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Micro(nano)plastics: A threat to human health?

Messika Revel, Amélie Châtel and Catherine Mouneyrac

Abstract

The presence and effects of plastic debris is increasingly investigated. The majority of studies focuses on microplastics (MPs), but few reports suggest that plastic fragments in the <100 nm size range, referred to as nanoplastics (NPs), may also be formed in the aquatic environment and further to humans. This paper provides a review on routes of human exposure and potential effects of MPs and NPs to human health. MPs/NPs could potentially induce: physical damages through particles itself, and biological stress through MPs/NPs alone or leaching of additives (inorganic and organic). Future research should evaluate trophic transfer of MPs/NPs with their associated chemicals through the marine food web.

Addresses

Laboratoire Mer, Molécules, Santé (MMS, EA 2160), Université Catholique de l'Ouest, Angers F-49000 France

Corresponding author: Mouneyrac, Catherine (catherine.mouneyrac@uco.fr)

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Microplastics, Nanoplastics, Additives, Food chain, Ingestion.

Introduction

Today, plastic products can be found in several fields such as health, construction, and textiles. Global production of plastic has increased significantly, from 1.7 million tons in the 1950s to over 322 million tons in 2016 [1]. Plastic is made of synthetic organic polymers; the majority being polyethylene (PE, high and low density), polystyrene (PS), polypropylene (PP), polyvinyl chloride (PVC), polyurethane (PUR) and polyethylene terephthalate (PET). In addition, additives may be added to plastics to improve their characteristics such as strength, coloration or flame retardant properties. To understand MPs impacts, it is crucial to study their fate and their potential effects and their additives (e.g., Bisphenol A, phthalates, polybrominated diphenyl ethers, and metals or metalloids) which for some of them can be classified as carcinogenic or endocrine disrupting.

In recent years, the presence of plastic debris called microplastics (MPs), define as fragments smaller than 5 mm has been reported in diverse aquatic ecosystems [2–4]. Though the presence of nanoplastics (NPs) is difficult to ascertain, due to the inherent technical difficulties, recent studies shown that NPs are also being introduced in important quantities into the natural environment [5–7]. Since plastic items undergo continuous fragmentation, it is likely that MPs could become NPs and some studies suggested that the average size of sampled plastic particles seems to be decreasing [8].

Concerns about toxic impacts of MPs and eventually NPs for human health have been raised, but investigations are still sparse [9]. To compare the number of studies focusing on MPs/NPs effects towards human health or the environment, the number of articles found in Web of science using different keywords ("Microplastics human health", "Microplastics environment", Nanoplastics human health", "nanoplastics environment") was summarized in Fig. 1. Clearly, a much higher number of studies are available on MPs in the environment compared to human exposure (articles published from 2006 to 2017). The aim of this review is to present an overview of the different exposure routes for humans and potential effects of MPs and NPs, including their additives, from commercial items and discarded debris through the food chain. Since to date reports on human health is very sparse, we used previous work from environmental studies on MPs, and engineered nanoparticles for NPs to try to predict potential translocation and eventually effect on humans.

Routes of human exposure

Oral

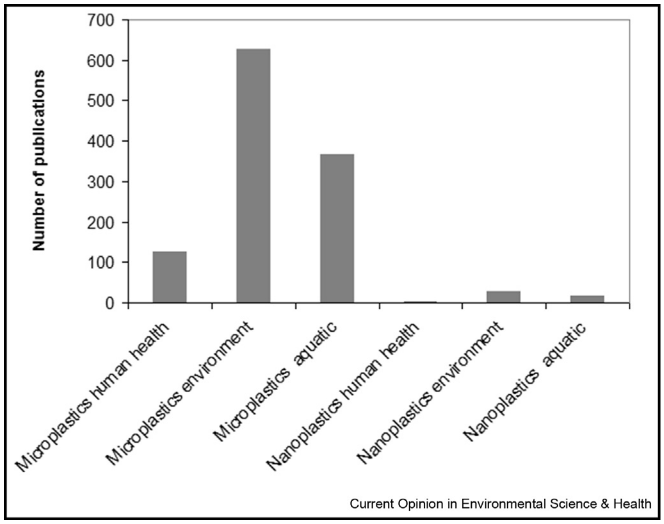
Drinking water

The presence of MPs in soil and freshwater ecosystems has been measured, including in locations used as sources of drinking water representing a way of MPs human exposure, particularly if plastic particles can pass through the filtration systems of wastewater treatment [10,11]. It has been estimated that daily discharges could ranged from ∼50,000 up to nearly 15 million particles [12].

Food chain: marine products

Aquatic organisms may be contaminated by MPs (and NPs), either through loaded water or the feeding from other organisms and may serve as a source of human exposure. Concerning bivalves, humans consume the whole soft tissues which may contain microscopic plastic

Fig. 1



Search results on micro/nanoplastics and environmental or human health depending on word selection at 14/09/2017.

debris. In addition, fish may be contaminated after fishing during their storage and transportation in plastic containers of friable polystyrene.

Plastic particles have been detected in various organisms from the lowest levels of food chain such as zooplanktonic organisms [13,14] to the highest levels in both invertebrates (Crustacea, mollusks) and vertebrates (fish) [15,16]. Along the Mediterranean coast of Turkey, 1822 MP particles were extracted from stomachs and intestines of 1337 fish specimen with the majority of ingested particles represented by fibers (70%) and hard plastics (20.8%) [16]. In different species of fish from coastal (21) and freshwater (6) of China, MPs were abundant in 26 species, accounting for 55.9–92.3% of the total number of plastics items in each species [17]. For benthopelagic fish, MPs were higher in sea fish than freshwater organisms. In Norwegian coast, lower level of plastics (including MPs) was measured in the Atlantic cod (*Gadus morhua*) fish with 3% of plastic found in the stomachs examined [18]. Low quantities of MPs were found in bivalves from German (0.36 ± 0.07 particles/g) and French/Belgian/Dutch farms (0.2 ± 0.3 particles/g) [15,19]. In Canada, 500 times greater quantities of MPs were measured in the same bivalve, suggesting different levels of contamination between sites or differences between MPs extraction methods [20].

Translocation of MPs across the gastrointestinal tract has been demonstrated in the laboratory for crabs and mussels [21,22]. The presence of MPs/NPs in tissues beyond the gastrointestinal tract has yet to be evaluated in fish [23]. However, a study reported the presence of MPs in the livers of fish fed plastic particles [24].

Other food items

Humans may also be directly exposed to MPs and NPs through the actual ingestion of these particles from, honey [25] and beers [26]. After the examination of 24 German beer brands, authors measured from 2 to 79 fibers L^{-1} and from 12 to 109 fragments L^{-1} in samples. Recently, MP-like particles, predominantly fragments of PP and PE larger than 149 μm were measured out of 17 salt brands from 8 countries [27]. Even so, authors concluded a negligible health risks associated with the consumption of these salts, MPs can still reach the human organism through other type of food such as fish and bivalves [28].

MPs can also be ingested indirectly through personal care products (toothpaste, scrubs).

Dermal exposure: water and cosmetics

Dermal contact may occur when humans interact with water contaminated with MPs/NPs during washing or through facial/body scrubs also containing MPs/NPs [5]. But, due to the size of MPs and since uptake of particles across skin requires penetration of striatum corneum which is limited to particles below 100 nm, absorption through the skin is unlikely to occur. However, NPs could eventually penetrate into/through human skin [29].

Inhalation: air

Human exposure to MPs/NPs through inhalation could occur after MPs/NPs become airborne, potentially from wave action in aquatic environments or the application of wastewater treatment sludge. Furthermore, MPs have been detected in atmospheric fallout suggesting another