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Review article

The effect of plastic substances on the pituitary gland

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Abstract

Approximately 6,300 million metric tons of plastic waste were produced from 1950 to 2015. Hazardous chemicals, like styrene monomers, could be found in plastics produced throughout recycling. Water, food, and the environment are all susceptible to such chemicals' leaching. Today's environment is largely made up of microplastics (MPs), which could magnify, adsorb, and spread contaminants like PCBs as well as include hazardous chemicals as part of the plastic. Since various chemicals that leach from plastics are EDCs, hazardous chemicals in plastics are a matter of concern. Those EDCs include phthalates, metals, brominated flame retardants, alkylphenol ethoxylates, bisphenols, perfluorinated compounds, and UV stabilizers. It is concerning that such EDCs are leaching from plastics because research has indicated that they can lead to abnormalities in immune, thyroid, metabolic, neurological, and reproductive functions. To safeguard the environment and public health from potentially dangerous EDCs in plastics, more work is still required, various compounds have not yet been studied for EDC activity and possible health effects. Study's objective: Our review aims to increase public awareness of the risks associated with plastic use because, along with their obvious effects on one of the most vital systems of the body, which is the endocrine system, including the pituitary gland which is regarded as the master regarding all endocrine glands and is responsible for the function of all other glands in the body plastic materials also represent a threat to the environmental pollution and, consequently, human health. Our study encourages the recycling and use of plastic materials.

Keywords: Pituitary gland, Plastic, Endocrine system

Abbreviations: (EDCs) endocrine disrupting chemicals, (BPA) Bisphenol A, Tetrabromobisphenol A (TBBPA), (PBDE) Polybrominated diphenyl ether (PBDE), (PCBs) polychlorinated biphenyls, (MPs) microplastic, (LHR) Luteinizing hormone receptor,

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Introduction

Nowadays, the gas and oil industry's fossil fuel feedstock is used to make the majority of plastic materials. Petrochemicals, particularly propylene and ethylene, are processed to create long polypropylene (PP) and polyethylene (PE) chains, or they can be utilized to create other plastics like polyvinyl chloride. Subsequently, chemicals are introduced to confer particular characteristics on the vast and heterogeneous class of polymeric materials known as plastics. Plastics can be categorized according to different factors, and the

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most often-used categorization system divides them into seven classes according to the monomers that make up their building blocks [1]. To help recyclers and consumers distinguish between various types of plastics, the Society of Plastics Industry produced this (see "Table 1"). [2]. Plastics, such as polycarbonate, nylon, and acrylic fall under the "other" group. Plastics based on fluorinated chemicals are known as fluoropolymers. Perfluorinated chemicals like PFOA could be broken down or leach out of fluoropolymers like PTFE [2]. For decades, the use of plastic products has grown, significantly increasing the pollution caused by plastic waste [1, 2]. Plastic waste is broken down into particles and fragments by wave action, photodegradation, UV radiation, and biodegradation [3, 4]. MPs are small polymers with diameters of less than 5 mm. Their stable chemical characteristics, difficulty in degrading, and small size have drawn attention [5, 6].

Table (1): classification system for plastic

Category	Type of plastic
1 PET	Polyethylene terephthalate (PET)
2 HDPE	High-density polyethylene (HDPE)
3 PVC	Polyvinyl chloride (PVC)
4 LDPE	Low-density Polyethylene (LDPE)
5 PP	Polypropylene (PP)
6 PS	Polystyrene (PS)
7 O	Other

MICROPLASTICS

The use, manufacture, and disposal of plastics cause MPs to be released into the environment. All plastic particles with a diameter of no more than 5mm are referred to as MPs. It must be understood that not all MPs are created equal and that such classification is merely based on size; instead, the characteristics of each form of MPs vary depending on its composition, shape, and chemical additives [3]. MPs are created purposefully, like microbeads in fibers and cosmetics in synthetic clothing that break down into MPs when washed. MPs can also arise from the natural plastic items' breakdown. MPs could find their way into the environment through a variety of channels, including washing machine runoff, artificial lawns and building materials, tire wear, building materials and nets utilized through the fishing industry, and unintentional spills of plastic granules utilized in plastic manufacture. However, they could be detected in oil, and soil, and even become airborne [3]. MPs have mostly been researched in seas and freshwater systems. In the case when sewage treatment plant sludge is utilized as fertilizer, MPs are often trapped in the sludge as well as transferred to the soil oil, where they have the potential to change the soil's oil characteristics and impact plant growth [4,5]. The different plastic materials employed in agricultural techniques are a prevalent source of MPs in soil. Even the most remote environments, such as the Arctic, the deepest Pacific Ocean trenches, and isolated mountain regions, are now home to MPs [6, 7]. Food and drinks have been the subject of several recent studies that look into the potential exposure to MPs. Over 5 trillion MPs particles, or 270,000 tons of plastic waste, are thought to have contaminated the oceans [8]. According to a recent analysis, the global plastic reservoir for buoyant MPs (those larger than 100 micrometers) is estimated to be between 12.5 and 125 trillion particles [9]. This suggests that the actual amount is substantially higher.

BIOPLASTICS

The area of bioplastics has evolved as an attempt to alleviate a few of the numerous issues associated with conventional plastics. Bio-based and bio-degradable plastics are included in the category of bioplastics [10]. Renewable plastic monomer sources have taken the role of non-renewable ones in bio-based plastics. For instance, sugar cane starch is used to make the plastic monomer ethylene in bio-PE rather than petrochemicals. The shift to plant-based sources reduces the need for petrochemicals, which is a good thing, but there are still drawbacks, including the requirement for intensive chemical processing, increased pesticide use, and deforestation. The qualities of bio-based plastics are identical to those of conventional plastics, and they also contain comparable chemical additives. Unlike ordinary plastics, bio-degradable plastics could break down water, carbon dioxide, and compost in the environment when particular conditions are met by microorganisms [10]. The term "biodegradable" is applied to plastic without any time constraints; the process can take several months, and if certain conditions aren't satisfied, bio-degradable plastics will not break down and will contaminate landfills just like the conventional types of plastic. Biodegradable plastics are generally employed in short-life applications including disposable dinnerware, food packaging, and some agricultural uses [10]. They could be made from renewable resources like crops, wood, and food waste, as well as non-renewable fossil fuels. The field of bioplastics as a whole illustrates the necessity for the plastics industry to shift toward more ecologically friendly alternatives. Yet, much more work needs to be done before we can completely address issues with recyclable materials, using pesticides, water, and land in the cultivation of plants that contain starch for the production regarding bio-based plastics, and hazardous compounds in plastics [10].

HUMAN EXPOSURE TO PLASTICS AND EDC ADDITIVES:

The exposure of humans and the environment to plastics is a worry. Every day, significant volumes of plastic waste are released into the environment, and numerous recognized EDCs leach from the plastic and into the body while using different products. EDCs known to leach from plastics include TBBPA, phthalates, BPA, and PBDE. High concentrations of phthalates, which leach from IV tubing as well as blood bags, are, for instance, exposed to patients in intensive care units [11]. Concerns exist regarding the exposure of MPs by humans. MPs could bind and accumulate hazardous chemical materials from the surrounding environment, like water, sea, and sediment (fig 1) [26]. In addition, endogenous chemical additive materials that aren't attached to MPs and could leach out of it and expose the population, are also present in MPs. Polyaromatic hydrocarbons (PAHs), pesticides, and PCBs are just a few examples of hydrophobic contaminants that MPs can easily concentrate on. Additionally, they gather dangerous metals like lead and cadmium. POPs from the environment seem to be drawn to various types of polymers in different ways. For instance, compared to PVC and PET fragments, adsorption happens more easily onto LDPE and PP plastic debris [12]. Eating shellfish is one of the main ways that people get exposed to MPs. Nine of the most widely consumed shellfish species in China were found to be polluted with MPs. MPs polluted wild and farmed mussels in Canada and Belgium. Since farmed mussels have been cultivated on polypropylene lines, it is possible that they were polluted with MPs. It is estimated that consumers of shellfish in Europe consume up to 11,000 MPs particles annually due to the contamination of shellfish with MPs [13]. Furthermore, it was discovered that bottled water contains MPs, with an estimated 40 mg/kg body weight added to human exposure each day [14]. Commercial (pelagic and benthic) species of fish from the English Channel, Baltic Sea, North Sea, Mediterranean Sea, Indo-Pacific Ocean, Adriatic Sea, and Northeastern Atlantic were reported to contain MPs [15]. MPs tainted every deep-sea fish sample taken from the South China Sea [16]. MPs have been discovered in the gastrointestinal tracts, skin, gills, muscle, and liver of Persian Gulf fish, and they were discovered in exoskeleton and, most significantly, the Persian Gulf tiger prawns' muscle [17]. MPs could be inhaled by people at home and work. PVC exposure at work could reach 0.5 particles/mL, while nylon exposure could reach 0.8 particles/mL [13].

Individuals employed in the plastic manufacturing industry are more likely to be exposed to phthalates than those in other industries, like waste management [18]. According to one study, there are 88–605 MPs particles with sizes ranging from 250–500 mm in 30 g of dry dust [19]. The research calculates that street dust could lead to 3223 adult MPs particle ingestion and 1063 children MPs particle ingestion annually, making it a significant source of MPs contamination in urban contexts. Measurable amounts of EDCs from plastics are also present in humans. For instance, research suggests that using plastic kitchen utensils exposes persons to 60 ng of flame retardants per day [20]. Additionally, it is believed that food contact materials may raise urine levels of unconjugated BPA, which range from 2-4 ng/mL [21]. The levels of phthalates in the body are also influenced by food contact products. In the United States, women are predicted to consume 41.7 mg/kg of phthalates per day, which is more than the recommended daily consumption of 37 mg/kg [22]. According to recent research, almost all analyzed urine samples from humans contain phthalate metabolites [23,24]. DEHP can be found in a variety of beverages, including wine, milk, and bottled water, where concentrations can reach up to 242, 30, and 13mg/L, respectively [25]. Commercial fish and shellfish caught all over the world were found to contain MPs. EDCs. Even though DEHP isn't used to create water bottles, it was found in a lot of water samples from bottles made of different materials, indicating contamination from manufacturing and water sources [25].

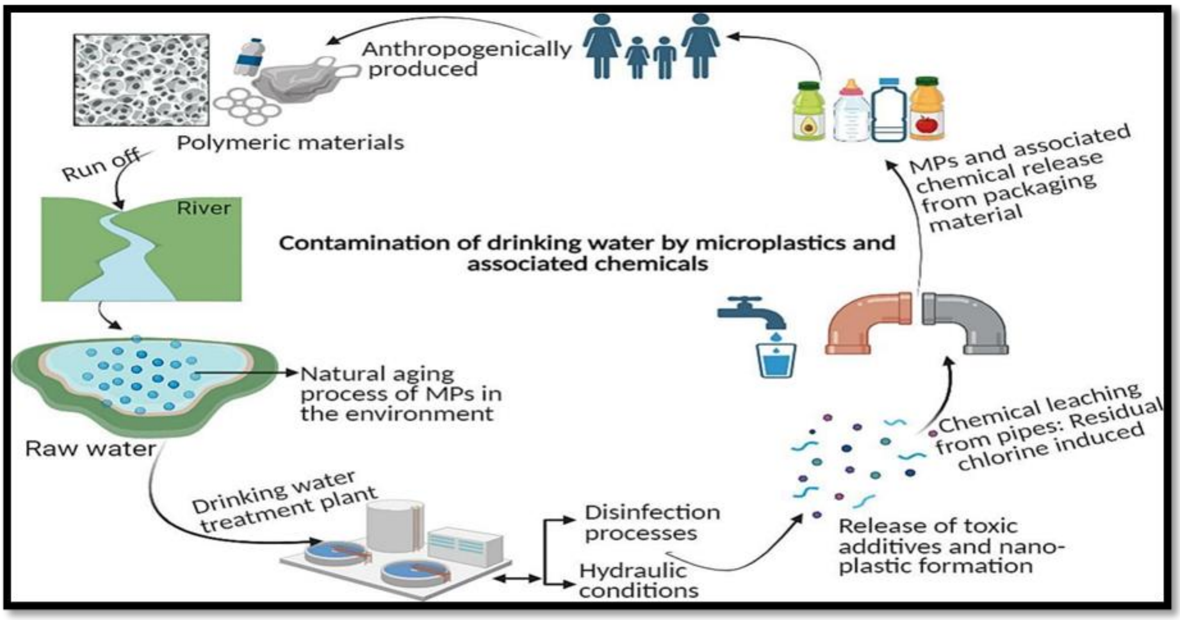

Figure (1): Contamination of drinking water by MPs and associated chemicals (26).

Effect of Microplastic on the male reproductive system:

PET, PE, PS, PP, and PVC represent the primary constituents of MPs in the environment [27, 28]. MPs have the potential to accumulate and become harmful to organisms. Furthermore, MPs pose a concern to human health since they are easily incorporated into food chains [29, 30]. As a result, MP toxicity needs to get extra consideration. MPs have been shown in earlier research to be detrimental to a variety of organs in both aquatic and mammalian species, including the brain, gastrointestinal system, kidney, and liver [31,32,33,34,35,36,37,38,39,40]. In organisms, the reproductive system is very important. MPs are reproductively harmful to a variety of aquatic species, including Daphnia, Hydra attenuate [40], Medaka fish [41], and oysters [42]. A few studies showed that after acute and brief exposure to MPs, the testis experienced oxidative damage disrupted hormone levels, and reduced sperm quality [43,44,45]. It is yet unknown, nevertheless, how harmful long-term exposure to MPs can be for mammals' reproductive systems. The anterior pituitary releases LH, which binds to the LH receptor (LHR) on the Leydig cells' membrane to raise the concentration of cAMP. Subsequently, protein kinase A (PKA) activation results in an increase in steroidogenic acute regulatory protein (StAR) and steroid synthase (P450c17, P450scc, 17β-HSD, and 3β-HSD) levels. StAR facilitates the translocation of free cholesterol from the outer membrane of mitochondria to the inner membrane of the latter. Pregnenolone is produced from cholesterol by the intima's P450scc enzyme. Pregnenolone reaches the endoplasmic reticulum in a sequential manner, where 3β-HSD, P450c17, and 17β-HSD convert it to testosterone [46]. Furthermore, prior research revealed a strong correlation between the particle size of the MPs and their toxicity in various tissues. It was demonstrated by Deng et al. [35] that exposure to 5 µm and 20 µm PSMPs caused disruptions in lipid and energy metabolism. The growth rate and fecundity were shown to decrease with treatment with 0.05µm, 0.5µm, and 6µm PS-MPs, as revealed by Jeong et al. [47]. They also noted that MP toxicity has been size-dependent, with smaller micro-beads being more harmful. In the meantime, certain research revealed that MP toxicity depended on concentration [36, 38, 48].

Chemical substances of MPs and their effect on endocrine dysfunction:

MPs that have been produced during the degradation of plastic might linger in the environment for thousands or even hundreds of years [49]. The lifespans of polystyrene foam, disposable diapers, and plastic bottles are 450, 500, and more years, respectively [goecopure. com/lifespan-of-plastic.aspx]. Up to 70% of plastics are made from plastic additives utilized in plastic processing [49]. Over 10,000 chemicals were found to be added to plastic, and 2400 chemicals were found to be harmful to both marine and terrestrial biota [51]. Those additives consist of flame retardants, UV stabilizers, plasticizers, antioxidants, and colors. Certain substances, like polybrominated diphenyl ethers [PBDEs][51], alkylphenol [52], organotins, phthalates, dioxin, perfluorinated compounds [53], bisphenol A [BPA], and heavy metals such as cadmium, lead, and chromium [54, 55], are considered to be very concerning. Endocrine and developmental disorders result from about 1,000 chemicals categorized as EDCs (i.e., endocrine disruptor chemicals), which change the expression of different hormone receptors and obstruct the synthesis, transport, secretion, and actions of the hormones [55, 56]. Human feces from various nations have been found to contain nearly nine distinct types of MPs, indicating their existence in the human food chain and alerting them to their detrimental impact on the health of humans [57]. The hypothalamic-pituitary-thyroid (HPT), hypothalamic-pituitary-adrenal (HPA), and hypothalamic-pituitary-gonadal (HPG; Figure 2) axes are just a few of the hypothalamic axes that could be disrupted by MPs and their composite toxic additives because they could cross a variety of biological membranes, hormone receptors, and blood-brain barriers. With the use of mice and rats as model species, several metabolic diseases, gut dysbiosis, and intestinal barrier dysfunction brought on by the MPs were investigated. Comparably, rats exposed to MPs directly experienced metabolic stress, altered thyroid function, and neurobehavioral alterations [58,59,60,61,62].

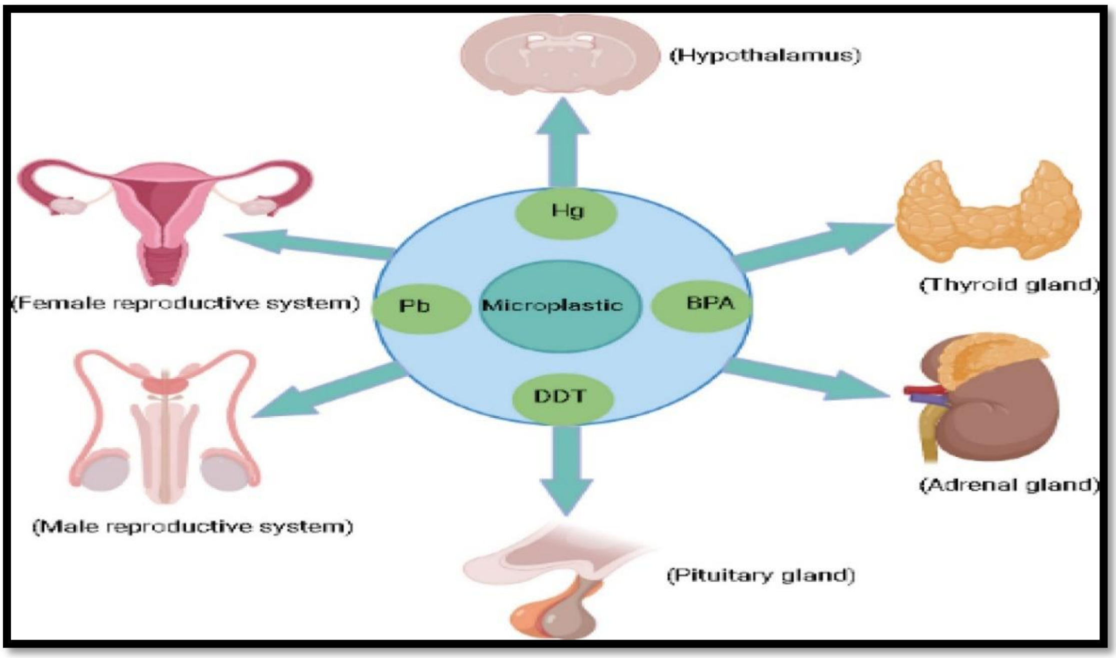

Figure (2): Microplastics and their related chemical exposure can have an impact on the endocrine glands (55,58,59,60,61,62)

Conclusion

The presented work concludes that, despite the topic being rarely documented, ingested MPs bioaccumulate in the tissues and organs of mammals with detrimental results that include reproductive toxicity, endocrine abnormalities, gut microbiota dysbiosis, and impaired immune responses in rats, mice, and rodents. This indicates that the toxicity of the endocrine that is induced by MPs represents one of the emerging issues. Regulations that limit exposure to these tiny plastic particles must be based on research into the possible risks posed by NPs and MPs.

Conflicts of Interest:

The authors declare no conflict of interest.

Fund:

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