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PREVALENCE AND QUANTIFICATION OF MICROPLASTICS IN BOTTLED WATER

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Abstract

Plastics are commonplace contaminants that we utilize on a daily basis. Microplastics (small particles less than five millimeters in size) are being found in water systems and could pose a threat to human health via routes such as bottled water. This study aims to identify and quantify microplastics in drinking water that is sold in bottles. An Olympus BX51 microscope was used to check the microplastic after separation on filter and staining with methylene blue and total number counted by using ImageJ software. Microplastic separated and stained were found in the range between 22-246/L. the particles stained on filter paper were further analyzed by using FTIR-ATR spectroscopy to check the nature of particles and compared it against the standard spectra of most commonly found popular plastics like polyethylene (PE) and polypropylene (PP). Polyethylene (PE) was found to be mostly occurring micro contaminates in water system. The findings imply that bottled water contains microplastics, which may pose risks to human health. This necessitates further investigation into the sources and effects of microplastic contamination.

Keywords: *Microplastics, Bottled water, ATR-FTIR, ImageJ, Polyethylene, Polypropylene, water contamination*

1. Introduction

Plastics are widely utilized in packaging, construction, medicine, electronics, agriculture and personal care items due to its light weight and affordability (Andrady, 2011; Geyer, Jambeck, & Law, 2017). However, plastics are difficult to biodegrade which leads to significant and long-lasting environmental issues (Haider, Völker, Kramm, Landfester, & Wurm, 2019). Over time, larger plastic objects break up into tiny bits known as microplastics (MPs) as a result of physical, chemical, and biological deterioration. The presence of these microplastics in water may be associated with serious adverse health effects in consumer (Cole, Lindeque, Halsband, & Galloway, 2011; Jambeck et al., 2015).

Microplastics are generated when bigger plastic objects decompose in the environment (Cole et al., 2011). Microplastics are generated primarily through human activities such as industrial pellet loss, microfiber shedding from synthetic clothing during laundry and plastic waste mismanagement in agriculture and fisheries (Yadav, Negi, & Verma, 2024). Microplastic pollution in the environment is generally most prevalent in industrialized and densely populated areas (Hidalgo-Ruz, Gutow, Thompson, & Thiel, 2012). Additionally, it has been demonstrated that common consumer goods like tea bags shed microplastics and nano plastics when used, creating an additional pathway for human exposure (Hernandez et al., 2019).

Microplastics are now widely regarded as emerging contaminants of worldwide significance, primarily as a result of their small size and environmental persistence (Lambert & Wagner, 2017). Their ability to travel great distances has been demonstrated by the fact that they have been found in soil, water and air in a variety of settings including isolated locations distant from human habitation (Allen et al., 2019; Dris et al., 2015). Microplastics have been discovered in a variety of drinking water sources, including tap water (Mintenig, Int-Veen, Löder, Primpke, & Gerdts, 2017) and bottled water (Mason, Welch, & Neratko, 2018) a finding of particular concern for public health. Although many people believe that bottled water is safer than tap water, contamination can occur at multiple stages, including the source water, treatment procedures, bottling operations, and the plastic packaging itself (Schymanski, Goldbeck, Humpf, & Fürst, 2018). Synthetic polymer contamination has been reported in bottled drinking water all over the world (Mason et al., 2018).

Concern over the effects of consuming microplastics on one's health is growing. Toxic contaminants including heavy metals and persistent organic pollutants (POPs) can be transported by microplastics (Bakir, Rowland, & Thompson, 2014; Rochman, Hoh, Kurobe, & Teh, 2013) and biological consequences like oxidative stress and inflammation have been documented in experiments (Chen, Feng, & Wang, 2020). However, the long-term effects of chronic human exposure are still mostly unclear and require immediate research (Vázquez-Rowe, Ita-Nagy, & Kahhat, 2021). Therefore, this study was conducted to assess human exposure to microplastics by determining their prevalence in bottled water by using Optical microscopy and FTIR-ATR spectroscopy.

2. Materials and methods

2.1 Sample Collection

Ten commercially available bottled water samples were collected for this study from a local market in Hyderabad. In order to reflect the most popular brands of bottled water in the local market, bottles were chosen at random. To avoid contamination during handling and storage, every sample was securely sealed and brought to the lab under controlled circumstances.

2.2 Sample Preparation

In order to visualize the microplastic, we used methylene blue as a staining in order to assess the microplastic content. The methylene blue was prepared by dissolving 0.1 g and added five to six drops of the methylene blue solution to each water sample. In order to count and identify the microplastic particulates in water, samples after adding the methylene blue were vacuum-filtered using a membrane filter with a pore size of 0.45 µm. The filter sheets were allowed to air dry and examined under a microscope.

2.3 Microscopy

Microplastic particles in the samples were visually identified and quantified using microscopy. Following filtration, the form, size of suspected microplastic particles were observed in each sample using an Olympus BX51 microscope. This method allows separation of natural detritus from artificial particles, based on morphological characteristics, so it is often used to detect particles as early as possible (Hidalgo-Ruz et al., 2012). Each anomalous micro plastic particle was carefully documented and put up for further digital analysis and spectroscopic validation.

2.4 ImageJ Software Analysis

Microplastic particles were examined and quantitatively analyzed using ImageJ software (National Institutes of Health, USA). Microscopic images were imported into the program to count particles, measure their sizes, and enhance visualization. ImageJ is a well-established tool in microplastic research, valued for its precise digital measurements and ability to minimize manual counting errors (Schneider, Rasband, & Eliceiri, 2012). The software also supports consistent particle size distribution analysis, which improves data reliability and ensures repeatability across samples.

2.5 FTIR- ATR Spectroscopic Analysis

The type of microplastic and polymer identification of the separated microplastic particles were identified by using Attenuated Total Reflectance Fourier Transform Infrared (ATR-FTIR) spectroscopy. This technique is able to identify polymers with unique IR spectra and can be used on solid samples without significant sample preparation. The spectra obtained were compared with known reference spectra to determine the type of the polymer, including polyethylene (PE), polypropylene (PP), polyethylene terephthalate (PET), and polystyrene (PS). The method that has been well established and reliable to verify the presence of microplastics in environmental samples (Löder & Gerdts, 2015; Shim, Hong, & Eo, 2017).

3. Results and discussion

The commercially available bottled water that was commercially sold was analyzed under the microscope and it was seen that each of the water samples contained micro plastic particles and hence the nature of the micro plastics contamination in commercially sold bottled water was demonstrated. Three major categories—colored fibers, pieces, and irregularly shaped particles were seen in the water samples. Some of the observed images are shown in the figure 1 given below.

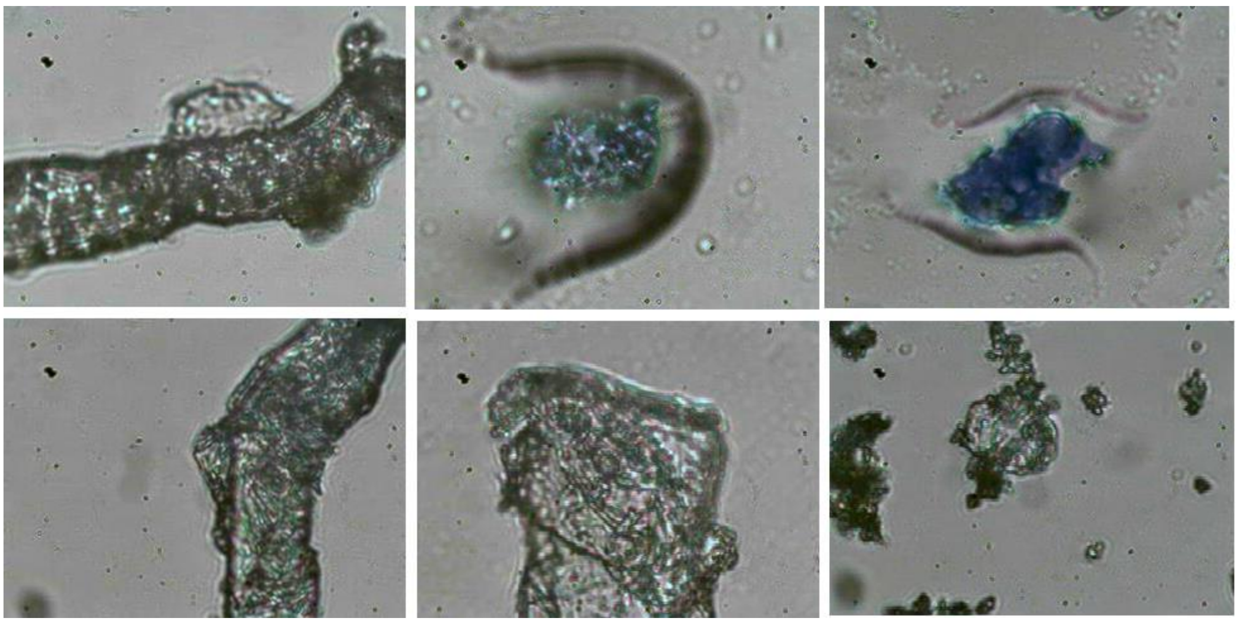

Figure 1: Shape of different microplastic observed under microscope

The results of Mason et al. who similarly identified fibers, fragments, and granules as the predominant particle types in their extensive examination of bottled water from several multinational brands, are in line with this morphological diversity (Mason et al., 2018). The most noticeable particle type was fibers, which were found in a variety of colors and strongly suggested contributions from the laundering of synthetic textiles, a known route for the release of microfibers into water systems (Dris et al., 2015). Secondary microplastic development, which results from the physical and photochemical breakdown of bigger plastic items during the production, transportation, or storage of the bottled products themselves, is indicated by irregularly shaped particles (Jambeck et al., 2015; Tinel et al., 2025).

Microplastic contamination in all 10 samples, regardless of brand or source, is reflective of the increasing global evidence of microplastic contamination as a systemic problem with bottled water as a product category, rather than a specific problem or brand. Similarly, Schymanski et al. found microplastic particles in each of the bottled water products they analyzed, PET and composite packaging – demonstrating contamination is not restricted to a particular type of packaging (Schymanski et al., 2018). The morphology variation of this study regarding particle size, shape, and color also matches with Kosuth et al.'s global survey (Kosuth, Mason, & Wattenberg, 2018) that revealed the presence of synthetic polymer particles in the bottled water samples collected from multiple continents, reflecting the worldwide and geographically non-discriminatory contamination.

Ten bottled water samples were subjected to quantitative analysis using ImageJ software, which showed a wide range of microplastic contents, with particle counts ranging from 11 to 123 particles per 500 mL(Schneider, Rasband, & Eliceiri, 2012). The large inter-sample variation in particle load is probably due to variations in the quality of the source water, the effectiveness of the water treatment, the filling and capping procedures, and the kind and state of the plastic packaging that various commercial brands utilize (Mason et al., 2018; Schymanski et al., 2018).

In general, the quantities found in this study are similar to those found in earlier studies. Within the upper range of contamination found in the current study, Mason et al. found an average of 325 microplastic particles per liter among eleven globally recognized bottled water brands, or roughly 162 particles per 500 mL(Mason et al., 2018). In their global bottled water survey, Kosuth et al. also reported widespread contamination with an average of 10.4 microplastic particles per liter(Kosuth et al., 2018). This is within the lower range of the values reported here, suggesting that regional variations in manufacturing processes, analytical methods and packaging materials can result in significant differences in contamination levels.

The inter-sample variation observed in the present study could be attributed in part to the report of Schymanski et al. that different packaging types and materials release different amounts of particles; the PET bottles releasing more particles than glass or composite bottles. Importantly, the detection of microplastic in all 10 samples, without regard for concentration, is consistent with the literature in many of the commercially-bottled water samples that were tested (Mason et al., 2018; Schymanski et al., 2018).

Chemical identification of the microplastic particles extracted from each of the ten samples was carried out by FTIR-ATR spectroscopic analysis. The absorbance values for the different types of microplastics reported in bottled water are presented in Table 1. Our results, upon analysis, showed the presence of absorbance bands falling within this region. The FTIR-ATR spectra obtained are shown in Figure 2

Table 1. Microplastic particles showing absorbance bands reported from bottled water

Polymer Type	Characteristic ATR-FTIR Absorption Peaks (cm^{-1})
PP	~2950, ~1455, ~1375, ~840–800
PP + PE	~1455, ~1470, ~1375
PP	~1376
PP + PE	~1470, ~2950
PE (C–H_2 stretching)	~2915, ~1470
PP (methyl group vibrations)	~2950, ~1455, ~1375
PE	~1470, ~720
PP	~2950, ~1455, ~1375
PET	~1715, ~1240, ~1100
Polystyrene	~1600, ~1490, ~700–750

PE = Polyethylene; PP = Polypropylene; PET = Polyethylene Terephthalate; PS = Polystyrene

The bands observed in our spectra correspond to several polymer types. Polypropylene (PP), either alone or in combination with polyethylene (PE), was the most common polymer identified. In some samples, PE was shown to be the predominant polymer, while other samples verified the co-occurrence of PP and PE. Distinctive absorption peaks at approximately 1715, 1240, and 1100 cm^{-1} were identified as polyethylene terephthalate (PET). Additionally, peaks at roughly 1600, 1490, and 700–750 cm^{-1} were used to confirm polystyrene. The different sample spectra obtained are presented in Figure 2.

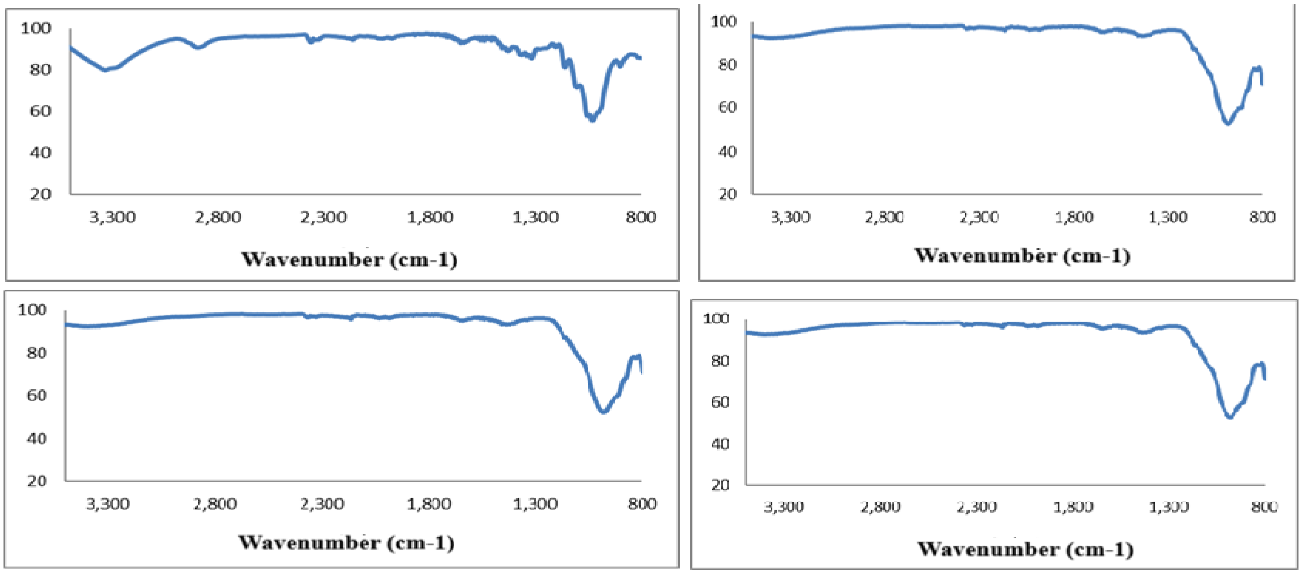

Figure 2: FTIR-ATR Spectra of microplastics collected from the Bottled water

The results of several independent studies have shown that most of microplastics belong to PP and PE. Mason et al. found that PP was one of the most common polymers present in bottled water, which was explained as due to its great usage in the production of bottle caps and closures(Mason et al., 2018). In a similar study, Schymanski et al. confirmed that PP and PE were the primary polymers leaching into bottled water from plastic packaging, and that the spectral profiles for these were very similar to those observed in this investigation (Schymanski et al., 2018). Given that PET is the main component used in the production of disposable plastic water bottles, the discovery of PET in one sample is especially noteworthy. Horton et al has have demonstrated that micro plastic particles being released directly from the PET bottle into the liquid it contains, especially when the bottle is put under physical stress, temperature fluctuations or is stored for long periods(Horton & Dixon, 2018). The presence of polystyrene has been reported in one sample but it is not as common. However, Kosuth et al. detected polystyrene particles in some of their samples of bottled water from around the world, suggesting that the polymer is being introduced into the water through contact with the processing equipment or secondary contamination during filling.

The high spectral similarity between the peaks in this study and the polymer reference libraries reported by (Löder & Gerdts, 2015) and Shim et al. (W. Shim, S. Hong & S. Eo, 2017) validates the FTIR-ATR method for the identification of microplastics in bottled water. The polymer profile identified for all samples analyzed, consisting mostly of PP and PE and with small amounts of PET and polystyrene, indicates that the most common source of microplastic contamination in the analyzed products is the bottle body, caps and closures.

4. Conclusion

The analysis of all ten bottled water samples confirmed the ubiquitous presence of microplastics. Morphological inspection revealed colored fibers, fragments, and irregular shapes, indicating degradation and fragmentation of larger plastic products. Quantitative analysis showed particle counts ranging from 11 to 123 particles per 500 mL, with high inter-sample variations attributed to differences in source water quality, manufacturing processes, and packaging materials. ATR-FTIR spectroscopic characterization identified polypropylene (PP) and polyethylene (PE) in all samples, while polyethylene terephthalate (PET) and polystyrene were detected in selected samples, strongly suggesting that plastic packaging components such as bottles, caps, and closures are the primary sources of contamination.

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