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Partial and Temporal Variations in Concentration of Micro Plastic in Drinking Water of Al-Hilla River

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ABSTRACT

In aquatic ecosystems, a great concern was has been increased about contaminants by microplastics (MPs). Only a small number of researches on contamination of MP in drinking water have been released up until now. In this research, tap drinking water collected in different places in a densely populated region in Al-Hilla city: Al-Bakarly area, Al-Khusrawiya and Al-Tayyara area was analyzed. The collected water samples were tested using different techniques, including Fourier infrared spectrometer (FTIR), Scanning Electron Microscope (SEM) and Micro Raman spectrometer (MRS). Results showed the presence of microplastic particles with that size smaller than 5 mm, as the diameter of the drinking water ranged between (0.5–4.8) nm. The means of Fourier infrared spectrometer (FTIR) was used to analyze component of all found particles chemically. The main components of the tested samples are metal oxides, Poly Vinyl Chloride (PVC), polyamides polymer like Nylon6, 6 and skeletal of cellulose. In addition, Micro-Raman spectroscopy (MRS) results indicated a variation in polyethylene (PE), and it was between (121.404–4391.729) cm^{-1} for collected samples.

Keywords: microplastic; drinking water; Al-Hilla River.

INTRODUCTION

In general, the main characterizations of microplastic particles are solid, polymer and water-insoluble with a size less than 5 mm (Bergmann et al. 2015). The lower boundary size is not defined, but particles with size below 1 µm are normally known as nanoplastics (Koelmans et al. 2015). Although, the contamination of environment by microplastics, only a few know about their threats. The variety of the physical and chemical characteristics, content, the particles intensity is a significant obstacle in determining the risks that microplastics pose to both individuals and the environment. Furthermore, there are no established techniques for identifying microplastics in the environment, and it is challenging to do so (Mintenig et al. 2018). The main microplastics supplier is fragmenting of larger plastics debris; however it is unknown how quickly this process occurs naturally in the environment (Eerkes-Medrano and Thompson 2018). The evaluation of dangers and exposure in the future is affected by these unknowns and complications (Koelmans et al. 2017). Regulational initiatives to look into the safety of microplastics have increased in this uncertain field (SAM 2018a, b). In recent years, the effects of microplastics on public health have been studied (Wright and Kelly 2017). Microplastics have been detected in air samples, food samples, and drinking water (EFSA 2016, Gasperi et al. 2018, Lusher et al. 2017, Wright and Kelly 2017, Yang et al. 2015). Although exposure to microplastics through inhalation or ingestion may happen, its consequences on human health are still unknown. Animal studies provide scant evidence about accumulation of microplastics that leads to induce immune reaction due to particle toxicity when they are ingested or inhaled. Little evidence from researches about animals indicates accumulation of microplastics that leads to particle toxicity by eliciting an immunological response if inhaled or consumed (Deng et al. 2017, Gasperi et al. 2018). Leaching of chemicals based on plastic (additives as well as adsorbed toxins) may result chemical toxicity (Diepens and Koelmans 2018, SAPEA 2019). These effects depend mainly on dose; however there is a lack in knowledge about levels of exposure. Moreover, microbial pathogens may be present in biofilms that are developing on microplastics (GESAMP 2016).

Hence, although microplastics have a possible chemical, particle and microbial hazards, there is a need to firstly examine current levels of exposure, including drinking water. This concern has been raised because of the spread of microplastics in bodies of surface water, groundwater and wastewater with different particle size (SAPEA 2019). Only a small number of studies have addressed this topic thus far, but those that have reported the presence of microplastics in both bottled and tap water. The drinking water in bottles has some of plastic particles (118 88 MPs L1 in multi-use and 14 14 MPs L1 in one-use bottles), and it was found that packaging materials were mostly the main source for the contamination (Schymanski et al. 2018). Kosuth et al. (2018), Pivokonsky et al. (2018), Mintenig et al. (2019), Tong et al. (2020) have studied the contamination of MP in their academic studies. Some of these studies attracted a lot of media and scientific attention, which helped public health organizations around the world prioritize the problem of human microplastic exposure from drinking water. More generally, attaining clean water is a political priority; the Sustainable Development Goals specifically include clean, accessible water as one of its goals (SDG 6) (WHO and UNICEF 2017).

Therefore, this research aims to identifying the microplastics (MPs) in tap water at regions with high population in Al-Hilla city; as well as testing its chemical properties. The samples were examined at three different locations in Al-Hilla city: Al-Bakarly area, Al-Khusrawiya and Al-Tayyara area.

METHODOLOGY

Tap water samples were collected from three different locations in Al-Hilla city to investigate intensity of MPs in that water. One sample was collected from Al-Bakarly area, two from Al-Khusrawiyah and two from Al-Tayyara area; as shown in Figure 1. These locations were selected because they are close to Al- Hilla River and are classified as highly populated areas. The physical and chemical characteristics of the collected water samples were tested using different techniques, including Fourier infrared spectrometer (FTIR), Scanning Electron Microscope (SEM) and Micro Raman spectrometer (MRS).

Station 1 (DS1) (Al-Bakarly area): It is one of the important areas in Babylon Governorate, as it has markets, schools, and the police station, in addition to the railway station.

Station 2 and station 3 (DS2 and DS3) (Al-Khusrawiya area): It is considered one of the urban areas in Babylon Governorate, as it has markets, schools, and hospitals, as well as a health center.

Figure 1. Sampling location to determine MP in drinking water supply network

Station 4 and station 5 (DS4 and DS5), Al-Tayyara area: This area is considered a link between Babylon Governorate and neighboring governorates. In addition, it has Al-Tayyara district water treatment plant, as well as markets and schools.

RESULTS AND DISCUSSION

Scanning electron microscopy (SEM)

Figure 2(a) reveals the characteristics of morphological samples of drinking water which were studied from Al-Bakrly area in the center (DS1) after their magnification by 5 μm. It was found that the diameter of the particles ranged from (1 μm to 4 μm), The diameter of the particles was observed to range from (2.2 μm to μ4.8 m) at the first and second stations (DS2), (DS3) in Al-Khusrawiya area in (b) and (c), and from (0.5 μm to 2.5 μm and 1.3 μm to 3.5 μm), respectively, at the first and second stations (DS4) and (DS5) in Al-Tayyara area in (d) and (e). These solid particles are microplastics, according to the particle dimension found in image 4.2. These findings were in line with those of an earlier study (Andrady, 2011).

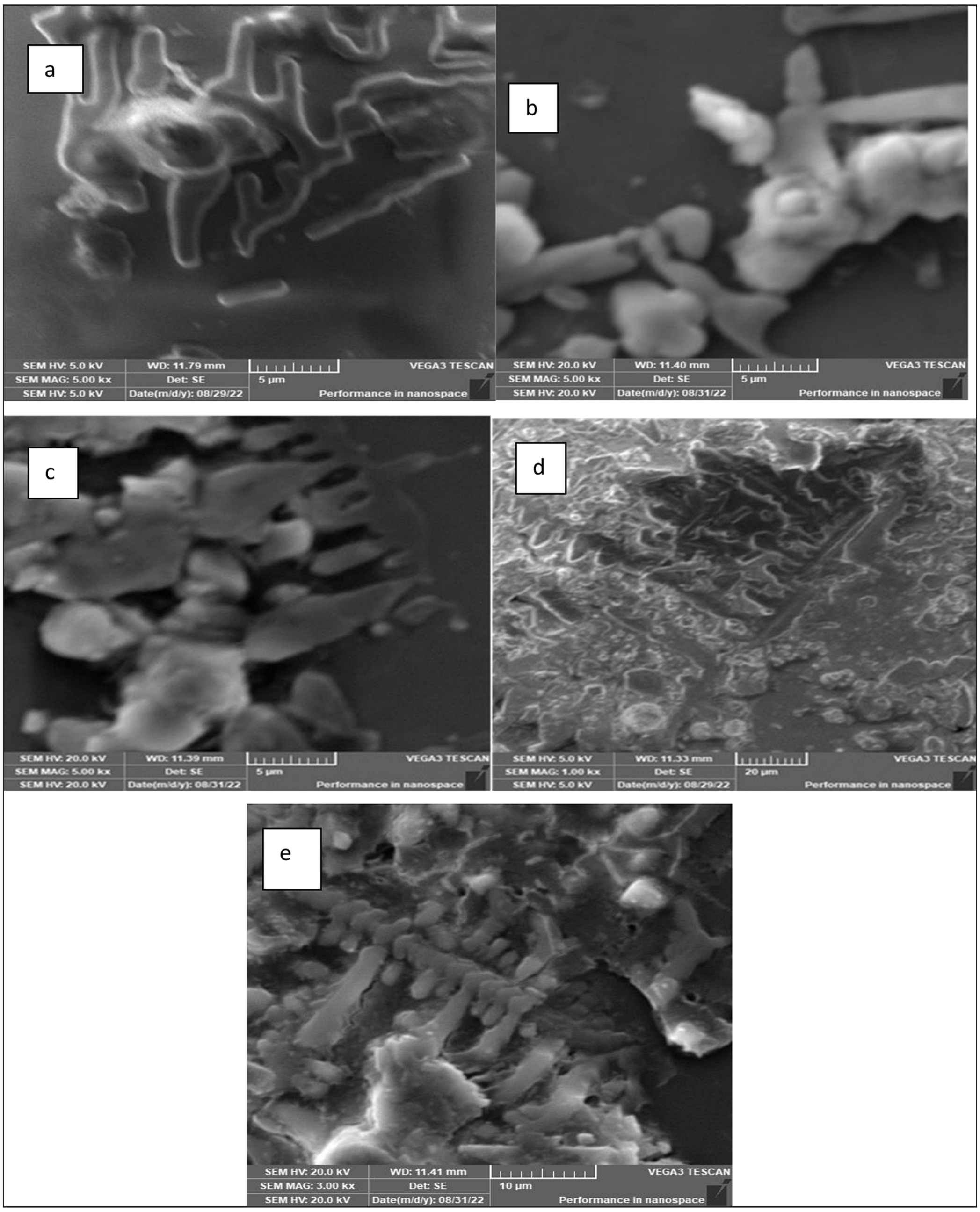

Figure 2. SEM test of drinking water sample at a) Al-Bakrly area, b) AL-Khusrawiya area first station, c) AL-Khusrawiya area second station, d) Al-Tayyara area first station, e) Al-Tayyara area second station

Fourier infrared spectrometer

In Al-Bakarly area (DS1), by interpreting the results obtained during the FTIR examination Figure 3, a set of chemical bonds was obtained (424.34–486.06) cm^{-1} metal oxides, the band C–Cl groups can be corresponded to the band at 601.79 cm^{-1} and this can be revealed that of Poly Vinyl Chloride (PVC). The band at 1118.71 cm^{-1} can be attributed to groups of C-O or C-N. While the band at 1627.92 cm^{-1} of the bond NH of amide. The bands of 1427.32 and 3402.43 cm^{-1} fit with the bonds of O-H and C-C skeletal of cellulose. The same results were achieved by (Alonso-Simo´n A, 2011).

The results of FTIR for the other locations were illustrated in Figures 4 to 14.

All the drinking water sampling stations for the study area contain metal oxides, polyvinyl chloride (PVC), polyamide polymer such as nylon 6,6 and structural cellulose.

Micro-Raman spectrometer

Figs. 15 to 19 display the spectra for drinking water samples obtained from Al-Bakarly, Al-Khusrawiya first and second areas, and Al-Tayyare first and second areas. Polyethylene, Polypropylene, Polycarbonate, and Polyamide were found in the samples tested. The vibration of stretching of the -CH chain at 2994.918 – 3523.232 cm^{-1} generates signals which differ visually and that can be used to complete a qualitative examination of the polymers. Two

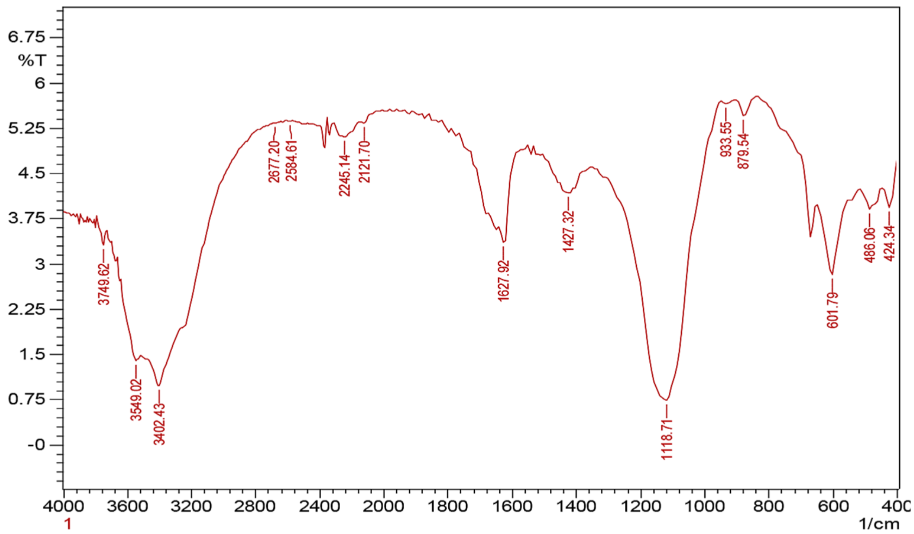

Figure 3. FTIR test of drinking water sample at AL-Bakarly area

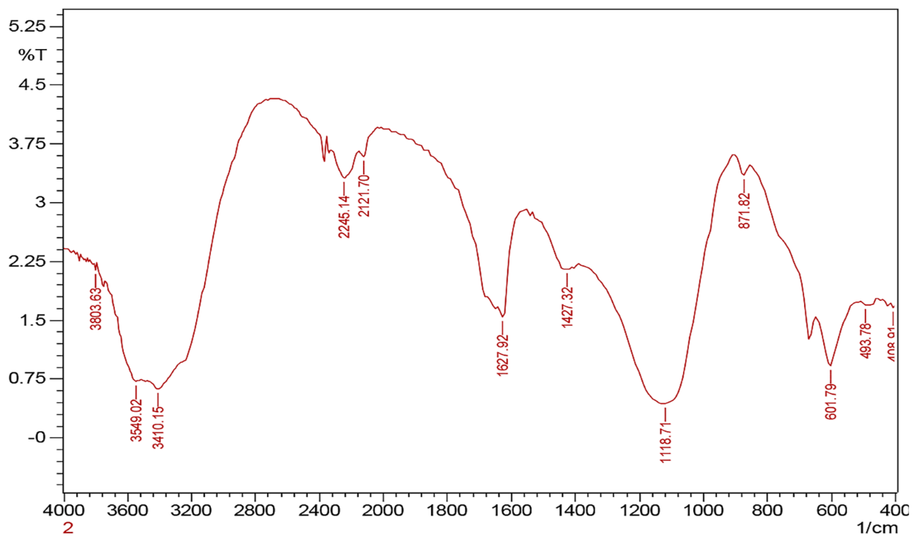

Figure 4. FTIR test of drinking water sample at Al-Khusrawiya area (first location)

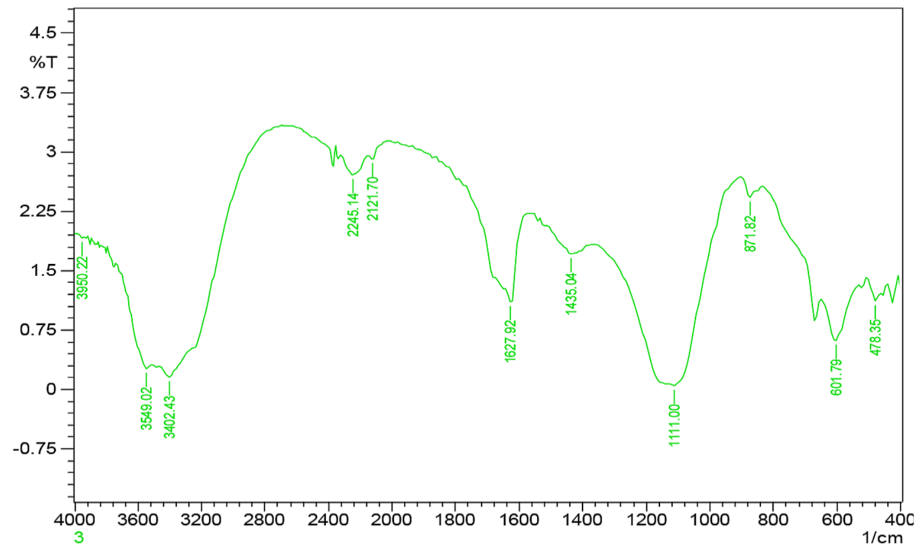

Figure 5. FTIR test of drinking water sample at Al-Khusrawiya area (second location)

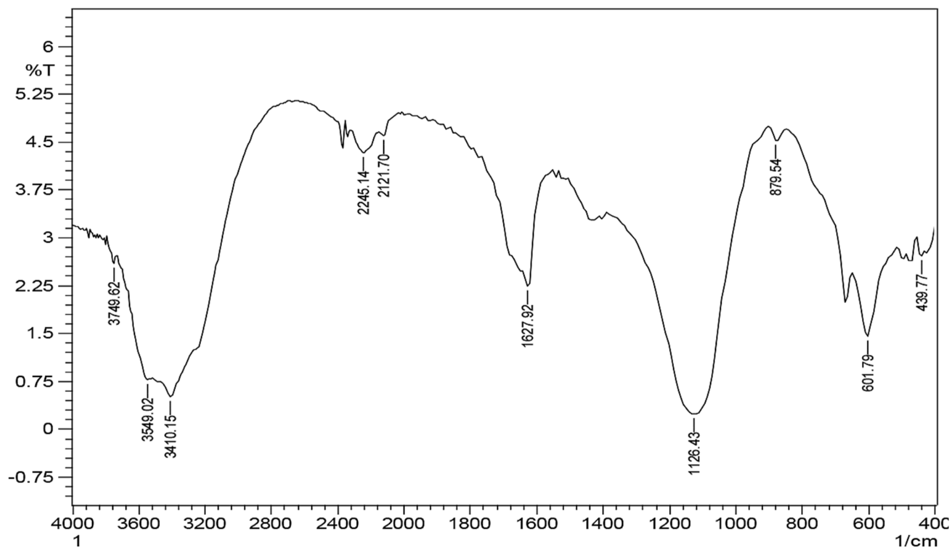

Figure 6. FTIR test of drinking water sample at AL-Tayyara area (first location)

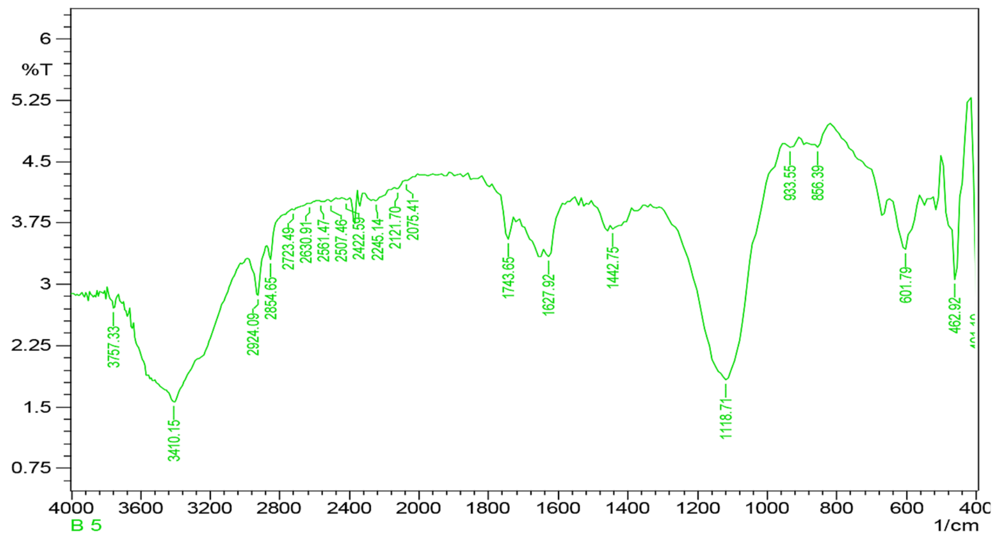

Figure 7. FTIR test of drinking water sample at Al-Tayyara area (second location)

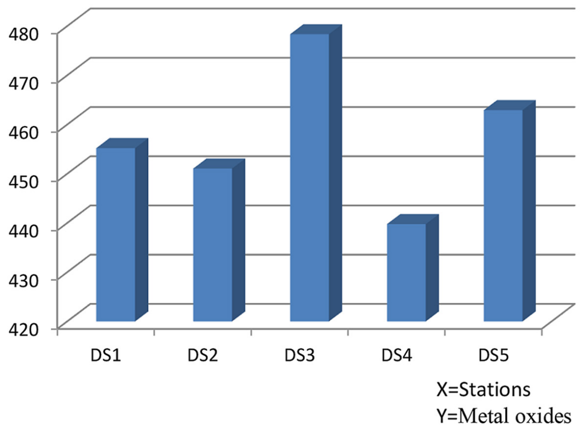

Figure 8. Variation of Metal oxides for drinking water samples in five stations

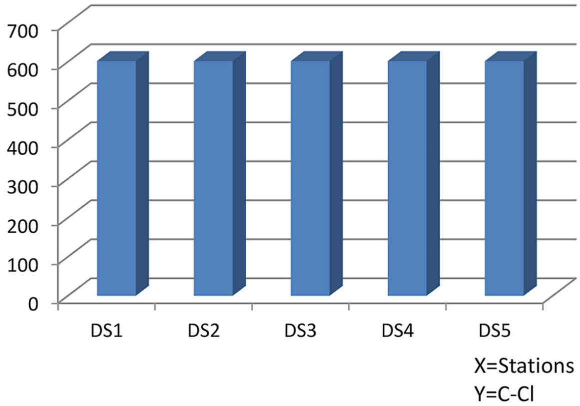

Figure 9. Variation of C-Cl for drinking water samples in five stations

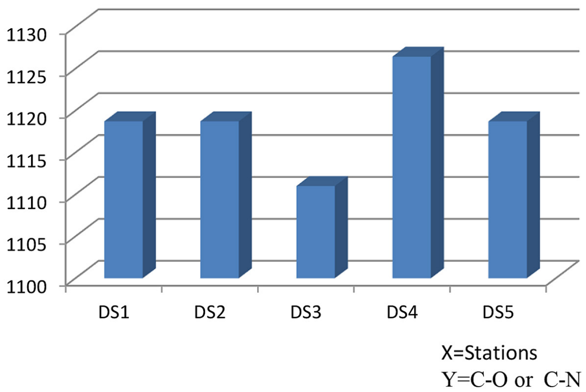

Figure 10. Variation of C-O or C-N for drinking water samples in five stations

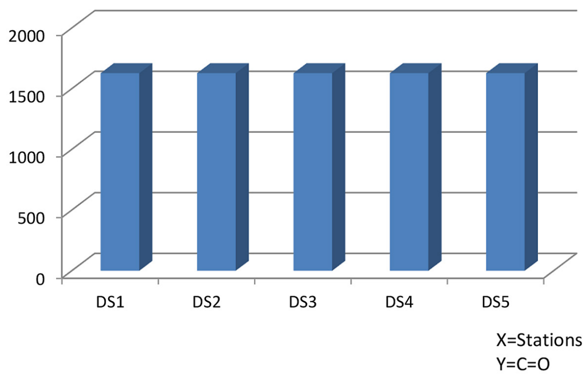

Figure 11. Variation of C=O for drinking water samples in five stations

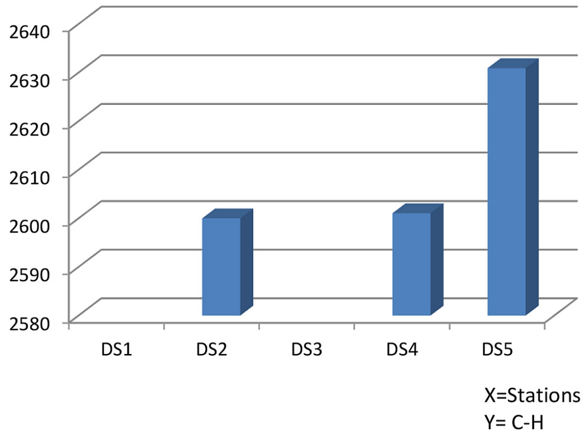

Figure 12. Variation of C-H for drinking water samples in five stations

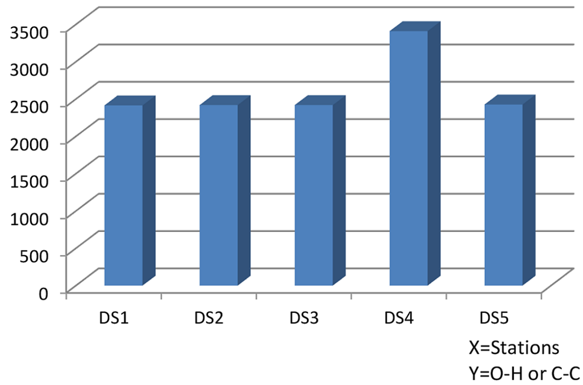

Figure 13. Variation of O-H or C-C for drinking water samples in five stations

different groups that corresponded to "asymmetric stretching "in the phase of crystalline at 2882 cm^{-1} and "symmetric stretching" in the phase of amorphous, at 2848 cm^{-1}, are visible in the polymer region of these. This was in line with the results that had been (Hiejima, 2018). The asymmetric vibrations in the phase of crystalline is different from the symmetric vibrations in the phase of amorphous by the high-density polyethylene (HDPE) and low-density polyethylene (LDPE). The density of the polymer is inversely correlated with the degree of crystallinity. In comparison to amorphous domains, HDPE has more of them than LDPE does. Since the vibrations of asymmetric stretching (2882 cm^{-1})

generates a signal which is stronger than the signal from symmetric stretching vibrations, it is highly unlikely that all polyethylene spectra that have been recorded are LLDPE (2848 cm^{-1}).

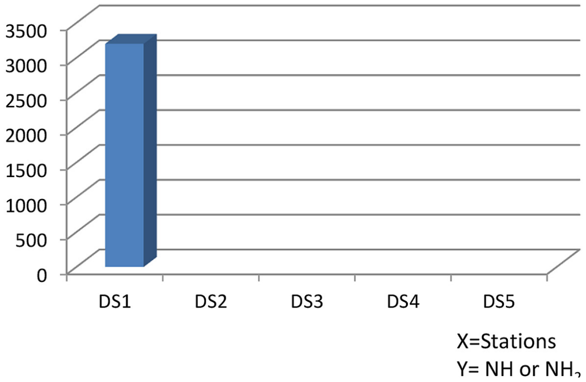

Figure 14. Variation of NH or NH_2 for drinking water samples in five stations

Additionally, the intensity of the band invented from crystalline vibrations group -CH2 is larger than the band of vibrations created in the liquid phase in the 1200-1500 cm^{-1}. At DSI were identified as polypropylene, the most common polyamide, displays the following groups: deformation of C-C at 791.461 cm^{-1}, stretching of C-CO at 1038.867 cm^{-1}, stretching of skeletal at 1193.495 cm^{-1}, CN stretching and -NH bending of amide III at 1417.707cm^{-1}, $-CH_2$ twisting at 1629.032 cm^{-1}, $-CH_2$ bending at 2043.952, 2355.787 and 2585.152 cm^{-1} and –CH stretching at 2884.101 cm^{-1}.

Spectra for samples collected from four locations (Al-Khusrawiya area first location, Al-Khusrawiya area second location, Al-Tayara area first location and second location) the phenomenon of luminescence occurred. In this identified sample, found polycarbonate, polystyrene and polypropylene.

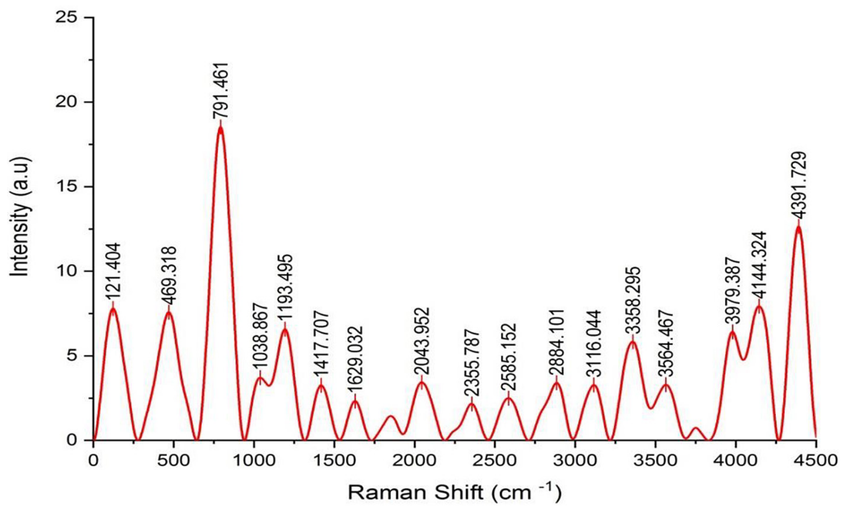

Figure 15. MRS test for raw water at AL-Bakarly area of the center

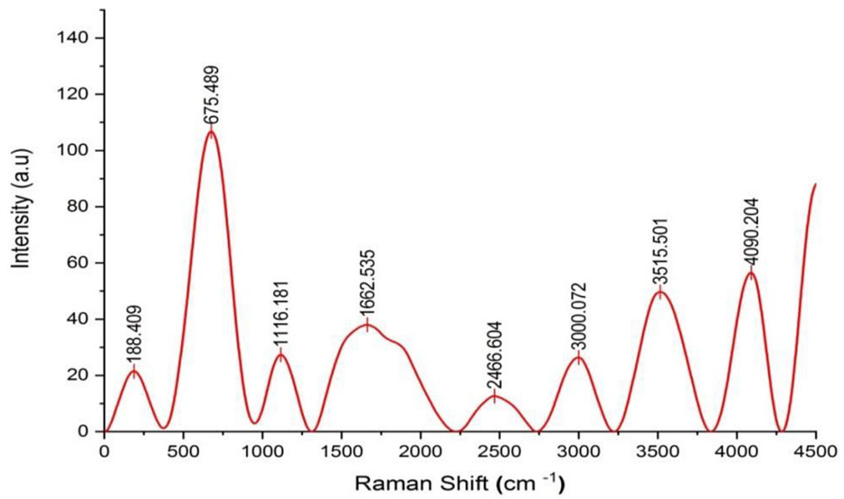

Figure 16. MRS test for raw water at AL-Khusrawiya area first location of the center

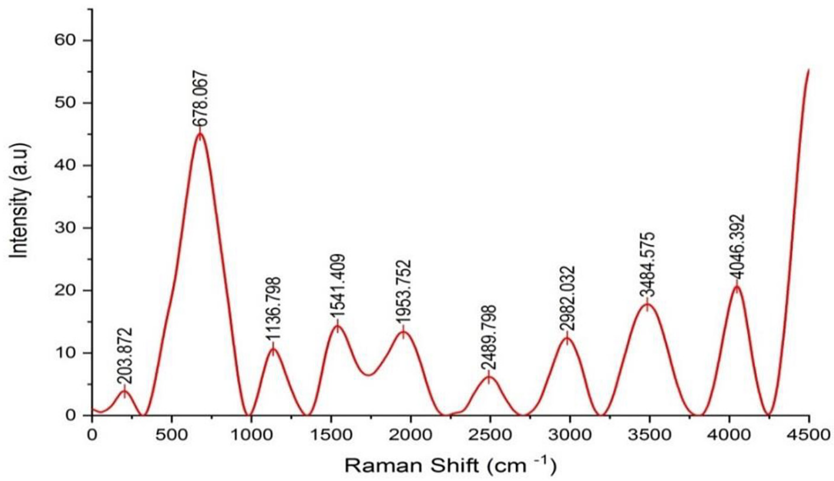

Figure 17. MRS test for raw water at AL-Khusrawiya area second location of the center

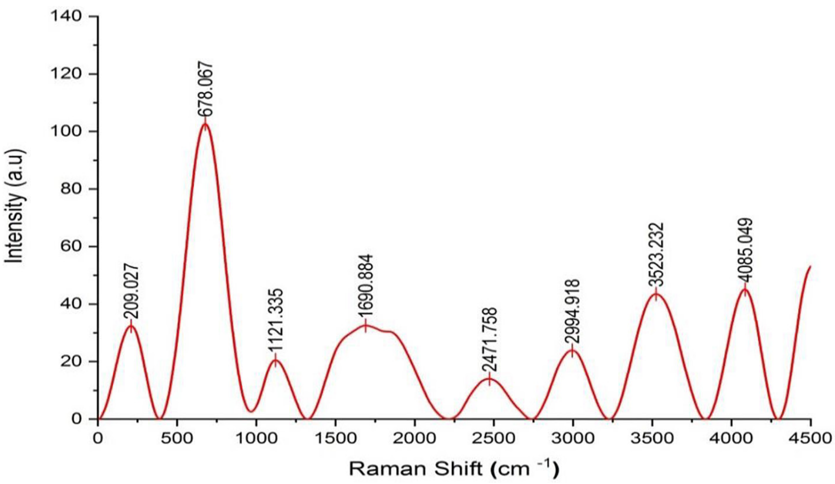

Figure 18. MRS test for raw water at AL-Tayyara area first location of the center

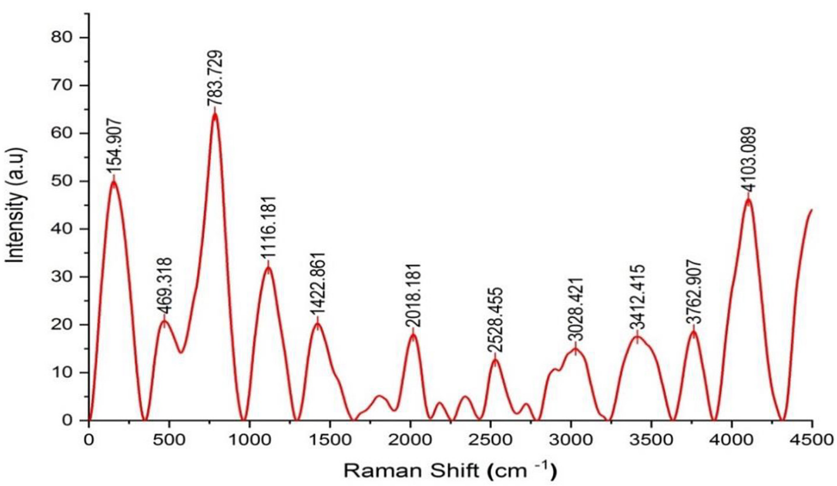

Figure 19. MRS at Tayara area second location of the center

Spectra unambiguously indicates polystyrene Microplastics 1116.181and 2466.604 because of the simplicity of identifying the characteristic bands when the tensile vibrations -CH are in the range of (2800–3200 cm^{-1}). A signal can appear in a typical of bending vibrations -CH in the ring of aromatic, when the frequency is applied at approximately 1000 cm^{-1}. In all spectra, the most frequency of signal at about 3000 cm^{-1}, which resembles to the vibration of stretching of the phenyl ring. Similar outcomes were achieved by (Zimmerer, 2019).

CONCLUSION

Based on the results obtained, the following conclusions where be drawn. SEM results of drinking water samples showed the presence of microplastic particles with that size smaller than 5 mm. Based on SEM results, the range of diameter of drinking water ranged between (0.5 - 4.8) nm. FITR results of drinking water are metal oxides, Poly Vinyl Chloride (PVC**)**, polyamides polymer like Nylon6, 6 and skeletal of cellulose. Micro**-**Raman spectroscopy (MRS) results indicated a variation in polyethylene (PE), and it was between (121.404–4391.729) cm^{-1} for samples of drinking water.

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