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Review Article

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Microplastics as Emerging Contaminants: Investigating their Potential to Alter Human Metabolic and Endocrine Systems

Shyam S Kunjwal[1*] and Ruchi Pandey[2]

[1]*Department of Zoology, Uttarakhand Open University Haldwani, Nainital, Uttarakhand, India*
[2]*Department of Chemistry, Uttarakhand Open University Haldwani Nainital, Uttarakhand, India*

[*]**Corresponding author**
Shyam S Kunjwal, Department of Zoology, Uttarakhand Open University Haldwani, Nainital, Uttarakhand, India.

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ABSTRACT

Micro plastics (MPs), which are plastic particles smaller than 5 mm, have drawn a lot of attention as new environmental pollutants. They are widely found in freshwater, marine, and terrestrial habitats, and they are increasingly found in human food, water, and air. These particles have the potential to seriously harm human health, with the metabolic and endocrine systems being of particular concern. The mechanisms by which micro plastics reach the human body, their impact on metabolic regulation, and their potential to cause endocrine system disruption through chemical exposure are all examined in this research. The analysis also addresses possible long-term health effects, highlighting the pressing need for additional study and legislative actions to lessen these effects.

Keywords: Microplastics, Human Health, Endocrine Disruption, Metabolic Function, Contaminants

Introduction

Plastics have transformed various industries, offering durability, flexibility, and low production costs. But the widespread use of plastics has deteriorated the ecosystem and made microplastics (MPs) a ubiquitous contaminant. Primary microplastics (MPs) are created purposefully, while secondary microplastics are created when bigger plastics break apart. These particles are so tiny that they can pass through a variety of environmental channels and finally enter human systems.

In order to maintain homeostasis and control development, reproduction, and energy consumption, the metabolic and endocrine systems are essential. Diabetes, obesity, and hormone-related illnesses are just a few of the serious health issues that can arise from disturbances in these systems. There is growing evidence that MPs can affect these systems in a variety of ways, ranging from physically interfering with cellular functions to serving as carriers of dangerous substances.

An overview of the possible health effects of micro plastics is provided in this publication, which reviews the state of our knowledge regarding their effects on human metabolic and endocrine processes.

Pathways of Microplastic Exposure

Ingestion

There are several ways for humans to be exposed to MPs through ingestion, such as through tainted food, drinking water, or even food packaging materials. MPs have been found in seafood in a number of studies, particularly in filter feeders like mussels and oysters, whose tissues store MPs. Furthermore, common consumables like salt, honey, and even bottled water have been discovered to contain micro plastic particles [1].

MPs consumed with food may pass through the gastrointestinal (GI) tract and may be absorbed into systemic circulation through the gut wall. Studies have demonstrated that MPs smaller than 150 micrometers can potentially pass through the intestinal barrier, entering the lymphatic system and bloodstream, which raises concerns about their bioaccumulation in tissues.

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Inhalation

Micro plastics are presents in both the indoor and outdoor air. Indoor spaces are major sources of airborne micro plastics, especially those with heavy usage of plastic products (e.g., textiles, household items). These particles can lodge in the lungs and cause respiratory and systemic consequences since they are small enough to be breathed. Airborne micro plastic particles have the ability to penetrate deeply into the respiratory tract and may enter the bloodstream by alveolar transfer, according to a study by Gasperi et al [2].

Dermal Absorption

While the skin acts as an effective barrier against many external agents, dermal exposure to micro plastics is still a possibility, especially through the use of personal care products like exfoliants and scrubs that contain micro plastic beads. Although the extent of microplastic penetration through the skin remains under-researched, the potential for chemical absorption from MPs and their additives is a growing area of concern.

Impact of Micro Plastics on The Human Metabolic System

Disruption of Cellular Energy Processes

At the cellular level, microplastics have a direct impact on metabolic processes. According to studies, MPs-especially those that are nanosized-have the ability to pass through cell membranes and disrupt biological processes. MPs have the ability to cause oxidative stress once they are within cells, which leads to the generation of reactive oxygen species (ROS) that harm mitochondria and other parts of the cell [3]. Energy production may be impacted by this disturbance, which could result in a compromised metabolism.

Type 2 diabetes and insulin resistance are metabolic diseases that are intimately associated with oxidative stress. Chronic oxidative stress impairs cells' ability to use glucose, which may ultimately result in systemic metabolic deregulation.

Gut Micro biota Alteration

The regulation of metabolism and general health is greatly influenced by the gut microbiota. According to recent studies, MPs have the ability to disrupt the gut microbiota, which may result in symbiosis. Ingestion of MPs can increase the diversity of hazardous bacteria species while decreasing the diversity of beneficial gut bacteria, according to studies conducted in animal models. Because gut bacteria have an impact on energy collection and fat storage, gut dysbiosis is linked to a number of metabolic disorders, including diabetes and obesity.

Micro Plastics and Endocrine Disruption

Micro plastics as Vectors for Endocrine-Disrupting Chemicals (EDCs)

One of the most significant concerns about MPs is their role as carriers of endocrine-disrupting chemicals (EDCs). MPs are known to absorb environmental pollutants, such as pesticides, heavy metals, and persistent organic pollutants (POPs), due to their hydrophobic nature. These chemicals, when released into human tissues, can interfere with hormone signaling pathways [4].

Common plastic additives like bisphenol A (BPA), phthalates, and flame retardants are known EDCs that disrupt the endocrine system by mimicking or blocking natural hormones. For instance, BPA can bind to estrogen receptors, triggering estrogen-like effects that can lead to hormonal imbalances, which are linked to metabolic disorders such as obesity and insulin resistance [5].

Thyroid Function and Hormonal Imbalance

The thyroid gland regulates metabolism by producing thyroid hormones, which are essential for maintaining energy balance. Exposure to EDCs associated with MPs, such as phthalates and polychlorinated biphenyls (PCBs), has been linked to altered thyroid hormone levels, leading to metabolic dysfunctions like hypothyroidism or hyperthyroidism.

Additionally, MPs may disrupt the hypothalamic-pituitary-gonadal (HPG) axis, which regulates reproductive hormones. Disruption of this axis can result in fertility issues, developmental problems, and even increased susceptibility to hormone-related cancers.

Long-Term Health Impacts

Obesity and Metabolic Syndrome

Given their potential to alter energy balance, disrupt mitochondrial function, and carry EDCs, MPs could contribute to the growing prevalence of obesity and metabolic syndrome. Obesity is characterized by excess fat accumulation, often driven by hormonal imbalances and metabolic inefficiencies. MPs may exacerbate this by promoting oxidative stress, disrupting gut micro biota, and delivering chemicals that impair glucose metabolism.

A study by Zhang et al. demonstrated that mice exposed to MPs exhibited increased weight gain, fat accumulation, and insulin resistance. These findings, while preliminary, suggest that chronic exposure to MPs could lead to similar metabolic outcomes in humans.

Reproductive Health

The reproductive system is particularly sensitive to hormonal disruptions caused by EDCs. Research indicates that exposure to MPs and the chemicals they carry could result in reproductive health issues, such as decreased fertility, altered puberty timing, and increased risks of reproductive cancers [6]. The ability of MPs to bioaccumulation and persist in the body raises concerns about the long-term effects on future generations [7,8].

Conclusion

Micro plastics have the ability to interfere with metabolic and endocrine processes, making them a major environmental and public health problem. Because MPs are found in food, water, air, and the environment, human exposure to them is unavoidable. Their capacity to bioaccumulate and disrupt vital biological functions emphasizes the urgent need for studies on their long-term effects on health.

MPs have been connected to metabolic diseases like obesity, diabetes, and problems with reproductive health because they can increase oxidative stress, change gut flora, and act as transporters for substances that disrupt hormones. The preliminary evidence suggests that broad regulatory action is necessary to restrict exposure to MPs and diminish their prevalence in the environment, even though the current body of research is still in its early stages of development.

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