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Microplastic pollution-A major health problem-An update

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Abstract

Microplastics are small plastic pieces less than five millimeters long which can be harmful to ocean, aquatic and human life. Plastic is everywhere. A lot of it ends up in the ocean. Most plastics in the ocean break up into very small particles. These small plastic bits are called "microplastics. Other plastics are intentionally designed to be small. They're called microbeads and are used in many health and beauty products. Human uptake of microplastic occurs via inhalation of airborne fibers and ingestion of microplastic-contaminated foods and beverages. Contamination of food can also stem from airborne deposition and the release of microplastic particles and fibers from clothing, production lines and packaging. Additional chemicals are added to give the plastic particular characteristics. Some of these are carcinogens or endocrine disruptors such as bisphenol A and phthalates (plasticizers). Phthalates are associated with elevated blood pressure, obesity, elevated levels of triglycerides. Bisphenol A (BPA) is associated with breast, prostate, ovarian, and endometrial cancers. However, following the intake of microplastics into the human body, their fate and effects are still controversial and not well known and warrants further detailed clinical studies.

Keywords: Bisphenol A (BPA); Cancer; Dioxins; Endocrine Disruptors Microplastics; Phthalates; Plasticizers; Toxic Chemicals

1. Introduction

Microplastics (MPs) are defined by as “synthetic solid particles or polymeric matrices, with regular or irregular shape with size ranging from 1 µm to 5 mm, of either primary or secondary manufacturing origin, which are insoluble in water [1-40-125]. Microplastics are a prolific environmental contaminant that have been evidenced in human tissues [1-40].

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Human uptake of microplastics occurs via inhalation of airborne fibers and ingestion of microplastic-contaminated foods and beverages [1-50]. A key concern of microplastics pollution is whether they represent a risk to ecosystems and human health. However, there is much uncertainty associated with this issue [1-80]. Data on the exposure and effect levels of microplastics are therefore, required to evaluate the risk of microplastics to environments and human health [1-80-125]. The adverse effects on organisms that are exposed to microplastics can be separated into two categories: physical effects and chemical effects [40-85]. The former is related to the particle size, shape, and concentration of microplastics, and the latter is related to hazardous chemicals that are associated with microplastics [1-40]. Though data on microplastic exposure levels in environments and organisms have rapidly increased in recent decades, limited information is available on the chemicals that are associated with microplastics [1-40]. Now a days, microplastic particles have been ubiquitously detected in a broad range of shapes, polymers, sizes and concentrations in the environments of marine water, freshwater, agroecosystems, atmosphere, food, drinking-water, biota, and other remote locations [1-85-125]. Plastic and PTFE-coated cookware and food contact materials may release micro- and nanoplastics into food during food preparation [78]. Plastics are chemically stable compounds, comprised of a diverse suite of polymers, chemicals and additives used in a variety of industrial commercial and domestic products [78-125].

Microplastics come from a variety of sources, including from larger plastic debris that degrades into smaller and smaller pieces [1-60-125]. In addition, microbeads, a type of microplastic, are very tiny pieces of manufactured polyethylene plastic that are added as exfoliants to health and beauty products, such as some cleansers and toothpastes [1-60-125]. These tiny particles easily pass through water filtration systems and end up in the ocean and Great Lakes, posing a potential threat to aquatic life. Of growing societal concern is the risk microplastics pose to human health [1-60-125]. To date, microplastics have been found in the gastro-intestinal tract, lung tissues, blood and the placenta of humans. Intake can occur via inhalation of airborne microplastics, or ingestion of contaminated food and liquids [1-78-125]. Microplastics have been widely evidenced in fresh and bottled drinking water, with concentrations ranging 0–10,000 microplastics L^{-1} and a range of foodstuffs, including seafood, animal-products, plant-products, beverages, table salt, sugar, honey, milk, and tea bags [1-83-125]. Prior to harvest, microplastics can be ingested, adhered or otherwise taken-up by animals and plants used in food [1-78-125]. Contamination of food can also stem from airborne deposition and the release of microplastic particles and fibers from clothing, production lines and packaging [1-40-125]. There is also growing evidence that preparing food with plastic food contact materials and cookware may also be contributing micro- and nanoplastics into prepared food [1-78]. One of the studies by Cole et al., (2024) [78] provides an estimation of the release of >10 μm microplastics from plastic cookware used to prepare food in a real-world scenario [1-78-125]. Both new and old plastic cookware were shown to release significantly greater amounts of microplastics and PTFE particles than non-plastic cookware [1-78]. The results of this study provide a warning that plastic and PTFE-coated cookware may introduce microplastics and PTFE-particles into food [1-78-125]. Based on the wider literature, the release of microplastics stem from thermal and mechanical degradation; as such, microplastic release is likely to be exacerbated if using hard or sharp utensils with plastic and PTFE-coated cookware or heating these materials at higher temperatures [1-78-125]. There is currently a paucity of high-quality data assessing the risks posed by microplastics and PTFE particles to human health [78]. In the following section, toxic chemicals and their effect on human health has been discussed and updated.

2. Microplastic: Toxic Chemical and Effects on Human Health

Microplastics can contain two types of chemicals: (i) additives and polymeric raw materials (e.g., monomers or oligomers) originating from the plastics, and (ii) chemicals absorbed from the surrounding ambience [1-78-83-125]. Additives are chemicals intentionally added during plastic production to give plastic qualities like color and transparency and to enhance the performance of plastic products to improve both the resistance to degradation by ozone, temperature, light radiation, mold, bacteria, humidity, mechanical, thermal and electrical resistance [1-78-83]. Plasticizers are complex chemical products that have low vapor pressure, are insoluble in liquids, are chemically stable, and which are inserted between molecular chains to reduce their forces of physical attraction and increase their mobility, workability or dispensability [1-78-83]. In this way, the flexibility and plasticity of a resin that is processed and the impact resistance of the product during use are increased [1-78-83-125].

Microplastics (MPs, with a particle size from 1 μm to <5 mm) are ubiquitous pollutants on earth. These emerging pollutants have been found everywhere that they have been looked for in terrestrial and in aquatic (marine and freshwater) systems, as well as in the air (atmospheric transport and deposition) [1-78-83-125]. These plastic particles are readily taken up into organisms via ingestion and respiration and are found throughout food webs [1-78-83-125]. Their effects have been studied extensively in a wide range of plants and animals; health effects ranging from genetic and biochemical up to organismal levels have been reported [1-78-83-125]. Some of their observed negative impacts (i.e., tissue injury) can be tied to physical effects caused by their shape, size, volume, density, and roughness, while other impacts are due to the toxicity of chemical additives that can leach from the plastic (e.g., bisphenol A (BPA), phthalates,

polybrominated diphenyl ethers (PBDEs), and per- and polyfluoroalkyl substances (PFASs), among other toxic substances) [1-78-83-125].

Plastics, including microplastics, have generally been regarded as harmful to organisms because of their physical characteristics [1-78-83-125]. There has recently been a call to understand and regard them as persistent, bio-accumulative, and toxic [1-78-85]. Furthermore, these chemicals can be released into tissues of animals that consume microplastics and can be responsible for the harmful effects observed on biological processes such as development, physiology, gene expression, and behavior [1-78-85-125]. In addition, microplastics that have been in the environment for a period of time get "weathered" and acquire additional chemicals adsorbed from the environment [1-78-83]. Microplastics are polymers created from monomers [1-78-83]. Additional chemicals are added to give the plastic particular characteristics. Some of these are carcinogens or endocrine disruptors such as bisphenol A and phthalates (plasticizers) [1-78-85]. Many of these chemicals have not been studied, so their toxicity is unknown [1-78-83]. Some toxic chemicals that are used in the production of microplastics include per-fluorooctanesulfonic acid (PFOS) [1-78-83-125]. **Bisphenol A (BPA)** and phthalates are known endocrine-disrupting chemicals that affect development and reproduction in humans and other species [1-78-83]. BPA and phthalates from microplastics may also induce changes in the neuroendocrine system and signaling [1-78-83-125]. Bisphenol A (BPA) can pass through the blood–brain barrier, and exposure is linked with neuropsychological dysfunction, neurobehavioral disorders, and neurodegenerative disease, as well as affecting DNA methylation, and epigenetic alterations that impact heart development and metabolism [1-78-83]. Other sources of microplastics include carpeting and personal care products [1-78-83]. Cigarette filters, made of cellulose acetate fibers (semi-synthetic plastic), are another major source of microplastics. It has been estimated that 4.5 trillion cigarette filters are littered annually, generating about 0.3 million tons of microplastics annually [1-78-83]. Toxic chemicals that are associated with cigarette filters (butts) include polycyclic aromatic hydrocarbons (PAHs) and metals [1-78-83-125]. **Phthalates** from cigarette filters have been shown to be toxic [1-78-83]. Following are the toxic chemicals of plastic preparation and affecting human health. These toxic chemicals might be leaching out when food material is heated in plastic container in microwave or exposure and inhalation of microplastic [1-78-83-125].

3. Brominated flame retardants (BFRs)

Brominated flame retardants (BFRs) are a class of chemicals used to reduce flammability in plastic products and prevent the spread of fires [1-78-83-125]. They are used in foams, polystyrenes, and epoxy resins that are used to manufacture electronic casings and wire coatings (examples include the plastic casings for computers, TVs, and home appliances), textiles, furniture foams, carpets, building materials, and are commonly found in plastic children's toys [1-78-83-125]. BFRs leach from products and are present in household dust. Small children ingest BFRs from hand to mouth behavior, and from mouthing toys made from recycled plastics that contain BFRs [1-78-83]. Processing of plastic waste is a significant source of human BFR exposure because although BFRs are controlled, the Stockholm Convention allows some BFRs in plastic materials for recycling [1-78-83-125]. Global sampling has demonstrated that the widespread presence of BFRs in plastic children's toys made from recycled plastics are available in stores throughout the world [1-78-83-125]. Brominated flame retardants (BFRs) disrupt male and female reproductive development, alter thyroid development, and affect neurodevelopment [1-78-83]. BRF exposure is associated with psychomotor and attention-related IQ performance in children [1-78-83-125].

4. UV stabilizers

UV stabilizers are chemical additives used to protect plastic building materials, automotive parts, waxes, and paints from deterioration due to UV radiation [1-78-83-125]. Several UV stabilizers are on the Candidate List of Substances of Very High Concern by the European Chemicals Agency (ECHA) because of their persistent, bio-accumulative, and toxic nature [1-78-83]. The Swiss government has recently submitted a proposal to the Stockholm Convention to list UV-328, for listing as a Persistent Organic Pollutant under provisions of the Stockholm Convention [1-78-83]. UV stabilizers can leach from food packaging materials into our food. The chemicals also have been found in house dust. Several studies demonstrated that UV stabilizers disrupt endocrine function, impeding normal development and inducing estrogenic effects [1-78-83-125].

5. Dioxins

Dioxins, considered the world's most toxic substances, are byproducts of industrial and combustion processes [1-78-83-125]. Dioxins occur in the production of plastic products with BFRs. When plastics with BFRs are incinerated or heated in a recycling process to be re-molded into new products. There is no safe level of dioxin exposure [1-78-83-125]. They are fat soluble, bind to soils, and can accumulate in animal and human fatty tissues. Dioxin exposures affect

brain development, disrupt thyroid and immune system functions, and are associated with increased risk of multiple cancers, and immune system damage. Dioxin exposures can occur through oral, dermal and inhalation routes [1-78-83-125]. Children mouthing toys made of recycled plastic that derives from e-waste are at risk of dangerous health effects from the toxic material. Dioxin contamination of local food chains has been documented in communities where e-waste shipments are dumped and incinerated, landfills where plastic waste accumulates, and where plastic waste is incinerated for fuel at levels that are comparable to dioxin hotspots [1-78-83-125].

6. Phthalates

Phthalates are chemical additives widely used to produce or promote flexibility and to reduce brittleness in plastics [1-78-83-125]. Phthalates are used as plasticizers in PVC consumer, medical, and building products, as matrices and solvents in personal care products, and as fillers in medications and dietary supplements, food and beverage packaging, and children's toys [1-78-83-125]. The phthalate DEHP is common in medical devices such as plastic tubing. Some phthalates are restricted in the European Union and are classified as substances of very high concern [1-78-83-125]. Daily human exposures via oral ingestion, inhalation, and skin contact are common. Phthalates frequently leach from items such as food packaging, cosmetics, body care products, and toys into the environment and into products that humans use and consume. The most common routes of exposure are via oral ingestion from food packaging and the use of cosmetic products, but high levels of phthalates are also present in household dust [1-78-83-125]. They are metabolized quickly and are present in 90-100% of amniotic fluid samples from second-trimester fetuses, cord blood samples from newborns, breast milk from nursing mothers, and even in human ovarian follicular fluid [1-78-83-125]. Phthalates reduce testosterone and estrogen levels, block thyroid hormone action, and have been identified as reproductive toxicants [1-78-83-125]. Decreased pregnancy and high miscarriage rates, anemia, toxemia, pre-eclampsia, early menopause, and abnormal sex steroid hormone levels are associated with phthalates. Phthalate exposures are not only associated with reduced fertility but can affect fertility across multiple generations [1-78-83-125]. Developmental exposure to phthalates affects gene expression, and perinatal phthalate exposure affects asocial behaviors [1-78-83]. Phthalate exposure increases the risk of insulin resistance and has been persistently linked to diabetes. Phthalates are associated with elevated blood pressure, obesity, elevated levels of triglycerides [1-78-83-125].

7. Alkylphenols

Commonly used in latex paints, pesticides, industrial cleaners, detergents, personal care products, and many different kinds of plastics as UV stabilizers, alkylphenols are used to spread substances like paints and coatings over surfaces [1-78-83-125]. Alkylphenols are used in numerous applications that contribute to human exposures, including cleaners and degreasers, adhesives, emulsifiers, cosmetics, and personal care products, paints, and dust control agents [1-78-83-125]. Some alkylphenols are approved for use as indirect food contact substances, and others are used as heat stabilizers for PVC in water pipes and flooring [1-78-83]. These chemicals mimic estrogen and disrupt reproductive systems. Alkylphenols are linked to male infertility, low sperm count, and disrupted prostate development. Studies have shown occupational exposures is associated with heightened risk of male and female breast cancers [1-78-83-125].

8. Bisphenols (bisphenol A -BPA)

Bisphenols, such as bisphenol A (BPA), are used as chemical building blocks in polycarbonate plastics and epoxy resins and are used in reusable food and beverage containers, re-usable water bottles, the linings of food cans, medical and sports equipment, eyeglass lenses, thermal paper receipts, and plastic water pipes [1-78-83-125]. BPA leaches from landfills to contaminate wastewater, groundwater, and freshwater, and has been found around the world in beach sand from plastic marine waste. BPA, listed as a substance of very high concern by the European Union, and has been demonstrated to be toxic by hundreds of chemicals studies [1-78-83-125]. Many countries have moved to ban PBA from baby bottles, but there is strong evidence that replacement chemicals exhibit the same health impacts [1-78-83]. A large body of evidence confirms that BPA can affect brain development and behavior. Exposure can increase anxiety, depression, hyperactivity, inattention, behavioral problem, and is also associated with adverse reproductive outcomes affecting cell division in eggs [1-78-83-125]. BPA is associated with Polycystic Ovary Syndrome (PCOS)—a complex hormonal condition associated with irregular menstrual cycles, reduced fertility, and increased risk of diabetes. In men, BPA affects fertility and is associated with sexual dysfunction among men exposed to high occupational levels. BPA is associated with breast, prostate, ovarian, and endometrial cancers [1-78-83-125].

9. Perfluorinated chemicals

Perfluorinated chemicals are widely used in water and stain-resistant clothing, food contact wrappers, lubricants, carpet treatments, paints, cookware, and as a dispersant in firefighting foams, as well as other industrial and consumer applications [1-78-83-125]. PFAS and PFOA are listed under the Stockholm Convention on Persistent Organic

Pollutants, and PFHxS, used as a substitute, has been recommended for listing by the convention's technical experts[1-78-83-125]. Perfluorinated chemicals are used to make fluoropolymers for plastics. PFAS chemicals contaminate local water sources. The use of PFAS chemicals in industry and firefighting foam used in airports and military bases are sources of pervasive drinking water and groundwater contamination throughout the world. Most people are exposed to PFAS from drinking tap water [1-78-83-125]. PFAS also leaches into local water systems from PFAS containing waste in landfills. In addition, PFAS leaches from wrappers and cookware into our food [1-78-83-125]. PFAS are metabolism disrupting chemicals affecting the immune systems, liver, and thyroid function. They alter puberty, raise breast cancer risk, and are associated with kidney, testicular, prostate, and ovarian cancers, and non-Hodgkin's lymphoma [1-78-83-125].

The intake of microplastics by humans is quite evident. According to the literature survey by Campanale et al., (2020) [79], the entry point may be through ingestion (through contaminated food or via trophic transfer), through inhalation, or through skin contact [1-78-83-125]. Following the intake of microplastics into the human body, their fate and effects are still controversial and not well known [79-125]. Only microplastics smaller than 20 μm should be able to penetrate organs, and those with a size of about 10 μm should be able to access all organs, cross cell membranes, cross the blood–brain barrier, and enter the placenta, assuming that a distribution of particles in secondary tissues, such as the liver, muscles, and the brain is possible [79]. Not enough information is available to fully understand the implications of microplastics for human health [1-79-83]. However, effects may potentially be due to their physical properties (size, shape, and length), chemical properties (presence of additives and polymer type), concentration, or microbial biofilm growth [1-79-83-125]. How toxic chemicals adsorb/desorb onto/from microplastics is not well known, but plausible mechanisms include hydrophobic interactions, pH variations, the ageing of particles, and polymer composition [79-125]. Furthermore, not enough studies have fully explained the primary sources of pollutants that are present on microplastics and whether their origin is extrinsic from the surrounding ambient space, intrinsic from the plastic itself. Furthermore probably, from a combination of both and from a continuous and dynamic process of absorption and desorption that is related to the spread of the particles into the environment and to their consequent exposure to weathering[1-79-83-86-125].

10. Conclusion

On the basis of literature survey, it is reported that microplastics (1) contain toxic chemicals, including bisphenols and phthalates that are carcinogens or endocrine disruptors. Microplastics can adsorb additional chemicals from the aquatic environment, including metals, PAHs, chlorinated pesticides, and industrial chemicals such as PCBs. Studies have also demonstrated that these chemicals can be transferred to exposed organisms and chemicals from plastics can cause toxic effects. A large body of evidence confirms that bisphenol A (BPA) can affect brain development and behavior. Exposure can increase anxiety, depression, hyperactivity, inattention, behavioral problem, and is also associated with adverse reproductive outcomes affecting cell division in eggs. Alkylphenols are linked to male infertility, low sperm count, and disrupted prostate development. Decreased pregnancy and high miscarriage rates, anemia, toxemia, pre-eclampsia, early menopause, and abnormal sex steroid hormone levels are associated with phthalates. Phthalate exposures are not only associated with reduced fertility but can affect fertility across multiple generations. Children mouthing toys made of recycled plastic that derives from e-waste are at risk of dangerous health effects from the toxic material. Brominated flame retardants (BFRs) are a class of chemicals used to reduce flammability in plastic products and prevent the spread of fires. Brominated flame retardants (BFRs) disrupt male and female reproductive development, alter thyroid development, and affect neurodevelopment.

Therefore, avoid drinking tea, coffee and any hot beverages in the plastic cups. Toxic chemicals of the plastic cups enter into beverages leading to cancer and other health related issues. Avoid warming food in plastic containers in microwave. This also resulted in the leakage of toxic chemicals of the plastic and ends up in the major health issues like cancer, loss of male sterility, and other health issues.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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