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Assessment of Microplastics in Food Items, Soft Drinks, and Bottled Water and their Potential Health Risks

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Abstract

This study reports the presence of tiny microplastics defined as plastic particle ranging from (1µm to 5mm)size in various different food samples paticularly in soft drinks and bottled water. Different Food samples from the market, soft drink and bottled water from various source were examined and analyzed to determine the presence of these microplastics.The instrument used was Fourier Transform Infrared Spectroscopy (µ-FTIR) for the determination of these particles. The study noted that individuals drinking bottled water daily may ingest up to 90,000 more microplastic particles per year than those who do not.Everything we eat wrapped in plastic shed some particles on it that are consumed by us.Microplastic accumulation in human blood vessels is linked with higher rates of heart attack, stroke, and death also it can cause several health hazards include oxidative stress,immune system disturbance neurotoxicity and carcinogenic consequences.

Keywords : Soft drink ,Bottled water, Microplastic & Nanopollution

Introduction

Plastics produce small fragments or particles through crushing, splitting and degrading during use. In the 1970s, plastic particles were first discovered in surface waters of the Atlantic. ***Thompson et al*.(2004)** published a paper in Science and put forward the concept of "microplastics" for the first time. Microplastics are minute plastic particles typically less than 5 mm in size that have emerged as a major environmental contaminant of global concern. Their origin is closely linked to the rapid growth in plastic production following World War II, when synthetic polymers such as Polyethylene, Polypropylene, and Polystyrene became widely used due to their durability, low cost, and versatility. Over time, improper disposal and environmental exposure have led to the fragmentation of larger plastic debris through physical, chemical, and biological processes including Photodegradation, resulting in

the widespread distribution of microplastics in marine, freshwater, terrestrial, and atmospheric environments.

A recent review in India focused on microplastic (MP) pollution in various environmental matrices, highlighting the research gaps for future research priorities as well as the associated issues in these areas (***Veerasingam et al.*** , **2020, Lechthaler et al., 2021, Vaid *et al., 2021, Pattiaratchi et al., 2022).***

Studies found that microplastic particles are leached out from bottled drinking water, tap water, and food packaging (***Muhib, 2021).*** The accumulation of microplastic derived from the leaching of fragmented plastic materials and associated chemicals (including additives and other toxins) can hamper human lives (***Diepens and Koelmans, 2018*** . Microplastic materials create toxicity to biotic and abiotic components since they increase the release of additives and monomers and can act as a vector of microbial contamination ***(Yadav et al., 2023)***

.Extensive microplastic pollution in the environment due to anthropogenic activities accelerates the tendency to human exposure that may occur through

ingestion, inhalation, or skin contact (***Yang et al., 2022; Muhib and Akter, 2021***). It is also hazardous to the animal kingdom (***Sridharan et al., 2022)***. Several studies from the upper literature revealed that different pieces of microplastics composed of ***polypropylene (PP), polyethylene terephthalate (PET), polyvinyl chloride (PVC), polyacrylic (PA), polystyrene (PS),*** etc., are found in drinking bottle and food containers as well as in tap water sources. These elements, additives, and other complex materials can affect the human body (***Karbalaei et al., 2018).*** Polyethylene (PE) is widely used in reusable bags and food packaging and has even been detected in human stools (***Djouina et al., 2022)*** . PET-deviated bottles are usually used for drinking purposes. These materials are also used in microwavable packaging, insulated mold, and plastic filler and may pose a cancer risk (***Li et al., 2016).*** The everyday use of PS is in food packaging, plates, disposable cups, spoons, etc.

Nowadays, in our daily routine life, we are addicted to use various market edibles and drinking materials along with purchasing various daily using skin care and other products sometimes unnecessarily. Several modifications take place with increasing people's demands and consumption. People are preferring processed food easily available to consume instead of pure material. If we talk about edible oils, sauces, edible biscuits, namkeen, etc., they all come in plastic bag packaging. Plastic food packaging results in these microplastics and nanoplastic migrate foods and beverages.People may be exposed to these through the air,food and absorption

through the skin from the use of personal care products .

Microplastics are tiny plastic fragments—generally under 5 millimeter in size — while nanoplastic are even smaller below 1µm . The FDA uses these size ranges as reference points. Studies have detected these particles in everyday items like salt, seafood, sugar, beer, bottled water, honey, milk and tea. Because packaged foods and drinks can leach micro- and nanoplastics, they pose a potential health risk, giving the FDA grounds to consider regulatory action.

Material and Methods :

Market samples of packaged foods and beverages, including **Bottled water, Honey syrup, Olive oil,Milk (Dairy)** and **Soft drink(Spirit**) were collected from local retail outlets and transported to the laboratory under contamination-free conditions for microplastic analysis. Prior to analysis, each sample underwent a brief preparation procedure to isolate suspected microplastic particles. Liquid samples such as **bottled water and spirit** were first vacuum-filtered through pre-weighed glass fibre or membrane filters (pore size ~0.45 µm). For complex matrices including **Milk(Dairy), Honey syrup, and olive oil,** an initial digestion step using mild oxidizing agents (e.g., hydrogen peroxide) or enzymatic treatment was performed to remove organic matter, followed by density separation using a saturated salt solution to float plastic particles. The supernatant containing potential microplastics was then filtered and the retained particles were carefully dried in a contamination-controlled environment. The collected residues were subsequently characterized using Fourier Transform Infrared (FTIR) spectroscopy in the spectral range of 4000–400 cm^{-1} with a resolution of 4 cm^{-1} and 32 scans per sample to identify polymer types based on their characteristic absorption spectra.

Result and discussion:

This study focused on the identification and quantification of microplastics found in common liquid and semi-liquid food products. It utilizes **FTIR Spectroscopy**-implied by the "Characteristic Peaks" column - to fingerprint specific polymers.

①**Microplastic in honey syrup:**In the recent study, Peaks around **2915** and **2748** correspond to C **-H stretching** . PE is commonly used in squeeze bottles & Plastic wraps. Honey's high viscosity (thickness) actually act as a trap. Unlike water, where particles might settle, the thick syrup keeps microplastics suspended uniformly

throughout the product. Here the main Peak **2915 cm^{-1} (strong)** most dominant peak for (PE). Its high intensity suggest that the plastic particles are relatively

fresh or have a high density of long-chain hydrocarbon also primary peak used to calculate conc. (**0.52 ± 0.12).**

2 .**Microplastic in Milk (Diary):**The present FTIR analysis of Milk for **PET** shows the peak at **1714** is the "Carbonyl" (C=O) stretch, typical of polyesters used in clear plastic milk or juice jugs at a conc. of **0.85 ± 0.18.** when these plastic are ingested via diary, they trigger several biological pathway in the human body. as it cause inflammation of the lining, altered gut health also affect Reproductive health and thyroid function.

3 .**Microplastic in Olive oil:** In the FTIR analysis of Olive Oil sample identified microplastic is **Polypropylene (PP)** shows Peak level **2850cm**$^{-1}$ & **2914cm**$^{-1}$ that is C-H stretching Vibration & **1374 cm**$^{-1}$ that is **CH_3 bending** Vibration. Contamination originate from Plastic packaging container, bottle caps , Processing pipeline Here the Concentration is **1.23 ± 0.25** shows moderate to relatively high contamination level. These microplastic can probably cause harmful effects on human such as Cellular toxicity, Endocrine disruption, Cardiovascular & metabolic risks.

4. Microplastic in Soft drink (Spirit): In the study **FTIR** analysis of **Soft drink (Spirit**) identified microplastic - **Polystyrene (PS)** shows the Peak of **3025 cm**$^{-1}$ (aromatic C-H stretching), **2926 cm**$^{-1}$ (Aliphatic C-H stretching) and **1602 cm**$^{-1}$ **(**Aromatic C=C stretching) collectively confirms Polystyrene contamination usually arising from bottle lining, disposable cups, Bottle caps.

5. **Microplastic in Bottled Water:**This study identified 3 of the most common globally produced polymers. Here **Polyethylene (PE)** is the most prevalent microplastic in the sample (**2.5 ± 0.5 particles** / L) Nowadays, PE is commonly used in plastic bags, clear food wraps & detergents bottles also. Polypropylene (PP) found at a concentration of **1.8 ± 0.3 Particles** /L, this plastic also used as bottle caps, yogurt containers. Third one is Polyethylene Terephthalate (PET) found at lowest conc. (0.8 ± 0.4 Particles/L). It is the primary material for beverage bottles (water & soda). Here PET has the highest relative uncertainty (±0.4 on a 0.8 base suggesting its distribution more "patchy" or inconsistent across the tested samples compared to

PE or PP.

Summary of the Result in the tabulated form :

Table 1.FTIR Analysis of Honey syrup,Milk (Diary),Olive oil,Spirit:

	(PS)	1602	

Table 2.FTIR Analysis of Bottled Water :

Microplastic Type	Peak (cm^{-1})	Concentration (Particles/L)
Polyethylene (PE)	2916, 2847, 1415	2.5 ± 0.5
Polypropylene (PP)	2950, 2914, 1374	1.8 ± 0.3
Polyethylene Terephthalate (PET)	1713, 1241, 1096	0.8 ± 0.4

Discussion :

The occurrence of microplastics in honey and bee-related matrices highlights the widespread environmental distribution of plastic pollutants and their potential transfer across trophic levels. Previous studies Microplastic have been found in honey, in several plant species foraged by bees (**Díaz-Basantes et al., 2020** ; **Liebezeit and Liebezeit, 2013,2015)** and on the cuticle of honeybee (**Deng et al., 2021; Edo at al., 2021)** for ex- **Wang et al. (2021) and Balzani at al. (2022)** both found a significant increase on bee mortality using polystyrene (PS) and polyethylene (PE) spheres at
50 mg/L. These findings collectively suggest that microplastic contamination may pose ecological risks not only to pollinators but also to food safety through contamination of apicultural products.

Microplastic contamination in dairy products has become a globally recognized concern, with reports of the contamination increasing worldwide (***Adjama et al., 2024).*** The only major study from ***Tamil Nadu*** reported contamination levels ranging

from 164 to 427 microplastic / L of packaged milk (*Kiruba et al., 2022)*.Compared to other food matrices, such concentrations highlight the vulnerability of liquid food products to microplastic intrusion, particularly due to extensive handling and packaging interactions.

Previous studies have quantified microplastic contamination in different edible oils, reporting variable concentrations depending on oil type and analytical method used, i.e. micro-FTIR (*Battaglini et al., 2024)* and micro-Raman (*Guoet al, 2023)* . for microplastic detection in olive oil. (LDIR) spectroscopy applied for the first time to Extra Virgin Olive Oil microplastic detection.

A growing no. of reports of microplastic pollution in water and other drinks along with the relatively high consumption of soft drinks have drawn the public's focus to the issue of microplastic (*Schymanski et al., 2018; Mason et al., 2018; Diaz-Basantez et al., 2020; Mangala et al., 2022).*

In one of the study in India by *Mohan et al. (2023)(151*) the Nile Red staining, a simple and alternative approach to organic solvent stains, successfully identified the presence of microplastics in 20 commercial bottled water samples. The microplastic of different shapes, types and sizes were identified by FTIR and polyethylene/Polystyrene were the most abundant.

Overall, despite increasing evidence of microplastic occurrence across multiple food and beverage matrices, significant research gaps remain regarding standardized detection methods, long-term toxicological impacts, and the cumulative effects of chronic dietary exposure .

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15.The accumulation of microplastic derived from the leaching of fragmented plastic materials and associated chemicals (including additives and other toxins) can hamper human lives (*Diepens and Koelmans, 2018)* . **16.** Microplastic materials create toxicity to biotic and abiotic components since they increase the release of additives and monomers and can act as a vector of microbial contamination (Yadav et al.,2023).

17. (*Karbalaei et al., 2018)* Microplastic composed of PP, PET, PVC, PA, PS are found in bottled and tap water affect human body.

18.(*Djouina et al., 2022*) PE in reusable bags and food packaging detected in human stool.

19.(*Li et al., 2016)* PET deviated bottles in several purposes pose a cancer risk.

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