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Impacts of Microplastics on Food Safety and Human Health

Amanda Clara Shakira[1]

[1] Poltekkes Kemenkes Jakarta I, Jakarta, Indonesia

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Abstract

Microplastics are environmental pollutants that are receiving increasing global attention due to their widespread distribution and potential impact on human health. This study aims to comprehensively examine the presence of microplastics, exposure pathways, and their implications for food safety and human health through a literature review. Data were collected from various scientific literature sources published over the past five years. The results of the study indicate that microplastics have been found in various environmental compartments, including water, soil, and air, and can enter the food chain through the consumption of food products, particularly fishery products. Human exposure to microplastics has the potential to cause health effects such as oxidative stress, inflammation, and immune system disorders. Additionally, microplastics act as vectors for hazardous chemicals that can increase the risk of toxicity. In the context of food safety, the presence of microplastics poses a new challenge that requires serious attention. Therefore, integrated efforts are needed to reduce microplastic pollution through increased public awareness, improved waste management, and the development of environmentally friendly alternatives.

1. Introduction

The use of plastic has become an integral part of modern life due to its lightweight, durable, and economical nature. This material широко is used in various sectors, especially as a single-use packaging material that dominates global consumption. However, the increase in plastic production that is not balanced by an effective waste management system has led to the accumulation of large amounts of plastic waste in the environment. The low rate of plastic recycling further exacerbates this condition, causing serious pressure on the global ecosystem (Lau et al., 2020). In the long run, degraded plastic waste will fragment into small particles known as microplastics.

Microplastics are plastic particles with a size of less than 5 mm that can come from the degradation of large plastics or from products that are deliberately produced in micro sizes. The presence of microplastics has been widely detected in various environmental compartments, including marine waters, freshwater, soil, and even air (Karkanorachaki et al., 2021). This shows that microplastics are persistent pollutants and have the ability to spread widely through natural processes such as water currents and wind, as well as through human activities. In addition, microplastics also have characteristics that are difficult to decompose so that they can survive in the environment for a very long time (Gupta et al., 2023).

The impact of microplastics on the environment is a major concern because these particles can enter the food chain through living organisms. Microplastics can be ingested by a variety of organisms, from plankton to fish, which then have the potential to undergo physiological and biological disorders. Several studies have

shown that the presence of microplastics can affect the growth, reproduction, and metabolic systems of organisms (Unuofin & Igwaran, 2023). In addition, microplastics can also function as carriers of harmful substances such as heavy metals and plastic additive chemicals that can increase the risk of toxicity in the body of such organisms (Campanale et al., 2020).

The entry of microplastics into the human food chain is becoming an increasingly important issue in the context of food safety. Fishery products are one of the main sources of microplastic exposure for humans, as marine organisms are often contaminated by these particles. In addition, microplastics are also found in drinking water and various other types of food, thus increasing the likelihood of continuous exposure in daily life (Vázquez-Rowe et al., 2021). These findings suggest that microplastics are not only an environmental problem, but have also evolved into a serious public health issue.

Exposure to microplastics in humans has the potential to cause various health impacts. Microplastic particles can trigger oxidative stress, inflammation, and disorders in the body's immune system. In addition, microplastics can also carry harmful chemical compounds that can disrupt the human hormonal system (Prata et al., 2020). The very small particle size allows microplastics to enter the body's tissues and potentially accumulate in certain organs, thereby increasing the risk of long-term health problems (Donisi et al., 2024).

Although various studies have shown the potential negative impact of microplastics, the level of public awareness of this issue is still relatively low. Lack of understanding of the sources and impacts of microplastics causes the use of

single-use plastics to remain high. Therefore, efforts are needed to increase public awareness and encourage behavioral change in plastic use (Kumar et al., 2021).

Based on these conditions, a literature review on microplastics is important to provide a comprehensive understanding of their existence, exposure pathways, and impact on food health. This study aims to examine various latest scientific findings to support efforts to control microplastic pollution in a sustainable manner.

2. Literature Review

Microplastics have become a major focus in various environmental studies in recent years due to their persistent nature and wide spread. Microplastics can come from two main sources, namely primary microplastics that are deliberately produced in small sizes, and secondary microplastics that are formed from the degradation of large plastics due to physical, chemical, and biological processes in the environment. The presence of microplastics has been reported in various environmental media such as water, soil, and air, suggesting that these particles have high mobility and are capable of moving across ecosystems (Karkanorachaki et al., 2021).

Research shows that microplastics can accumulate in living organisms through the process of ingestion, especially in aquatic organisms. Microplastics ingested by low-level organisms such as plankton can move to higher trophic levels through the food chain. This process leads to the bioaccumulation and biomagnification of microplastics in the ecosystem. The impact of this accumulation includes physiological disorders, such as decreased appetite, growth disorders, and tissue damage to exposed organisms (Unuofin & Igwaran, 2023).

In addition to physical impacts, microplastics also have the potential to be vectors for various harmful chemicals. Microplastic surfaces can absorb and bind toxic compounds such as heavy metals, pesticides, and chemical additives from the plastic itself. When microplastics enter the body of an organism, they can be released and increase the level of toxicity. This is a serious concern because the toxic effects caused come not only from plastic particles, but also from the chemicals attached to them (Campanale et al., 2020).

In the context of human health, exposure to microplastics can occur through a variety of pathways, including the consumption of food, drinking water, and inhalation of contaminated air. Fishery products are one of the main sources of exposure because marine organisms often contain microplastics in their digestive tract. In addition, research has also shown that microplastics have been found in a variety of other food products such as salt, bottled water, and even fresh foodstuffs. This condition suggests that exposure to microplastics to humans is widespread and has the potential to occur continuously (Vázquez-Rowe et al., 2021).

Although research on the impact of microplastics on human health is still developing, some studies have indicated significant potential risks. Microplastics can trigger inflammatory responses, oxidative stress, as well as disorders of the immune system. In addition, the very small particle size allows microplastics to penetrate the biological barrier and be distributed to various organs in the body. Therefore, further research is needed to comprehensively understand the long-term impacts of microplastic exposure on human health as well as its implications for food safety (Prata et al., 2020).

3. Methods

This study uses a literature review method that aims to systematically examine various results of previous research related to microplastics, especially those related to their existence, exposure pathways, and impact on food health. The literature study method was chosen because it is able to provide a comprehensive overview of the development of research in a field by utilizing published scientific sources. This approach allows researchers to integrate various empirical findings so that a deeper and more comprehensive understanding of the issue under study can be obtained.

The data collection process is carried out through literature search on various scientific databases, such as Google Scholar, ScienceDirect, and SpringerLink. Keywords used in the literature search included "microplastics", "food safety", "human health", "plastic pollution", and "environmental impact". The inclusion criteria in this study include scientific articles published in the last five years, available in full-text form, and relevant to the topic of microplastics and their impact on health and the environment. Meanwhile, the exclusion criteria include articles that have not gone through a peer-review process, lack methodological clarity, or are not directly related to the focus of the research.

After the literature identification process is carried out, the next stage is the selection and evaluation of the quality of the sources. The articles that have been collected are then selected based on the suitability of the title, abstract, and content with the purpose of the research. The selected literature is then analyzed in depth to identify key concepts, research methods used, and relevant key findings. This

process is carried out systematically to ensure that the information used in this study has high validity and reliability.

The data analysis in this study was carried out with a qualitative descriptive approach. Data obtained from various literature sources are organized into several main categories, such as microplastic sources, distribution in the environment, pathways of exposure to humans, and their impact on food health. Furthermore, information synthesis was carried out to find patterns, relationships, and research gaps that still exist. This approach allows researchers to not only summarize the results of previous research, but also provide a more in-depth interpretation of the phenomenon studied.

To maintain the objectivity and accuracy of the results, each reference used in this study was critically analyzed by considering the research method, sample size, and research context of each study. Thus, the results of the study obtained are expected to provide a valid scientific contribution and can be used as a basis for the development of further research as well as in the formulation of policies related to microplastic management and public health protection.

4. Results

The results of a literature review show that microplastics have evolved into one of the most complex and widespread forms of environmental pollution in recent decades. The increase in global plastic production that is not balanced with an effective waste management system is the main factor in the formation of microplastics in the environment. Plastics that are discarded into the environment

will be degraded due to exposure to ultraviolet light, mechanical stress, and biological activity, which are then fragmented into small particles known as microplastics (Gupta et al., 2023). This process takes place continuously, so the number of microplastics in the environment tends to increase over time.

The distribution of microplastics in the environment shows that these particles have been found in almost all environmental compartments, including marine waters, freshwater, soil, and atmosphere. Microplastics can be dispersed through various mechanisms, such as ocean currents, river flows, as well as air movements, allowing these particles to reach regions far from pollution sources. Research shows that the size, shape, and density of microplastics affect their distribution patterns in the environment, where small-sized particles have higher mobility compared to larger particles (Zhang et al., 2021). In addition, microplastics can also accumulate in sediments and water columns, thus becoming a source of long-term exposure for living organisms.

In aquatic ecosystems, microplastics have been detected in a variety of organisms of different trophic levels. Organisms such as plankton, mollusks, and fish are known to be able to ingest microplastics accidentally due to their size and shape that resemble natural food. This process of ingestion causes microplastics to enter the digestive system of organisms and has the potential to cause various physiological disorders. Some studies report that exposure to microplastics can lead to decreased appetite, growth disorders, as well as tissue damage in exposed organisms (Walkinshaw et al., 2020). In addition, ingested microplastics can move

from one organism to another through the food chain, causing bioaccumulation and biomagnification.

In addition to having a physical impact, microplastics also function as vectors for various harmful chemicals. Microplastic surfaces have properties that allow these particles to absorb toxic compounds from the environment, such as heavy metals, pesticides, as well as persistent organic pollutants. When microplastics enter the body of an organism, these substances can be released and increase the level of toxicity in the body. Thus, the impact caused by microplastics comes not only from the plastic particles themselves, but also from the chemicals attached to them (Campanale et al., 2020). This makes microplastics a pollutant that poses a double risk to living organisms.

Literature review also shows that microplastics have entered the human food chain through various pathways. The consumption of fishery products is one of the main routes of exposure to microplastics, because marine organisms often contain these particles in their bodies. In addition, microplastics are also found in drinking water, both in the form of bottled water and tap water, as well as in various other food products such as salt and fresh food (Conti et al., 2020; Vázquez-Rowe et al., 2021). These findings suggest that exposure to microplastics in humans is widespread and can occur repeatedly in daily life.

Exposure to microplastics in humans has the potential to cause various health impacts. Some studies have shown that microplastics can trigger oxidative stress, which is a condition characterized by an imbalance between the production of free radicals and the body's ability to neutralize them. This condition can cause damage

to cells and tissues in the human body. In addition, microplastics can also trigger a prolonged inflammatory response, potentially leading to various chronic diseases (Prata et al., 2020; Yong et al., 2021). Another impact that is of concern is the disruption of the hormonal system due to the presence of plastic additive chemicals that are endocrine disruptors.

The very small size of microplastics allows these particles to penetrate various biological barriers in the human body. Research shows that microplastics can pass through the intestinal wall and enter the circulatory system, potentially distributing them to various organs of the body. In fact, some studies have found the presence of microplastics in the tissues of human organs, such as the lungs, which suggests that these particles can accumulate in the body (Amato-Lourenço et al., 2021). This accumulation has the potential to increase the risk of long-term health problems, although the exact mechanism still requires further research.

In addition to food consumption, exposure to microplastics can also occur through inhalation of contaminated air. Microplastics in the air can be inhaled and enter the human respiratory system. This exposure has the potential to cause disruption to the respiratory system, especially if it occurs over a long period of time. This suggests that microplastics are not only an environmental problem, but also a direct threat to human health (Donisi et al., 2024).

In the context of food safety, the existence of microplastics is an increasingly important issue. Microplastic contamination in food can affect the quality and safety of products consumed by humans. Microplastics entering the food chain can carry harmful substances that are potentially toxic or carcinogenic, which can increase

health risks for consumers (EFSA, 2021). Therefore, the presence of microplastics in food is a serious concern in efforts to maintain public health.

On the other hand, human behavioral factors also contribute to the increase in microplastic pollution. The high use of single-use plastics and the lack of public awareness of environmental impacts are one of the main causes of the increase in the number of microplastics in the environment. Research shows that changes in people's behaviors, such as reducing plastic use and improving waste management, can have a significant impact on reducing microplastic pollution (Kumar et al., 2021; Lau et al., 2020).

Furthermore, efforts to control microplastics require a comprehensive approach and involve various parties. The government, industry, and society need to work together to reduce plastic production, improve recycling systems, and develop more environmentally friendly material alternatives. In addition, education and public awareness raising are important factors in encouraging more sustainable behavior change (Kumar et al., 2021).

The results of this study show that microplastics are a multidimensional problem that includes environmental, health, and social aspects. The widespread spread of microplastics, their ability to enter the food chain, and their potential impact on human health make this issue one of the main challenges in efforts to maintain environmental sustainability and public health in the future.

5. Discussion

The results of the literature review show that microplastics are a complex and multidimensional problem, because they involve aspects of the environment, health, and human behavior. The wide spread of microplastics in various environmental compartments indicates that these pollutants have persistent characteristics and are difficult to control. This condition is in line with the finding that microplastics can move across ecosystems through various natural mechanisms, so that their control efforts cannot be carried out partially, but rather require an integrated approach (Gupta et al., 2023).

In the context of ecosystems, the presence of microplastics has a significant impact on living organisms, especially through the process of ingestion that causes physiological disturbances. This impact becomes even more serious when microplastics enter the food chain and undergo a bioaccumulation process. This suggests that microplastics not only impact individual organisms, but can also affect the stability of the ecosystem as a whole (Unuofin & Igwaran, 2023). Therefore, microplastics can be categorized as a long-term threat to environmental sustainability.

In terms of human health, the findings of the study show that there are potential risks that need serious attention. Exposure to microplastics through food, drinking water, and air indicates that humans are in a state of continuous exposure. Although the exact mechanism of the impact of microplastics on the human body is still being researched, the available evidence suggests a link with oxidative stress, inflammation, and immune system disorders (Prata et al., 2020). This confirms that

microplastics have the potential to become a new risk factor in public health problems.

In addition, the presence of microplastics in food reinforces the urgency of this issue from a food safety perspective. Microplastic contamination in the food chain shows that food quality is not only affected by conventional biological and chemical factors, but also by new pollutants such as microplastics. These findings are in line with reports that microplastics have been detected in various types of food, requiring special attention in food safety monitoring systems (EFSA, 2021).

On the other hand, human behavior factors are one of the important aspects that affect the high level of microplastic pollution. The high use of single-use plastics and low public awareness of environmental impacts are the main causes of the increase in the number of microplastics in the environment. Therefore, mitigation efforts do not only depend on technology or policies, but also on changes in people's behavior. Educational and awareness-raising approaches are effective strategies in reducing plastic use and encouraging more sustainable waste management practices (Kumar et al., 2021).

5. Conclusion

Microplastics are a form of environmental pollution that is increasingly drawing global attention due to their widespread distribution and persistent nature. The presence of microplastics in various environmental compartments, such as water, soil, and air, indicates that these pollutants have become part of an environmental cycle that is difficult to control. Microplastics can enter the food

chain through various pathways, primarily through the consumption of fishery products, drinking water, and other foodstuffs, thereby increasing the potential for human exposure.

From a health perspective, microplastics have the potential to cause various negative effects, such as oxidative stress, inflammation, and disruptions to the immune and hormonal systems. Additionally, the ability of microplastics to carry hazardous chemicals and penetrate biological tissues adds to the complexity of the risks involved. In the context of food safety, microplastic contamination presents a new challenge that must be addressed to maintain the quality and safety of food products.

The issue of microplastics is not only related to environmental and health aspects but is also influenced by human behavior, particularly regarding the use of single-use plastics and waste management. Therefore, integrated efforts involving various stakeholders, including governments, industry, and the public, are needed to reduce microplastic pollution. Education-based approaches, improved waste management, and the development of environmentally friendly alternatives are crucial steps toward addressing this issue sustainably.

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