ScienceDirect

Environmental Pollution

Volume 315, 15 December 2022, 120494

Microplastics in Malaysian bottled water brands: Occurrence and potential human exposure

Sarva Mangala Praveena [a b], Nur Izzati Shamsul Ariffin [a], Ayu Lana Nafisyah [c]

Show more

https://doi.org/10.1016/j.envpol.2022.120494

Get rights and content

Highlights

- The amount of microplastics in bottled water samples ranged from 8 to 22 particles/L.
- The most dominant particle size in bottled water was between 100 and 300μm.
- The most common shape of microplastics found in bottled water was fragment.
- Polymer types found in bottled water are attributed to packaging materials and bottle caps.
- Low EDI values were estimated, but potential human health risks should be heeded.

Abstract

The World Health Organization noted that there is a growing need to determine the occurrence of microplastics in bottled water and its potential risks to human health. Thus, present study analyzes microplastics in eight major bottled water brands available in Malaysia and estimates the potential human exposure. Membrane filtration method followed by visual and polymer identifications were utilized to identify microplastics particles in these eight major bottled water brands. Microplastic concentrations in bottled water samples ranged from 8 to 22 particles/L, with an average of 11.7±4.6 particles/L. Particle sizes ranging between 100 and 300μm were dominant and accounted for approximately 31% in these bottled water brands. Fragments were the most identified microplastics in bottled water with transparent color being the most prevalent. The polyethylene terephthalate (PET) and polypropylene (PP) polymer types found in this study are consistent with prior results in that microplastics in bottled water are mainly derived from packaging materials and bottle caps. The Estimated Dietary Intake (EDI) for adults was between 0.068 and 0.19 particle/kg/day, while the EDI for children was between 0.089 and 0.25 particle/kg/day. Although consumption of bottled water was estimated to have low EDI values, the potential risks to human health should be heeded due to the presence of numerous plastic additives and residual monomers in these particles, which have the potential to increase inflammatory reactions and cytotoxicity in human body. Future studies should concentrate on understanding microplastics particles less than 1.5μm and other associated factors (bottled material quality, consumption behaviour, bottled water storage conditions, and the frequency of bottle opening and closing) to further understand the effects of these microplastics particles on human toxicological aspects.

Introduction

Microplastics pollution is becoming increasingly evident in a variety of environmental medias and is a prominent pollutant (Shruti et al., 2020). Microplastics are small particles ranging from 1μm to 5mm with various shapes and colors. Primary microplastics consist of microbeads from personal care products and pellets used in industrial manufacturing. Secondary microplastics involve the breakdown of larger plastics into smaller plastics particles (Oβmann et al., 2018). The rising use of plastics in daily human activities has resulted in the increased entry of microplastics particles into the environment (Makhdoumi et al., 2021; Schymanski et al., 2018). Microplastics have been detected in marine environments (Cole et al., 2011; GESAMP, 2015), terrestrial habitats (de Souza Machado et al., 2018; Duis and Coors, 2016), lakes (Sruthy and Ramasamy, 2017; Su et al., 2016), rivers

(Dai et al., 2022; Yu et al., 2022), and the atmosphere (Purwiyanto et al., 2022; Truong et al., 2021).

Along with its presence in environmental medias, microplastics have entered the food chain, posing food safety concerns (Danopoulos et al., 2020). Microplastics have been reported in a variety of food products, including seafood (Van Cauwenberghe et al., 2015), sugar (Liebezeit and Liebezeit, 2013), salt (Peixoto et al., 2019), milk (Kutralam-Muniasamy et al., 2020), bottled water (Oβmann et al., 2018; Zhou et al., 2021), and tap water (Tong et al., 2020). Schwabl et al. (2019) have revealed microplastics in human stool, indicating unintended microplastics consumption from a variety of sources which may have a negative impact on human health. Although there is a growing interest in the prevalence of microplastics in environmental medias in Malaysia, quantitative findings are still scarce. Nonetheless, only a few studies have documented microplastics in food, notably in commercial fish (Ibrahim et al., 2017; Karbalaei et al., 2019; Sarijan et al., 2019) and bivalve (Shauib Ibrahim et al., 2016). In light of microplastics' abundance in food samples, microplastics are potentially present in bottled water sold in Malaysia. However, this has not been verified highlighting the need for further investigation. The World Health Organization has stressed the importance of accessing the microplastics level of bottled water brands worldwide and to explore the concomitant health risks of microplastics consumption (World Health Organization, 2019).

In Malaysia, plastic bottled water sales exceeded USD 167.39 million in 2019 (Cheng, 2015) and it is forecasted to transcend USD 322.30 million in 2025 (Market Research, 2022). According to Cheng (2015) and Mordor Intelligence (2022), the growing trend in bottled water consumption among urban Malaysians is linked to the consumers' growing health and wellness awareness to reduce sugar and calorie intakes. Additionally, the perceived chemical (e.g., chlorine) taste (Aini et al., 2007), bottled water esthetic (Aini et al., 2007), and poor perception of tap water quality (Ng, 2016; Wahid et al., 2017) are principle reasons for the growing trend of bottled water consumption in Malaysia. In Malaysia, two types of bottled water are available, namely, natural mineral water and packaged drinking water and they can be differentiated by the bottle cap. Natural mineral water comes from an underground water table and is filtered and tapped at a spring. Packaged drinking water is treated tap water derived from a river source. This treated water then undergoes additional treatments such as reverse osmosis, distillation, or deionization before being packaged as bottled water. Bottled natural mineral water has colored caps, primarily blue or green, and manufactured bottled drinking water has white caps (Aris et al., 2012).

The Ministry of Health (Malaysia) is responsible for monitoring bottled water quality and safety and relevant state water authorities monitor the tap water quality used for packaged drinking water (Azlan et al., 2012). Thus far, bottled water quality in Malaysia has been investigated by Aris et al. (2012) and Azlan et al. (2012) concerning its physical–chemical characteristics, major and minor ions, and selected minerals. These two studies have concluded that bottled water in Malaysia were in accordance with the World Health Organization (WHO) guidelines and Ministry of Health (Malaysia). In light of the growing trend of bottled water consumption in Malaysia, especially in urban areas, assessing bottled water quality, in particular, microplastics quantity is critical in understanding the potential human health risks.

Therefore, the purpose of this study is to investigate both the presence and characteristics (shape, size, and color) of microplastics in eight bottled water brands in Malaysia. Furthermore, the present study explores the possible microplastics sources in these bottled water brands. Finally, the estimated daily intake (EDI) of bottled water was calculated to assess human exposure levels for both adult and children groups. The present study provides evidence of microplastics in bottled water relative to the bottled water type and the possible sources of these microplastics. These findings also lay the groundwork for the analysis of microplastics particles less than 1.5 μm and estimation of daily human exposure due to microplastics consumption from bottled waters.

Section snippets

Bottled water selection and purchasing

A survey was conducted to screen bottled water brands in major supermarkets and retail shops in and around Serdang and Seri Kembangan cities (Malaysia). Based on the survey, eight single use bottled water brands were selected, as these brands are highly accessible at major supermarkets and retail shops in the region. Supplementary 1 shows the bottled water characteristics, specified water type, water source, and bottle packaging type. The identical-sized (1.5L polyethylene terephthalate, PET…

Occurrence of microplastics in bottled water

On average, a recovery rate of 98.7% was obtained thereby making the applied method suitable for microplastics detection (Supplementary 3). In the present study, fragment-shaped particles (n=2.67±0.25) were found in blank samples. They may have originated

from the filter housing of deionized water system, similar to the findings of Oβmann et al. (2018) and Weisser et al. (2021). Furthermore, no fiber form particles were found in the blank samples indicating no laboratory contamination…

Conclusion

Eight different bottled water brands from major supermarkets and retail shops in Malaysia were analyzed for the presence of microplastics. Microplastics particles were found in all eight brands of bottled water. The highest microplastic particles concentration were found in brands that packaged drinking water from municipal tap water and processed it using traditional drinking water treatment methods. The smallest particles concentration were discovered in bottled water brands whose raw water…

Author contributions statement

Sarva Mangala Praveena: Conceptualization, Methodology, Sample Analysis, Supervision, Writing - Original Draft.: **Muhammad Aiman Fahim Ishak Hisham**: Sample Analysis.: **Ayu Lana Nafisyah**: Sample Analysis.…

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.…

Special issue articles Recommended articles

References (58)

M. Cole *et al.*
Microplastics as contaminants in the marine environment: a review
Mar. Pollut. Bull. (2011)

L. Dai *et al.*
Pollution characteristics and source analysis of microplastics in the Qiantang River in southeastern China
Chemosphere (2022)

D. Kankanige *et al.*
Smaller-sized micro-plastics (MPs) contamination in single-use PET-bottled water in Thailand
Sci. Total Environ. (2020)

S. Karbalaei *et al.*
Abundance and characteristics of microplastics in commercial marine fish from Malaysia
Mar. Pollut. Bull. (2019)

G. Kutralam-Muniasamy *et al.*
Branded milks – are they immune from microplastics contamination?
Sci. Total Environ. (2020)

D. Lithner *et al.*
Environmental and health hazard ranking and assessment of plastic polymers based on chemical composition
Sci. Total Environ. (2011)

P. Makhdoumi *et al.*
Occurrence of microplastic particles in the most popular Iranian bottled mineral water brands and an assessment of human exposure
J. Water Process Eng. (2021)

B.E. Oßmann *et al.*
Small-sized microplastics and pigmented particles in bottled mineral water
Water Res (2018)

D. Peixoto *et al.*
Microplastic pollution in commercial salt for human consumption: a review
Estuar. Coast. Shelf Sci. (2019)

S.M. Praveena *et al.*
Heavy metal exposure from cooked rice grain ingestion and its potential health risks to humans from total and bioavailable forms analysis
Food Chem (2017)

View more references

Cited by (30)

First occurrence and risk assessment of microplastics in enteral nutrition formulas

2024, Food and Chemical Toxicology

Show abstract

Assessment of anthropogenic particles content in commercial beverages

2024, Food Chemistry

Show abstract

Human exposure to microplastics via the consumption of nonalcoholic beverages in various packaging materials: The case of Hong Kong

2024, Journal of Hazardous Materials

Show abstract

Microplastic contamination in some beverages marketed in türkiye: Characteristics, dietary exposure and risk assessment

2024, Food and Chemical Toxicology

Show abstract

Microplastics in water: Occurrence, fate and removal

2024, Journal of Contaminant Hydrology

Show abstract

Microplastic prevalence and human exposure in the bottled drinking water in the west Godavari region of Andhra Pradesh, India

2024, Journal of Contaminant Hydrology

Show abstract

View all citing articles on Scopus ↗

View full text