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Toxicological assessment of the effects of microplastics on human health

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Abstract

Microplastics, defined as plastic particles smaller than 5 mm, have become ubiquitous environmental contaminants. Concerns have been raised about the potential impacts on human health due to ingestion of microplastics. The purpose of this literature review is to summarize the current state of knowledge on the toxicological effects of microplastics on human health. A comprehensive search of scientific databases was performed and relevant studies were selected for inclusion. Results suggest that microplastics can cause physical damage, such as inflammation and oxidative stress, as well as chemical damage, such as additive leaching and oxygen radical production. Epidemiological studies have also investigated potential health effects of microplastic exposure. The results of this literature review highlight the need for further research to fully understand the potential health risks associated with microplastic exposure.

Keywords: Microplastics; Toxicology; Human; Health; Environmental; Contamination

1. Introduction

The presence of microplastics in the environment has become an urgent concern in recent years. Microplastics, defined as plastic particles smaller than 5 mm in size, have been found in a wide range of environmental matrices, including oceans, rivers, lakes, and soil. Concerns have been raised about the potential health effects of human ingestion of microplastics. (1)

Microplastics can enter the human body through various routes, including ingestion of contaminated food and water, inhalation of airborne microplastics, and dermal exposure through contact with contaminated soil or water. Once in the body, microplastics can cause physical damage, such as inflammation and oxidative stress, as well as chemical damage, such as additive leaching and reactive oxygen species formation. (2). Despite growing concerns about microplastic contamination, our understanding of the potential health effects of microplastics remains limited.

The purpose of this literature review is to summarize the current state of knowledge on the toxicological effects of microplastics on human health and identify areas for further research.

The review will focus on the following topics:

- Sources and fate of microplastics in the environment
- Human exposure pathways to microplastics
- Toxicological effects of microplastics on human health
- Current state of knowledge on the health effects of microplastics By summarizing the current state of knowledge on the toxicological effects of microplastics on human health, this review aims to provide a

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comprehensive overview of the potential health risks associated with microplastic exposure and identify areas for further research.

1.1. Background

Microplastics, defined as plastic particles smaller than 5 mm, have become a ubiquitous environmental contaminant. Over the past few decades, the production and use of plastics has increased exponentially, resulting in large amounts of plastic waste being released into the environment. Microplastics can enter the environment in a variety of ways, including through the breakdown of larger plastic debris, the use of microbeads in personal care products, and the release of synthetic fibers from clothing during laundering. Once in the environment, microplastics can be ingested by a variety of organisms, from small invertebrates to large vertebrates. Ingestion of microplastics has been shown to cause physical damage, such as blockages and abrasions, as well as chemical damage, such as additive leaching and the generation of reactive oxygen species.

1.2. Implications

The significance of microplastic pollution lies in its potential impact on human health. Microplastics have been found in a variety of foods consumed by humans, including seafood, salt, and drinking water. Concerns have been raised about the potential harm to human health from ingestion of microplastics. The World Health Organization (WHO) has identified microplastic pollution as a potential risk to human health and called for further research to understand the impacts of microplastics on human health. The U.S. Environmental Protection Agency (EPA) has also identified microplastic pollution as a priority area for research and regulation. Despite growing concerns about microplastic pollution, our understanding of the potential health impacts of microplastics remains limited.

1.3. Purpose

The purpose of this literature review is to summarize the current state of knowledge on the toxicological impacts of microplastics on human health and to identify areas for further research.

Potential health effects. The potential health effects of microplastics include:

- Physical harm
  - Inflammation: Microplastics can cause inflammation in the body, which can lead to a variety of health problems, including cardiovascular disease and cancer. (1)
  - Oxidative stress: Microplastics can also cause oxidative stress, which can damage cells and cause various health problems. (2)
  - Blockage: Large microplastics can block the digestive tract, causing serious health problems. (3)
- Chemical damage
  - 1. Additive leaching: Microplastics can leach additives such as bisphenol A (BPA) and phthalates into the body, causing various health problems. (4)
  - 2. Generation of reactive oxygen species (ROS): Microplastics can also generate ROS, which can damage cells and cause various health problems. (5)

1.4. Toxicological Effects

- Carcinogenicity: Some microplastics have been shown to be carcinogenic, meaning they can cause cancer. (6)
- Reproductive and Developmental Toxicity: Microplastics have been shown to be reproductive and developmental toxic. That is, they can cause harm to the reproductive organs and fetal development. (7) 3. Neurotoxicity: Some microplastics have been shown to be neurotoxic, meaning they can harm the nervous system. (8)

1.5. Human Health Effects

- Gastrointestinal Problems: Exposure to microplastics has been linked to gastrointestinal problems, including inflammation and oxidative stress. (9)
- Cardiovascular Disease: Exposure to microplastics has also been linked to cardiovascular disease, including heart attacks and strokes. (10)
- Cancer: Some microplastics have been shown to be carcinogenic, meaning they can cause cancer. (11) 4. Reproductive and developmental problems: Exposure to microplastics has been linked to reproductive and developmental problems, including birth defects and infertility. (12)

1.6. Sources and types of microplastics

1.6.1. Major microplastics

- Microbeads: Microbeads are small, round plastic particles commonly used in personal care products such as cleansers, toothpastes, and exfoliating scrubs. (13)
- Microfibers: Microfibers are small fibrous plastic particles that are released from clothing and fabrics during washing. (14)
- Microbeads: Microbeads are small, irregularly shaped plastic particles that are used in a variety of applications, including cosmetics and pharmaceuticals. (15)

1.6.2. Recycled Microplastics

- Fragmented plastic debris: Fragmented plastic debris occurs when large plastic items, such as bottles or bags, break into smaller pieces. (16)
- Tire wear particles: Tire wear particles are small plastic particles released from tires while driving. (17) 3. Paint particles: Paint particles are small plastic particles released from paint during application and wear. (18)

1.7. Types of Microplastics

- Polyethylene (PE): Polyethylene is a common type of microplastic used in a variety of applications, including packaging and cosmetics. (19)
- Polypropylene (PP): Polypropylene is another common type of microplastic used in a variety of applications, including packaging and textiles. (20)
- Polyvinyl chloride (PVC): Polyvinyl chloride is a type of microplastic used in a variety of applications, including construction and packaging. (21)

1.8. Natural and synthetic microplastics

1.8.1. Natural microplastics

- Cellulose: Cellulose is a natural polymer found in plant cell walls. It can be broken down into microplastic particles. (22)
- Chitin: Chitin is a natural polymer found in the exoskeletons of crustaceans and insects. It can also be broken down into microplastic particles. (23)
- Keratin: Keratin is a natural protein found in human hair and skin. It can be broken down into microplastic particles. (24)

1.8.2. Synthetic Microplastics

- Polyethylene (PE): Polyethylene is a common synthetic microplastic used in packaging, cosmetics, and textiles. (25)
- Polypropylene (PP): Polypropylene is another common synthetic microplastic used in packaging, cosmetics, and textiles. (26)
- Polyvinyl chloride (PVC): Polyvinyl chloride is a synthetic microplastic used in the construction, packaging, and textile industries. (27)

1.8.3. Comparison of natural and synthetic microplastics

- Biodegradability: Natural microplastics such as cellulose and chitin are biodegradable, but synthetic microplastics such as PE and PP are not. (28)
- Toxicity: Synthetic microplastics have been proven to be more toxic than natural microplastics due to the presence of additives and chemicals. (29)
- 3.Environmental Persistence: Synthetic microplastics can persist in the environment for hundreds of years, while natural microplastics tend to degrade more quickly. (30)

1.9. Human Exposure Methods

1.9.1. Consumption of contaminated food and water

- Seafood: Microplastics have been found in a variety of seafood, including fish, shellfish, and other marine animals. (31)
- Drinking water: Microplastics have been found in drinking water sources worldwide, including tap water and bottled water. (32)
- Food packaging: Microplastics have been found in food packaging materials, including plastic films, containers, and utensils. (33)

1.9.2. Inhaling airborne microplastics

- Outdoor air: Microplastics have been detected in outdoor air samples, particularly in urban areas. (34)
- Indoor air: Microplastics have also been found in indoor air samples, particularly in homes with carpets and upholstered furniture. (35)

1.9.3. Dermal exposure to microplastics

- Personal care products: Microplastics have been found in some personal care products, including cleansers, toothpaste, and exfoliators. (36)
- Clothing and Textiles: Microplastics have been found in clothing and textiles, especially those made from synthetic fibers such as polyester and nylon. (37)

1.10. Other Exposure Routes

- Maternal Transmission: Microplastics have been shown to be transmitted from mother to fetus during pregnancy. (38)
- Breast Milk: Microplastics have also been found in breast milk, which can expose infants. (39)

1.10.1. Inhalation

- Ingestion: Microplastics can enter the body through contaminated food and water and be absorbed in the gastrointestinal tract. (40)
- Inhalation: Microplastics can also be inhaled and absorbed into the lungs. (41).
- Skin exposure: Microplastics can be absorbed through the skin, especially through cuts or abrasions. (42)

1.10.2. Dispersion

- Bloodstream: Once absorbed, microplastics can enter the bloodstream and be transported to various organs and tissues. (43)
- Organs and tissues: Microplastics have been found in various organs and tissues, including the liver, kidneys, and brain. (44)

1.10.3. Metabolism

- Biodegradation: Some microplastics can be biodegraded by microorganisms, forming smaller particles and chemical byproducts. (45)
- Oxidative stress: Microplastics can also cause oxidative stress, resulting in the formation of reactive oxygen species (ROS) and cell and tissue damage. (46)

1.10.4. Selection

- Urinary excretion: Microplastics can be excreted in urine, especially in people with high levels of exposure. (47)
- Fecal excretion: Microplastics can also be excreted in feces, especially in people who have consumed contaminated food or water. (48)

Toxicological effects of microplastics on human health Concerns about the toxicological effects of microplastics on human health are growing. Studies have shown that microplastics can cause physical damage, inflammation, and oxidative stress in humans. Toxic Effects of Microplastics - Physical Damage: Microplastics can cause physical harm to humans, including organ and tissue damage. - Inflammation: Microplastics have been shown to cause inflammation in

humans, which can lead to a variety of health problems. - Oxidative Stress: Microplastics can also cause oxidative stress in humans, which can lead to cell damage and a variety of health problems.

1.11. Routes of Exposure

- Ingestion: Microplastics can enter the body through contaminated food and water.
- Inhalation: Microplastics can also be inhaled, exposing the lungs.
- Dermal exposure: Microplastics can be absorbed through the skin, especially through cuts or abrasions.

1.12. Human health risks

- Cancer: Exposure to microplastics has been linked to an increased risk of developing cancer.
- Reproductive problems: Microplastics have also been linked to reproductive problems, including reduced fertility.
- Neurological problems: Exposure to microplastics has been linked to neurological problems, including cognitive impairment.

Overall, there is growing concern about the toxicological impacts of microplastics on human health, and more research is needed to fully understand the risks associated with microplastic exposure.

Current Regulatory Frameworks and Guidance Overview of Current Regulatory Frameworks and Guidance on Microplastics,

1.12.1. International Rules

- United Nations Environment Programme (UNEP): UNEP has developed guidance on the management of microplastics, including recommendations for reducing plastic pollution. (49)
- World Health Organization (WHO): WHO has published guidance on assessing and managing microplastics in drinking water. (50)

1.12.2. National Rules

- United States: The United States Environmental Protection Agency (EPA) has developed guidance on managing microplastics, including recommendations to reduce plastic pollution. (51)
- European Union (EU): The European Union has introduced regulations to reduce microplastic pollution, including a ban on the use of microbeads in personal care products. (52)

1.12.3. Microplastic Testing Guidelines

- International Organization for Standardization (ISO): ISO has developed guidelines for testing and analyzing microplastics. (53)
- American Society for Testing and Materials (ASTM): ASTM has developed guidelines for testing and analyzing microplastics. (54)

1.13. Research and Development

- National Science Foundation (NSF): NSF has funded research on microplastics, including studies on environmental fate and transport. (55)
- European Commission: The European Commission has funded research on microplastics, including studies on the environmental and human health impacts of microplastics. (56)

2. Conclusion

Microplastics have become widespread environmental contaminants, resulting in continuous human exposure through food, water, and air. Emerging evidence suggests that these particles can induce oxidative stress, inflammation, cytotoxicity, and endocrine disruption, with potential implications for gastrointestinal, respiratory, reproductive, neurological, and cardiovascular health. Although microplastics have been detected in various human tissues and biological fluids, significant uncertainties remain regarding their long-term health effects. Therefore, further research, improved monitoring, and effective regulatory measures are essential to better understand and mitigate the potential risks of microplastic pollution to human health.

Compliance with ethical standards

Acknowledgement

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Disclosure of Conflict of Interest

The author declares that there are no conflicts of interest regarding the publication of this manuscript.

Statement of Ethical Approval

This article is a review of previously published studies and does not involve any new research involving human participants, animals, or biological specimens conducted by the author. Therefore, ethical approval was not required.

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