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Microplastics as an emerging threat to human reproductive health: From environmental contamination to systemic biological risk

Maryam Khashij[1], Edris Bazrafshan*[1]

[1] Health Sciences Research Center, Torbat Heidariyeh University of Medical Sciences, Torbat Heidariyeh, Iran

***Corresponding Author Email: bazrafshane1@thums.ac.ir**
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Dear Editor,

Microplastics (MPs), typically defined as plastic particles smaller than 5 mm, have rapidly transitioned from an environmental concern to a potential systemic health threat. Their ubiquitous presence has been documented across marine and freshwater ecosystems, agricultural soils, food products, drinking water, and atmospheric air (1,2). Recent investigations have confirmed the presence of MPs in human biological matrices, including blood, lung tissue, placenta, and breast milk, suggesting that chronic internal exposure is not only plausible but already occurring (3,4). Humans mainly ingest or inhale MP, taking in tens of thousands of particles yearly (2). MPs may cross epithelial barriers, enter systemic circulation, and accumulate in secondary organs. Their biological interactions appear to be strongly influenced by physicochemical characteristics such as particle size, morphology, polymer composition, and surface reactivity (5).

Based on the studies, MPs may induce oxidative stress, mitochondrial dysfunction, inflammatory signaling, and cytotoxic responses across a variety of mammalian cell types (5,6). MPs may also function as vectors for chemical additives and adsorbed environmental contaminants, including bisphenols, phthalates, flame retardants, and persistent organic pollutants that are recognized endocrine-disrupting chemicals (7). Of particular concern are the potential reproductive and developmental consequences associated with chronic exposure. Experimental animal models have demonstrated that exposure to MPs may impair spermatogenesis, reduce sperm motility, disrupt ovarian function, and alter circulating sex hormone levels (8,9). In rodent studies, polystyrene MPs have been associated with decreased testosterone levels, testicular inflammation, and structural damage to reproductive tissues (8). Similarly, ovarian fibrosis and impaired folliculogenesis have been observed following prolonged exposure (9). Oxidative stress and endocrine disruption are increasingly recognized as key mechanistic pathways underlying these reproductive effects. Although direct epidemiological evidence in humans remains limited, the detection of MPs in the human placenta raises the possibility of fetal exposure during critical developmental windows (4). Given the global rise in infertility prevalence and the established vulnerability of reproductive systems to endocrine-disrupting agents, MPs represent a biologically plausible approach through longitudinal cohort studies integrating exposure metrics with

reproductive health outcomes. Beyond reproductive toxicity, studies suggest that MPs may contribute to respiratory inflammation, immune dysregulation, metabolic disturbances, and cardiovascular dysfunction (6). Inhaled synthetic fibers can cause chronic airway irritation and inflammation. Interactions between microplastics and gut microbiota may affect metabolic and immune balance through new mechanisms.

Despite the rapid expansion of this field, critical knowledge gaps persist. There is currently no standardized methodology for quantifying human exposure to MPs, and dose-response relationships remain poorly characterized. Variability in sampling protocols, analytical techniques, and reporting units continues to hinder cross-study comparability (5). Addressing these issues needs unified methods and teamwork across scientific disciplines. In light of the exponential growth in global plastic production and the inadequacy of existing waste management infrastructures, MP pollution must now be recognized as a priority issue within environmental health policy. Preventive strategies should extend beyond environmental mitigation to encompass safer material design, exposure surveillance, and translational research linking environmental contamination to clinically relevant health outcomes. Ultimately, addressing MP exposure is not solely an ecological imperative but a fundamental requirement for safeguarding human reproductive health and future generations.

Keywords: Microplastics, Reproductive Health, Environmental Contamination, Biological Risk

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