Uttar Pradesh Journal of Zoology

Volume 45, Issue 14, Page 340-348, 2024; Article no.UPJOZ.3699
ISSN: 0256-971X (P)

Presence of Microplastic in Bottled Water from Mumbai Market

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Authors' contributions

This work was carried out in collaboration between both authors. Authors AS and MBT conceived the idea of the project. Author AS developed the theory and performed all experiments to test the theory. Author MBT verified the methods and contributed as a reviewer to the final manuscript. Both authors read and approved the final manuscript.

Article Information

DOI: https://doi.org/10.56557/upjoz/2024/v45i144211

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://prh.mbimph.com/review-history/3699

Original Research Article

Received: 26/04/2024
Accepted: 29/06/2024
Published: 03/07/2024

ABSTRACT

The abundance of microplastics in the global environment has raised concerns about their transfer into various ecosystems, including water sources. Bottled drinking water, often considered a symbol of purity is not exempt from the infiltration of microplastics. The aim of this paper was to check for presence, if any, of microplastics in bottled drinking water. Overall, five top-brand water bottles available in supermarkets were analyzed. Microplastic contamination was found in all five brands of bottled water with almost similar concentrations with a mean size of 82 ± 22 µm with an average number of microplastics present was 15 ± 20 microplastics/ 30ml of water. Microplastics were filtered using appropriate-size filter paper. Key findings suggest that microplastics are indeed present in bottled drinking water with variations in concentration and polymer types. The sources of contamination, including the manufacturing process, packaging materials, and the environmental surroundings, are explored to shed light on potential entry points for microplastics. Further

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Cite as: *Singh, A., & Talpade, M. B. (2024). Presence of Microplastic in Bottled Water from Mumbai Market. UTTAR PRADESH JOURNAL OF ZOOLOGY, 45(14), 340–348. https://doi.org/10.56557/upjoz/2024/v45i144211*

investigation of the contaminants is necessary to understand the discrepancy in the presence of microplastics in bottled water and essential precautions must be implemented in the purification process of bottled water packaging.

Keywords: Drinking water; microplastics; bottled water contamination.

1. INTRODUCTION

"Plastics made of long-chain polymers are widely used in a variety of industries, including health and food, because of their lightweight, strong flexibility, thermal and electrical insulation, chemical resistance, durability, and low cost. Plastic waste degrades in the environment through both biotic (biodegradation by bacteria) and abiotic (photodegradation by UV exposure or weathering by waves and winds) processes" [1]. "Primary microplastics are small particles that have been manufactured for commercial use like cosmetics, textiles, etc. Secondary microplastics are bigger plastic particle materials. Nanoplastics are so small that they can easily sneak past any conventional water-cleaning process" [2-6].

"Plastic has greatly enhanced our lives by serving as an economical, flexible, and hygienic substance employed in diverse fields like construction, household appliances, medical tools, and food preservation. The production of plastic has surged significantly over the past seven decades. In 1950, global plastic output stood at a mere two million tonnes, whereas today it reaches approximately 450 million tonnes" [7]. "Plastic pollution in the environment is caused by increased manufacturing and consumption, as well as poor waste management. This has raised worries about the impact on human and animal health" [8]. "India is one of the world's largest contributors of plastic garbage, producing approximately 9.46 million tonnes annually. The country is currently confronting a major problem with plastic trash. The country generates startling amounts of plastic waste, which is becoming a serious environmental concern". [9]. "In 2021, India had a per capita plastic use of 15 kilograms. Polymer demand has steadily climbed over the last three decades, up from one kilogram per capita in 1990. Plastic use in India is predicted to exceed 21 million tonnes by 2021" [10]. "The fundamental source of this problem is a lack of efficient waste management infrastructure in India, which results in polluted streets, overflowing landfills, and plastic garbage in water bodies" [9].

"Bottled water is widely utilized for its several advantages, including taste, purity, safety, and convenience. Bottled water is classed as spring water, natural mineral water, and processed water depending on its source and treatment technique. Between 2010 and 2020, the bottled water industry experienced a 73% increase, and it's projected to continue growing. Consumption is expected to climb from 350 billion liters in 2021 to 460 billion liters by 2030, as per the U.N. University's Institute for Water, Environment, and Health. In 2021, Mumbai, a metropolitan city in India, used the most bottled water. The city's consumption of packaged bottled water stood at 1,190 million litres" [11,12,13]. The reason for the growth in bottled water consumption is the declining quality of tap water available. This poses a bigger health risk to underdeveloped and developing countries. However, countries such as the United States and other wealthy countries have higher-quality tap water. Although being the world's largest consumers of bottled water [14,15,16].

"Bottled water may include microplastics (MPs) due to processing and packaging, making it important to investigate their presence in these popular goods" [17]. "As per a CNN report by Sandee LaMotte dated January 8, 2024, an average of 240,000 plastic particles from seven different types of plastics, predominantly nanoplastics (90%) with the remaining being microplastics, were found in one liter of water, equivalent to two standard-sized bottled water. Microplastics were identified in water from all bottle types, including single-use and reusable PET bottles, as well as glass bottles. PET was the most prevalent polymer found in plastic bottles, and glass bottles contained polyethylene and styrene-butadiene-copolymer. As a result, in addition to the packaging, other possible sources of contamination must be investigated" [18,19,20,21].

"Since the discovery of microplastics in commercial seafood, the issue of food contamination with microplastics has become increasingly serious. Studies on the prevalence of microplastics in German beer, honey, sugar, table salts, drinking, and mineral water [21,22,23,24,25,26,27]. Bottled waters contain microplastics owing to packaging (plastic bottle and cap) and preparation methods" [8].

"Numerous investigations in scholarly research have shown the presence of diverse microplastic fragments composed of materials like polypropylene (PP), polyethylene terephthalate (PET), polyvinyl chloride (PVC), polyacrylic (PA), polystyrene (PS), and others in drinking bottles, food containers, and tap water" [1,21]. "Acute exposures of Polyethylene in fish demonstrated early hatching and dramatically lowered hatching rates" [28]. "Birds with plastic in their stomachs had more lower chlorinated PCBs in their tissue than those without, and their PBDE congener patterns are comparable to those found on ingested plastics. PBTs, discovered in plastic waste collected globally, accumulate within food chains and are associated with various harmful effects such as endocrine disruption, declining fish populations, and diminished diversity and abundance of species". [29,30,31].

Polyvinyl chloride (PVC) is one of the world's most common plastics, used in a variety of products including containers, pipes, vehicle parts, construction materials, and furniture. Vinyl chloride is a well-known carcinogen for both animals and humans. It is most closely related to liver cancer, namely the rare, sentinel neoplasm of hepatic angiosarcoma, a malignant tumor of the liver's endothelial cells [30,32,33,34,35-37].

2. MATERIALS AND METHODS

2.1 Sample Collection and Preparation

Five single-use plastic bottled water brands were chosen that are widely available in supermarkets and retail stores in and around Mumbai. To preserve brand anonymity, all bottled water brands were labelled 1-5, stored at room temperature, and analyzed within a week. The bottles were selected which had expiration days of more than 6 months to avoid any other contamination. All bottles and glassware were carefully cleaned with deionized water to avoid any external contamination. Each brand bottle sample was filtered in triplicates with 0.45 µm Whatman filter paper [38]. Pre-screening of samples was done by observing the filter paper under the Light microscope with 40X and 100X magnification.

Later, the filter paper was stained with Nile Red dye and oven-dried at 40 ◦C for about an hour. Once the filter papers are dried, they are transported to sterilized glass petri dishes for further analysis.

2.2 Sample Analysis

Oven-dried filter papers were cut into four quadrants for better analysis with the Fluorescence microscope. After Nile red staining the plastic polymers left on the filter paper membrane will emit fluorescence light as shown in Fig. 1. The non-plastic materials can be distinguished as not emitting any fluorescence light.

3. RESULTS AND DISCUSSION

Microplastic contamination was found in all five brands of bottled water with almost similar concentrations with a mean size of 82 ± 22 µm. The most abundant size of microplastics were within the range of 23-70 µm as shown in chart 1. Transparent fragments were more common than fibres and threads. The average number of microplastics present was 15 ± 20 microplastics/ 30ml of water. Figs. 1, 2, and 3 show images of filter paper under the light microscope. Mostly fragments of transparent and coloured were observed and coloured threads were observed in bottle no. 3 and 4 as depicted in Fig. 3.

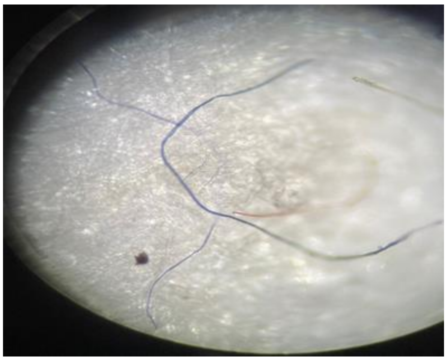

Fig. 1. Filter paper images under the light microscope

Fluorescence images are shown in Figs. 4, 5, and 6 confirming the presence of particles are plastic polymers after taking the Nile red dye. Figs. 1, 2, and 6 depict the presence of long thread under light and fluorescence microscope.

Comparing the results of investigations by [38,17, and 39] revealed a lower amount of microplastic contamination than observed in our study. However, [21,40, and 41] reported significantly greater amounts of microplastic contamination, contradicting the current study.

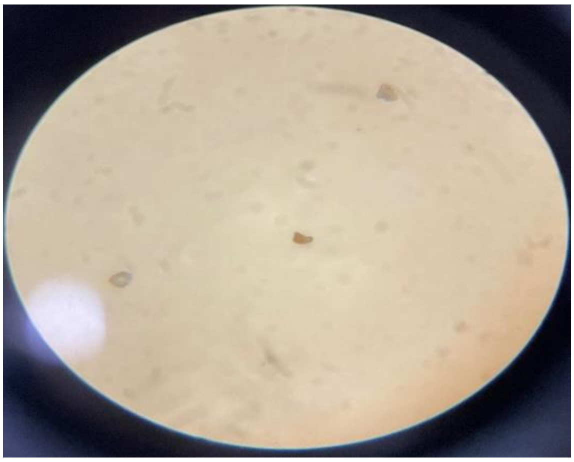

Fig. 2. Filter paper images under the light microscope

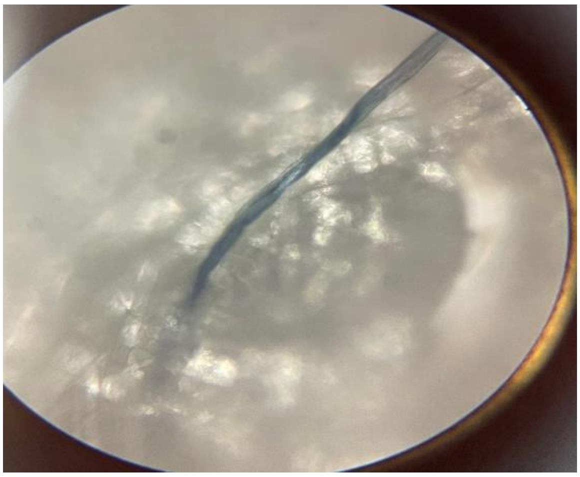

Fig. 3. Filter paper images under the light microscope

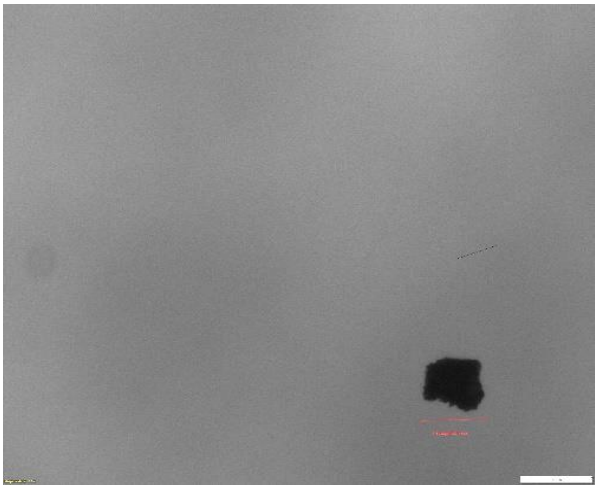

Fig. 4. Fluorescence images confirms Presence of plastic polymers

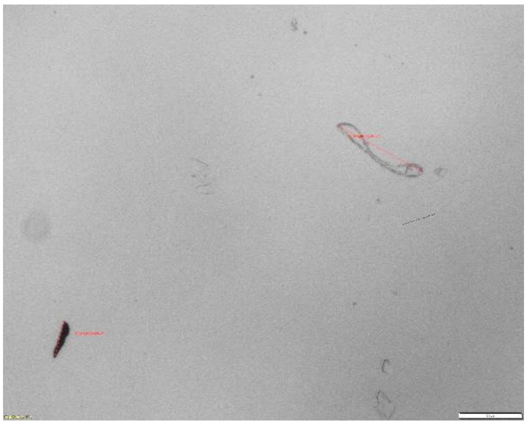

Fig. 5. Fluorescence images confirms Presence of plastic polymers

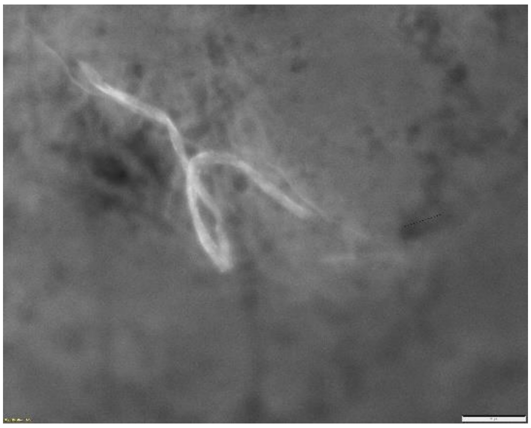

Fig. 6. Fluorescence images confirms Presence of plastic polymers

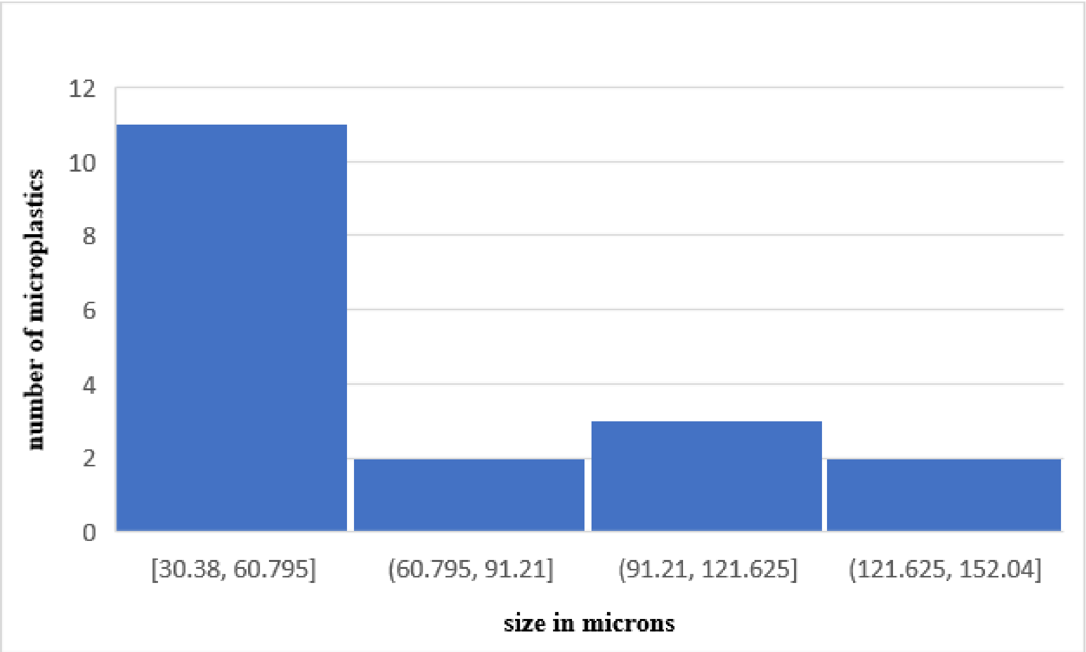

Chart 1. Size distribution of microplastics

4. CONCLUSION

Microplastics in drinking water are one of the numerous leakages of plastic waste from technical cycles into biological cycles globally. Enforcing strict regulations may be necessary to address environmental contamination issues [42]. The most common particles observed in water from returnable plastic bottles were polyester polyethylene terephthalate and polypropylene. This is not surprising because the bottles are made of PET and the lids are made of polypropylene [40,1]. The probable transparent fragments could be polymer types of Polyethylene (PE) and polypropylene (PP). Packing materials, bottle cap abrasion, and contamination during the filling process were among the possible contamination sources [38].

According to the [41] contamination came from surface runoff, wastewater effluents, and the packing or bottling process itself. The presence of microplastics in tap water, while lower than in bottled water, indicates environmental contamination both before and after treatment. Bottled water has nearly twice the level of microplastic. [1]. Food containers made of PET, PP, PE, and PS can leach microplastics over time. Flushing the interior area of a packaging might lead to microplastic leaching. Microplastics can easily penetrate food with minimal mechanical power. Hot water and food may also contribute to microplastic migration [43].

The U.N. University's Institute for Water, Environment, and Health report provides an overview of plastic pollution stemming from bottled water, indicating that globally, around 600 billion plastic bottles are produced annually, leading to 25 million tonnes of waste that remain unrecycled, ending up in landfills or uncontrolled waste channels. Despite growing societal recognition of plastics' adverse environmental impacts, no clear-cut solution has emerged to substantially mitigate these implications. Plastic pollution is expected to continue in the coming years. Microplastics can adsorb pollutants like polycyclic aromatic hydrocarbons (PAH) and heavy metals like Cd, Pb, Cu, and Zn, resulting in the creation of plastic pollutant mixes in the environment [44].

While drinking water treatment plants cannot completely eliminate microplastics from water, the leakage of microplastics from the drinking water distribution system into treated water causes microplastic pollution in potable water. However, the absence of consistent sampling, extraction, and identification methodologies for Microplastic analysis makes it difficult to compare results between investigations. Adopting a standard operating procedure to develop filters that can entrap microplastics in the drinking water treatment plants can play a major role in reducing the microplastics from drinking water. Due to the micro sizes of these particles and difficulty in identifying the microcontaminants, it becomes a rather difficult task to identify the microplastics. Adopting the standard procedure for Microplastic analysis allows for direct comparison of data across research and improves comprehension of the topic [8].

CONFERENCE DISCLAIMER

Some part of this manuscript was previously presented and published in the conference: An International Conference on Coastal and Marine Conservation CMC-2024 dated from 1st and 2nd March, 2024 in Mumbai, India. Web Link of the proceeding:
https://mithibai.ac.in/wp-content/uploads/2024/02/CMC2024-CONFERENCE-brochure..pdf

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

ACKNOWLEDGEMENT

The authors would like to extend gratitude to Prof. Krutika Desai, Principal for providing the opportunity and the non-teaching Staff of the Zoology Department SVKMs' Mithibai College for providing the laboratory for completing the project work.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
https://prh.mbimph.com/review-history/3699