PE were in the production and living activities [46,47].

4.3. Microplastics Degradation in Remote Areas

Plastic particles usually decompose into fragments through a slow degradation, which could be classified into mesoplastic (1mm-4.75mm), microplastic (0.15mm-1mm) and nanoplastic (<0.15mm) [48,49]. Combined with the results of our experiments, it can be classified as mesoplastic (1mm-4.75mm), microplastic (0.15mm-1mm) and nanoplastic (<0.15mm). As showed in figure 3, for different sampling sites, the proportions of mesoplastics, microplastics and nanoplastics varied. In the sampling point AB, TD, BL and ZY, mesoplastics account for the largest proportion, while microplastics as the largest distributed size in HM. In KD, microplastics and nanoplastics occupied half of the detected microplastics. Mechanical degradation is an important factor with regard to plastics, the plastics are then shredded into smaller particles by friction forces occurring during the movement through different environmental habitats. As the microplastics detected in the sediments of Taihu Lake, the third largest Chinese lake located in one of the most developed areas of China, the abundance ranges 11 to 236 per kilogram and the size of them are mainly less than 1mm [50]. While in the same place as Tibet, the size of detected microplastics in the lake sediment is larger than that in the river sediments for the current force place an important role in microplastics degradation [30,39]. As well, in the coastal area, the size of detected microplastics is much smaller as those microplastics exposed to sunlight cause of the photodegradation in environments will be degraded into smaller size, which could be proved by the microplastics found in Maldives that the size of the detected microplastics in 2015 is larger than that in 2018 [40,45]. Compared to the large microplastics, smaller microplastics are with the larger specific surface area and can easier absorb other pollutants, which may be uptake by plans or other organisms and impact the ecology [7,8].

In conclusion, Northwest China is a remote area with low human activities, but microplastics are still detected in this place with a relatively low abundance compared with that in the coastal area. The
source of microplastics and the driving force of the microplastics migration will influence the morphologies of microplastics in different sampling point. However, fibers are the main morphologies, PP and PE are the common polymers detected in the study area. The proportion of larger size microplastics in the northwest of China seems higher in comparison with other studied area, the slow degrade progress may play an important role. But due to the exposure time increases, microplastics will degraded into smaller microplastics and it could absorbed more pollutants or microorganisms, which may threat the health of ecology and environment. So it is urgent to get the microplastics distribution in the environment and find an efficient way to control this pollution.

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