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Environmental Distribution and Health Risks of Microplastics: A Global Review

Andy Dhifa Nur Rahmaini[1]

[1] Institut Teknologi dan Bisnis Nobel Indonesia, Makassar, Indonesia

Abstract

Microplastics have become one of the environmental pollutants receiving global attention due to their persistent nature and widespread distribution. This study aims to examine the sources, distribution, and potential impacts of microplastics on the environment and human health. The method used is a descriptive qualitative approach through a literature review of various relevant scientific publications from the past five years. The results of the study indicate that microplastics originate from primary and secondary sources, most of which are influenced by human activities. These particles are found in various environmental compartments, including air, water, soil, and the ocean, and have the ability to transfer between environmental media. Microplastics also have the potential to enter the human body through ingestion, inhalation, and skin contact. From a health perspective, microplastics can cause oxidative stress and metabolic disorders, and act as vectors for other hazardous substances. However, research on their long-term effects remains limited. Therefore, comprehensive management efforts and further research are needed to gain a deeper understanding of the risks associated with microplastics.

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1. Introduction

Plastic has become a very important material in modern life due to its lightweight, strong, and durable properties. Its use covers various sectors, ranging from packaging, textiles, to the construction industry. Along with increasing human needs, global plastic production has also seen a significant increase in recent decades, ultimately contributing to the increasing amount of plastic waste in the environment (Wang et al., 2021). This hard-to-decompose plastic waste then undergoes a physical, chemical, and biological fragmentation process to produce small particles known as microplastics.

Microplastics are generally defined as plastic particles less than 5 mm in size that can come from both primary and secondary sources. Primary microplastics are particles that are produced in small sizes, such as in cosmetic and industrial products, while secondary microplastics are formed from the degradation of large plastics due to environmental exposure (Horton et al., 2017). The existence of microplastics is a global concern because of its persistent nature, difficult to degrade, and has the ability to be widely distributed in various environmental compartments.

Various studies show that microplastics have been found in almost all components of the environment, including air, freshwater, soil, and the ocean. This wide distribution is influenced by various factors such as human activities, waste management systems, as well as natural processes such as wind and water flow (Hale et al., 2020). In addition, microplastics also have the ability to move between environmental media, thereby increasing their potential for global spread. This

condition shows that microplastics are no longer a local problem, but have become a complex global environmental issue.

The presence of microplastics in the environment not only impacts ecosystems, but also has the potential to affect human health. Microplastics can enter the human body through various routes, such as the consumption of contaminated food and beverages, inhalation of airborne particles, and direct contact through the skin (Prata et al., 2020). Some studies have also shown that microplastics have been found in a variety of consumer products such as drinking water, salt, and seafood, indicating the presence of constant exposure to humans.

From a health perspective, microplastics have the potential to cause various biological effects, including oxidative stress, metabolic disorders, and potential toxicity due to chemicals contained or adsorbed on their surfaces (Wright et al., 2019). In addition, microplastics can also act as vectors for microorganisms and other pollutants, increasing the risk of exposure to hazardous materials. However, research on the direct impact of microplastics on human health is still limited and requires further studies to understand the mechanisms and levels of risk more comprehensively.

On the other hand, the complex characteristics of microplastics, including size, shape, as well as chemical composition, are challenging in the process of identification and analysis in the environment. In addition, the presence of various types of chemical additives in plastics can also affect the toxic properties of these microplastics (Hahladakis et al., 2018). This shows that the study of microplastics is

not only related to environmental aspects, but also involves chemical, biological, and health dimensions.

Based on these conditions, research on microplastics is very important to be carried out to understand the source, distribution, and potential impact on the environment and human health. By understanding the characteristics and risks of microplastics in more depth, it is hoped that effective management and mitigation strategies can be developed to reduce their negative impacts in the future.

2. Literature Review

Research on microplastics has grown rapidly in recent years, especially related to their source, distribution, and impact on the environment and human health. Microplastics are known to come from various anthropogenic activities, both in primary and secondary forms. Primary microplastics are directly produced in small sizes for industrial purposes and consumer products, while secondary microplastics are formed as a result of the degradation of large plastics exposed to environmental factors such as ultraviolet light, temperature, and mechanical activity (Horton et al., 2017). This degradation process causes the plastic to fragment into smaller particles and is increasingly difficult to identify and control.

The distribution of microplastics in the environment is very wide and includes a wide range of compartments, such as air, water, soil, and the sea. Global studies show that microplastics can move between environmental media through natural transportation processes such as wind, water currents, and human activities (Avio et al., 2017). The presence of microplastics in the air, for example, suggests that these

particles can be dispersed over long distances, while in aquatic environments, microplastics can accumulate and enter the food chain. This shows that microplastics have high mobility and persistence characteristics that make them difficult pollutants to control.

In addition, the research also highlights the potential impact of microplastics on living organisms. Microplastics can interact with biota through the process of ingestion and direct contact, which has the potential to cause physiological and biological disorders. Several studies show that microplastics can induce oxidative stress, inflammation, as well as metabolic disorders in organisms (Wright & Kelly, 2018). Not only that, microplastics can also serve as vectors for harmful chemicals and microorganisms, thus increasing the complexity of the impact they have on ecosystems.

In the context of human health, exposure to microplastics is an issue that is getting more and more attention. Humans can be exposed to microplastics through the consumption of contaminated food and beverages, inhalation of airborne particles, and contact with products containing plastic. Prata et al. (2020) state that although exposure to microplastics in humans has been identified, understanding of its long-term impacts is still limited. This is due to the complexity of the characteristics of microplastics, including their diverse size, shape, and chemical composition, as well as the limitations of currently available analytical methods.

Based on these various studies, it can be concluded that microplastics are pollutants that have a wide distribution, persistent properties, and potential significant impacts on the environment and human health. However, there are still

research gaps mainly related to the mechanism of toxicity and the actual level of risk to humans. Therefore, further studies are needed to understand the interaction of microplastics with biological systems and develop effective mitigation strategies.

3. Methods

This study uses a descriptive qualitative approach that aims to systematically describe the phenomenon of microplastics in the environment and its potential impact on human health. This approach was chosen because it is able to provide an in-depth understanding of the characteristics, sources, distribution, and implications of microplastics without manipulating the research variables. Through this method, the researcher focuses on the collection and analysis of narrative and conceptual data to produce a comprehensive interpretation of the topic studied.

The data collection technique in this study was carried out through literature study, namely by examining various sources of scientific literature that are relevant to the topic of microplastics. The data sources used include international scientific journals, research reports, and other academic publications published in a certain time frame. The selection of sources is carried out selectively by considering the credibility, relevance, and up-to-date of the information presented. Thus, the data obtained is expected to be able to provide a representative picture of the condition of microplastics globally.

The data analysis process is carried out by organizing, categorizing, and interpreting information obtained from various sources. The data that has been collected is then compiled based on main themes, such as the source of

microplastics, distribution in the environment, the path of exposure to humans, and the impact caused. Furthermore, a synthesis process is carried out to connect various findings from the literature so as to produce an integrated understanding. This approach allows researchers to identify patterns, relationships, as well as trends that emerge from various previous research results.

In addition, the descriptive method is used to present the results of the analysis in the form of a systematic and easy-to-understand description. Researchers not only describe the findings, but also interpret the meaning of the findings in a broader context. Thus, this study not only serves as a compilation of information, but also as an effort to provide a deeper understanding of the microplastic phenomenon.

To maintain the validity of the data, this study refers to the principle of source validity by selecting literature that has gone through a peer-review process and comes from reputable journals. In addition, source triangulation is also carried out by comparing various research results that have similar topics to ensure the consistency of information. This approach is expected to increase the level of trust in the research results obtained.

By using a descriptive qualitative method, this study is expected to be able to provide a comprehensive picture of microplastics in the environment and their implications for human health. This approach also allows researchers to identify gaps in research that still exist, so that it can be the basis for further more in-depth research.

4. Results

The results of this study show that microplastics are one of the environmental pollutants that have a very wide and complex distribution. Microplastics are found in various compartments of the environment, including air, freshwater, soil, and the ocean, suggesting that their presence has spread globally. The significant increase in plastic production in recent decades has been a major factor driving the accumulation of microplastics in the environment. Plastics that are not properly managed will degrade through physical, chemical, and biological processes, resulting in persistent microplastic particles (Wang et al., 2021).

The sources of microplastics in the environment are very diverse and most of them come from human activities. Primary microplastics are produced directly from industrial products such as cosmetics, synthetic textiles, and plastic pellets, while secondary microplastics come from the fragmentation of large plastics that undergo weathering in the environment (Horton et al., 2017). Transportation activities, especially vehicle tire abrasion, as well as industrial activities are also important contributors to the release of microplastics into the environment. In addition, less effective waste management systems have also accelerated the spread of microplastics to various environmental media.

The distribution of microplastics in the environment is influenced by a variety of factors, including environmental conditions, the physical properties of the particles, as well as human activities. In the atmospheric environment, microplastics can be carried by the wind and dispersed over long distances, allowing for cross-regional spread. Studies show that microplastics in indoor air tend to have higher

concentrations compared to outdoor air, which is related to internal sources such as textiles and household dust (Vianello et al., 2019). This shows that exposure to microplastics does not only occur in the outside environment, but also in the indoor spaces where humans carry out their daily activities.

In the aquatic environment, microplastics are found in significant amounts, both in freshwater and the sea. Wastewater treatment plants are known to be one of the sources of microplastics released into water bodies, although most particles can be filtered out during the treatment process (Kay et al., 2018). However, microplastics that escape the process still have the potential to pollute waters and enter the food chain. In addition, rivers act as the main route of microplastic transportation from land to sea, thereby strengthening connectivity between ecosystems (Lebreton & Andrady, 2019).

The presence of microplastics in the soil is also an important concern, especially since the soil serves as a reservoir that can store microplastics for long periods of time. Microplastics in the soil can come from a variety of sources, such as the use of waste-based fertilizers, agricultural activities, and atmospheric deposition. Microplastic particles accumulated in the soil can affect soil structure, microbial activity, as well as plant growth (Chae & An, 2018). In addition, microplastics can also move into deeper soil layers through natural processes, potentially contaminating groundwater.

In marine ecosystems, microplastics have been found in a variety of locations, from the surface to seafloor sediments. The ocean serves as the final accumulation site for most of the plastic waste that comes from land. Microplastics in the ocean

can interact with marine organisms through the process of ingesting, potentially causing physiological and biological disturbances (Hale et al., 2020). In addition, microplastics can also undergo the process of biofouling, which is the formation of biofilms of microorganisms on their surfaces, which can affect the physical properties and behavior of these particles in the environment.

Exposure to microplastics to living organisms, including humans, occurs through a variety of pathways. In humans, the main routes of exposure include the consumption of contaminated food and beverages, inhalation of airborne particles, and contact with products containing plastic (Prata et al., 2020). Microplastics have been found in many different types of foods, such as seafood, salt, and drinking water, suggesting that exposure to humans is continuous. In addition, exposure through air is also a concern, especially in indoor environments that have higher concentrations of microplastics.

The impact of microplastics on living organisms has to do with their physical and chemical properties. Microplastics can cause mechanical effects, such as tissue irritation, as well as chemical effects due to the release of the additives contained in them. Some studies suggest that microplastics can induce oxidative stress and metabolic disorders in organisms (Wright et al., 2019). In addition, microplastics can also serve as vectors for harmful substances such as heavy metals and persistent organic compounds, thereby increasing the risk of exposure to other pollutants.

The diverse characteristics of microplastics, such as size, shape, and chemical composition, also affect the level of impact caused. Particles of smaller size, especially nanoplastics, have a greater potential to enter biological tissues and cause

more significant effects. In addition, the presence of chemical additives in plastics can also increase the potential toxicity of microplastics (Hahladakis et al., 2018). This suggests that the impact of microplastics depends not only on their number, but also on the specific characteristics of the particles.

Although various studies have identified the existence and potential impact of microplastics, there are still limitations in understanding the mechanisms of their toxicity as a whole. Many of the studies conducted are still experimental and use laboratory conditions, so they do not fully represent real environmental conditions (Avio et al., 2017). In addition, the limitation of analysis methods is also an obstacle in detecting microplastics, especially those that are very small.

Based on the overall results, the results of this study show that microplastics are pollutants that have a wide distribution, diverse sources, and potential significant impacts on the environment and human health. The complexity of their characteristics and interaction with the environment makes microplastics an issue that requires serious attention in scientific studies and environmental management. Therefore, more comprehensive efforts are needed to understand and overcome the problem of microplastics in the future.

5. Discussion

The results show that microplastics have become global environmental pollutants with a very wide distribution across various environmental compartments. These findings are in line with previous research that states that microplastics are not only limited to the aquatic environment, but have also been found in the air and

soil, thus increasing the complexity of the problems posed (Hale et al., 2020). This suggests that microplastics have high mobility characteristics that allow them to move between environmental media and reach a wider area.

The diverse sources of microplastics, whether from domestic, industrial, or transportation activities, reinforce the argument that this problem is multidimensional and difficult to control through just one approach. Secondary microplastics formed from the degradation of large plastics suggest that ineffective plastic waste management will continue to produce microplastics in the long term (Horton et al., 2017). Therefore, control efforts need to focus not only on reducing primary microplastics, but also on the overall management of plastic waste.

In addition, the distribution of microplastics in the environment shows a strong linkage between ecosystems. Microplastics originating from land can be carried through rivers to the sea, which then accumulate in marine ecosystems (Lebreton & Andrady, 2019). This phenomenon confirms that microplastic pollution is a cross-ecosystem issue that requires an integrated approach in its management. Thus, an integrated environmental policy is essential to effectively reduce the impact of microplastics.

From a health perspective, exposure to microplastics through various channels such as consumption, inhalation, and skin contact shows that humans are inseparable from the risk of microplastic contamination (Prata et al., 2020). Although the long-term impact on human health is still not fully understood, some studies have indicated the existence of potential negative effects, such as oxidative stress and metabolic disorders (Wright & Kelly, 2018). This shows that microplastics are

not only an environmental issue, but also have the potential to become a public health problem in the future.

The complex characteristics of microplastics, including their very small size and the presence of various chemical additives, further increase their potential risks. Microplastics can serve as vectors for other pollutants, thus increasing the likelihood of more complex toxic effects (Hahladakis et al., 2018). In addition, smaller sized particles have a greater ability to penetrate biological tissues, thus increasing the risk of impacts on living organisms.

However, limitations in microplastic research and analysis methods remain a major challenge in understanding their impact comprehensively. Many studies are still conducted in laboratory conditions, so the results do not fully represent real conditions in the environment (Hale et al., 2020). Therefore, more comprehensive follow-up research, especially those based on field conditions, is needed to gain a more accurate understanding of the impact of microplastics on the environment and human health.

6. Conclusion

Based on the results and discussion presented, it can be concluded that microplastics are environmental pollutants with complex characteristics and a very widespread distribution across various compartments, such as air, water, soil, and the ocean. The presence of microplastics originating from various sources, both primary and secondary, indicates that human activities are the primary factor driving the increase in microplastic levels in the environment. Their persistent and non-

biodegradable nature allows microplastics to persist for long periods and continue to accumulate. Additionally, microplastics have the ability to migrate between environmental media, thereby expanding the scope of their contamination. This means that microplastics not only impact a specific ecosystem but also have the potential to affect the overall environmental balance. The presence of microplastics in various food chains also indicates the potential for transfer to living organisms, including humans.

Human exposure to microplastics can occur through various routes, such as consumption of food and beverages, inhalation, and direct contact. Although the long-term health impacts still require further research, indications of biological effects suggest that microplastics have the potential to pose risks to human health. Therefore, serious attention must be given to this issue. Consequently, efforts to manage and control microplastics must be undertaken comprehensively through reducing plastic use, improving waste management systems, and conducting more in-depth research. An integrated and sustainable approach is expected to minimize the negative impacts of microplastics on the environment and human health in the future.

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