CHAPTER 09

Human Health and Microplastics: An Emerging Concern

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SUMMARY

Microplastics (MPs) contamination has become a significant global concern owing to its considerable impact on the natural ecosystem as well as human health. These microparticles originate from a wide range of sources incorporating personal care products, the rundown of bigger plastic items, soups, bags, and bottles as well as incineration of all kinds of plastic products or materials. In addition to this, MPs have been found in drinking water sources, food items and even in the air we breathe, making them a ubiquitous threat. The hazardous impacts of MPs on marine as well as other ecosystems are notable. The intake of MPs by wildlife and humans can lead to physical injuries, and bioaccumulation of harmful substances, resulting in severe toxicological responses in the body. Furthermore, MPs have been found to contain hazardous chemicals such as polybrominated diphenyl ethers which possess the capability to penetrate the environment and potentially induce endocrine disruption, reproductive issues as well as cancer. The World Health Organization (WHO) has recognized MPs as an emerging concern, and it is working to evaluate the considerable health hazards correlated with exposure to MPs particles from the environment. Therefore, in this chapter, we will examine the relationship between microplastics and human health.

INTRODUCTION

The presence of plastic material in fresh as well as marine ecosystem comes out as a global threat (Browne et al., 2011). These plastic materials entered the environment via different routes such as by the fragmentation of large plastic polymers and through various other gateways such as polishing, cutting, biting as well as rubbing. Plastic particles having less than 5 mm in diameter are designated as microplastics (MPs). Similarly, further breakdown of these MPs converts them into smaller sizes (nanoparticles) (Lambert & Wagner, 2016). The use of plastic products has caused an immense generation of plastic waste. Between 1950 and 2015, a total of 6300 million tons of plastic waste was manufactured globally. It is predicted that the production of microplastics will be doubled in the coming 20 years (Geyer et al., 2017). Due to lightweight, low cost, waterproof and recycling properties of plastics, their mass-production has been growing at threshold level due to their use in packaging, industry, electronic and electrical devices, medical treatment, construction, and building (Zhang et al., 2020a; Chae & An, 2018).

Nowadays plastics are accumulated in substantial amounts in the terrestrial and aquatic environment due to their durability, massive use, and improper dumping (Rillig, 2012). These accumulated plastics gradually fragmented into smaller particles and tiny fibers regarded as microplastics due to deterioration, weathering, and factors mediated by microbes (Andrady, 2011; Auta et al., 2017). It is investigated that there were 93-236 thousand tons of microplastics floated on oceanic surface, which is comparable to 51 trillion MPs particles (Van et al., 2015). Microplastic entered into the human body via various routes, such as the usage of various food products, drinking water and dust inhalation (Dris et al., 2017). It has been revealed that an average of 3223 and 1063 particles of microplastics are entered per year in kids and adults respectively through dust ingestion (Dehghani et al., 2017). Inhalation of these particles <10 µm could penetrate and injure the respiratory tract (Hale, 2018).

Recent studies investigated the harmful impacts related to microplastics in marine as well as terrestrial habitats, that reveal that microplastics are ingested by organisms at different energy levels, such as fishes (Besseling et al., 2015), mammals, zooplanktons, and crustaceans, which can lead to reduced fecundity, altered oxygen intake, shortened lifespan, lower feeding capacity, reduced growth, and elevated antioxidant enzyme activity (Cole et al., 2016).

The latest studies evaluated that the MPs could build up in the human digestive system and respiratory tract from where these particles are circulated through blood stream, placenta, and follicular fluid in the female body (Table 1). Polystyrene MPs (PSMPs) are the frequently present MPs in wastewater and surface sediments (Cunha et al., 2020). It is revealed that the absorption of PSMPs (3.54±0.39 µm) caused cytotoxicity in embryonic kidney 293 (HEK293) cells in humans (Chen et

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al., 2022). Recent investigation evaluated that ingestion of PSMPs damaged the intestinal mucosa, impede intestinal barrier function, influence microbiota and metabolism which are dangerous to human as well as animal health (Huang et al., 2021).

DEFINITION AND CLASSIFICATION

Microplastics are small particles with size of 5mm or less than 5mm (Lares et al., 2018; Zhang et al., 2018).

Microplastics are divided into two groups:

1. Primary microplastics are resin pellets and microbeads that are utilized for making different self-care items such as dentifrice, face washes and shower gel (Eriksen et al., 2014; Chang, 2015; Magni et al., 2019).
2. Secondary microplastics are produced from cracking of other plastics which are used in packaging and fabric industry. Secondary microplastics are majorly found in water (Sun et al., 2019).

Primary and secondary microplastics deteriorate continually and their different characteristics are changed such as color, texture, size, crystallinity and weight. These changes may have an effect on their physical and chemical properties and hence effect on the ecosystem as well as living things (Lambert & Wagner, 2016).

Common sources of microplastics

Plastics are produced at large scale and are not deposited properly in countries, so plastics are continuously entering in the soil (Mitrano & Wohlleben, 2020). Plastic used in making bags, bottles, medicines, agglutinates and electronic products are major source of microplastics (Heller et al., 2020). Following are the primary contributors of MPs:

Industrial waste: Different factories make plastic products. Plastics which are small in size are generally used in cosmetics, cleansing products and adhesives (Kalčíková et al., 2017). The fabric industry is also a major source of microplastics. During the production and washing of clothes, huge amount of Polyethylene Terephthalate, polyamide and many other synthetic fibers are released (Browne et al., 2011). Moreover, synthetic materials used in making tires, paints and building materials represent a major origin of microplastics (Galafassi et al., 2019).

Household waste: The major source of microplastics in water runoff come from laundering of household fabrics (Zambrano et al., 2019), along with generation from self-care items. Such as, polyethylene microplastics having diameter of 70 to 400 micrometers are included in self-care items, and 95000 small structures are released during one use of scrubs (Napper et al., 2015). The microplastics particles and filaments are the major types of indoor particulate deposition. Microplastics in air of houses have different sources such as materials used in clothes, ornaments as well as furniture (e.g. upholstered sofas, stuffed toys, floor coverings, drapes) (Cui et al., 2022).

Agricultural waste: In agricultural land microplastics are added due to: agricultural plastic sheets (Zhang et al., 2019), contaminated water for irrigation (Xia et al., 2020), particulate settling and rainfall (Can-Güven, 2021), synthetic fertilizers, organic matter, organic residuals and muck (Zhang et al., 2020; Ji et al., 2021). Our ecosystem is exposed to microplastics through wind and water discarding systems. Moreover, agricultural plastic sheets are often deteriorated due to oxidation and sun damage and converted into smaller particles, therefore causing the aggregation of microplastics in the agricultural lands (Huang et al., 2020). Furthermore, fishing equipments used in the fisheries generate a wide range of microplastics (Petersen & Hubbart, 2021).

Different types and sizes of microplastics

There are various kinds of microplastics in the environment such as, polyethylene, polyvinyl chloride, polystyrene, polypropylene, and polyethylene terephthalate (Esterhuizen & Kim, 2022). There are various shapes of microplastics such as beads, films, microfibrils, fibers, pellets, foams, and granules (Khalid et al., 2020). Films and fibers have deformed shapes and they are produced from

Table 1. Concentration of MPs in human consumables

Sources	Concentration of MPs	Description	References
Diet		Food products reported to contain MPs include bivalves, crustaceans, fish, seaweed and salt	Cox et al., 2019
Seafood	1.48 MPs/g		
Salt	0.11 MPs/g		
Drinking water		The authors suggested that avoiding the consumption of plastic bottled water might effectively reduce exposure to MPs. The calculated exposure dose from bottled water was 22-fold higher than that from tap water.	Cox et al., 2019
Bottled water	90,000 MPs/year		
Tap water	4000 particles/year		
Indoor/outdoor air and dust	26-130 partic4les/day	With their small size and low density, MPs can be suspended and transported by air, and airborne MPs are directly inhaled by humans.	Prata, 2018
Human specimens			Zhang et al., 2019; Ragusa et al., 2021
Human feces	20 MPs per 10 g of stool		
	12 fragments in 4 placentas		
Placenta	Cat: <2,300-340,000 ng/g dw		
Pet feces	(48)		
	Dog: 7,700-190,000 ng/g dw		

deterioration of different origins including discards, building materials, cleaning products and plastic sheets which are used in the greenhouse (Sharma et al., 2021).

There are following classification of microplastics: 1) large microplastics ranging from 5mm to 1mm. 2) small microplastics in size range of 1 mm to 1 µm. 3) nano plastics having size <1 µm [Crawford & Quinn, 2017 (Fig 1)].

ENVIRONMENTAL DISTRIBUTION AND PATHWAYS OF EXPOSURE

Microplastics are widely distributed in the ecosystem, including the atmosphere, potable water, sewage, ocean, packaged water, running water and eatables. Due to poor degradation in the environment and restricted retrieval of microplastics, they are continuously adding in the terrestrial and marine environments (Chae & An, 2018; Kawecki & Nowack, 2019; Lebreton et al., 2017). The recent studies have shown the spreading and ecological behavior of microplastics in land and water systems (Eerkes-Medrano et al., 2015; Free et al., 2014; Rochman, 2018). Microplastics have many environmental hazards and they are cycling in the food chains causing serious risks to well-being of humans and other organisms (Wright & Kelly, 2017; Barboza et al., 2018).

Under varying ecological situations, the different exposure routes of microplastics are through nose, mouth and skin. Humans are mostly exposed to microplastics through ingestion (Galloway, 2015). A person may intake 39,000–52,000 particles of microplastics through food in a year. Furthermore, Catarino et al. (2018) demonstrated that filth-covered plates is more significant as compared to microplastic particles pre-existing in the edibles. The use of plastic food containers is increased nowadays, and become a source of microplastics (He et al., 2021; Du et al., 2020).

A person may inhale 26 to 130 air suspended microplastics per day (Prata, 2018). A male with normal activity may inhale approximately 272 microplastics in a single day (Vianello et al., 2019). The large surface area of these tiny granules may release chemotactic factors that stop the transfer of macrophages in the respiratory system and this may cause persistent inflammation known as particulate burden (Donaldson et al., 2000). It has been demonstrated that microplastics having a size less than 5.5 µm and those having size of 8.12–16.8 µm are found in the human lungs and their

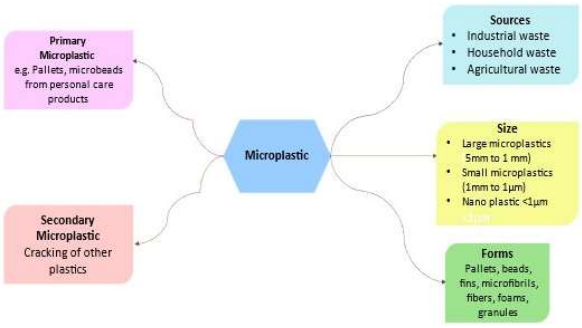


Fig 1. Different types of microplastics and their sources

major components are PE and PP (Amato-Lourenço et al., 2021).

There are fewer chances of exposure of microplastics through dermal contact, but it has been investigated that nanoplastics can pass through the skin (Revel et al., 2018). Human epithelial cells may face oxidative stress due to exposure of microplastics and nanoplastics (Schirinzi et al., 2017). Facial creams and cleansers (Hernandez et al., 2017), mobile covers (Li et al., 2023), skin contact through the ground and typical plastic additives are the routes of microplastics through the skin (Wu et al., 2022).

MICROPLASTICS IN THE HUMAN BODY

Overview of how microplastics can enter the human body

Plastics have been implemented in various human health products in a number of ways such as by increasing the safety of food and manufacturing of surgical instruments. They may have adverse impacts on the ecosystem and health if they are not managed properly like drainage blockage and the spread of diseases (Pullin & Knight, 2005). Nearly 250,000 tons of plastic components are being floated in water resources due to poor management of waste (Eriksen et al., 2014). According to an estimate, in 2010 about 4.8-12.7 mm tons of plastic were released into oceans by coastal countries (Jambeck et al., 2015).

In accordance with a study, humans ingest millions to several milligrams of microplastics (MPs) particles each year and every day respectively. The main routes of MPs exposure are breathing in the ecosystem and consuming water in plastic-bottles (Kannan & Vimalkumar, 2021). The major sources of MPs exposure were believed to be pathogenic water and food. In a study, it was found that each year a person ingests 74,000–121,000 products that contain microplastics via food, water and dust (Cox et al., 2019). MPs' existence in the diet of humans is not clearly described but an infant's exposure to MP is evident from feeding bottles and medical devices. A clear indication of MP exposure in newborns and in babies is given by placental, fetal and fecal biological monitoring of humans. According to reports, evaluations of MP exposure yearly established on mass (or weight) were to be 15-287g per person (Senathirajah et al., 2021).

Evidence of microplastics found in various tissues and organs

Across the world, MPs have been present in various species of fresh and marine water (Rochman et al., 2015). It is investigated through many scientific studies that MPs have been consumed by a number of organisms of tropical levels (Cole et al., 2013). Through an investigation, it was analyzed that MPs mostly utilized by the fishes (Wesch et al., 2016). MPs have been identified in more than 150 species of fish from nearly all kinds of habitats (Jabeen et al., 2017). The primary way of MPs accumulation in fish is ingestion (Vandermeersch et al., 2015). MPs are going to be settled in the gastrointestinal tract after consumption and then excreted eventually (Rummel et al., 2016). The physical impairment following intake of MPs

includes abrasions on the inside or outside, ulcers and digestive tract blockages (Wright et al., 2013). However, certain chemicals might be deposited in tissues and exposed internally. It has been demonstrated through a number of studies that MPs are present in muscles and liver (Akhbarizadeh et al., 2018). It is examined that inside the fish muscle, up to 5mm MPs is concentrated and within the liver is plastic film. MPs collected in fish will cause damage to human organs as fish meat has been swallowed by humans [Lu et al., 2016 (Fig 2)].

Several studies demonstrated the presence of MPs in a variety of tissues and organs of humans including the liver, placenta, kidney and blood. Various molecular changes as well as cell growth cessation have been reported to be induced by MPs (Rahman et al., 2021). It has been elucidated that the incorporation and retention of MPs influence the liver, kidney, breast milk, placenta, heart, intestine, meconium, lung, blood and cerebrovascular fluids (La Porta et al., 2023).

Mechanisms of absorption and potential health implications

Kidney impairment associated with inflammation, oxidative stress and disintegration of lipids have been exhibited by Tang et al. (2023). Renal assessment has revealed tubular atrophy, intrusion of inflammatory cells and disintegration of the glomerulus, all of which led to impeded kidney functionality when exposed to MPs. Contact with MPs, an organic toxicant, has a detrimental effect on the cardiovascular system too. Pitt et al. (2018) have exhibited that acquaintance to MPs to the heart can lead to a reduction in heart rate. One of the dominant causes of heart failure is cardiac fibrosis, an inflammatory disorder that leads to improper accumulation of high amounts of extracellular matrix (ECM) in the myocardium (Li et al., 2018). Yang et al. (2023) have shown the existence of MPs in cardiac tissues. MPs penetrate the body generally through the gastrointestinal and respiratory systems. Findings on diseases prevalent in the workers of vinyl chloride and textile industries confirm the ingestion of airborne MPs through inhalation (Prata, 2018). Damage to the respiratory system is instigated by the perpetual inhalation of MPs. Lung inflammation, fibrosis and apoptosis were introduced by MPs in the human body. OS in the lungs has been brought by MPs which is a significant contributor to air contamination. OS and severe inflammation caused by MPs lead to apoptosis, a programmed cell death. Damage to lung tissue can be the reason for fibrosis (Cao et al., 2023). MPs could inflict injury to the reproductive system by accumulating in the reproductive organs of mammals. Endocrine disruption, lower sperm vitality and structural abnormalities of sperm and testes are the destructions due to MPs in males that have been raised by OS, autophagy, testicular cell apoptosis, inflammation, erroneous cytoskeleton and hypothalamic-pituitary-testicular axis abnormality. Granulosa programmed cell death, OS, tissue fibrosis, inflammation and hypothalamic-pituitary-ovary axis anomalies induce endocrine instability and organizational defects in the uterus and ovary in females which are the negative effects of MPs (He et al., 2023).

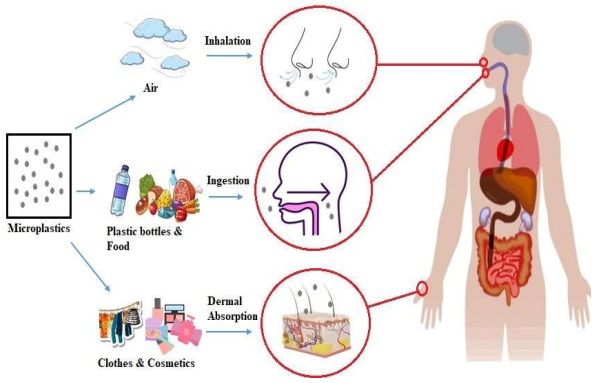


Fig 2. Main exposure routes of MPs

In the 21st century, effluence due to microplastics is the major health challenge. Recognizing the deleterious effects and significant health risks of MPs is a major difficulty due to complicated resources and more diverse occurrences (Vethaak & Legler, 2021). As a consequence of the existence of MPs in the environment, MPs could be potentially injurious to human health. General pathways of human introduction to MPs are dermal contact, oral ingestion and inhalation and oral intake is the fundamental way of contact among them (Prata et al., 2020). Everyday requirements like bottled water, tea bags, drinking water, salt, milk, seafood, sugar and so on comprise MPs (Praveena & Laohaprapanon, 2021). Generally, they are regarded as not passing through the skin, however, MPs raise risks of exposure by accruing on the skin (Prata, 2018). For instance, consumer products utilization having MPs, phone covers transfer MPs and children may come into contact with MPs while they play or crawl on the ground (Li et al., 2023).

In human cells, MPs can induce cellular destruction, genotoxicity and inflammation have been revealed through different studies (Roursgaard et al., 2022). Consuming MPs impairs the intestinal wall, which results in OS, inflammation and alterations in gut microbiota (Niu et al., 2023). Hazardous impacts on health like cancer, neurogenerative ailments and autoimmune syndromes may arise from this exposure. MPs could cause destruction to the respiratory system, and respiratory infections like asthma (Lu et al., 2022). MPs on disclosure to the skin might cause dermal irritation as well as inflammation, in addition to this further health impacts as reproductive toxicity as well as disturbance of the endocrine system might be possible (Dubey et al., 2022). MPs contain and concentrate damaging chemicals and contaminants apart from these direct health hazards (Campanale et al., 2020).

HEALTH RISKS ASSOCIATED WITH MICROPLASTICS

Microplastics are linked with several adverse effects on human health as numerous investigations indicate that microplastic exposure can lead to cellular damage (Palaniappan et al., 2022), inflammation (Caputi et al., 2022) as well as genotoxicity in humans (Roursgaard et al., 2022). These detrimental impacts are mostly dependent on the amount of exposure as well as individual's susceptibility (Prata et al., 2020). Furthermore, studies demonstrated that

exposure to MPs can lead to oxidative stress (Schirinzi et al., 2017), cytotoxicity (Anbumani & Kakkar, 2018) along with translocation to other tissues (Fiorentino et al., 2015). MPs can accumulate in the ecosystem as well as living organisms for extended periods. Therefore, prolonged exposure to MPs can cause chronic irritation which may result in inflammation, cellular changes, necrosis as well as damage to leukocytes (Smith et al., 2018). Additionally, MPs can also serve a function of carriers for several pathogens (Kirstein et al., 2016) and are able to absorb chemicals from the surroundings as well as release both organic and inorganic chemicals from their matrixes (Crawford & Quinn, 2017).

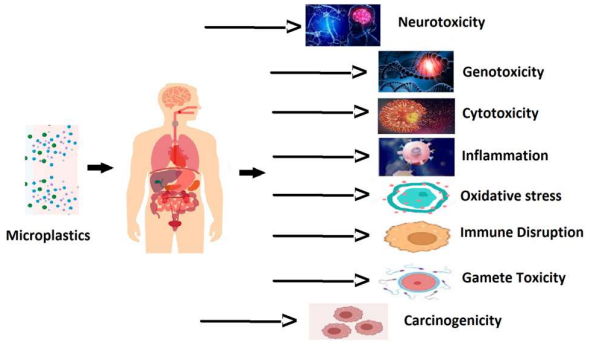
Health impacts of ingested and inhaled microplastics

Ingestion is considered as one of the primary pathways through which humans are exposed to microplastics (Prata et al., 2020). According to an estimate, humans ingest approximately 39,000-52,000 particles of microplastics annually through consuming food and drink (Cox et al., 2019). The ingestion of microplastics is affiliated with numerous detrimental impacts on human health involving digestive disorders, endocrine disruption and toxicity. Exposure to microplastics has raised concerns regarding significant gastrointestinal issues. Studies demonstrate that ingestion of microplastic particles can cause various kinds of gastrointestinal problems (Zhao et al., 2023) which may involve irritable bowel syndrome, constipation, changes in intestinal microbe, modifications in gut permeability as well as inflammation of the digestive system (Qiao et al., 2019). Furthermore, microplastics tend to build up in alimentary tract, thereby causing obstructions and irritations (Wright & Kelly, 2017). Additionally, exposure to microplastics can damage the symbiotic interaction among hosts and their intestinal microbiota which can result in a condition termed as dysbiosis. Dysbiosis can negatively impact the host's immune responses, ultimately giving rise to chronic disorders, enhanced susceptibility to diseases together with alterations in genetic capabilities and expression of the intestinal microbes (Deng et al., 2020).

Inhalation of microplastics has been associated with respiratory and cardiovascular issues as well as other health impacts. An individual typically inhales between 26 and 130 particles MPs particles daily. The intake of MPs via inhalation poses threats to humans by inducing chemical toxicity, inflammation as well as transported microorganisms (Prata, 2018). Taking into consideration the effects on the respiratory system, microplastics have a tendency to cause oxidative stress in the respiratory tract, bringing about inflammation as well as injury, leading to respiratory problems including sneezing, coughing as well as difficulty in breathing. Moreover, it may result in tiredness as well as vertiginous, owing to the reduced oxygen levels (Wright & Kelly, 2017). People working in industries involved in producing or consuming plastic products are more susceptible to health issues ascribed to microplastics. Microplastics can also serve a function of carriers for various environmental blood contaminants including polystyrene (PS) and contact with these toxins at high concentrations leads to hazardous effects on human pulmonary cells, ultimately elevating the likelihood of chronic pulmonary obstructive disease (Dong et al., 2020). Study demonstrates that exposure to microplastics can cause the onset or exacerbation of cardiovascular diseases such as atherosclerosis, hypertension as well as heart rhythm disorders (Persiani et al., 2023; Zhao et al., 2021). As these tiny particles have ability to induce oxidative stress (Fig 3), inflammation and also disrupt the normal cardiac function, therefore, risk of encountering cardiovascular diseases is increased (Prata, 2018).

Potential toxicity of microplastics and their chemical additives:

Plastic additives, which are used to enhance the qualities like color and performance, can be toxic. While they amend the qualities of plastic products, almost all are hazardous as well as possess a high risk of contaminating soil, water and air. Documentation exists in favor of the toxicity, carcinogenicity and mutagenicity caused by additives such as plasticizers and dyes (Gasperi et al., 2018). Phthalates, Bisphenol A (BPA) along with certain brominated flame retardants which are commonly utilized in domestic items as well as food packaging, have been identified to disrupt the hormonal balance and the presence of these endocrine disruptors can have detrimental effects on human health (Pironti et al., 2021). Endocrine-disrupting chemicals (EDCs) are the compounds that come from the external sources and have hormonal activity that disrupts the body's hormone balance (Miyagawa et al., 2021). EDCs have been associated with a wide range of conditions and illnesses which include endocrine tumors (breast, testes, prostate), reproductive issues (infertility, genital abnormalities), metabolic diseases (obesity, diabetes), asthma as well as neurodevelopmental disorders (learning disorders). BPA has gained a significant attention due to its ability to interfere with hormones in the human body. Phthalates, commonly used as plasticizers, have been associated with the onset of allergies asthma, particularly in infants (Ait Bamai et al., 2014). Moreover, it was found that exposure to phthalates has a biological impact during pregnancy and may shorten the pregnancy duration. It has been demonstrated that brominated flame retardants are persisting organic pollutants (POPs). According to the European community's risk evaluation, these chemicals are considered to be poisonous, may lead to cancer as well as significantly affect the hormonal balance (endocrine disruptor).



Fpig 3. Potential health impacts of Microplastics on human body

Role in inflammatory responses, oxidative stress and immune reactions

Oxidative stress, following inflammation as well as cytotoxicity was considered the primary mechanism associated with potential toxicity of microplastics (Valavanidis et al., 2013). Reactive oxygen species (ROS) are produced as byproduct of polymerization as well as processing of microplastics. It has been found that in vitro exposure to microplastics at levels ranging from 0.05–10 mg per liter elevated the concentrations of ROS, resulting in cytotoxic effects in human brain cells together with epithelial cells (Schirinzi et al., 2017). Thus, exposure to microplastics can induce oxidative stress as well as cytotoxicity in humans. Nevertheless, in various in vitro investigations, no detrimental effects were observed even at increased concentrations (Hesler et al., 2019; Wu et al., 2019).

Following exposure to MPs, it was found that they may induce immune responses, either locally or systematically, based on their distribution along with host response. Nonetheless, exposure to MPs in the environment had the potential to interfere with immunological function in genetically susceptible people, resulting in autoimmune disorders (Prata et al., 2020). The possible causes for autoimmune diseases resulting from exposure to MPs may include release of immune modulators, oxidative stress of cells as well as improper stimulation of immune cells (Farhat et al., 2011). This process may contribute to the generation of antibodies against body's own antigens. Additionally, exposure to MPs may be linked to autoimmune rheumatic disorder (Bernatsky et al., 2016). Although MPs are capable of disrupting the human immunological function, evidence is still lacking. Therefore, additional investigation is required to determine the impacts of microplastics on the human immune system.

Connection to chronic diseases and conditions

The human central nervous system is extremely susceptible to environmental contaminants during early stages of development (Rice & Barone, 2000). When neurons are exposed to microplastics, there may be increased production of ROS, causing cellular damage as well as elevated neuroinflammation in brain (Prüst et al., 2020). It is evident that exposure to the tiny particles can result in neurotoxicity in vivo. This can occur due to the oxidative stress, activation of microglia in the brain, either by coming into direct contact with particles or by being exposed to pro-inflammatory cytokines in the blood, ultimately causing harm to neurons. Furthermore, MPs exposure might obstruct acetylcholinesterase and alter the neurotransmitter levels, potentially contributing to changes in behavior patterns. Owing to the potential neurotoxicity of PS as well as MP found in studies involving both marine and land animals, the neurotoxicity of microplastics has recently become one of the most important issues (Barboza et al., 2020; Qu & Wang, 2020).

Moreover, it has been found that interaction of humans with plastic products has been linked to cancer. However, no solid evidence has been provided. It has been reported that persistent inflammation as well as irritation by virtue of intake of MPs may cause cancer through DNA damage (Prata, 2018). As MPs have the potential to build up in different body parts, they pose various threats to human health including tumors leading to lung cancer, liver cancer as well as neurodegenerative diseases (Senathirajah et al., 2021). There is evidence suggesting that exposure to phthalates during developmental periods is linked with sexual dysfunctions in both male and female individuals. Moreover, their exposure may also contribute to progression of breast cancer (Terry et al., 2019). Thus, contact with microplastics is found to be associated with various hazardous outcomes for human health.

CONCLUSION

The occurrence of microplastics in the environment exerts a significant global threat, with severe impacts on human's health. The significant effects of MPs on human body include damage to intestinal mucosa, influence on microbiota and metabolism as well as degraded intestinal barrier function, which ultimately results in hazardous complications. National as well as multinational organizations are recognizing the large-scale impacts of MPs and are developing policies to reduce their prevalence and degradation in ecosystems, including policies for usage, recycling and reduction of MPs in terrestrial as well as aquatic environments. Further advanced research and new advancements are necessary to investigate the damaging properties of MPs and evaluate the hazardous impacts and risks on human life.

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