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POLLUTION DETECTION OF FINE PLASTIC PARTICLES IN BOTTLED WATER AND TAP WATER

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Abstract

This study provides evidence of the presence of microscopic plastic particles in tap water and three brands of bottled water. This work investigates the effect of time and storage conditions on these resources, using the microscopic counting method by microfiber filter papers. The results showed that the presence of plastic particles in all water samples in the form of single fibers and some in the form of intertwined fibers in different sizes and colors with the concentrations ranging between (36-1236) particles / liter. These concentrations were directly proportional to the length of the storage period under the sun.

Key words: micro plastics, plastic pollution, micro-counting method, Plastic Particles, water quality.

Introduction

Plastic production has experienced tremendous growth after entering the consumer stage, due to its properties of hardness and low costs. Its industrial applications have become widespread, as a result, plastic production has increased strongly in the past decades to reach 311 million tons in 2014 (Mason *et al*., 2018). The increase in the plastics industry is the cause of the high pollution of particle plastic in the external environment (Carpenter and Smith, 1972).

Smaller plastics known as a maximum of 5mm plastic particles have gained increased scientific attention (Koehler *et al*., 2015). It results from the decomposition and fragmentation of plastics into nanoscale microscopic volumes by physical and chemical actions, ultraviolet rays, microbes (Lee *et al*., 2014), or by heating that leads to a decrease in ductility and fragility as a result of a partial division due to heat. This makes plastic particles susceptible to biodegradation into fine plastics particles allowing them to move more easily and possibly even through the digestive system (Shah *et al*., 2008) (Sharma and Chatterjee, 2017).

In the early 1970s, small plastic parts were first reported in the Atlantic Ocean (Carpenter *et al*., 1972). Since then the has been a continuous increase in pollution of small plastics in marine waters (Thompson *et al*., 2004). There are relatively few studies focusing on small plastic pollution in consumer products (Yang *et al*., 2015).

The groundbreaking study in this field was (Kosuth *et al*., 2017) conducted on drinking water in seven countries (Uganda, India, Indonesia and Lebanon, The United States, Cuba and Europe). The plastic particles were analyzed optically by staining them with the pink Bengal pigment after filtering the sample through a cellulose filter size of 2.5 microns. The results showed that among the 159 samples tested, 83% contained plastic particles with a maximum of 57 particle / liter and 99.7% in the form of fibers with lengths ranging between (0.1-5 mm).

The researchers' study (Schymanski *et al*., 2018) showed water used in plastic bottles used for one time and more, using the method of Micro-Fourier Transform Infrared Spectroscopy (m-FT-IR). It was found that all samples contain plastic particles in the form of small fragments of sizes (50-500ìm) and very small (1-50μm). The average content of microscopic materials was 88 - 118 particle\ L in bottles used more than once against 14 particles\ liter, most of these fine plastic particles from plastic bottles consist of Primary polyethene terephthalate (PET) and Polypropylene (PP).

Another study conducted by (Mason *et al*., 2018) have detect plastic pollution in bottled water in nine different countries using the Red Nile dye. This study

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confirmed that 93% of them were polluted with an average of 325 Particle / liter. Infrared spectroscopy revealed that most of these plastic particles are made of polypropylene (used to make bottle caps).

Other researchers (Mintenig *et al*., 2019) have revealed plastic pollution of drinking water in tap water. This showed the presence plastic particles with an average of 0.7 particle / liter. These particles were identified as polyethylene, polyamide, polyester, polyvinyl chloride. (Chaudhury *et al*., 2020) found small plastics in bottled water at a rate of 10,000 particle / liter. Their sizes ranged from 5 to 10 microns. The study indicated that the source of plastic particles in bottled water is polypropylene (PP) and polyethylene terephthalate (PET) used in the manufacture of the bottle.

The storage method has become a growing concern especially when some studies have shown that plastic bottles (polyethylene terephthalate) are susceptible to degradation due to elevated temperatures and ultraviolet radiation (Anayo *et al*., 2018; Bach *et al*., 2009). Bottled water stored in the car outside the market and some may expose to sunlight (Muhammad *et al*., 2011)

The aim of this study is to assess the pollution of tap water and plastic bottled water in the city of Mosul - Iraq, as well as to study the effect of time and storage conditions on this type of pollution.

Materials and Methods

Sample Collection

Water samples, with bottled volume 0.5 liters, were collected randomly from the local markets in Mosul city. Three of the most popular distributed brands were selected, (Life, Tiyan and Lava) fig.1. As well as one sample of tap water was collected to detect accurate plastic pollution.

Fig. 1: Examination of trademarks of studied brands.

Fig. 2: Demonstrate sample filtering using a micro-fiber filter.

To assess the effect of storage conditions on water quality, 12 bottles for each company were placed in different storage locations (sunlight at a temperature ranging between 8-26^{o}C, Shade 21-23^{o}C, basement 16-24^{o}C, refrigeration freezing at temperatures 4-15^{o}C (Duwiejuah *et al*., 2013).

Analyzing

Samples were prepared using (Petri glass dishes, a microfiber filter, a measuring cylinder, a vacuum filter device, a microscope). Sample size, company type and storage location were recorded on Petri dishes.

The vacuum filtering process was done through a microscopic glass filter using filter papers (mesh film, diameter 47 mm, size (0.45) and the filter papers were kept inside closed Petri dishes to dry before calculating and identifying the particles under the microscope (Ali, 2019) fig. 2 and 3.

Optical analysis was performed using an anatomical microscope with a lens with a magnification force (10x)

Fig. 3: Filter papers on Petri dishes.

Fig. 4: Determination of plastic particles. Using an anatomical microscope from (OLYMPUS).

and an objective lens with a magnification force (40X) fig. 4.

How to read the filter paper

Each filter paper has been read under the anatomical microscope from left to right, then moved down by one row and read from right to left, to ensure that the plastic particles are not counted twice fig. 5 (Hidalgo- Ruz *et al*., 2012).

Quality Assurance

To distinguish between plastic particles, organic and inorganic substances of the same size and shape, three methods were used:

1. The hardness test fig. 6 where it was assumed that every piece of plastic can withstand pressure without disintegration (Kosuth *et al*., 2017).

2. The hot needle test fig. 7, so that the needle is hot and fixed near the relevant piece (without blocking vision) and in the case of very hot needles the plastic particles melt or shrink. (CPH Business, 2017).

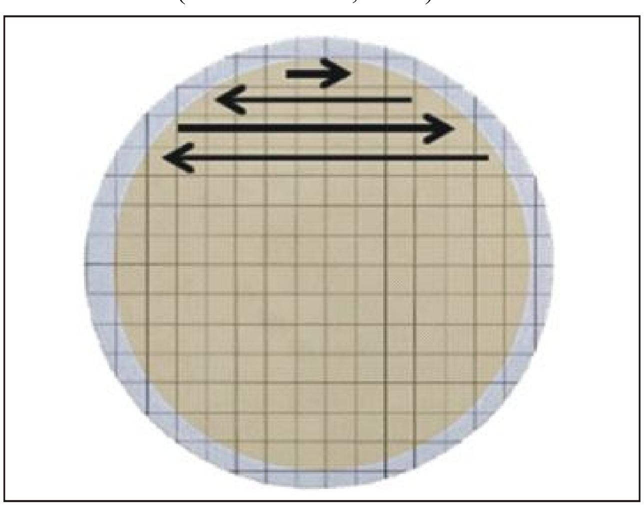

Fig. 5: Method for counting the plastic particles on the filter paper.

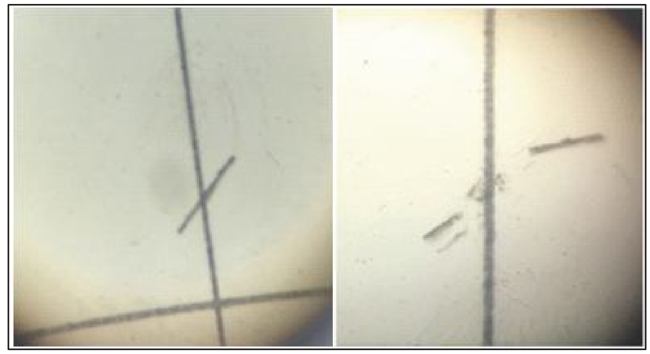

Fig. 6: Demonstrates the strength test of hardness to distinguish between plastic and non-plastic particles.

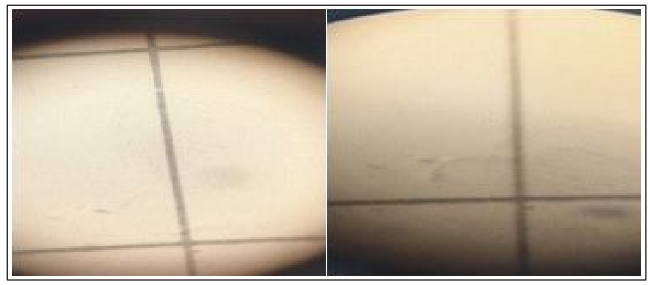

Fig.7: Shows the hot needle test to distinguish plastic particles from non-plastic materials.

Fig. 8: Shows the shapes of the plastic particles under the optical microscope with a magnifying force of (10x).

3. To avoid the similarity of the plastic particles with the fibers of other living organisms such as (algae and fungal strings) the particles were removed by forceps carefully and examined under a compound microscope, where the biological formations are more clear fig. 8 (Swedish, 2007).

Results and Discussion

Detecting plastic contamination of tap water and bottled water before storage

Plastic particles were distinguished in all samples on the basis of their concentration and shapes. The concentration of plastic particles was measured in number of particles / liter (Ali, 2019).

Fig. 9: Demonstrates the shapes and colors of fine plastic particles under anatomical microscope.

The results showed the presence of plastic particles in all samples with concentrations of (94-80-309) particles / liter for Lava, Tiyan and Life, respectively, with an average value of 161 plastic particles / liter. Whereas, the concentration of plastic particles in tap water was 121 particles / liter.

Plastic particles appeared in a large majority in the form of single fibers, whereas, some of them in the form of interlocking fibers of different sizes and multiple colors fig. 9.

Fine plastic pollution arises in bottled water during the filling process (Ali, 2019), while the source of plastic pollution in tap water is due to the decomposition of plastic waste and the corrosion of plastic tubes used in the tap water distribution system and convey to the consumer (Oâmann *et al*., 2018; Schymanski *et al*., 2018; Mason *et al*., 2018).

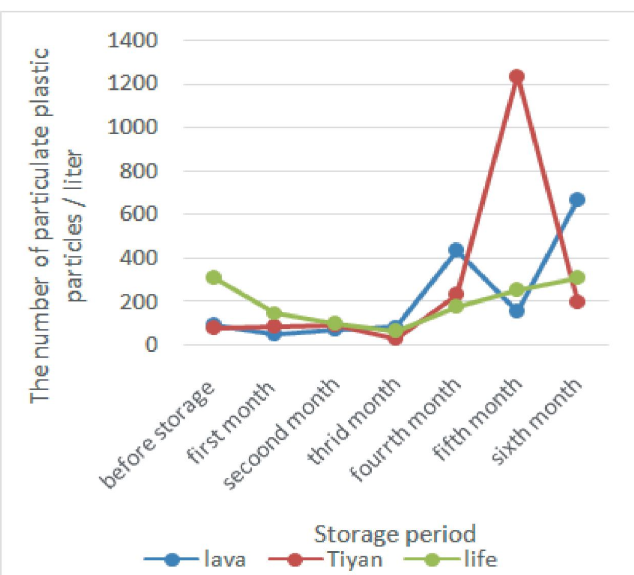

Fig. 10: Changes in the values of microscopic plastic particle numbers for samples stored in the sun for 6 months.

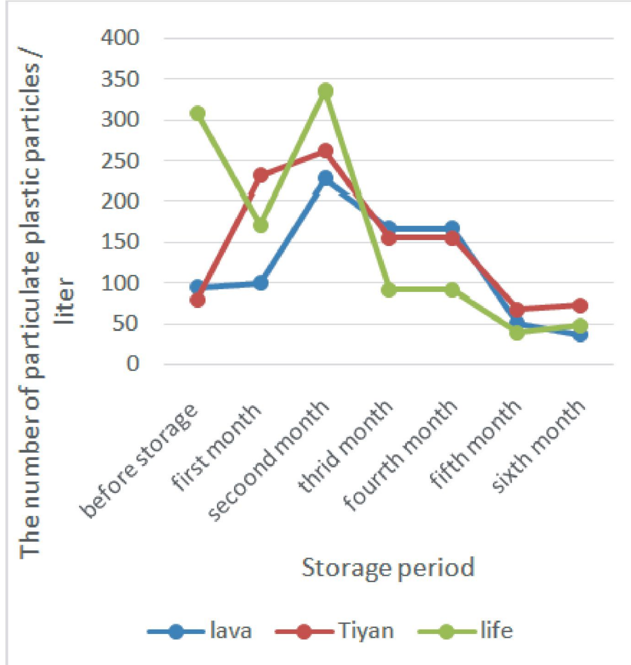

Fig. 11: Changes in the values of the plastic particle counter for samples stored in the shade for 6 months.

The effect of storage conditions on plastic pollution

The studied brands (Lava, Tiyan and Life) were stored in different locations and under different storage conditions. The following fig. 10, 11, 12, 13 and 14 represent the numbers of fine plastic particles for the brands stored in different storage locations and conditions for a period of 6 months 2.

As shown in the figures, plastic particles were found

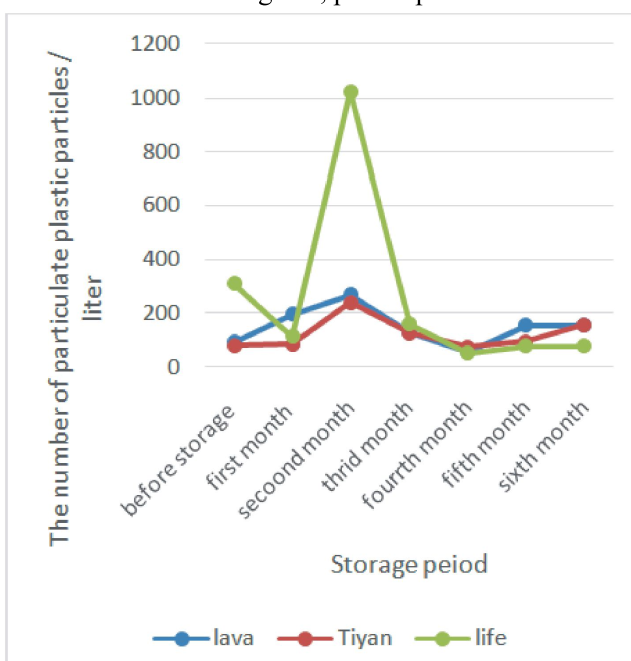

Fig. 12: Changes in the values of plastic particle numbers for samples stored in the refrigerator for 6 months.

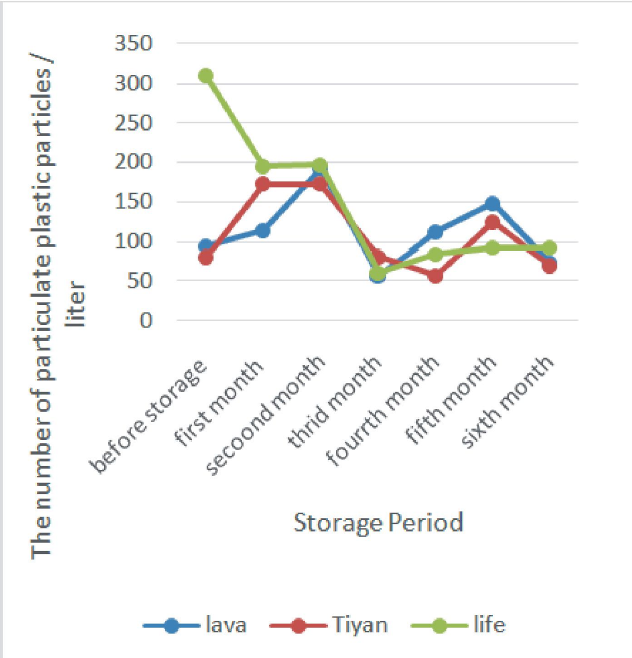

Fig. 13: Changes in the values of plastic particle numbers for samples stored in the freezer for 6 months.

in all brands and under all storage conditions during the study period. The presence of fine plastic particles for brands before storage ranged between (80-309) particles/ liter and during the storage period in different storage locations and conditions ranged between (36-1236) particles/liter. Shapes appeared fig. 10, 11, 12, 13 and 14 plastic particles are present in all marks and under storage conditions during the study period the highest values of particle numbers were recorded at storing samples in the

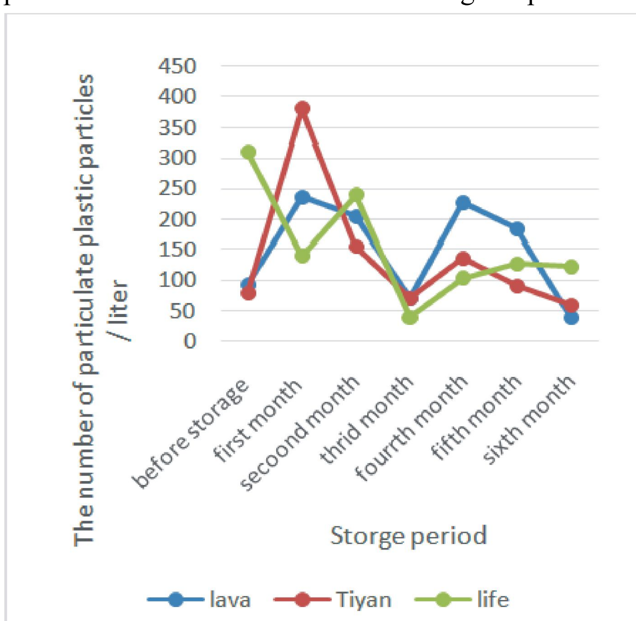

Fig. 14: Changes in the values of plastic particle numbers for samples stored in the basement for a period of 6 months.

sunlight, which is (1236) plastic particles/liter for the sign Tiyan after five months of storage in the sunlight.

As shown in fig. 10 An increase in the number of microscopic plastic particles was observed during the months stored in the sunlight, due to the degradation of plastics. Most plastics tend to absorb high-energy radiation in the ultraviolet part of the spectrum, which increases the interaction of the electron and leads to the oxidative formation and thus makes the plastic biodegradable (Ha and Yeo, 2018). When exposed plastics to solar UVA for a period of time, the plastics are fragile enough to break apart into fine fragments/plastic) (Andrady, 2011).

Conclusions

This study presented the examination of the presence of plastic particles of tap and bottled water and investigate the effect of time and the different storage conditions on them.

Microscopic examination showed the presence of plastic particles in all water samples in the form of single fibers and some in the form of intertwined fibers in different sizes and colors with concentrations ranging from (36-1236) particles / liter. These concentrations were directly proportional to the length of the storage period under the sun.

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