Chapter 9

The Existence of Microplastics as an Emerging Concern in Daily Routines and the Implications of Global Mitigation Efforts

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A. The Definition of Microplastics

It has been known that plastic materials are remarkably persistent and potentially interfere environment due to their durable and chemical-resistant characteristics. Plastic items cannot be completely degraded in the natural environment, but they will produce microplastics over time as a trace of the degradation process. Microplastics can be defined as a plastic material that goes through fragmentation, which subsequently forms particles less than 5 mm in size (GESAMP, 2019; Liu et al., 2020). However, there is no explicit agreement in the definition of microplastic size. Some researchers also speculate that nano-sized plastic can be categorized into microplastics (Gigault et al., 2018). Therefore, microplastic size can be included in the size of 5

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mm to 1 nm. The microplastics' sources are categorized in two main ways: primary and secondary microplastics (Hanun et al., 2021) as shown in Figure 9.1.

The meaning of primary sources is intended for microplastics contained in the discharge of wastewater deliberately produced for specific purposes in the manufacturing process. These microplastic types were usually found in the shape of pellets or microbeads. The mass production of microplastics aims to meet the needs of producing various personal care products (PCPs) or other essential items. Some applied wastewater treatment technologies can relieve microplastics from wastewater, such as membrane bio-reactor (MBR), gravity sand filtration (GSF), dissolved air flotation (DAF), and aerated biological filter (BAF), disc-filter (DF), and advanced oxidation. But, there are still few amounts of smaller microplastic particles that survive (± 0.1%-0.5%), which in size larger than 100 μm particularly (Wu et al., 2021).

Meanwhile, secondary microplastic is derived from the fragmentation of larger plastics. It happened due to several environmental factors like UV exposure (photodegradation), temperature, mechanical abrasion, or even chemical oxidation. These intense natural pressures that impact plastics' physical and chemical nature are also known as weathering/aging processes (Hanun et al., 2021). The weathering process will affect several microplastic properties: color, surface morphology, size, crystallinity, and density (Guo & Wang, 2019). Microbial activities, although in a minor role, also become one of the causes of microplastic degradation since microplastics are created to be resistant to biodegradation (Thompson et al., 2005).

Several shapes or morphologies of microplastics are commonly distributed in the environment, such as microbeads (including spherical or irregular shapes), pellets, films, fragments, and foams. Some of the researchers also investigate microplastics' color and shapes. Identifying microplastic shapes and colors aims to help inform the distribution's origin (Helm, 2017).

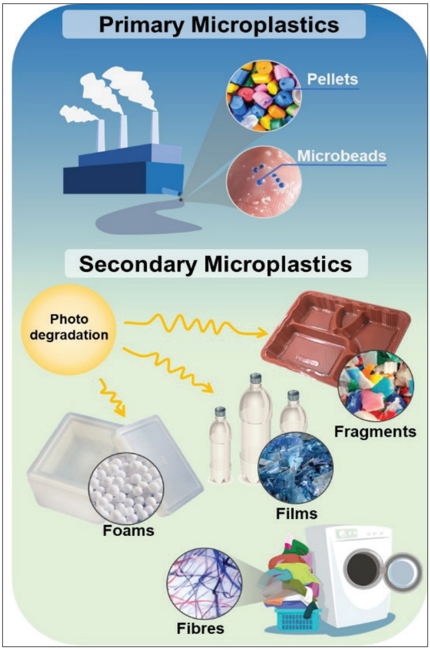

Figure 9.1 Primary Sources of Microplastics in the Environment

The term fibers is usually found as the results of clothing shreds produced during washing and drying or even the friction of cloth-made material such as carpet, upholstery, blanket, or doll fur. Foams often come from expanded polystyrene foam products such as insulation or food packaging. Henceforth, fragment and film microplastics generally yielded from the fragmentation of more oversized plastic items such as water mineral bottles, carry bags, construction materials, containers, electronics, toys, etc. The difference between fragments and films is based on color. Film microplastics are figured as fine pieces, while fragments come up as colored pieces. In addition, polymer types are also considered to inform microplastics' physical and chemical properties (Rochman et al., 2019).

Microplastics spread in seawater, fresh water, terrestrial, and atmospheric ecosystems. We cannot stop it from spreading unless we have been prevented and aware of the dangers since early. Therefore, education and socialization about microplastics is indispensable so prevention movements can be carried out optimally and avoid the dangers before severe effects occur.

B. Microplastic Exposures in Daily Life

Throughout this time, we have been unknowingly contaminated by microplastics through our daily habits. Microplastics form in tiny particles, making them easily carried by the wind and settle in the dust around the house. Moreover, the tiny size of microplastics results in inhalation and can deposit in the respiratory tract. Cox et al. (2019) revealed that annual inhalation of microplastic particles for female and male children in the United States (US) were 35338 and 40225 items, while female and male adults were 48270 and 61928 items. Possible sources of airborne microplastics inside the house may come from synthetic textiles (composed of nylon, polyester, polyurethane, polyolefin, acrylic, and vinyl-type polymers), erosion of synthetic rubber tires, city dust transferred by the wind, clothes, house furniture like carpet and blanket, materials in buildings, tumble dryer exhaust, etc.

Moreover, Zhang et al. (2021) revealed several parameters in textile washing that will influence in the release of fiber from the clothing. It includes viz. washing cycle and time, detergent and softener, temperature, water hardness, washing machine type, drying, textile aging, textile structure and surface configuration, and so on. Indeed, synthetic clothing seems to be the most significant contributor to airborne microplastics, yet fiber materials and quantity depend on the fashion and season. O'Brien et al. (2020) investigated that 58 fibers/m3 were released from fleece polyester blankets during mechanical drying into the surrounding air with the experimental conditions set into the 'Normal Dry' program at 56-59°C for 20 minutes. Poor ventilation and indoor airflow result in higher concentrations of indoor microplastics, whereas people spend 70% to 90% of their time at the house (Prata, 2018).

During the pandemic, the use of masks is a must to prevent the transmission of the Covid-19 virus. Surgical face masks, made of polymer materials, have recently become a potential microplastic source in the environment. L. Li et al. (2021) simulated the inhalation of microplastics by wearing some types of masks such as N95, surgical, cotton, fashion, non-woven, and activated carbon masks for 720 hours by using a vacuum pump with a flow rate of 15 L/min as the breathing simulation. It was found that spherical and fiber-like microplastic inhalation risk increased with increasing inhalation time, except for N95 masks. The number of microplastics accumulated during the simulation reached at least 300 particles performed by the N95 mask. Meanwhile, the highest microplastics were produced by activated carbon masks, with the particles reaching 2149 items.

On the other hand, microplastics can be accidentally consumed via tap water, drinking water, bottled water, salt, honey, sugar, alcohol, vegetables, and seafood. According to a report established by Cox et al. (2019), female and male children were at least consuming 38722 and 41106 items annually, while female and male adults were ingesting 46013 and 51814 items annually via foods and beverages. Dowarah et al. (2020) also revealed that microplastic intake from the local community in India at least gained around 3917.79 ± 144.71 particles/year through bivalve consumption. In a single meal, the average family consumed between 300 and 700 grams of mussels/clams, excluding the weight of shells. Exposure to microplastics from plants is also possible, considering that contaminated soil or irrigation water can carry microplastics to the plant's organs through the roots (Enyoh et al., 2020). It will be more severe if the plants are for consumption, such as vegetables and fruits.

Another invention of microplastic exposure to the human body is revealed by Fadare et al. (2020). It stimulates the presence of microplastics in commercial plastic food containers known for food packaging, fast food delivery, and water consumption. One of the polymer types is inscribed as a polypropylene material. The results showed that the extraction of microplastics generated 3 to 38 mg of microplastics per item. This number can be exacerbated by the addition of washing or shaking during the delivery process. Hernandez et al. (2019) also revealed that a single plastic teabag released 11.6 billion microplastics and 3.1 billion nano plastics into a cup of steeping at a brewing temperature of 95°C. Other than that, D. Li et al. (2021) revealed more severe problems, which found that propylene-based baby bottle carries the potential for release of microplastics during cleaning, sterilizing, and mixing liquids in the bottle. It was shown that the number of microplastic particles increased from 6 million to 55 million particles per liter during the boiling process at 70–95°C. Meanwhile, the sterilization process increased the release of microplastics by up to 35%.

Other microplastic sources inherent in our daily life can be found as cigarette butts, food wrappers, plastics straw, shopping bags, plastic bottles and the cap (Free et al., 2014), tennis ball, glitters, and paint (Gaylarde et al., 2021; Yurtsever, 2019). Sun et al. (2020) found that the distribution of microplastics from personal care products (PCPs) like cleansing products, hand sanitizer, toothpaste, soap, shaving cream, bubble bath, sunscreen, and shampoo that drifted from WWTPs discharge was approximately 1500 tons/year.

C. The Impacts of Microplastic Exposures on Human Health

Microplastics in the environment occur in a low concentration. However, susceptible individuals can be severely affected and worsen their health conditions. An illustration of the conclusion of the effects of microplastics on human health can be seen in Figure 9.2. Microplastics, formerly regarded as harmless particles and without toxicity, are now recognized as potentially harmful to human health, depending on the level of exposure and sensitivity. Several pieces of research have acknowledged microplastics' toxication, such as oxidative stress, cytotoxicity, altering metabolism, immunity disruption, translocation to a distant organ, etc. (Rahman et al., 2021). In addition, microplastic particles are difficult to remove from our body, leading to chronic inflammation and increasing the risks of cancer as the result of deposition and accumulation. Moreover, combining microplastics with other particles may increase immunological and neurological disorders (Crawford & Quinn, 2017).

Microplastic particles have been identified as having a large surface area prone to performing as a carrier for microorganisms (biofilm) or other pollutants. Additives and monomers may leak from the microplastic particles into the organism corpus when those are ingested. Organic compounds incorporated in persistent organic pollutants (POPs), such as polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), and UV filters, have been found in microplastics collected from the ecosystem (Prata et al., 2020; Santana-Viera et al., 2021). Also, microorganisms may generate and colonize on the microplastic surface, leading to biofilms forming. According to the research conducted by Murphy et al. (2020), microorganisms such as *Clostridium perfringens, Arcobacter spp., Enterobacter spp., Helicobacter spp.,* and *Escherichia coli* were discovered in polyethylene microplastics cultivated in river water in situ for 14 days. Therefore, microplastics will be considered hazardous materials and bring higher toxicity to the human body while ingested, judging from their chemical contents inside the particles.

Animal studies, such as mice or cell culture, were used to investigate the effects of microplastics on human health. These studies have considered various aspects of standard clinical research with animals (Prata et al., 2020). Experiments on mice found that ingestion of a dose as low as 0.01 mg of 5-micron polystyrene microparticles each day resulted in a reduction in spermatogenic cells, as well as a reduction in the number of sperm produced after 42 days (Xie et al., 2020). Adverse Outcome Pathways, which systematically interpret the available toxicological data, concluded that the presence of microbeads formed reactive oxygen species (ROS), which trigger the occurrence of oxidative stress. This illness becomes a major toxicological threat to human health despite the great uncertainty about its use (Jeong & Choi, 2019).

Inhalation of atmospheric microplastic quantities and properties is another method of exposure. Smaller and denser particles are more likely to lodge farther into the lungs. At high levels, dust may trigger the overloading of microplastics, resulting in an intensive release of chemotactic chemicals that widens blood vessels and prevents macrophages from migrating. In addition, proinflammatory microplastics in the lungs exhibit vigorous oxidative activity (Vianello et al., 2019). Besides that, dermal contact with microplastics must be reflected regardless of its fewer effects. According to Prata et al. (2020), nano plastics can cross the dermal barrier and cause toxicity.

Until this publication, there is no proof that microplastics negatively impact human health. Primarily, the observations are based on organism models (in vivo/in vitro), even though they have the same limitations as those used to evaluate microplastics' impact on animal health. Despite the absence of evidence that microplastics pose a risk to human health at current ambient concentrations, researchers have found that microplastics are also detectable in the human placenta. Ragusa et al. (2021) investigated microplastics in six women's placentas and found about 12 pigmented microplastics with a size range of 2 to

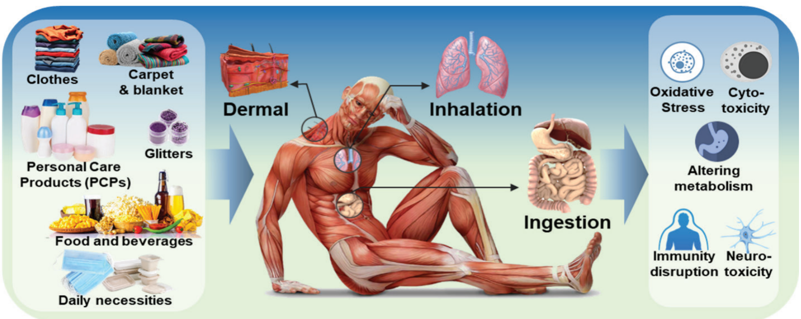

Figure 9.2 Potential Effects of Microplastic Exposures on the Human Body

10 μm. This microplastic is thought to be derived from paints, nail polishes, cosmetics, and other types of personal care items.

D. Actions of Minimizing Microplastics in the Environment

Mitigation strategies are necessary to reduce microplastic contamination in the environment since the number of microplastics increases with the increase in plastic usage. It will make more efficient to do the prevention contamination that starts ourselves. The support of environmental enthusiasts or the environmentalist community will also be beneficial in terms of socializing and campaigning the dangers of microplastics and the importance of reducing the use of plastic items in daily life.

1. Self-prevention from the Contamination of Microplastics

The movement to reduce the spread of microplastics cannot be separated from the reduction of plastic as a precursor material. Several steps can be taken to reduce the spread of microplastics in the environment, especially in the neighborhood where all the loved ones gather. Launched an article published by Global Citizen, there are a few ways to decrease microplastic trace. Some of them are installing a filter to catch microplastics, washing hands and air drying; preventing to purchase of synthetic clothing and changing to natural clothing instead, such as cotton, silk, wool, hemp, or linen; reducing the consumption of plastic products as well as purchase for plastic-free products (PCPs), and utilizing public transportation. Researches agree that microfiber dominates the abundance of microplastic in the environment (Huang et al., 2021; Wright et al., 2020; Zhang et al., 2020). Therefore, changing washing and drying techniques from machine system to hand washing and air drying will greatly impact the microplastics. Change that starts from ourselves is better than having to wait for others. One of the changes in our habits can change the state of the environment for the better.

2. The Role of Community Movement in Spreading Awareness of Microplastics

Community movements with those diverse backgrounds have grown worldwide, addressing eliminating microplastics. For example, Wasser 3.0 (a German non-profit research group) has rapidly used the microplastic agglomeration method to reduce water microplastics. TeamSeas, Ocean Conservancy, and The Ocean Cleanup communities are concerned about microplastic distribution in oceans, rivers, and beaches. In Taiwan, the Micro PC community is dedicated to reducing microplastics and minimizing biological and environmental damage through innovative non-consumable filtration technologies. A Netherlands community called "Beat the microbead" has encouraged customers to be more selective about purchasing items in cosmetics issues. In this case, the customers can check the product risk level and the specific microplastics contained through a mobile application. Besides that, a community developed by a London student group named The Tyre Collective concerns mitigation movement in tire wear emissions by capturing tire wear at the source to ensure clean air and safeguarding the environment and health.

Furthermore, specific communities, such as Waste Bazaar (revolutionize in Africa) and Tontonton (plastic community from Vietnam), are using app-based platforms for more accessible accommodation on reducing microplastic sources. In Indonesia, the Siklus community disseminates creative information by conducting door-to-door campaigns. Specifically, they provide an alternative by replacing refill stations with low-value plastic, enabling residents to obtain daily necessities in any quantity without using plastic packaging.

Regarding the awareness of the microplastics survey conducted by Zhang et al. (2020), only 26% of the 437 valid respondents had heard of microplastics. For this reason, some communities aim to reduce the number of microplastics, spread knowledge, and increase awareness of microplastics since most people raise awareness from life experience and ordinary senses rather than knowledge and research.

E. Global Mitigation Efforts in Overcoming the Issue of Microplastics

On the topic of removing plastic pollution from the environment and reducing plastic usage in general, citizens continue to participate in the trend of responses to global environmental concerns that began in the 1960s and still lasted in these days (Völker et al., 2020). Although it does not directly regulate "Microplastic" at the international level, there have been several agreements made by global organizations such as the United Nations (UN), The Group of 7 (G7), and the World Economic Forum (WEF), and the World Bank. At the international level, this agreement and discussion forum discuss plastic policies from an economic perspective, plastic waste management, and clean production efforts. Indeed, these agreements do not specifically target microplastic as an object of policy, but at least they have targeted plastic and solid waste management as microplastic sources (Klein et al., 2018).

Several countries have set and implemented regulations to deal with microplastic issues. For example, the United States (US) has banned the usage of microbeads in several cosmetic products as a scrub material which is prohibited at the federal level under the "Microbead-Free Waters Act." The same agreement was also made by Cosmetics Act which prohibits using microbeads as a scrubber. Besides that, additional state-level regulations have been developed or are still being implemented in several countries like China. China is likewise at the forefront of research projects in the microplastics field, so many publications related to microplastics have been established. This country's goal is to ban the manufacture of "Microplastic" after December 31, 2020, and the sale of "Microplastic" after December 31, 2022.

Moreover, the same implementations were done by Korea and the US, which committed to employing microbeads as a scrub in cosmetic products. In European Union (EU), microplastic challenges are being discussed in terms of polymer types associated with waste contamination. Restriction of Restrictive Chemicals proposed by the

EU may take effect as early as 2022 (Mitrano & Wohlleben, 2020). Steensgaard et al. (2017) suggested that plastic litter, as the initiation of microplastic distribution in the environment, should undergo monitoring and reporting requirements similar to hazardous waste, including an evaluation of polymer persistency and its degradation rate.

At smaller-scale like industrial and manufacturing levels, a standard has been set in the form of an environmentally friendly label in the format of ISO 14006, namely eco-design, as part of an environmental management system. Eco-design refers to action-made during the development phase of a product to minimize the product's environmental impact throughout its entire life cycle (Pigosso et al., 2013).

Reducing the amounts of microplastics released into the environment is generally linked to the four Rs hierarchy in the plastics industry, such as reduction at the source, reuse of goods, following collection, and recycling of those products. Legislation managing plastics manufacture, waste management, and the use of sustainable resources should be consolidated and enforced (Calero et al., 2021). By learning from implemented action and the dangers of microplastics

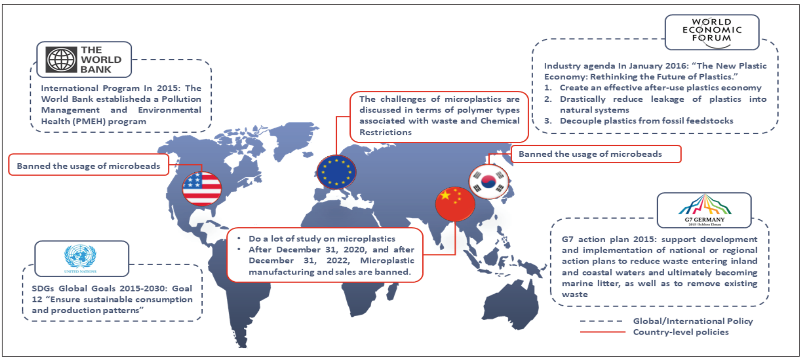

Figure 9.3 Examples of Mitigation Efforts in Several Countries and Global Communities

mentioned above, it will be very worthy for the government to start implementing policies on producers and support the development of alternative materials in the future while still in the early stages.

F. Conclusion

The longer the microplastics spread, the more severe the distribution along with the increase in plastic production and use by the community. Microplastics originated from wastewater treatment plant discharge produced by industrial systems and the fragmentation of more oversized plastic items or plastic litter in the environment due to weathering. Microplastics have become a complicated and challenging issue since it adheres to us through inhalation and ingestion. Besides that, microplastics is harmful for human health because of their microplastic properties, even though they pose risks and are still in development nowadays. The harmony of the self-prevention movement and the community's role is fundamental in reducing the number of microplastics in the environment.

Furthermore, the government should pay attention to the distribution of microplastics and start evaluating and monitoring their existence while it is still in the early stage to prevent more significant impacts in the future. There is no harm in educating, outreaching, and preventing microplastics to minimize the possible impacts of their existence. The assessment of microplastics in natural environments is indispensable to provide tangible results of microplastic occurrence. Therefore, it is hoped that this study can help the public be more aware and believe that microplastics and their impacts are a real threat to us in the future.

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