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

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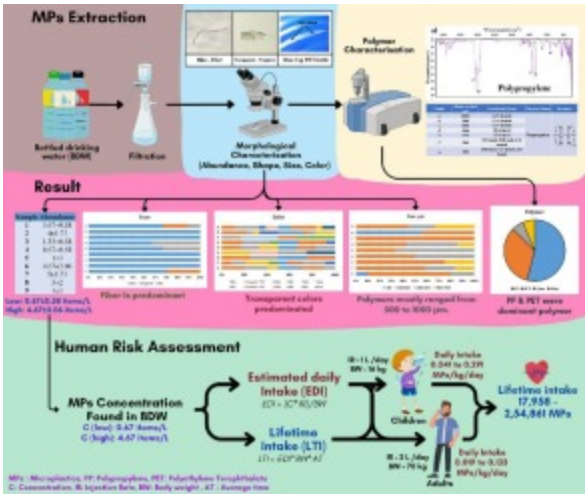
Highlights

- The bottled drinking water had an average concentration of 2.89±0.48 items/L.
- Most Microplastics were found as PP by ATR-FTIR analysis.
- The daily intake of microplastics ranged from 0.019 to 0.291 MPs/kg/day for both children and adults.
- The Lifetime intake of microplastics for an individual ranged from 17,958 to 254,861 MPs.

Abstract

Microplastics (MPs) are widespread, minute plastic particles present in various aquatic environments, raising concerns about their effect on human health and ecosystems. The detrimental effects of MPs on the environment, include the contamination of ecosystems, harm to aquatic life through ingestion, potential disruption of food chains, and long-term ecological consequences. Despite numerous studies confirming the MP's presence in aquatic environments, research specifically focused on MPs in bottled drinking water (BDW) is limited. Research on MPs in drinking water is vital to assess potential health risks and develop strategies for ensuring water safety and quality. This study fills a research gap by investigating microplastics (MPs) in nine brands of BDW in the West Godavari region of Andhra Pradesh, India. The average MP concentration in BDW was found to be 2.89±0.48 items/L, with fibers being the predominant shape and sizes ranging from 500 to 1000μm. Transparent and blue were the most common colors. From ATR-FTIR analysis, the dominant polymer found was polypropylene (PP) followed by polyethylene terephthalate (PET). The human risk assessment was also calculated using the formula of Estimated daily intake (EDI) and Lifetime intake (LTI). The calculation found that the EDI of MPs for children and adults ranged from 0.041 to 0.291 MPs per kilogram per day and 0.019 to 0.133 MPs per kilogram per day, respectively. The mean LTI of MP consumption of an individual, ranged from 17,958 to 2,54,861 MPs, considering an average age of 75 years. The current findings offer valuable information for ongoing evaluations of the potential human risks linked to MP exposure.

Graphical abstract



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Introduction

Plastics are extensively utilized globally due to their cost-effectiveness, resistance to corrosion, minimal thermal and electrical conductivity, and durability. However, despite its widespread use and convenience plastic carries several significant disadvantages including limited biodegradability, substantial disposal challenges, and environmental pollution to name a few. The extensive utilization of plastic products and inadequate handling of plastic trash have led to an unparalleled level of plastic pollution in virtually every part of the globe (Chen et al., 2024; Liu et al., 2024). As per (Plastics Europe, 2019) the world's annual production of plastic stands at 300 Mt. (Million tons), whereas waste plastic is recycled only in 20%. In 2015, over 79% of the 6300 Mt. of global plastic waste generated was dumped in the environment (Geyer et al., 2017). However, because of existing manufacturing and trash management practices, it is predicted that by the year 2050, around 12,000 Mt. of plastic waste will be disposed of in landfills or the environment (Geyer et al., 2017). Presently, India produces over 56 lakh tons of plastic waste annually, of which about 85% is inadequately managed and tends to enter the environment, particularly surface water systems (Suchithra et al., 2022).

Microplastics (MPs) are tiny plastic particles formed when plastic materials deteriorate through chemical, physical, and biological processes and are generally defined with a size of <5mm (Sekar and Sundaram, 2023a). Categorized by their origin (primary and secondary), Primary MPs are made on purpose: examples include plastic pellets, and microbeads used in PCCPs (personal care and cosmetic products), etc. to increase their performance (Bhatia et al., 2024; Sutkar et al., 2023; Zhou et al., 2023). Conversely, secondary MPs originate from the plastic breakdown due to a variety of physical, chemical, and biological processes (e.g., photodegradation, mechanical breakdown, tyre abrasion, microbial degradation, etc. (Ali et al., 2024; Thiele et al., 2023). In recent years, numerous studies have revealed the existence of MPs in various aquatic and terrestrial environments including rivers, lakes, estuaries, freshwater sediments, seawater, marine sediments, soil, and aquatic organisms to name a few (Chen et al., 2024; Gupta et al., 2024; Khedre et al., 2024; Kim et al., 2023; Kumar et al., 2024; Liu et al., 2024; Tan et al., 2023; Xia et al., 2023). It is reported that MPs are found all over the planet, from Mount Everest to the deepest part of the Mariana Trench (Napper et al., 2020; Venkata Siva Naga Sai et al., 2021).

The detection of MPs in different aquatic samples like surface water, wastewater, and groundwater prompts the inquiry into potential contamination of drinking water. Research on MPs in surface water continues to increase, but there remains a significant gap in understanding MP contamination in drinking water. While surface water studies have

provided valuable insights into the distribution, sources, and environmental impacts of MPs, research focusing on MPs in drinking water and bottled water is comparatively limited. In a recent statement, the World Health Organization (WHO) emphasized the significance of determining the MPs content of bottled water brands all over the world and investigating the health concerns that are associated with the intake of MPs (WHO 2019). The first examination of MPs in bottled mineral water was conducted by (Wiesheu et al., 2016), revealing the presence of polyester fibers. However, the authors could not verify the authenticity of their findings because they noticed comparable levels and types of fibers in their blank samples. Ever since, there has been a consistent effort to identify the MP concentration in bottled drinking water across the globe (Kankanige and Babel, 2020; Kirstein et al., 2021; LI et al., 2023; Makhdoumi et al., 2021; Mangala Praveena et al., 2022; Nacaratte et al., 2023; Oßmann et al., 2018; Samandra et al., 2022; Winkler et al., 2019; X. jun Zhou et al., 2021). Recent research indicates that MPs are found in bottled water mostly as fibers or fragments, with sizes ranging from 1 to 100μm and abundance levels ranging from 8 to 2600 particles per liter. These particles are mainly derived from PET (polyethylene terephthalate), PVC (polyvinyl chloride), HDPE (High-density polyethylene), PP (polypropylene) and LDPE (low-density polyethylene) (Kankanige and Babel, 2020; LI et al., 2023; Makhdoumi et al., 2021; Nacaratte et al., 2023; Samandra et al., 2022).

As per the European Drinking Water Directive (EU, 2020) particular attention be paid to the MPs risk assessment in case of water destined for human consumption. Additionally, a significant pathway of human exposure to these pollutants has been identified in several studies (Montero et al., 2023; Zuri et al., 2023). Researchers have verified the MPs presence in food and water, such as commercial fish (29.9±2.73 items/fish) (Abbasi et al., 2023), table salt (700–5470 MPs/kg) (Taghipour et al., 2023), packet milk (6±5 particles/L) (Basaran et al., 2023), and soft drinks (7.3 to 10.4 items/L) (Altunışık, 2023a). The MPs presence in the human body poses both direct and indirect threats to human health by inducing chemical or physical stress in the digestive and circulatory systems (Joseph et al., 2023). Furthermore, MPs along with various harmful contaminants pose a multitude of health risks in humans, contributing to conditions such as diabetes, disruption of the development and reproductive problems, cardiovascular complications, pulmonary diseases, and endocrine system (Marfella et al., 2024; Montero et al., 2023; Zuri et al., 2023). Because of their slow rates of degradation, MPs can persist in nature for extended periods leading to significant environmental pollution as well (Bhatia et al., 2024; Gupta et al., 2024). However, it is difficult to consistently compare and aggregate data on MP abundance and to conduct a thorough risk assessment of its presence due to the diversity in sample processing methods followed across the studies. Therefore, it is essential to establish standard methods for

accurate MP analysis and collaboratively test and refine these methods across various research groups.

Although extensive research has been conducted on MPs in the environment, studies investigating MPs in the human diet such as drinking water remain limited (Nizamali et al., 2023). Bottled drinking water (BDW) is treated tap water sourced from rivers, then undergoes further treatments like distillation or reverse osmosis before being bottled (Mangala Praveena et al., 2022). These drinking waters are packed in a transparent bottle with colored caps. In India, BDW consumption has increased significantly, contributing to the total global consumption. Along with Brazil, China, Indonesia, Mexico, and Thailand, these six countries account for approximately 80% of the world's BDW consumption. Between 2004 and 2016, India alone experienced a staggering 174% increase in BDW consumption (Taheri et al., 2023). Assessing BDW quality, particularly regarding MPs, is crucial in India, especially in urban areas where consumption keeps increasing. This evaluation helps to understand potential human health risks associated with BDW consumption. Addressing these data limitations is essential for advancing risk assessment efforts in this area.

This study focuses on investigating the presence and distribution of MPs in BDW brands commonly available in the West Godavari region of Andhra Pradesh, India. In addition, it also investigates the particle shape, size and color of the MPs found. Furthermore, it involves conducting human risk assessments for MPs in both adults and children by calculating the estimated daily intake (EDI) and lifetime intake (LTI) for BDW. These findings offer important information for continuously assessing the possible risks to human health linked with MPs.

Section snippets

BDW selection and purchasing

A comprehensive study was initiated to evaluate the major BDW brands available in most retail and supermarket stores in the West Godavari region of Andhra Pradesh. From the search 9 brands of BDW widely available at the stores were chosen for examination. From each brand, three bottles (PET plastic bottles) of 1l were randomly picked from various stores all having their expiration dates between September and October 2024. The brands included were as follows: Aquafina, Bailley, Bisleri, Divya…

Abundance and size of MPs

Risk evaluation for MPs is difficult due to their diverse chemical content, physical properties, and concentration. Fig. 2a illustrates the total count of MPs detected in each 1l sampled BDW. Remarkably, it discovered MPs in nearly all the brands, with all bottles examined exhibiting distinct levels of MP contamination. Notably, out of the 27 BDW bottles tested, four of them displayed the highest MP concentrations, whereas two of them showed no presence of MPs. A total of 78 MPs were found in…

Conclusion

The presence of MP particles in BDW has emerged as a significant environmental and public health concern. Our study examined nine different branded BDWs in the West Godavari region of Andhra Pradesh, India, and we found MPs in all the samples, each with varying concentrations. The predominant shape of these MPs was in the form of fibers, with a substantial portion falling within the size range of 500–1000μm. The primary color of the MPs was transparent, followed by blue. Through ATR-FTIR…

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CRediT authorship contribution statement

Vijaykumar Sekar: Writing – original draft, Validation, Methodology, Investigation, Formal analysis, Conceptualization. **Sheha Shaji:** Writing – original draft, Validation, Methodology. **Baranidharan Sundaram:** Writing – review & editing, Resources, Project administration, Funding acquisition.…

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 word reported in this paper.…

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