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A critical perspective on early communications concerning human health aspects of microplastics

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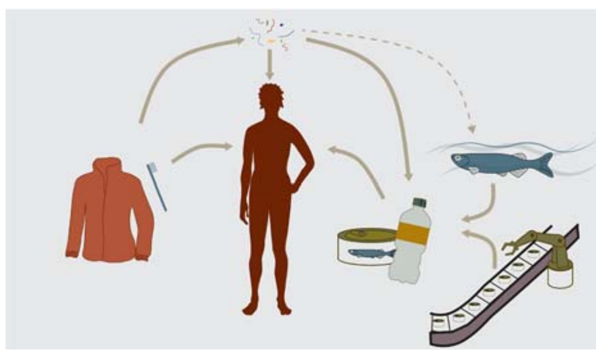
HIGHLIGHTS

- There is data supporting possible chemical and particle toxicity effects of plastic.
- The current debate on human health effects of plastics is unbalanced.
- There is a disproportionate focus on microplastics in individual food products.
- Exposure to additives and microplastics is mainly related to general plastic use.
- We urge for a more balanced discussion on human exposure to plastics.

GRAPHICAL ABSTRACT



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ABSTRACT

Microplastic research in recent years has shown that small plastic particles are found almost everywhere we look. Besides aquatic and terrestrial environments, this also includes aquatic species intended for human consumption and several studies have reported their prevalence in other food products and beverages. The scientific as well as public debate has therefore increasingly focused on human health implications of microplastic exposure. However, there is a big discrepancy between the magnitude of this debate and actual scientific findings, which have merely shown the presence of microplastics in certain products. While plastics can undoubtedly be hazardous to human health due to toxicity of associated chemicals or as a consequence of particle toxicity, the extent to which microplastics in individual food products and beverages contribute to this is debatable. Considering the enormous use of plastic materials in our everyday lives, microplastics from food products and beverages likely only constitute a minor exposure pathway for plastic particles and associated chemicals to humans. But as this is rarely put into perspective, the recent debate has created a skewed picture of human plastic exposure. We risk pulling the focus away from the root of the problem: the way in which we consume, use and dispose of plastics leading to their widespread presence in our everyday life and in the environment. Therefore we urge for a more careful and balanced discussion which includes these aspects.

1. Introduction

An increasing number of studies show that plastics in general, and microplastics in particular, are ubiquitous in all environmental compartments, including sediments, soils, water columns and surface layers

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in marine and freshwater systems (Li et al., 2016; van Sebille et al., 2015). It seems that wherever we look we find plastics, and some of the supposed sources include abrasion of plastic products and paints (Lassen et al., 2015), fragmentation of mismanaged plastic waste, discarded/lost fishing equipment (Andrady, 2011), and microplastic fibers from textiles (Browne et al., 2011). Plastic pollution is thus mainly a diffuse source problem. However, major pathways for release into the environment have been identified and include WWTP effluents and storm water drains (Lattin et al., 2004; van Wezel et al., 2015). Although plastic pollution may cause adverse effects in all environmental compartments the ecological effects of plastic pollution have so far mainly been studied in marine environments where numerous species of birds, fish and invertebrates have been found to ingest macro- and microplastics (GESAMP, 2015) and over 800 species are known to be affected by marine litter (UNEP, 2016). Field measurements have also shown their presence in marine species used for human consumption, like bivalves and fish (Dehaut et al., 2016; Rochman et al., 2015). Furthermore, microplastics have been reported in tap water, bottled water, sugar, salt, beer and honey (Karami et al., 2017; Kosuth et al., 2017; Liebezeit and Liebezeit, 2013, 2014; Schymanski et al., 2017; Yang et al., 2015). The issue of microplastic contamination in food products and beverages has gained increasing public interest and media attention in recent years, triggering the logical question: are there implications for human health? This concern likely results from a synthesis of different inputs: the easily identifiable environmental pollution associated with macroplastic littering and mismanaged waste, a fear of the seemingly omnipresent and invisible microplastics, and finally the well-known harmful effects of some plastic additives and plasticizers such as for example phthalates. In combination, this has led to numerous publications (both scientific and popular) speculating about the human health consequences of microplastic exposure. There is, however, a large discrepancy between the current state of scientific evidence concerning effects of microplastics and the ongoing public discussion and subsequent fears, leading to a potentially incorrect focus and path forward. We will explain why this is problematic.

Since their first commercial production in the mid-20th century plastics have revolutionized society; from healthcare to food safety and transport (Andrady and Neal, 2009). In fact, plastics have allowed for a technological leap in many areas directly or indirectly related to human health. Conversely, plastic materials have the potential to pose or contribute to direct or indirect human health risks. Plastic bags have for example been seen to provide breeding habitats for mosquitoes carrying malaria (Njeru, 2006) or causing flooding by blocking drains as it happened in Bangladesh in 2002 (NOLAN-ITU, 2002). Plastic materials are also associated with thousands of chemicals; several of which are found in human blood, urine and breastmilk and some of which are known to have adverse effects on animals and potentially humans (Talsness et al., 2009). There are many areas in the world that lack proper waste management, which often results either in the creation of vast landfills or in a routine burning of waste. When incinerated, plastic materials have long been known to release polycyclic aromatic hydrocarbons (PAHs) (Li et al., 2001) and toxic gases, for example furan and dioxin (Menad et al., 1998). Moreover they can leave residues of lead and cadmium (Korzun and Heck, 1990), two metals known to be toxic to human health. A more recently explored aspect of plastic-related human health effects concerns particles in the micro- and nano-scale, which are either intentionally produced in that size or created through the fragmentation of larger plastics. Potential effects of such particles have to a degree been studied in the field of arthroplasty where plastic prosthesis have been shown to fragment, creating small plastic particles (Hicks et al., 1996). Human health effects of particles in general have also been extensively documented within the field of air pollution (Chen et al., 2016; Stone et al., 2007).

As noted above there are a number of reasons to assume that plastic materials, as we use and dispose of them today, may pose risks to human health. While pollution in general is recognized as a major contributor to human disease and premature death (Landrigan et al., 2017), many research scientists express a mixture of skepticism and concern over the extent and associated human health risks of plastic pollution as a whole (Seltenrich, 2015). Nevertheless, human health effects of specifically microplastics have been the primary focus of the recent public debate. These public concerns are largely linked to potential exposure to microplastic contaminants in food and beverages, for example in seafood or tap water, even though these are not likely to be among the major exposure pathways of microplastics and associated chemicals to humans. Plastics are such an integrated part of our everyday lives that the few added fibers or particles that may occur in some food products or beverages are likely not even comparable to the quantity of plastic materials and chemicals that we are exposed to through our usage of clothes, food contact materials, packaging, building materials and kitchen appliances. In fact, it is reasonable to assume that the amount of microplastic fibers that is reportedly found in tap water may be equivalent to the amount that ends up in a glass of water standing on a kitchen counter as a result of settling of dust or air particulate matter which consists largely of microplastic fibers from clothing. Somewhat ironically, this widespread occurrence of microplastics is why researchers face such challenges in avoiding sample contamination even in the cleanest lab environments. Still, the potential human health risks of microplastics in food products and beverages are often exaggerated, even in the scientific literature (Koelmans et al., 2017), not surprisingly leading to strong reactions in public media.

Plastics in the environment comprise a 'wicked problem' (Hastings and Potts, 2013), complicated by numerous stakeholders, as well as complex moral, ethical and political considerations. Through focusing on the risk of microplastics in specific food items, such as seafood or tap water, we risk pulling focus away from the root of the problem, namely the way that we produce, use and dispose of plastic materials in modern society. While research into fate, effects and consequences of microplastics is warranted, here we focus on the contrast between the current debate of microplastics as a potential human health hazard and known health effects of plastic materials and associated chemicals. Moreover, we want to draw attention to the manner in which scientific results of this field are communicated within the scientific community as well as to the general public. We urge for a more balanced and careful interpretation of findings. Lastly, we want to encourage a discussion on how our consumption, use and disposal of plastics may fit into the debate on human health effects.

2. Potential mechanisms of plastic-related adverse effects on human health

2.1. Toxicity of chemicals in plastic products

Plastic materials are made from mono- or oligomeric building blocks arranged through different techniques and chemical reactions into polymeric chains. In order to create the many different types of plastics with differing properties that we see on the market today, the industry also makes use of a wide array of plastic additives including different types of fillers, flame retardants, antioxidants, plasticizers and colorings (Halden, 2010). The produced materials will contain a majority of polymeric chains, but also some residual monomers, catalyzing agents used in the chemical processing, additives and potentially non-intentionally added substances carried over from the raw materials (usually petroleum oil). Overall there are tens of thousands of chemicals used in plastic products and an extensive review of their associated risks and hazards is beyond the scope of this article. For more information there are several reviews on the topic (Hahladakis et al., 2018; Halden, 2010; Hauser and Calafat, 2005; Sjödin et al., 2003). Here, we will, however, provide a few examples to illustrate the potential health issues associated with chemicals in plastic products and discuss some known exposure pathways.