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Low numbers of microplastics detected in drinking water from ground water sources

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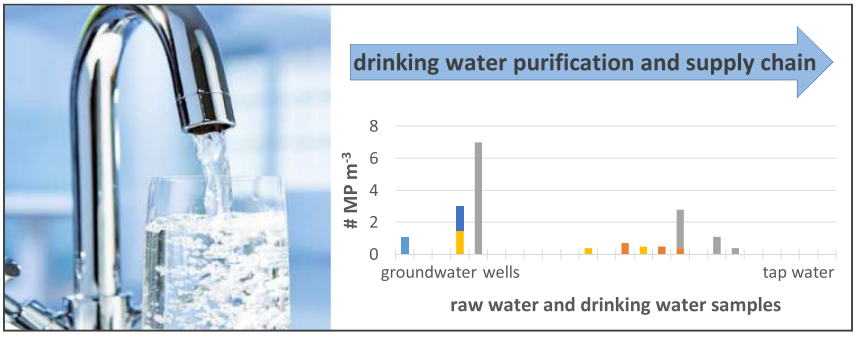
HIGHLIGHTS

- Identification of microplastics >20 μm using FTIR imaging.
- Examination of 40 m^3 ground water and drinking water for microplastics.
- Negligible microplastic contamination of drinking water (<1 particle m^{-3}).

GRAPHICAL ABSTRACT



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ABSTRACT

Microplastic particles have been detected in various natural habitats and the digestive tracts of several species. These particles have also been reported in commercially available seafood, salt or bottled water starting discussions on potential implications for human health. To be able to assess the related risks, exposure concentrations and pathways need to be known. Here, we analysed ground water and drinking water for the presence of microplastics (>20 μm) using FTIR imaging. Samples were taken at different positions within the drinking water supply chain. Determined concentrations ranged from 0 to 7 microplastics m^{-3} raw water or drinking water with an overall mean of 0.7 microplastics m^{-3}. These particles were identified as polyethylene, polyamide, polyester, polyvinylchloride or epoxy resin and between 50 and 150 μm in size. Plastic is a resistant and durable material, still, the abrasion of plastic equipment used during water purification or transport is a likely explanation for the plastic particles detected in water samples.

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1. Introduction

The contamination of natural habitats with plastic litter can be observed in many places and is considered a topic of emerging concern (Eerkes-Medrano et al., 2015). A lot of research has been conducted on microplastics, which are polymer particles or fibres smaller than 5 mm. These plastics have been detected in the marine (do Sul and Costa, 2014) and freshwater environment (Eerkes-Medrano et al., 2015; Jambeck et al., 2015; Mani et al., 2015), and in the digestive tracts of several species (Rummel et al., 2016; van Cauwenberghe and Janssen,

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2014). So far, it is not yet completely known if and how ingested microplastic might harm organisms. Ingested microplastics might cause local inflammations in the gut, but a transport via membranes or into organs, as it might occur for nanoplastics (<100 nm), seems unlikely (Bouwmeester et al., 2015). In recent years microplastic particles and fibres have been reported in commercially available seafood (Tanaka and Takada, 2016; van Cauwenberghe and Janssen, 2014), salt (Iniguez et al., 2017; Yang et al., 2015), honey (Liebezeit and Liebezeit, 2015) as well as tap water (Kosuth et al., 2017). Though partly questioned and criticized for missing contamination controls or for omitting the identification of selected particles (Lachenmeier et al., 2015; Mühlschlegel et al., 2017; Rist et al., 2018), these studies started discussions on potential implications of these microplastics for human health. Schymanski et al. (2018) identified small plastic particles in bottled drinking water and concluded that packaging materials were responsible for the contamination (Schymanski et al., 2018).To be able to fully assess the risks microplastics could pose to human health, actual exposure and pathways need to be determined (Bouwmeester et al., 2015; Wright and Kelly, 2017). While it is necessary to examine food and beverages, we should not forget the impacts of packaging materials, or our general wide usage of plastic materials in daily life (Rist et al., 2018).

The purpose of this study was the identification of microplastics in large volumes of drinking water that derived from the purification of ground water. The samples were taken at different positions in the supply chain, ranging from groundwater wells to drinking water from conventional household taps to asses if and where a contamination with microplastics would occur. To identify potential microplastics, Fourier transform infrared (FTIR) microscopy coupled to a focal plane array (FPA) detector was applied which enabled the identification of microplastic particles down to a size of 20 μm (Löder et al., 2015; Mintenig et al., 2017).

2. Material and methods

2.1. Drinking water purification

The Oldenburg-East-Frisian water board (OOWV) supplies the drinking water for an area of 7500 km^2 in the north-western part of Germany. Per year, the OOWV provides 71 million cubic meters of drinking water. Exclusively groundwater (extracted from wells at least 30 m deep), hereafter referred to using the technical term 'raw water', is transported to fifteen drinking water treatment plants (DWTP) and purified by applying several filtration and aeration steps (Fig. 1). After purification, the drinking water is stored in tanks or directly fed into the distribution system and transported to the consumers. All pipes are made of high- density polyethylene (HDPE), polyvinylchloride (PVC) or cast iron. In the DWTP, all reaction and storage tanks have an inner layer of epoxy resin to avoid corrosion, and aeration tanks have built in rings of polypropylene (PP) to enlarge the surface area.

The responsibility for quality and transport of the drinking water ends for the water board at the water meter of each household, the water pipes within houses are handled by the individual consumers.

2.2. Sampling

The sampling took place between August 13th and 20th 2014. The DWTPs in (1) Nethen, (2) Holdorf, (3) Grossenkneten, (4) Sandelermoens and (5) Thuelsfelde were chosen, here the raw water at the DWTP inlet and the drinking water at the plant outlet were sampled. Additionally, one consumer household in the distribution system of each DWTP was selected where the drinking water was sampled at the water meter and at a conventional water tap. The distance between the DWTP and the household varied between 5 and 42 km. Additionally the ground water of three wells with an approximate depth of 30 m was sampled in the area of Holdorf. Thereby, the samples covered all steps of drinking water purification, transportation and supply (Fig. 1).

The raw water and drinking water samples were filtered through 3 μm stainless steel cartridge filters (4 7/8″, Wolftechnik, Germany) that were placed in filter housings (made of styrene acrylonitrile (SAN) and PP) with flexible PVC hoses attached. The inlet tube was attached directly to a water tap which was opened far enough to allow a water flow of approximately 10 L min^{-1}. The pressure at the DWTP inlet was generally lower and the raw water was filtered with a flow rate of about 5 L min^{-1}. A flowmeter (Gardena, Germany) was connected to the outlet tube of the filter housing to determine the volume of filtered water.

Before usage, the filter units (filter housing with stainless steel cartridge filter) were rinsed with analytical grade water (Milli-Q), closed and not opened outside the laboratory. At each sampling position the inlet tube was primed for five minutes and a new filter unit was used. The filtration of raw water was stopped earlier when iron oxide blocked the cartridge filters and led to a significant reduction of the water flow. Between 300 and 1000 L of raw water and 1200 to 2500 L of drinking water were filtered. After completion, the filter units were kept closed and stored refrigerated at 4 °C.

2.3. Sample treatment

In the laboratory, residual raw water and drinking water was removed from the filter units by using filtered (0.2 μm) compressed air. Then, the units were filled again with diluted hydrochloric acid (Carl Roth GmbH & Co. KG, Germany, 0.2 μm filtered, pH = 2) to dissolve calcium carbonate and iron precipitates. After 24 h the filter units were emptied, the cartridge filters removed from the units and rinsed with

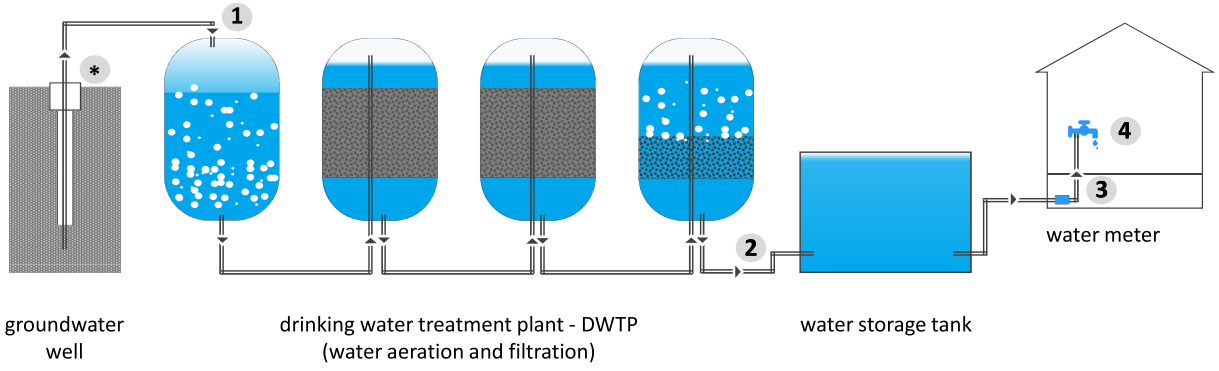

Fig. 1. Scheme of the drinking water purification and supply chain (OOWV), with locations marked where (1) the raw water, (2) the drinking water at plant outlet, the drinking water at the (3) water meter and (4) a conventional water tap in a selected household were sampled. This was repeated in five drinking water supply areas. Additionally, the ground water at three wells was sampled in one area (*).

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