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Early screening of suspected microplastics in bottled water in the Santiago Metropolitan Region of Chile ☆

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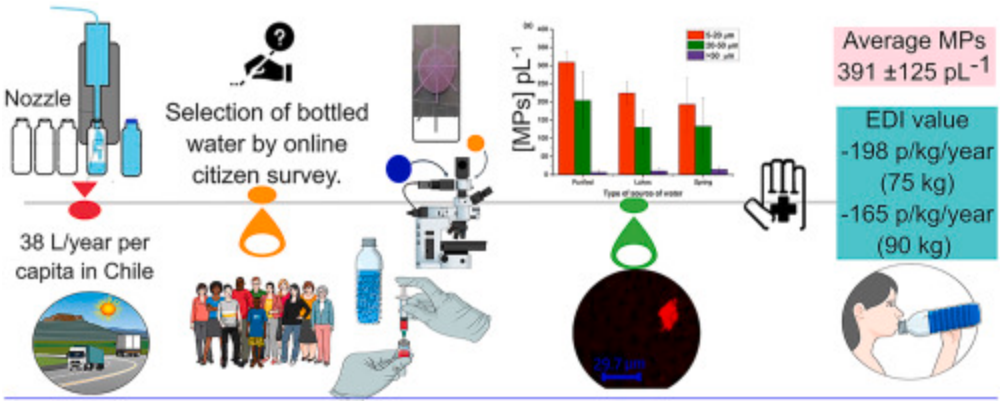
Highlights

- Nile Red and fluorescence microscopy were used to identify microplastics in bottled water.
- The average concentration of microplastics in commercial bottled waters of Chile was 391±125 p L^{-1}.
- Purified (filtered or processed) bottled water showed the highest concentrations of suspected microplastics.
- Microplastics of sizes between 5 and 20μm represented more than 50% of the particles found in each bottle.

Abstract

Bottled water has emerged as a possible healthier alternative due to concerns about the quality of drinking water sources. However, recent studies have detected worrying concentrations of environmental contaminants in bottled water, including microplastics. Therefore, it is an emerging need to quantify their concentrations in local suppliers which could differ among countries and regions. In this work, we used fluorescence microscopy with Nile Red for the identification and quantification of potential microplastics in twelve brands of bottled water distributed in the Santiago Metropolitan Region of Chile. The average concentration of microplastics was 391 ± 125 p L^{-1}, while the highest concentration observed was 633 ± 33 p L^{-1}. Microplastics between 5 and 20 μm were the major contributors, a size fraction that has been reported to be susceptible to accumulate in the digestive tract or generate potential alterations in the lymphatic and circulatory systems. The estimated daily intake value for per capita was estimated to be 229 p kg^{-1} $year^{-1}$ for people weighing 65 kg and 198 p kg^{-1} $year^{-1}$ for those weighing 75 kg.

Graphical abstract



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Introduction

It is undeniable that plastic materials have many important uses in modern societies and have brought great benefits to modern life. For instance, their use in the food industry has helped maintaining higher hygiene and innocuity standards, improving handling and transportion, as well as reducing production costs. However, the negative environmental

impacts produced by waste plastic have become more evident in recent years, and several replacement materials have been suggested (Pang et al., 2022).

Plastics have different mechanical and wear resistances, depending on the chemical characteristics of the main polymer and additives used. They are permanently exposed to mechanical and environmental factors that contribute to their wearing during manufacturing, packaging, handling, use, and disposal. These factors can deteriorate the surface of the material, causing the formation of smaller fragments with different shapes, including irregular pieces of plastic with diameters from 1 μm to 5 mm called microplastics (MPs) (GESAMP, 2015; Hartmann et al., 2019).

In recent years, there have been an increasing number of studies revealing the presence of MPs in different environmental samples, some of which suggest a significant route of human exposure (Shahul Hamid et al., 2018; Zhang et al., 2020). MPs have been found in beer, milk, honey, sea salt, drinking water, among others (Kutralam-Muniasamy et al., 2020; Oβmann et al., 2018; Rainieri and Barranco, 2019; Shruti et al., 2020).

Bottled water can be a significant source of MPs to the environment (Muhib et al., 2023), as polyethylene terephthalate (PET) and high-density polyethylene (PE) or polypropylene (PP) are commonly used for the bottle body and cap. Additionally, the demand for bottled water has increased worldwide mainly because it is considered to be of better quality compared to tap water, although some studies did not find significant differences between them (Ahmad and Bajahlan, 2009; Knox and McDermott, 2019).

Recent studies have reported the presence of MPs in bottled water in the shape mainly of fragments or fibers, ranging from 8 to more than 2600 particles per liter of water (p L^{-1}), derived from polyethylene terephthalate (PET), high- and low-density polyethylene (HDPE and LDPE), polypropylene (PP) or polyvinyl chloride (PVC), with sizes ranging from 1 to 20 μm (Kankanige and Babel, 2020; Makhdoumi et al., 2021; Oβmann et al., 2018).

A complete risk assessment regarding MPs in bottled water is still a complicated task, mainly due to the lack of exposure data and limits (Koelmans et al., 2019; Leslie and Depledge, 2020; Vethaak and Legler, 2021). However, it is well known that the toxicity of MPs increases in smaller size fractions, suggesting that they may move through physiological systems and increasing their potential accumulation in organs such as the liver and kidneys, as well as generating negative impacts at the cellular level (Amato-Lourenço et al., 2021; Hwang et al., 2020; Ibrahim et al., 2021; Stock et al., 2021; Wright and Kelly, 2017).

In this study, we determined the presence, shape, and sizes of MPs in twelve popular brands of bottled water distributed in the Santiago Metropolitan Region of Chile. We used epi-fluorescent microscopy combined with fluorescent staining using Nile Red (NR). This allowed us to generate new information on the presence and exposition of MPs and estimated the dietary intake from bottled water for consumers in the Santiago Metropolitan Area in central Chile.

Section snippets

Protocol to reduced cross-contamination

The recommendations from Woodall's et al. and Dris et al. were followed for glassware cleaning and to prevent cross contamination of the samples due to airborne microplastic (Dris et al., 2018; Woodall et al., 2015). All glass material was washed with two portions of ethyl acetate, Extran® MA 05, and deionized water (18.2 MΩcm at 25 °C, Type 1, Milli-Q water purification system). The glassware was then soaked in a HNO_3 solution (1 mol L^{-1}) for 24 h and was then rinsed with deionized water.…

Selection conditions for the sample processing and particle visualization

The use of the NR dye was optimized following the methods and recommendations of previous studies (Cole, 2016; Dutta et al., 1996; Erni-Cassola et al., 2017; Greenspan et al., 1985; Maes et al., 2017; Mason et al., 2018; Sancataldo et al., 2020; Shim et al., 2016; Wiggin and Holland, 2019).

It was observed that using 10 mL or less of bottled water resulted in higher background noise and thus was not useful to identify MPs. On the other hand, using 125 mL resulted in overlapping of MPs, making it …

Conclusions

Nile Red staining is a suitable method for a quick analysis rather than a viable alternative for identifying suspected MPs because the staining technique identifies the presence of lipophilic particles and does not identify the polymer composition. We found MPs in all samples analyzed with an average concentration of 391 ± 125 p L^{-1} with the 5–20 μm fraction accounting for more than 50% of the particles found in each bottle, specifically samples G and H. The presence of MPs in bottled water…

Author statement

Fallon Nacaratte: Conceptualization, Methodology, Investigation, Resources, Writing-Original draft preparation, Supervision. **Paula Cuevas**: Investigation, Data curation, Formal analysis, Visualization. **Mercedes Becerra-Herrera**: Conceptualization, Writing-Review and Editing. **Carlos Manzano:** Resources, Writing-Review and Editing.…

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:Fallon Nacaratte reports financial support was provided by Agencia Nacional de Investigación y Desarrollo.…

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