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Plastic Debris Is a Human Health Issue

A. Dick Vethaak*,[†,‡] and Heather A. Leslie[‡]

[†]Deltares, Marine and Coastal Systems, P.O. Box 177, 2600 MH Delft, The Netherlands

[‡]VU University Amsterdam, Institute for Environmental Studies (IVM), De Boelelaan 1087, 1081 HV Amsterdam, The Netherlands

The global threat of highly persistent plastic waste accumulating and fragmenting in the world's oceans, inland waters and terrestrial environments is becoming increasingly evident.[1−3] Humans are being exposed to both plastic particles and chemical additives being released from the plastic debris of consumer society. This material is fragmenting, leaching and spreading throughout the biosphere, including indoor and outdoor air, soil, and water systems. What started as a marine environmental contamination issue is in fact very much a human health issue as well. What do we know so far about the impacts of this plastic debris for humans?

Humans can be exposed to plastic particles via consumption of seafood and terrestrial food products, drinking water and via the air.[1,4] Uptake of plastics by humans (and animals) can cause adverse health effects by at least three possible means:

1. PARTICLE TOXICITY

Our knowledge of the interaction of plastic particles themselves with tissues and cells in humans is still poor. However, the physical effects of particles observed to date in human cells and tissues and in animal models give insight into the possible risks of particle exposure in humans. The studies show that plastic particles can cause lung and gut injury, and specially very fine particles can cross cell membranes, the blood-brain barrier and the human placenta.[1,4] Observed effects include oxidative stress, cell damage, inflammation, and impairment of energy allocation functions.[1,4]

2. CHEMICAL TOXICITY

Plastic debris can be regarded as complex cocktails of contaminants, including both micromolecular substances (i.e., chemical additives, residual monomers and ambient chemical substances that sorb to plastic) and macromolecular substances (i.e., polymeric materials). A number of these substances, such as bisphenol A, phthalates and some of the brominated flame retardants, are known to be endocrine disruptors that adversely affect human health upon exposure via ingestion and inhalation.[1,4] In addition, air- and waterborne hydrophobic contaminants (with large plastic-air and plastic-water partition coefficients) sorb to plastic litter, an excellent hydrophobic sorbent phase.[1] Exposure to plastic debris means exposure to these chemical substances in addition to fragments of the polymeric materials.

Toxic chemical additives in plastic that leach out over the product life cycle are generally widely distributed throughout the global environment, already exposing organisms before plastic particle ingestion or inhalation occurs. Therefore, the chemical concentration gradients are often not steep enough to allow for large net transfers of chemicals from plastic to the tissues.[1] As chemical partitioning models predict, both sorbed chemical toxicants and additives in ingested plastics often do not contribute significantly to the observed total chemical bioaccumulation from all exposure routes. However, very fine plastic particles carrying chemical substances are able to cross cell membranes and may enhance the chemicals' bioavailability, analogous to nanosized polymeric drug delivery vehicles which facilitate uptake, distribution and delivery of pharmaceutical agents in human systems.[1] The hypothesis of this Trojan horse type mechanism, by which unintentionally ingested or inhaled plastic (nano)particles facilitate the transport of toxicants to sites of toxic action, has not been empirically studied in aquatic or mammalian organisms and requires special attention.

3. PATHOGEN AND PARASITE VECTORS

Both large and small plastic debris can act as a substratum for pathogenic micro-organisms and parasites.[1,3,5] For example, plastic debris off the Belgian coast has been found to contain human pathogenic bacteria (e.g., *Escherichia coli*, *Bacillus cereus*, *Stenotrophomonas maltophilia*), some distinct from the surrounding water and sediment, indicating that plastic debris can act as a distinct habitat and reservoir for pathogens.[3,5] Human pathogens, such as bacteria, can colonise plastic surfaces in stable biofilms when they come into contact in wastewater treatment plants or in households where wastewater from washing machines (containing microplastic fibers from

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synthetic textiles) and lavatories (pathogens) are combined. Once emitted to surface water, plastics carrying pathogens may enter bathing or drinking water, leading to human exposure and increased risk of infection. Plastic debris capable of holding stagnant water on land can also create habitats for mosquito larvae that transmit parasites or viruses such as Zika and dengue. Similarly, plastic debris may create favorable habitats for the proliferation and distribution of parasite-bearing freshwater snails (e.g., *Schistosomiasis*) and thereby worsens the spread of disease. People may be more at risk in more vulnerable highly populated delta areas where sanitation facilities are poor, plastic is cheap and waste management underdeveloped, and after flooding events. Given the high dispersal capabilities of floating plastic debris in aquatic systems and the increase in plastic pollution around the world, especially in developing countries with poor waste management, a new health issue is coming into view.

While the hazards of certain plastic additives are relatively better studied, the hazards of plastic particles to humans are slowly emerging from a handful of studies. The level of human exposure, chronic toxic effect concentrations and underlying toxicological mechanisms by which micro- and nanosized plastic particles elicit effects are still too poorly understood to make a full assessment of the risks to humans. Plastic debris is a notorious marine issue, but we touched on evidence here indicating it should now be recognized as an emerging *human health issue* as well. We now need dedicated and robust research and information on the human health risks of plastic debris in order to make progress toward protecting both public health and the environment from the hazardous consequences of living in a plastic age. In this effort, we will need to overcome the current analytical challenges of identifying and quantifying the ultrafine plastic particle fractions down to the nanoscale in food, air, water, and biological matrices.

Plastic debris' persistent nature and deleterious effects makes this issue one of the world's foremost environmental concerns, alongside climate change and ocean acidification. The negative externalities caused by the profusion of plastic litter is an example of market failure, that comes with exorbitant social costs (estimated to be in the billions of euros) and damages human welfare and health.[1] All of these problems are symptoms of the contemporary linear system of production, transport, and consumption of largely unsustainably designed goods around the globe. At least humans themselves are in charge of the system that keeps creating more and more plastic debris and with it, the potential risks. One of the major factors leading to systems malfunctioning is a lack of information. Timely availability of data and information about the risks of plastic debris to human health will aid regulatory authorities and industrial sectors to make informed decisions on eco-design and waste-to-resource management.

■ AUTHOR INFORMATION

Corresponding Author

*E-mail: dick.vethaak@deltares.nl.

Notes

The authors declare no competing financial interest.

■ REFERENCES

(1) GESAMP Sources, fate and effects of microplastics in the marine environment: a global assessment. Kershaw, P. J., (ed.). (IMO/FAO/UNESCO-IOC/UNIDO/WMO/IAEA/UN/UNEP/UNDP Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection). *Rep. Stud.* **2015**, GESAMP No. 90, 96 p.

(2) Gasperi, J.; Dris, R.; Rocher, V.; Tassin, B. Microplastics in the continental area: an emerging challenge. *Norman Bulletin* **2015**, *4*, 18−19.

(3) McCormick, A.; Hoellein, T. J.; Mason, S. A.; Schluep, J.; Kelly, J. J. Microplastic is an abundant and distinct microbial habitat in an urban river. *Environ. Sci. Technol.* **2014**, *48* (20), 11863−11871.

(4) Galloway, T. S. Micro-and nano-plastics and human health. In *Marine Anthropogenic Litter*; Springer: New York, 2015; pp 343− 366.

(5) Van der Meulen, M. D.; Devriese, L.; Lee, J.; Maes, T.; Van Dalfsen, J. A.; Huvet, A.; Soudant, P.; Robbens, J.; Vethaak, A. D. Socio-economic impact of microplastics in the 2 Seas, Channel and France Manche Region: An initial risk assessment. *MICRO Interreg project Iva* **2014**.

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