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Research Progress of Microplastics

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ABSTRACT: Microplastics (MPs) pollution has become a global persistent pollution problem and endangers human health, so it has received widespread attention from the public. Therefore, it is of great significance to find accurate and efficient microplastic pollution detection methods in the field of environmental protection. In this paper, the common processing and detection methods of microplastics are described, which provides a reference for future research on microplastics.

KEYWORDS: microplastics; pollutants; detection method

I. FOREWORD

Plastics are widely used in medicine, industry, packaging and other fields due to their light weight, corrosion resistance and stable chemical properties. Over the past 50 years, global plastic production has reached about 9.1 billion tons, with an annual growth rate of 8.7 %[1]. Plastics are widely used in various industries and have become an indispensable part of human life. It is estimated that by 2050, the country will be expected to produce up to 1.2 billion tons of plastic waste into the natural environment [2]. Due to external conditions, large-sized plastics will break into small-sized plastics. Microplastics (MPs) are often defined as plastic particles with a particle size of less than 5 mm[3]. MPs have attracted more and more attention in recent years because they can cause harm to organisms[4]. MPs produced directly are called primary MPs, and MPs broken by large plastic fragments through environmental pressure sources such as water, wind and sunlight are called secondary MPs[5]. Studies have shown that it is reasonable for humans to be exposed to MPs frequently. MPs have been detected in air, food and drinking water, such as seafood, sugar, beer and salt, which we often eat [6,7]. It is worth noting that MPs have been found even in human feces[8].

II. TOXICOLOGICAL EFFECTS OF MICROPLASTICS

A. Adsorption of microplastics

Microplastics have large specific surface area, strong hydrophobicity and strong adsorption capacity[9,10]. Microplastics are easy to absorb organic pollutants and some heavy metals in the environment, such as polycyclic aromatic hydrocarbons, polychlorinated biphenyls and cadmium, zinc, nickel and lead[11]. Polycyclic aromatic hydrocarbons adsorbed on the surface of microplastics can enter the human body through the food chain, and then re-transport in the body, affecting biological and physiological processes such as protein synthesis and energy storage [12]. Similarly, heavy metals can also enter the human body through the food chain and accumulate in the human body to cause harm to the human body.

B. Adsorption of microplastics

In the production process of plastic products, some additives will be added to them to improve the performance of plastics, such as flexibility and durability. These commonly used additives, such as polybrominated diphenyl ethers, phthalates and bisphenol A. They are typical endocrine disrupting chemicals, which can compete with endogenous hormones or destroy the synthesis of endogenous hormones. These additives also interfere with the nervous system, affect the synthesis of enzymes, and ultimately cause damage to organisms. When the plastic aging, these additives released into the environment, through the food chain into the human body, the human endocrine system interference[13].

C. Physical damage of microplastics

Due to the small particle size of MPs, it is easy to be eaten by some animals, resulting in intestinal obstruction or direct damage to their digestive system, resulting in satiety. These eventually lead to reduced biological feeding efficiency, slow growth, and ultimately lead to damage or death of organisms[6,14,15].

III. MICROPLASTIC PRETREATMENT TECHNOLOGY

A. Density separation

Density separation is a common method for separating microplastics from environmental samples[16,17]. The method is to separate microplastics from impurities by the density difference between microplastics and other inorganic particles. The most used salt solution is saturated NaCl solution, which is cheap and harmless with a density of about 1.2 g / cm^{-3}[18]. However, there are also shortcomings. Due to the low density of saturated NaCl solution, it may not be possible to extract high density microplastic particles [19]. The separation effect of CaCl2 was better than that of NaCl, but calcium ions would promote the soil organic matter to agglomerate and interfere with the experimental results. ZnCl2 solution can effectively separate various MPs with low cost, but it has poor separation effect and strong corrosion for aged MPs. The extraction effect of NaI solution is the best, but the price is expensive.Han[20]et al. From the perspective of economy and efficiency, different salt solutions are used in combination, and the amount of NaCl and NaI substances is mixed with 1 : 1, which reduces the economic cost of NaI and has high extraction efficiency. It is currently considered to be the best flotation solution.

B. Digestion

Usually, there will be interference of organic matter in the sample. At this time, it is necessary to eliminate the interference by digestion. At present, several commonly used digestion methods include acid digestion, alkali digestion, enzyme digestion and oxidation digestion. At present, most studies use H2O2 to digest the samples. Under the same conditions, H2O2 has more advantages than acid and alkali, which is manifested in faster and higher removal rate and lower degree of microplastic aging[21]. The Fenton reagent treatment method can effectively reduce the reaction time, reduce the reaction temperature, and remove the components that are difficult to be digested by H2O2 without changing the original surface structure of MPs. Acid and alkali treatment may cause surface degradation of plastics[22,23]. Studies have shown that the enzyme digestion method for biological samples is better[24,25]. Enzyme digestion is an emerging biological digestion method. Proteins, lipids and carbohydrates can be removed without affecting microplastics, but the disadvantage is that it takes a long time in the whole degradation process[25]. Ding et al. digested plastic microspheres cultured in sewage with NaOH, HCl Fenton reagent and protease solution respectively. It was found that enzymatic digestion had the least damage to microplastics and the highest recovery rate. However, molecular biological enzymes are expensive, so this method is not suitable for large quantities of samples[26,25].

IV. IDENTIFICATION OF MICROPLASTICS

A. Visual inspection method

Physical characterization detection and analysis technology is a commonly used method of micro-visual method, which only uses physical methods to determine, identify and analyze the physical properties of pollutants, and can only provide physical information but cannot provide chemical structure information. Visual detection is a simple and easy microplastic analysis and identification technology. Generally, microplastics with particle size of 1-5 mm are identified by naked eye or microscope. However, this method has great limitations. The results of visual detection by different staff are quite different. Many MPs cannot be identified by the naked eye, thus affecting the identification results, so that the statistical high or low abundance of microplastics can be estimated to reach 70 %. Due to a series of limitations of the visual method, it cannot be used as a separate method and needs to be further analyzed in combination with chemical characterization.Dekiff[27] et al. showed that the error of visual detection method increased with the decrease of the size of microplastics. In order to avoid errors, the following methods can be used : In order to facilitate particle counting, a petri dish or a grid filter membrane with a sequentially numbered grid is used[28].In addition, some studies have used staining methods to minimize the overestimation of suspected microplastics [29].

B. Raman spectroscopy (Raman)

Raman method is to detect the vibration frequency and intensity of the scattered light of molecules and atoms in the sample by irradiating the laser on the surface of the sample to be tested, and judge the chemical composition of the sample according to the generated characteristic spectrum. The premise of applying Raman spectroscopy is the change of chemical bond polarizability, so this method is suitable for compounds with aromatic bonds and C = H and C = C double bonds[30]. Raman has higher spatial resolution (< 1μm) and is more advantageous in detecting microplastics with small particle size. However, due to the large number of microorganisms, organic and inorganic substances in sewage samples, Raman spectroscopy is susceptible to fluorescence interference[31].

C. Fourier transform infrared spectroscopy (FTIR)

FTIR is one of the more mature techniques for the identification of MPs. Attenuated total reflection, transmission and reflection are usually used to identify microplastics[32,33]. In the FTIR analysis, the sample is irradiated with infrared light in a certain wavelength range, and the infrared light absorption in the wavelength range is detected. By comparing the infrared spectrum of the sample to be tested with the standard sample, it can not only determine whether the sample is a microplastic, but also identify the chemical composition of the plastic.

D. Pyrolysis-gas chromatography / mass spectrometry (py-GC / MS)

Pyrolysis products of microplastics can be used to analyze the chemical composition of microplastics by py-GC / MS. The outstanding advantage of this method is that it can provide detailed information on the chemical composition of polymers[34]. Because different polymers will produce the same product after combustion, it is possible to make a wrong judgment. Moreover, this method is not suitable for the determination of a large number of samples, and only a single sample can be determined one by one. However, the main disadvantage of thermal analysis technology is strong destructiveness, and it can only characterize microplastics, and can not describe the morphological characteristics of microplastics.

Ⅴ. CONCLUSION

Due to the increase in the production of synthetic plastics and the poor management of plastic waste, MPs pollution in the environment is gradually increasing, posing a potential hazard to the entire ecosystem. In recent years, the detection technology of microplastics has developed rapidly. However, the research and detection methods for microplastics still lack unified and standardized operating standards, and the evaluation system is not perfect. When using chemical reagents to pretreat samples, acid and alkali will cause damage to MPs, and the cost of enzymes is relatively expensive. H_2O_2 is a more common choice at present. The commonly used flotation solution is saturated NaCl solution, which is low-cost and has no environmental hazards, but the separation effect is poor and can be used in combination with other salt solutions. The commonly used methods for the qualitative analysis of MPs are Fourier transform infrared spectroscopy and Raman spectroscopy.

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