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Review Paper

Sources of Microplastics in the Environment and Human Exposure Routes: A Review

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ABSTRACT

In this study, the sources of microplastics in the environment, the ways of human exposure to microplastics, how to deal with them, and the policies and laws of different countries in this regard are discussed. Most of the microplastic pollution comes from textiles, tires and urban dust, which make up more than 80% of the microplastics in the environment. The human body is exposed to microplastics through eating food containing microplastics, inhaling microplastics in the air, and skin contact with these particles in products, textiles, or in dust. The main route of human exposure to microplastic particles in human diet is food and drink. Microplastics can enter food during food processing, storage, transportation and packaging process. Airborne microplastics are an underestimated hazard, potentially reaching deep into human lungs because they can pass through the defensive respiratory system. Humans may also be exposed to microplastics through skin contact, following the atmospheric fallout, in this case hair follicles, sweat glands or damaged skin are all ways of entry. Some researchers have suggested burning plastics and recovering the resulting energy. Nevertheless, plastic recycling is considered a more efficient solution because this method reduces the amount of plastic waste produced as opposed to burning.

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Introduction

Plastics are synthetic organic polymers to which other chemicals have been added to improve performance [1], usually obtained from petrochemical sources. Plastics can be synthesized from fossil fuels as well as from biomass of different origins. During the past few decades, plastic has been used in the manufacture of many products. Among the reasons for paying attention to this material, we can mention easy manufacturing, inertness (chemical resistance, temperature and light), cheapness, high strength, low weight and water resistance [2].

In recent years, there has been a sharp increase in plastic production, and in 2013 alone, 288 million tons of plastic were produced worldwide [3]. Disposal of plastic waste has become a major challenge due to its resistance to degradation [4] and therefore recycling is one of the effective solutions to manage the growing plastic pollution crisis, but unfortunately most plastic waste ends up in landfills. which takes a long time to decompose [5]. After entering the environment, these plastic materials are destroyed in different ways and lose their structural strength [6]. As a result of the degradation of plastics in the environment, finally there are microscopic-sized plastics called microplastics, whose size is <5 mm [7].

Microplastics can be from primary or secondary sources. Primary microplastics are micro-sized from their source, such as microplastic fibers from laundry detergents [8] and cosmetic products (facial cleansers) [9]. Secondary microplastics result from the degradation of larger plastic waste by physical, chemical, and biological processes. Microplastics have the ability to absorb and desorb pollutants such as polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), antibiotics, as well as additives, such as bisphenol A (BPA), phthalates, and other endocrine disruptors [10]. Thousands of wildlife can be affected by plastic debris as a result of their ingestion, as their size and chemical signatures are similar to natural prey [11].

Microplastic Sources

Clothes

More than 80% of microplastics in the environment come from textiles, tires and urban dust. It has been proven that many synthetic fibers, such as polyester, nylon, acrylic and spandex, can be removed from clothing [12]. Over 1,900 microplastic fibers may be released each time a garment is washed, and it should be noted that wool releases the highest amount of fibers, 170% more than other clothing [13]. For an average wash load of 6 kg (13 lb), more than 700,000 fibers are released per wash [8]. Research was also conducted by washing machine manufacturers to evaluate the performance of washing machine filters in reducing the load of microfibers that should be trapped by wastewater treatment plants. Persistence of unremoved microfibers has been demonstrated throughout the food chain from zooplankton to larger animals such as whales [14]. Polyester is the main fiber used in the textile industry due to its easy production and lower cost than cotton. However, these types of fibers contribute a lot to the sustainability of microplastics in the environment. The process of washing clothes on average releases more than 100 fibers per liter of water, which can have effects related to the health of humans and other organisms [15]. Persistence of unremoved microfibers has been demonstrated throughout the food chain from zooplankton to larger animals such as whales.

Shipping and fishing

Maritime transport plays a significant role in the pollution of seas and aquatic environments. Statistics show that in 1970, commercial shipping fleets worldwide dumped more than 23,000 tons of plastic waste into the sea. In 1988, an international agreement prohibiting the discharge of waste from ships into the marine environment was approved. In the United States, the dumping of plastic at sea, including from marine vessels, is prohibited by the Marine Plastic Pollution Control and Research Act of 1987. Nevertheless, maritime transport remains one of the main sources of plastic pollution, carrying around 6.5 million tons of plastic in the early 1990s [16].

Increased fishing, recreational and commercial uses of the ocean, and population migration to coastal areas will increase the future influx of plastic waste into the oceans. Plastic gear is currently used in global fishing fleets, and some of this plastic gear is lost at sea during use or may be carelessly discarded. Polyolefins (PE and PP) as well as nylons are among the polymers used in the manufacture of fishing tools. The fishing industry accounts for about 18% of the plastic waste found in the oceans. Aquaculture can also contribute significantly to plastic debris in the oceans [17]. The rest of the plastic waste is mainly obtained from terrestrial sources, including beach waste. Measuring the abundance of floating plastic waste by collecting surface waste with Noston nets seriously underestimates the amount of plastics in the ocean, this method ignores the plastics in sediments and middle water [18]. When the fishing gear becomes worn out and unusable, there is a possibility that it will be abandoned at sea by irresponsible fishermen. Finally, environmental conditions such as weathering, wear by sea waves, and degradation by UV rays cause fishing nets to break into smaller pieces [19]. Lost or discarded fishing gear is often not visible in low light. This fishing gear may get stuck on the rocky bottom or lost in adverse weather conditions. Since the loss of fishing gear is a financial loss for fishermen, it is likely that they will search for lost gear. However, the time and energy spent searching for lost gear depends on the value of that gear, and anglers may continue fishing rather than attempt to recover their lost gear.

Wastewater treatment plant

Population, density of the city center, volume of water area, waste management methods and proximity to the wastewater treatment plant's discharge point are among the factors that determine the abundance of microplastics in the fresh water environment. According to the relationship between the abundance of microplastics and the discharge of wastewater treatment plant effluent, microplastics that are not removed through the settling steps of wastewater treatment are transferred to fresh water. Using sampling, upstream and downstream of the wastewater treatment plants' effluent discharge point, it is possible to know the effect of wastewater treatment plants on the abundance of microplastics in the fresh water environment. Microplastics are not removed through settling in the primary and secondary stages of wastewater treatment [20].

The microbeads in facial cleansers, toothpastes, and toothpastes can enter wastewater directly through human consumption. Also, thousands of fibers, including polyester and nylon fibers, can enter the wastewater as a result of washing synthetic clothing. Studies have shown that microplastics are able to pass through the wastewater treatment plant and thus can enter receiving waters [21].

The population of the covered area, the use of the covered land, the presence or absence of a combined wastewater system, the type of wastewater (residential, commercial or industrial), etc. are among the factors that cause the variability of the abundance of microplastics in the effluent from the wastewater treatment plant. Since domestic discharges are a major contributor to the abundance of microplastics in wastewater, human activities in the catchment used, such as residents wearing synthetic clothing or using plastic products, may directly affect microplastic concentrations in wastewater. Although it is possible to remove microplastics in wastewater using skimming, sedimentation and tertiary filtration processes in wastewater treatment plants, none of these processes are designed to remove microplastics. Subsequently, a large number of microplastic particles will enter the receiving waters along with the effluent from the sewage treatment plant. Also, since most microplastics remain in wastewater sludge in wastewater treatment plants, The abundance of microplastics released into the environment through the application of sludge as fertilizer on agricultural land is higher compared to microplastics released through direct wastewater discharge. However, no specific treatment process aimed at removing microplastics has yet been applied in full-scale wastewater treatment plants, and treatment technology aimed at removing microplastics is still in the early research stage [22].

Production

Granules and small resin pellets are used as raw materials in the production of plastic products. In the United States, production increased from 2.9 million bullets in 1960 to 21.7 million bullets in 1987 [23].Through accidental spillage during land or sea transportation, improper use as packaging materials, and direct discharge from processing plants, these raw materials can enter aquatic ecosystems. Many industrial sites where raw plastic is frequently used are located near bodies of water. During production, these substances may enter the surrounding environment and pollute waterways [24]. More recently, operation clean up, a joint initiative of the American Chemistry Council and the Plastics Industry Association, aims to get industries to commit to zero bullet losses during their operations [5].

Cosmetics industry

For example, some personal care products (such as facial cleansers, body washes, cosmetics, and toothpaste) contain plastic "microbeads" as exfoliants or fillers. Due to the small size of the microparticles, wastewater treatment plants are unable to completely remove them, thereby allowing some to enter receiving waters [25]. In fact, due to the small design of wastewater treatment plants, they are able to remove up to 95%-99.9% are microbeads, this causes the discharge of 0-7 microbeads per liter of wastewater [26]. Considering that the world's treatment plants discharge 160 trillion liters of water every day, about 8 trillion microbeads are released into waterways every day.

Although many companies have pledged to eliminate the use of microbeads in their products, research shows that at least 80 types of face wash products containing microbeads are still being sold. In the UK, this problem leads to the dumping of 80 tons of micro grains every year. These microbeads not only have a negative impact on wildlife and the food chain, but also increase toxicity, as these particles have been shown to adsorb hazardous chemicals such as pesticides and PAHs [26]. European Chemicals Agency (ECHA) and United Nations Environment Program (UNEP) reports have proposed limits for these substances and stated that more than 500 types of microplastics are widely used in cosmetics and personal care products [27]. Figure 1 shows the electron microscope image of microbeads removed from cosmetics.

Car tire

Research shows that tire wear is one of the main sources of microplastics in aquatic ecosystems [28]. The mechanical wear of car tires by the road surface forms tire wear particles (TWP) [29] or tire and road wear particles (TRWP). It consists of a complex mixture of tire, asphalt and mineral substances in the road surface [30]. Therefore, the abbreviation TWP is used to indicate the particles caused by tire wear produced on the road. Small TWP are likely to be released in the air and are prone to dispersion in the air, while it is likely that large TWP are Deposit on the road surface. Other parts are transferred to soil, wastewater or surface water by rainfall runoff. TWP exist in all parts of the environment, including air, water, soil and living organisms [31]. It is rarely possible to find pure TWP in the environment because they are most often found in combination with other particles from road wear.

TWP contain tire polymers (about 50%) and other components such as fillers and softeners [32] as a significant contributor to the flux of microplastics into the environment. Recently, TWP have been measured in storm water [33], sediments and surface water [34]. It confirms that road runoff is likely to be an important route of microplastic pollution. Therefore, there is a need to evaluate the effect of TWP on living organisms and evaluate the potential ecological risks caused by TWP.

Effects in the aquatic environment may originate from the TWP themselves or from compounds released from the TWP. In addition, other traffic-related sources (brakes, lubricants, coolants, asphalt, road markings and auto parts) may also release microplastics and other pollutants [35].

Water bottle

The presence of microplastics in tap water and bottles has been proven. In a survey of tap water in 14 countries, enteropathogenic lesions were found in 81% of 159 tested samples, with an average of 45.5 particles per liter [36]. Mason et al. [37] examined 11 global bottled water brands purchased from 19 locations in 9 countries. The results showed that 93% of 259 bottled waters have some signs of microplastic contamination. Fragments were the most abundant in terms of morphology (65%) in bottled waters. The size of microplastic particles detected in drinking water is mainly in the range of 1-100 µm [37].

After finishing the purification processes in the drinking water treatment plant (DWTP), the water is transferred to the water consumption unit along the pipeline.

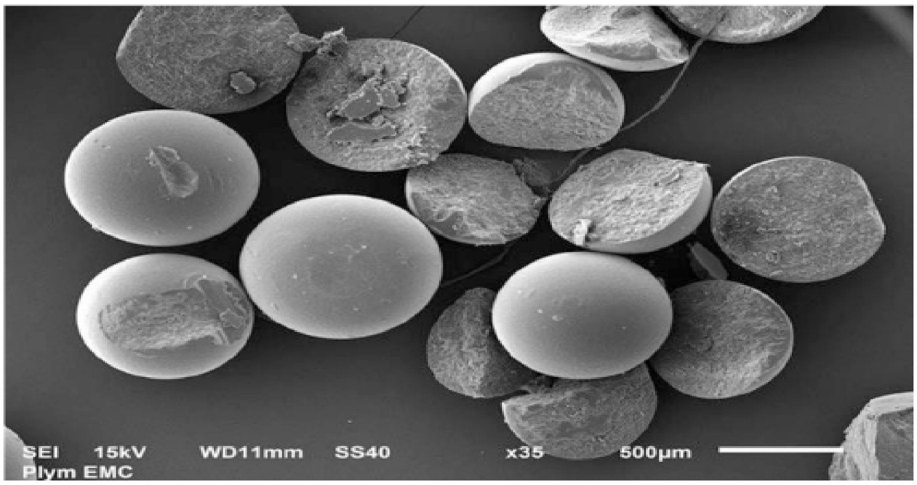

Figure 1. Electron microscope image of microbeads removed from cosmetics

Therefore, microplastics in tap water are mainly obtained from raw water, purification process and water transfer process. Also, in order to prevent corrosion of storage tanks in water treatment plants, these tanks are covered with epoxy resin. Polyvinyl chloride (PVC), PE and polyamide (PA) can be mentioned among the widely used polymers in the construction of transmission pipes and pipe connections [38]. Abrasion of the mentioned polymers during the transfer process as well as water storage is one of the sources of microplastics. In relation to bottled water, the plastic content in the water may be affected by the polymers used in the bottle. PP is the most common type of polymer (at least 54% of these larger microplastics), which may be derived from plastic bottle caps [36].

In a study to investigate whether microplastic pollution is affected by the materials used in packaging, different packaging materials (plastic, glass) of the same brand of water (Gerolsteiner) were tested. The results indicated a much lower microplastic contamination in glass bottled water (average number: 204 particles per liter) compared to plastic packaging water (average number: 1410 particles/L) of Gerolsteiner brand. In addition, packaging materials were divided into single-use plastic bottles, returnable plastic bottles, glass bottles, and beverage cartons. The number of plastic particles in water from returnable bottles (median: 118 particles/L) was much higher than water from single-use plastic bottles (median: 14 particles/L) and water from beverage cartons (median: 11 particles/L). However, high numbers of microplastics were also found in glass bottled water (median: 50 particles/L) in this study. Furthermore, fluorescence microscopy showed that approximately 25,000 microplastic particles were released into a cup of hot water within 15 minutes when using disposable paper cups [39].

Disposable plastic products

Common single-use plastic products, such as paper coffee cups lined with a thin layer of plastic, release trillions of microplastic particles per liter of water during normal use [40]. Single-use plastic products enter aquatic environments [41] and local and state policies that reduce single-use plastics have been identified as effective legislative measures that communities can take to control plastic pollution.

The spread of the COVID-19 virus caused a significant increase in the daily use of face masks worldwide. Billions of face masks are used around the world and these masks may eventually end up in the environment by being disposed of in landfills or thrown away. Among the plastic polymers that are used in making disposable face masks, we can mention polymers such as PP, PS, PC, PE and PES, although it is also possible to make masks from cotton [42]. The widespread use of face masks has raised widespread concerns about the mass production of plastic waste, which is likely to become a source of secondary microplastics (<5 mm) or even nanoplastics (<1 μm). PP fibers are the most common material used in the production of face masks, which, despite having enough pores for easy breathing, form an intricate network that can trap small particles [43].

It is possible that nanoplastics and microplastics released from face masks are ingested by marine organisms. Mask particles may affect the ability of diatoms to perform photosynthesis through absorption on their surface, and microplastics and nanoplastics released from face masks can also be ingested by organisms such as rotifers, shrimps, and snails during a short-term exposure. How these small plastic particles affect the health of marine organisms and aquatic life, as well as the possibility of their transfer to marine food chains, is unclear. However, a number of studies have reported that nanoplastics and microplastics have lethal effects in marine organisms, suggesting that plastic particles in masks may pose environmental risks [44]. In addition, fine plastic particles with micro and nano sizes, which accumulate in aquatic animals, can be another potential route for exposure to microplastics and nanoplastics through the consumption of these seafood by humans. It has also been reported that nanoplastics and microplastics of different sizes (30–100,000 nm) can pass through the epidermis of the mammalian gut and be transferred to other tissues [45].

Li et al. conducted a masked breathing simulation experiment to investigate the risk of inhaling microplastics. It was observed that fiber-like and spherical microplastics could pass through (or be released from) the masks by vacuum suction. The number of particles increased continuously during the test, reaching a level of several thousand microplastics per mask after 720 hours. It was likely that more These particles originated from the mask itself [46]. Figure 2 shows the sources of microplastics and their harm to aquatic life and humans.

Human Exposure to Microplastics

The human body is exposed to microplastics by eating food containing microplastics, inhaling microplastics in the air, and skin contact with these particles in products, textiles, or in dust.

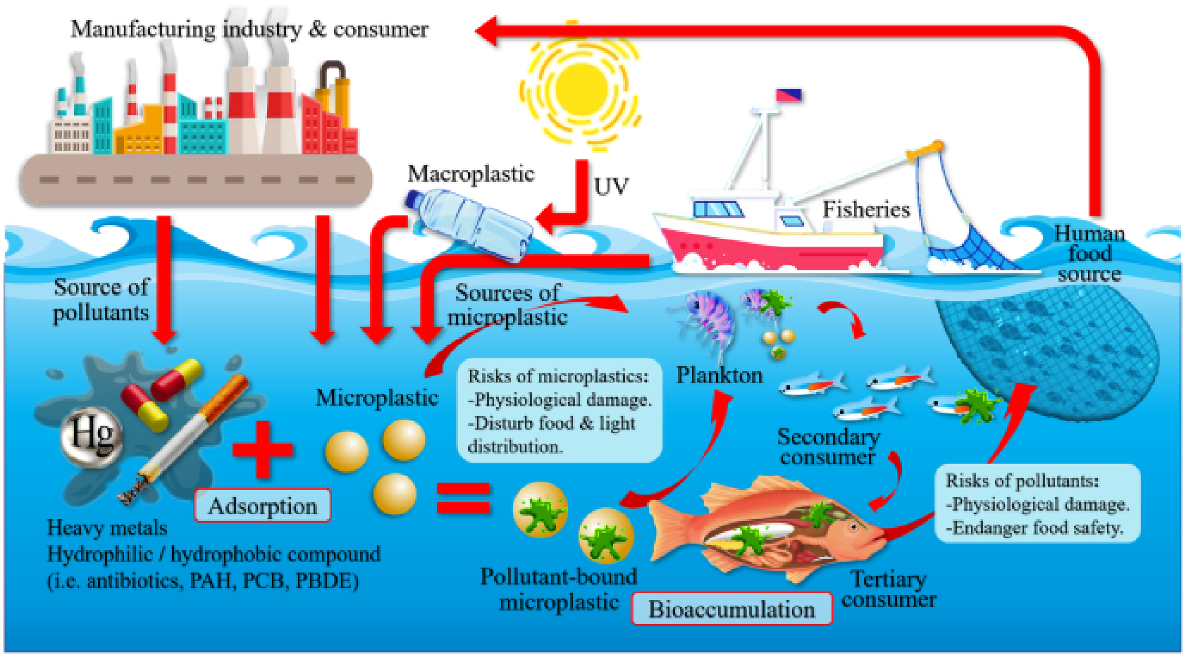

Figure 2. Sources of microplastics and damage to aquatic life and humans

Dietary exposure

Food and beverages are the potential route of human exposure to microplastics in the human diet. An approximation of the daily intake of microplastics through food and drink shows that: male children are exposed to 113 particles, male adults are exposed to 142 particles, female children are exposed to 106 particles, and female adults are exposed to 126 particles per day [47]. Ingestion of microplastics can block the digestive tract, slow growth, stop enzyme production, reduce steroid hormone levels, affect reproduction, and cause absorption of toxins [48]. In the following, some of the most important sources of microplastics in the diet have been investigated.

Seafood

Research shows that small plastic debris is widely found in aquatic organisms, including fish, crustaceans and bivalves. These aquatic food products appear to be the largest sources of microplastics in the diet [49]. In addition, Pfaller et al. (2020) showed that the smell of plastic debris induced foraging behavior in sea turtles, suggesting that the attractiveness of microplastics to marine animals stems not only from their appearance but also from their smell [50]. Research by Li et al. shows that oysters collected from different areas, including coastal waters and supermarkets, are contaminated with microplastic particles and predicted that consumers eat 70 microplastics in 100 grams of oysters [51]. Studies

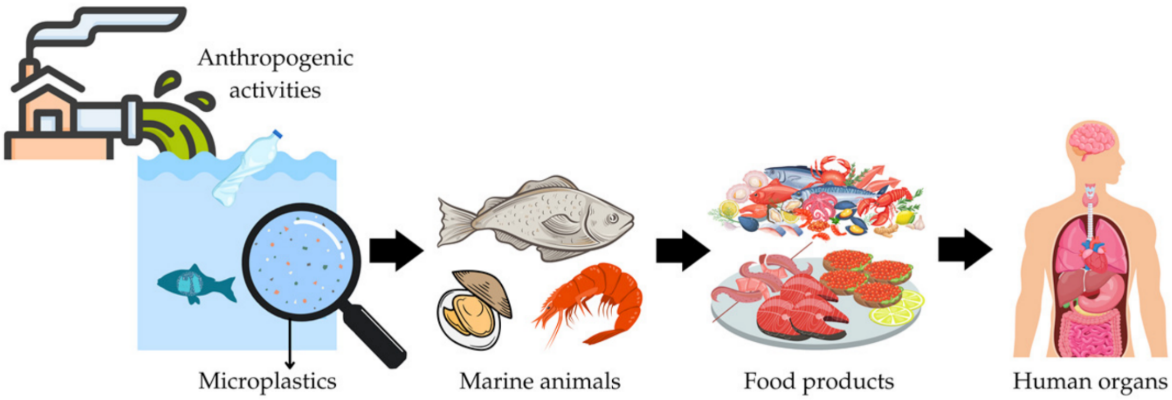

Figure 3. Human exposure to microplastics through seafood

indicate the transfer of microplastics to the circulatory system through the lymph nodes and digestive system [52].

Microplastics were also detected in sardines and sprats cans [53] and the organs (e.g. stomach contents and liver) of fish Squalius cephalus [54]. It has also been reported that consuming Mud carp (*Cirrhinus molitorella*) and Bighead carp (*Hypophthalmichthys nobilis*) have the potential risk of accumulating phthalate esters during gastrointestinal (GI) digestion [55]. Figure 3 shows human exposure to microplastics through seafood.

Salt

Microplastics have been identified in table salt obtained from seas, lakes, wells and rock salt in different countries [56]. Since commercial salt is a major food commodity, its microplastic contamination will be a special threat to public health. Lee et al. (2019) showed that microplastic particles are found in 94% of commercial table salt and polyethylene terephthalate (PET), PP and PE are among the most common types of polymers in table salt. As a result, Humans may consume several hundreds of microplastics annually through salt [57]. Salt is a long-term exposure pathway due to its daily consumption in the human diet.

Drinking water

Several studies reported microplastics in tap water, bottled water, and groundwater sources. For example, in a study conducted by Yang et al. [58] in relation to microplastics in water from different containers, they concluded that beverage cartons, plastic and glass bottles are all contaminated with microplastic particles. Surface runoff and wastewater effluent are the main ways of entering microplastics into aquatic environments. Treatment plants and conventional treatment processes can partially prevent microplastics from entering drinking water. However, some pollution may still be caused by plastic, including the wear and tear of plastic equipment during water treatment and distribution processes [58].

Other foods

After microplastics enter the soil through surface runoff or airborne, plants interact with microplastics. It has been shown that people may receive up to 80 grams of microplastics per day through the consumption of edible plants [59]. Sun et al. [60] showed that plastics accumulate in the Arabidopsis thaliana depending on their surface charge, for example, nanoplastics with a positive charge tend to accumulate in the lower levels of the plant, including the root tip. In contrast, negatively charged microplastics tend to accumulate in the apoplast and xylem [60]. The presence of microplastics in vegetables such as carrots, lettuce, broccoli, potatoes and fruits such as apples and pears was investigated [61].

Food packaging

It is possible to transfer microplastics during food processing, storage, transportation and packaging of food [62]. Microplastic contamination of packaged meat has been detected. Microplastics can also be transferred from food trays, as they are usually made of polystyrene [63]. Previous studies have shown that a plastic tea bag at brewing temperature can release approximately 6.11 billion microplastics and 1.3 billion nanoplastics (NPs) into a cup of beverage [64]. Microplastic contamination of mineral water in plastic bottles was strongly related to the pH of the water as well as the density and thickness of the plastic of the bottle [65].

Inhalation exposure

Airborne microplastics are an underestimated risk, they can penetrate deep into human lungs because they are able to pass through the defensive respiratory system. Microplastics are one of the constituents of suspended particles and are also a serious threat to public health [66]. Microplastics are also found in house dust, and make up a significant portion of indoor particulate matter [67]. The predominant form of microplastics in the atmosphere is fiber. They can cause health risks especially for industrial workers by reaching the human respiratory system [68]. A study of workers exposed to microplastics also documented the development of colon cancer. Several animal studies have also proven the possibility of the destruction of microfibers in the lung and the occurrence of harmful effects caused by it [69].

Tires, road wear particles, aerosol formation from sea salt, wind dispersal of wastewater sludge, degradation of construction materials, drying of clothing, apparel, and synthetic textiles are all potentially significant sources of airborne microplastics. In a study conducted by Liu et al. (2019), the results indicated the transfer of about 120.72 kg of airborne microplastics in Shanghai. An adult inhales about 21 microplastics per day [70]. In addition, microplastics in the air may also transfer pathogens to the human lung through biofilms, leading to infection.

Exposure through skin contact

Skin contact is another way of human exposure to microplastics. This exposure occurs through atmospheric fallout of synthetic fibers and fine particles in cosmetic products [71]. Among the main ways of entering microplastics in this type of exposure, we can mention hair follicles, sweat glands and damaged skin [72]. Furthermore, it has been reported that particles below 100 nm may cross the skin barrier and penetrate through human skin [73]. Chemicals used in cosmetics and personal care products and their fragmentation may lead to hazardous NPs [74]. Furthermore, Kuo et al. (2009) proved that chemical enhancers, such as oleic acid and ethanol, can enhance the transport of NPs through the skin [75].

Dealing With Microplastic Pollution

Treatment

Some researchers have suggested burning plastics and recovering the resulting energy. Nevertheless, plastic recycling is considered a more efficient solution because this method, unlike burning, reduces the amount of plastic waste produced [76]. Biodegradation is another possible solution for large amounts of microplastic waste, microorganisms break down plastic using enzymes. After decomposition, these plastics can be used in the form of energy and as a source of carbon. These microbes can reduce the release of microplastics in the environment through wastewater treatment [77] .

Filtering

Effective removal of microplastic particles through wastewater treatment plant processes is critical to prevent their entry into aquatic ecosystems. Microplastics that are trapped by treatment plants are transferred to the sludge of the treatment plant. It is possible that this sludge is used as an agricultural fertilizer and then the plastics in the sludge enter receiving waters through wind and runoff from rainfall [78].

Education and recycling

Holding training classes on recycling is one of the proposed effective solutions for microplastic pollution. While this would be a smaller scale solution, education has proven to be very effective in reducing plastic waste in urban environments. Following the increased efforts in the field of recycling, a cycle of use and reuse of plastic is created to reduce waste generation and thus reduce the need for new raw materials. To achieve this goal, states must implement stronger infrastructure and investment in recycling [79]. Improving recycling technology to be able to recycle smaller plastics is essential because it reduces the need to produce new plastics [76].

Actions taken to inform

The US Environmental Protection Agency (EPA) launched its "litter free waters" initiative in 2013 to prevent single-use plastic waste from entering waterways and ultimately the oceans [80]. EPA is working with the UNEP, the Caribbean environment program (CEP) and the peace corps to reduce as well as eliminate litter in the Caribbean [81].

Among the various projects that EPA has funded in the San Francisco Bay Area is one aimed at reducing the use of single-use plastics such as disposable cups, spoons, and straws [82]. In addition, there are many organizations that work in the field of dealing with microplastics and they consider spreading awareness about microplastics as one of the basic measures in this regard. One such group is the Florida microplastics awareness project (FMAP), which consists of a group of volunteers who look for microplastics in coastal water samples [83].

Collection devices

Computer model analyzes provided by the Dutch Ocean Cleanup Foundation show that collection devices closer to the coast are able to remove about 31% of the microplastics in the area [84]. On September 9, 2018, the Ocean Cleanup Foundation launched the world's first ocean cleanup system (001), nicknamed "Wilson," which was deployed in the Great Pacific Garbage Patch [85]. The 001 system was 600 meters long, serving as a The U-shaped barge used natural ocean currents to concentrate plastic and other debris on the surface of the ocean in a limited area so that it could be retrieved by ships [86]. Despite widespread public support, the project has faced criticism from oceanographers and plastic pollution experts [87]. Studies indicate that some bacterial species are adapted to plastics and as a result acquire the ability to remove plastic particles. Some bacteria were also manipulated in order to acquire this ability [88].

Laws and Policies

Expanding knowledge related to the harmful environmental effects of microplastics pollution, currently there is widespread support from groups to remove and ban the use of microplastics in various products [89]. One such campaign is "beat the microbead," which focuses on removing plastic from personal care products. For conservation, adventurers and scientists run the Global Microplastics Initiative, a project that collects water samples to better provide information on the distribution of microplastics in the environment [90]. United Nations Educational, Scientific and Cultural Organization (UNESCO) has funded global research and assessment programs due to the transboundary issue that microplastic pollution posess [91]. These environmental groups continue to pressure companies to remove plastics from their products to preserve healthy ecosystems.

China

In China in 2018, the import of recycled materials from other countries was banned, forcing those countries to re-examine their recycling plans [92]. 55% of all plastic waste that reaches the seas can be attributed to the Yangtze River in China. Including microplastics, the Yangtze carries an average of 500,000 pieces of plastic per square kilometer. Scientific American reported that China dumps 30% of all plastic in the ocean [93].

United States

In order to reduce the harmful effects of microplastics on the environment, some states of the United States have taken measures. Illinois was the first state in the United States to ban cosmetics containing microplastics [76]. At the national level, the clean water act was signed into law by president Barack Obama on December 28, 2015. The law prohibits "wash-off" cosmetic products that have an exfoliating function, This law does not include products such as household cleaning materials. [94].

Japan

On June 15, 2018, a bill aimed at reducing the production of microplastics, especially in aquatic environments, was approved by the Japanese government. This bill was proposed by the Ministry of Environment and unanimously approved by the parliament. It is also the first bill passed in Japan that specifically targets the reduction of microplastic production, especially in products like face wash and toothpaste. This law is derived from previous laws that emphasized the removal of plastic waste from aquatic environments. It also focuses on increasing education and public awareness about recycling and plastic waste. The Ministry of the Environment has also made a number of recommendations for ways to monitor the amount of microplastics in the ocean, however, the law does not specify any penalties for those who continue to manufacture products with microplastics [95].

United Kingdom

UK environment protection regulations 2017 ban the production of any washing personal care products containing microbeads. This particular law specifies specific penalties in case of non-compliance. Those who do not comply are required to pay a fine. If the fine is not paid, product manufacturers may receive a stop notice, which prevents the manufacturer from continuing production until it complies with regulations preventing the use of microbeads. If a stop notice is ignored, criminal proceedings may result [96].

European Union

In the European Commission, there are many concerns about the harmful environmental effects of microplastics. A comprehensive review of the scientific evidence was carried out in April 2018 by the European Commission's Chief Scientific Advisers on microplastic pollution [97]. The evidence review was conducted by a group nominated by the European Academies and presented in January 2019. A scientific opinion based on the report of the scientific advice for policy by the European academies (SAPEA) was presented to the Commission in 2019. , on the basis of which the Commission will examine whether policy changes should be proposed at the European level to curb microplastic pollution or not [98].

In January 2019, the ECHA proposed to limit intentionally added microplastics [99]. The European Commission's Circular Economy Action Plan sets mandatory requirements for recycling and waste reduction of key products such as plastic packaging. This plan begins a process to limit the addition of microplastics in products [100]. The European Commission intends to update the urban wastewater treatment directive to further address microplastic waste and other pollutants. Their purpose is to protect the environment against the discharge of industrial and urban wastewater [101].

Conclusion

Microplastic pollution comes from textiles, tires and urban dust, which make up more than 80% of microplastics in the environment. Small TWP are usually airborne and prone to air scattering, while large tire wear particles are deposited on the road surface. They are present in all environmental compartments, including air, water, soil/sediment, and living organisms. Microbeads added to facial cleansers, toothpastes can enter wastewater directly through human activities. Also, synthetic clothing, such as polyester and nylon, may release thousands of fibers into the wastewater during the washing process. However, it has been shown that microplastics can pass through wastewater treatment plants, enter waterways, and eventually accumulate in the environment. Despite the significant role of plastics in maintaining human health, including use in food packaging, their uncontrolled entry into the environment may have adverse effects. Plastic is very resistant to degradation, and therefore, disposal of plastic waste is a big challenge. Improving education through recycling campaigns is another proposed solution for microplastic pollution. While this would be a small-scale solution, education has proven to be very effective in reducing waste, especially in urban environments where there is often a high concentration of plastic waste.

Ethical Considerations

Compliance with ethical guidelines

This article is review with no human or animal sample. There were no ethical considerations to be considered in this work.

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Authors' contributions

Conceptualization and Supervision: Jalil Jaafari; Methodology: Aran Akbari and Kamran Taghavi; Investigation, Writing –original draft, Writing – review and editing: Aran Akbari and Jalil Jaafari;

Conflict of interest

The authors declared no conflict of interest

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