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Assessment of Microplastic Particles in Tap Water on The Right Side of Mosul City, Iraq

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ABSTRACT

In recent years, microplastics (MPs) contamination has become a serious concern in water distribution systems. Few studies on microplastics' numbers and their characteristics have been described. The current study focused on the abundance, characteristics, and polymer type of plastic particles in the tap water within 16 sites on the right side of Mosul city, including eight areas equipped by the Alayman aljadid drinking water treatment plant (AYJ-DWTP) and eight others that supplied by water from the Alayman alqadim plant (AYQ-DWTP). A stereomicroscope (SM) is used to detect MPs abundance and morphology by capturing images of plastic particles. Fourier transform infrared spectroscopy (FTIR) was applied to distinguish polymer types. In this study, results elucidated that the presence of microplastics in the tap water of both the AYJ-water distribution network (WDN) and AYG-WDN ranged from 28 to 69 MPs/L, with an average of 45 ± 10 MPs/L. Fibres and fragments were the dominant form of microplastics, estimated for (89-91%) of total particles. The transparent colour of particles was the most abundant. Polyvinylchloride (PVC) and Nylon Polyamide (PA) were the most common polymers of MPs around (39%) and (21%), respectively. Statistical analysis was applied by ANOVA test. The PVC risk index was very high.

Keywords:

Microplastics; Plastic pipes types; Fourier transform infrared; Stereomicroscope; Tap water

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1. INTRODUCTION

Plastics pollution affects the environment on a global scale. It also negatively impacts on organisms [1],[2]. In the past few decades, plastics industry has seen massive growth in the worldwide [3]. As a result of plastic's chemical composition, it can be made into useful products including chemical and temperature resistant packaging and plastic pipes [4]. Globally, 350 million tons of plastic pollution were generated in 2017, compared to 1.5 million tons in 1950 [5]. Plastics amount that produced has dramatically increased [6] . Plastic is expected to produce 33 billion tons by 2050, according to United States Environmental Protection Agency, EPA [7].

Microplastic (MPs) are small pieces of plastic a size between (1µm – 5 mm) [8],[9]. According to their origin, MPs are divided into two groups: primary and secondary. The first category is used in the plastic industry as tiny fibres, beads, and pellets made on a microscale, while the second category includes smaller particles resulting from fragmentation of primary plastic material [10]. There is a wide range of MP types, shapes, and sizes detected in different environmental samples [11]. The MPs are made from a wide range of polymers, including polyethelene (PE), polyproplene (PP), polystyrene (PS), polyamide (PA), polyethelene terephthale (PET) and poly vinyl chloride (PVC) [12]. There are MPs in aquatic environments, and they enter the human body through tap water and bottled water [13], [14].

MPs can easily enter the food chain by watering plants with water comtaining plastic particles and due to their small size, which has a disadverb effects on both wildlife and people [15]. A laboratory experiments that measured the amount of microplastics in human stool samples proved that people absorb microplastics [16]. Oxidative stress occurs in the brain and epithelium as a result of microplastics [17]. Human cells were used to study the impacts of MPs, and it was found that plastic particles may enhance cytotoxicity [18]. As a result of exposure to MPs, human cells may be damaged, neurological damage may occur, immune response malfunctions may occur, and other organs of the body may be affected by MPs [19]. Accumulation of MPs in the digestive system causes the stoppage of energy exchange in the body that result from body tissue exposed to MPs [20]. Heavy metals such as aluminium and antimony may be associated with MPs and then cause meatal estrogen and breast cancer [21]. The use of heavy metals in the plastic industry as pigments is associated with health risks. For instance, chromium is commonly used for polymers like PVC, polyethene, and polypropylene [21]. The particles smaller than 150 micrometres may pass through the digestive tract and generate chronic exposure, intake in humans after consumption by drinking is likely. However, scientists believe that only 0.3% of these items will be absorbed into the body while a smaller percentage (0.1%) which includes particles greater than 10 μm will be able to penetrate both cell membranes and tissues as well as cross the membrane of the placenta and blood-brain barrier [22] . The 5 mm microparticles, may be seen in the stomach, kidney and liver, and histological sections [23]. In addition to the plastic pieces may be available media for microorganisms growth [24].

These facts indicate that there may be dangers associated with microplastics that should not be disregarded. Almost few studies have looked at MPs contamination in tap water [8] and [25]. Scientists from all over the world have recently shown that MPs can be found in tap water that comes from a variety of sources, including desalinated, surface, and ground water [26]. Treatment plants for drinking water (DWTPs) offer a removal efficiency of 70%-89%, and a little amount of microplastics flow and leak through the process if the plants working correctly [27]. Treatment units in DWTPs of Mosul city include (raw water basin, mixing tank, settling tank and filteration tank) [28]. The past studies showed that the time affect on removal efficiency for example the sedimentation period play important role in efficiency removal [29] .

In distribution networks, plastic pipes were exposed to chlor that was found in water for a long time, resulting in changes in their mechanical surface and morphological features and possible contributor of MPs in drinking water [30]. Properties changes in pipes could be influenced by the characteristics of the material, environmental conditions, chlorine concentration, and exposure period [30]. The erosive corrosion of plastic pipes is the secondary cause of microplastic in tap water, according to previous research [31].

Fourier transform infrared spectroscopy (FTIR) and stereomicroscope (SM) are used to observe and analyse MPs. The goals of this study were to identify the different types of polymers, to count the MPs numbers and to characterise their colours and shapes. The results are useful in raising awareness of people about the level of MPs pollution in the drinking water of Mosul city. Furthermore, they should motivate the appropriate parties to take action to reduce the contamination percentage.

2. METHODS AND MATERIALS

2.1. Sampling

All samples were taken from tap water distributed along water distribution pipes of sixtheen locations in Mosul city from October 2022 to February 2023. In addition to the samples taken from DWTPs of raw water (influent) and treated water (effluent). Eight districts supplied water from Alayman aljadid (AYJ) drinking water treatment plant (DWTP) and the other 8 equipped by water from Alayman alqadim (AYQ) DWTP as shown in Figure 1. A list of material types used in manufacturing pipes in selected areas can be found in Table (1).

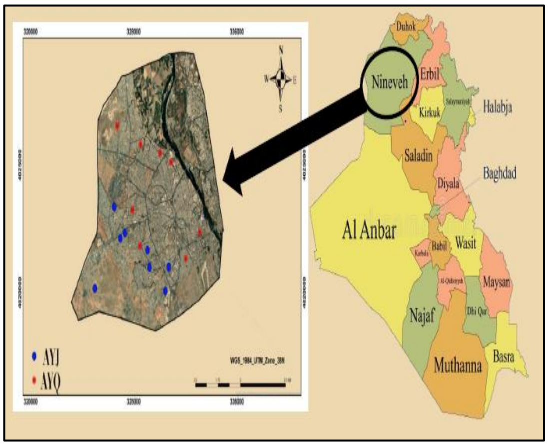

Fig. 1 Sampling sites in districts Supplied by AYJ-DWTP and AYQ-DWTP.

Table 1: Sampling sites and the manufacturing material of Networks water distribution pipes provided by the Nineveh water directorate in Mosul city.

DWTP	Sampling site	Pipe manufacturing material
AYJ-DWTP	RagomHadid	PVC
	Moaalamin	PVC
	Monosor	PVC
	Nahrawan	PE
	Alresalah	PVC
	Maamoun	DI (ductile iron)
	Alamel	PE
	Alaboor	PVC
AYQ-DWTP	tamoz 17	PVC
	Shafa	PVC
	New Mosul	PVC
	Wady hagar	PE
	Dawasah	PE
	Yarmook	PVC
	Alnajjar	PVC
	Aqtesadyeen	PE

2.2. Quantitative and qualitative analysis of microplastics

Glass bottles were rinsed in distilled water and samples were taken randomly from households [32]. Three duplicates were collected from tap water in one liter bottles and then transported to the laboratory for additional examinations [33].

The samples were filtered by cellulose nitrate filter (0.45µm) and the MPs that remained on the filter were observed by stereomicroscope (SM). A Microscope has been used to divide particles into fragments, fibre, foam, film, and others depending on forms [34], and MPs are divided according to their colours: transparent, black, red, blue, green, yellow, white, orange and others[35]. FTIR (SHIMADUZ, Japan) was used to specify the functional groups present in MPs to detect polymer type. The FTIR analysis was within spectral ranges between (600 to 4000) cm^{-1} with 16 scans at resolution 4 cm^{-1} and 3 seconds was the test time for the sample. The spectra that appeared in the experiences were compared with the previous databases from references to know the type of the polymer [36].

3. STATISTICALLY DATA ANALYSIS

The microplastic number is calculated as MPs/L. The samples collected from tap water were three repetitions in each district. MPs concentration was expressed as the average ± the standard deviation. Statistical analyses performed by Excel 2019. The data were analysed through the ANOVA test. If the difference between sampling sites depending on the number of MPs (ΔNMPs) were higher than the least significant differences (LSD) thus a statistically significant difference, whereas the ΔNMPs were lower than LSD considered insignificant. The following equation is used for the LSD account[37].

$$LSD = t \propto \sqrt{2MSE/n} \quad \text{........(1)}$$

t: t-value calculation from the distribution table.

∝: at 0.05 probability level.

MSE: mean square error taken from ANOVA table.

n: repetitions number.

4. RESULTS AND DISCUSSION

4.1. Microplastic pollution concentration in tap water

The plastic particles number in the both AYJ and AYQ water distribution networks were started from 28 to 69 MPs/L having an average of 45 ± 10 MPs/L. In the (AYJ-WDN), microplastic numbers were about (28 to 69) MPs/L with an average of 47 ± 11 MPs/L. While, in the (AYQ-WDN), MPs abundance was from 29 to 61 MPs/L with an average of 43 ± 9 MPs/L. The mean number of MPs in study areas is displayed in Figure 2 (a&b). A previous study, in Mexico, [38] showed that microplastic abundance in tap water ranged between (5 to 91 MPs/L) and another study [39] in the United States, found the concentration of MPs in tap water was within the range of (0 to 61) MPs per litre. These studies' results were nearly convergent with this study. There is a possibility that MPs may be released into drinking water through plastic pipes used in water distribution networks [40]. As proven by the study [41], which found that tap water samples containing microplastics similar to plastic materials of the equipment and water transport pipelines from drinking water plants to districts.

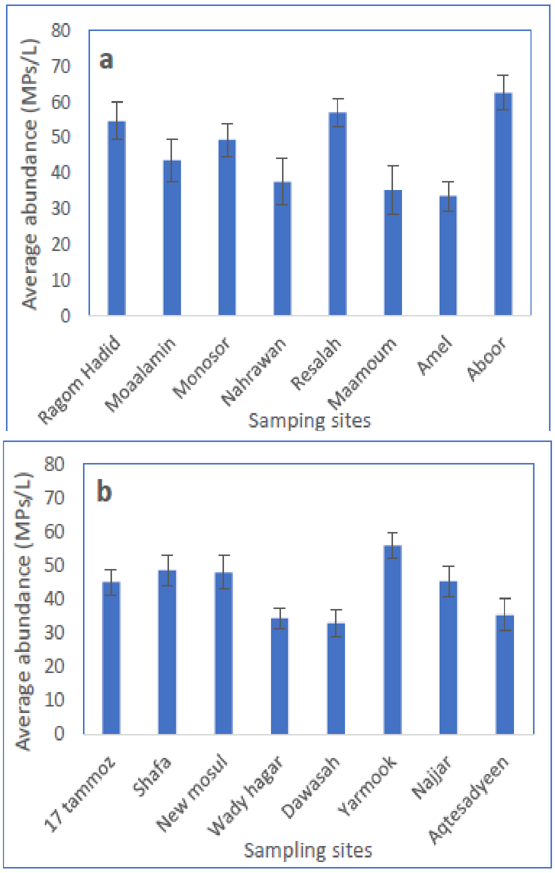

Fig. 2 The mean abundance of microplastics in study areas of (a) AYJ-WDN and (b) AYQ-WDN.

In the AYJ-WDN, the high average abundance of MPs in regions at the Alaboor, Alresalah, Ragom Hadid, Monosor and Moaalamin were as follows: 62 ± 5, 57 ± 4, 55 ± 5, 49 ± 5 and 44 ± 6 MPs/L, respectively, and the lowest values in the districts of Nahrawan, Maamoun and Alamel were 37 ± 7, 35 ± 5 and 34 ± 4 MPs/L, respectively. The high level of MPs/L in the regions of AYQ-WDN was of Yarmook (56 ± 4), Shafa (49 ± 5), New Mosul (48 ± 5), Alnajjar (45 ± 5) and 17 Tammoz (45 ± 4), whereas the Aqtesadyeen, Wady hagar, and Dawasah districts were the fewer than other districts (35 ± 5, 34 ± 3, and 33 ± 4 MPs/L), respectively. Plastic pipes start to change in characteristics, mechanical properties and surface properties after prolonged exposure to chlorine-containing water. This may explain the high levels of MPs in the Alaboor, Alresalah, Yarmook and Shafa regions. According to Gill et al., 2019 discovered that the temperature, chlorine concentration, pressure, pH, and exposure time can influence these changes [42]. Compared to the rest of the districts, the mean microplastic abundance in the Alamel, Aqtesadyeen, Wady hagar, Dawasah and Maamoun districts was low due to their new pipes, also the manufacturing material of pipes in the Maamoun region was ductile iron as illustrated in Table 2. Statistical analysis in both AYJ and AYQ areas shows there is a significant difference between sites. Except for difference between all of (Alresalah and Ragom Hadid), (Nahrawan and Maamoun), (Maamoun and Alamel), (17 Tammoz and New Mosul), (17 Tammoz and Alnajjar), (New Mosul and Shafa), (Alnajjar and New Mosul), (Wady hagar and Dawasah), (Wady hagar and Aqtesadyeen), (Dawasah and Aqtesadyeen), and (Alnajjar and Aqtesadyeen) were insignificant. The insignificant differences between theses regions may be due to the pipes that are used in these areas are similar to each other in manufacturing material as Table (2). Furthermore, plastic pipes in these regions may undergo mechanical, surface, and morphological changes when exposed to the same conditions such as exposure it to free chlorine for a prolonged period [42].

In raw water (influent), MPs levels varied from 91 to 125 items/L on average 107 ± 13 MPs/L in treated water (effluent). MPs levels varied from 30 to 44 items/L with an average of 35 ± 4 MPs/L. A possible source of MPs in tap water may be raw water and plastic pipes in supply networks.

4.2. Morphological characteristics of MPs

4.2.1. Shapes

Several shapes (fibers, fragments, films, and foam) found in microplastics are distributed in samples of all sites. Fibers and fragments were the dominant in this study as displayed in Figure 3 (a&b).

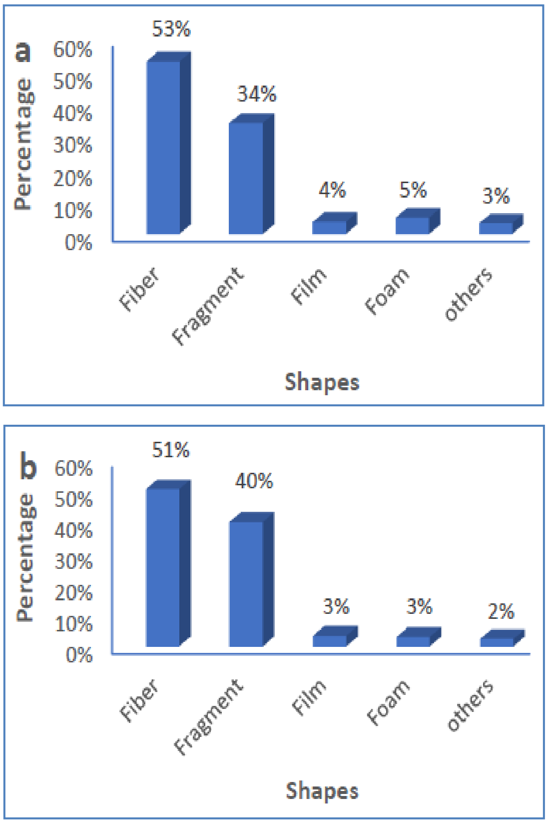

Fig. 3 Percentage of particles based on shapes in study locations of (a) AYJ-WDN and (b) AYQ-WDN

There were highest levels of fibrous and fragment in regions of AYJ-WDN and AYQ-WDN (53%, 34% and 51%, 40%, respectively), followed by film, foam and other shapes (4%, 5% and 3%) of AYJ districts and (3%, 3%, 2%) of AYQ districts [43]. Figure 4 shows the images of the forms in this study.

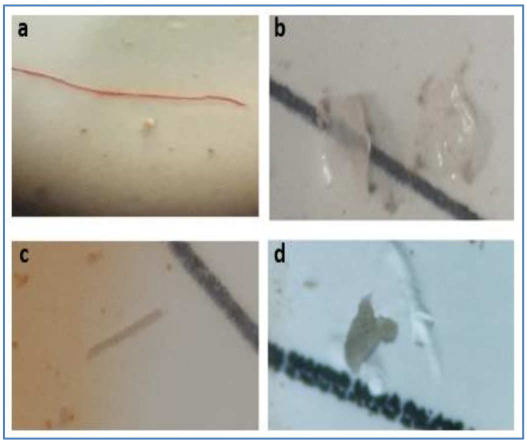

Fig. 4 Shapes of MPs, (a) fiber, (b) fragment, (c) film and (d) foam

4.2.2. Colours of particles

In Figure 5 (a&b), it can be seen that microplastics come in a variety of colours and in descending order as follows; transparent, black, blue, red, yellow, orange, and white. There is a difference in colour between the particles in each area. According to Zhao et al., 2022, the colours detected in Chinese tap water were transparent, black, white, and other [44].

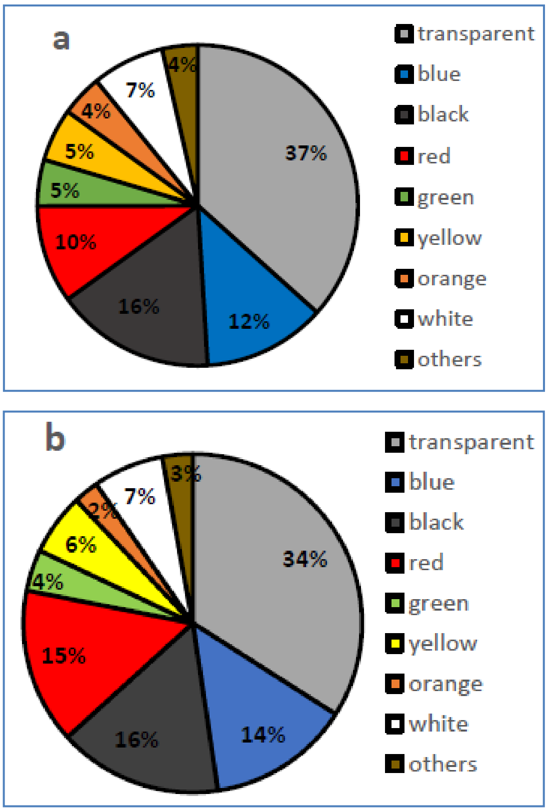

Fig. 5 Colours of MPs in selected districts of AYJ-WDN and AYQ-WDN.

A majority of MPs in districts of AYJ-WDN were transparent (37%), followed by black (16%), blue (12%), red (10%), white (7%) and green (5%), orange (4%) and other (4%). Also, the transparent colour dominated in districts of AYQ-WDN (34%), followed by black (16%), red (15%), blue (14%), white (7%), yellow (6%), green (4%), orange (2%) and other (3%).

4.2.3. Polymer types of microplastics

The polymers types detected using FTIR analysis were PVC, PA, PE, PET, PS, PP, and non-identification (NI). FTIR spectra of plastics obtained in transmission mode as depicted in Appendix Figure (A-1). Polymer types percentage in samples as seen in Figure 6 (a&b).

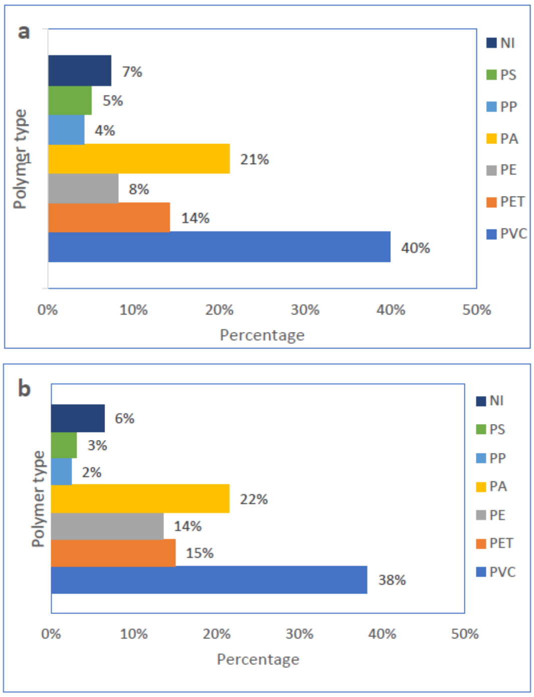

Fig. 6 Percentage of Polymer types in study areas of (a) AYJ-WDN and (b) AYQ-WDN.

Polymer types in AYJ and AYQ districts were as follows: PVC (38-40) %, PA (21-22) %, PET (14-15) %, PE (8-14) %, PP (2-4) %, PS (3-5) %, and NI (6-7) %. It is likely that MPs are released from polymer-containing plastic pipes because they are used in plastic pipe manufacturing [13], [41]. As PVC pipes are widely used to transport water from plants to households in Iraq, they may be the reason for the highest percentage of PVC in tap water samples. Almost 60% of the water supply systems in the world are PVC pipes [41]. Water contains different concentrations of PET, PE, PP and PS polymers depending on their initial concentrations in raw water and treatment units of DWTPs [45], [36]. PA is mainly used to manufacture nylon. This will result in an increase in PA percentage in the raw water supply thus increasing it in WDNs [46].

5. MPs risk evaluation

The classical method was used to assess MPs ecological risks [47] as expressed in Eqs. 2 and 3.

$$\mathrm{RI} = \sum_{i=1}^{n} Ei \;\ldots\ldots\ldots\; (2)$$
$$Ei = Ti \times \left(\frac{Ci}{C0}\right) \ldots\ldots\ldots\; (3)$$

RI and Ei are both potential risk factors for the environment, whereas Ti represents the polymer toxicity coefficient, and Ci/Co represents the ratio between the measured and background concentrations of microplastics, respectively. In this study, because there isn't enough background data thus the MPs concentrations at the lowest level can be defined as background values. In Table 2, based on Ei and RI, there are different risk levels in risk evaluation.

Table 2. Risk categories associated with microplastics [48].

Potential single risk index Ei	potential risk index RI	Risk category
<40	<150	Minor
40-80	150-300	Medium
80-160	300-600	High
160-320	600-1200	Danger
>320	>1200	Extreme danger

Table 3. Potential risk of different microplastics in selected districts of AYJ-WDN.

Polymer	MPs/L	C_i/C_0	T_i^*	E_i	Risk category	RI
PVC	18.58	0.56	10551	5941	Extreme danger	
PET	6.63	0.2	4	0.8	Minor	5960
PE	3.79	0.11	11	1.26	Minor	Risk category
PA	9.83	0.3	50	14.9	Minor	Extreme danger
PP	1.96	0.06	0	0	Minor	
PS	2.38	0.07	30	2.16	Minor	
NI	3.42	0.1	0	0	Minor	

*[33]

Table 4. Potential risk of different microplastics in selected districts of AYQ-WDN.

Polymer	MPs/L	C_i/C_0	T_i^*	E_i	Risk category	RI
PVC	18.58	0.56	10551	5941	Extreme danger	5294 Risk category Extreme danger
PET	6.63	0.20	4.00	0.80	Minor	
PE	3.79	0.11	11.00	1.26	Minor	
PA	9.83	0.30	50.00	14.90	Minor	
PP	1.96	0.06	0.00	0.00	Minor	
PS	2.38	0.07	30.00	2.16	Minor	
NI	3.42	0.10	0.00	0.00	Minor	

T_i^* [33].

The potential risk of 5 polymers types to drinking water was assessed in 16 areas for AYJ-WDN and AYQ-WDN. The RI value of AYJ-WDN was 5960 and in AYQ-WDN was 5294 as shown in Tables 3 and 4, respectively. Furthermore, both AYJ-WDN and AYQ-WDN had high Ei values for PVC because their Ti values were high. The high Ti value of PVC leads to dominating the range of Ri. As the current study only offered a very limited potential hazard index of the restricted polymer and the potential hazard index is counted based on the monomer [49].

6. CONCLUSION

In this work, MPs were found in tap water, and the causes of their presence were investigated. At each sampling site, there was evidence of microplastic contamination. The plastic particles' mean number in AYJ-WDN was 45 ± 10 MPs/L and the mean number in AYQ-WDN was 47 ± 11 MPs/L. Fibres and fragments represented the majority of microplastics found approximately 89%, and transparent was the dominant colour. The presence of PVC and PA polymer formed a high percentage in concentration compared with other types. The results show that MPs are abundant in tap water because some particles pass through treatment units and others come from plastic pipes of WDNs in sampling areas. In AYJ-WDN and AYQ-WDN, Ei for PVC polymer was the highest compared with other polymers because Ti value for PVC polymer was high, MPs risk assessment related with Indicator of polymer risk. There was a significant difference between each site and the other areas, except for some areas where the differences were insignificant because of the pipes type, its age, and exposure to the same conditions. Among some recommended solutions to overcome microplastic problems are: first, studying tap water filter devices' effectiveness in reducing plastic particles and ensuring the effectiveness these devices must be operated, maintained, and replaced frequently according to the manufacturer's recommendations; second, improving the efficiency and effectiveness of DWTPs in removing microplastics; third, replacing old pipes in DWNs to prevent releasing of microplastics into the water; and forth, to better drinking water quality, investigators need to understand how pollutants migration from plastic materials affects water quality, many knowledge gaps attributed to researchers' lack of understanding of polymer properties or manufacturing processes or how the different factors such as (temperature, pH, and others) can be to influence on the contamination of water by these plastic particles.

REFERENCES

[1] S. Zhang *et al.*, "Microplastics in the environment: A review of analytical methods, distribution, and biological effects," *TrAC - Trends Anal. Chem.*, vol. 111, pp. 62–72, 2019, doi: 10.1016/j.trac.2018.12.002.

[2] R. Rayan Faisal and Alsaffar, "Bioplastic Degradation, Production and Genetic Improvements of Bioplastic Producing Strains: A review," vol. 3, no. 2, pp. 69–74, 2023, doi: 10.33899/rjs.2023.178575.

[3] L. Almaiman *et al.*, "The occurrence and dietary intake related to the presence of microplastics in drinking water in Saudi Arabia," *Environ. Monit. Assess.*, vol. 193, no. 7, p. 390, 2021, doi: 10.1007/s10661-021-09132-9.

[4] G. Casillas et al., "Microplastics scoping review of environmental and human exposure data," Microplastics, vol. 2, no. 1, pp. 78–92, 2023. doi:10.3390/microplastics2010006

[5] Z. Fu and J. Wang, "Current practices and future perspectives of microplastic pollution in freshwater ecosystems in China," *Sci. Total Environ.*, vol. 691, pp. 697–712, 2019, doi: 10.1016/j.scitotenv.2019.07.167.

[6] T. A. Al-Tayyar, "Characteristics of Plastic Solid Wastes in Mosul City and Their Reuse," *IOP Conf. Ser. Earth Environ. Sci.*, vol. 779, no. 1, 2021, doi: 10.1088/1755-1315/779/1/012071.

[7] C. Wang *et al.*, "Microplastic Pollution in the Soil Environment: Characteristics, Influencing Factors, and Risks," *Sustain.*, vol. 14, no. 20, pp. 1–14, 2022, doi: 10.3390/su142013405.

[8] I. Semmouri, M. Vercauteren, E. Van Acker, E. Pequeur, J. Asselman, and C. Janssen, "Presence of microplastics in drinking water

from different freshwater sources in Flanders (Belgium), an urbanized region in Europe," *Int. J. Food Contam.*, vol. 8, pp. 1–11, 2022, doi: 10.1186/s40550-022-00091-8.

[9] R. S. Al-hussayni, K. K. Al-ahmady, and R. K.S. Mhemid, "Assessment of Indoor Microplastic Particles Pollution in Selected Sites of Mosul City," vol. 24, no. 9, pp. 322–332, 2023.

[10] K. Ho, D. Tang, and T. Hadibarata, "Microplastics removal through water treatment plants : Its feasibility , efficiency , future prospects and enhancement by proper waste management," *Environ. Challenges*, vol. 5, no. July, p. 100264, 2021, doi: 10.1016/j.envc.2021.100264.

[11] S. Singh, T. Trushna, M. Kalyanasundaram, A. J. Tamhankar, and V. Diwan, "Microplastics in drinking water: a macro issue," *Water Supply*, vol. 22, no. 5, pp. 5650–5674, 2022, doi: 10.2166/ws.2022.189.

[12] K. Waldschlager, "Microplastics in the Aquatic Environment: Occurrence, Persistence, Analysis, and Human Exposure," *Wasser und Abfall*, vol. 20, no. 1–2, pp. 50–55, 2021, doi: 10.3390/w13070973.

[13] A. A. Koelmans, N. H. Mohamed Nor, E. Hermsen, M. Kooi, S. M. Mintenig, and J. De France, "Microplastics in freshwaters and drinking water: Critical review and assessment of data quality.," *Water Res.*, vol. 155, pp. 410–422, May 2019, doi: 10.1016/j.watres.2019.02.054.

[14] F. Weber, J. Kerpen, S. Wolff, R. Langer, and V. Eschweiler, "Investigation of microplastics contamination in drinking water of a German city," *Sci. Total Environ.*, vol. 755, p. 143421, 2021, doi: 10.1016/j.scitotenv.2020.143421.

[15] M. Yan *et al.*, "Microplastic abundance, distribution and composition in the Pearl River along Guangzhou city and Pearl River estuary, China," *Chemosphere*, vol. 217, pp. 879–886, 2019, doi: https://doi.org/10.1016/j.chemosphere.2018.11.093.

[16] S. Rainieri and A. Barranco, "Microplastics, a food safety issue?," *Trends Food Sci. Technol.*, vol. 84, pp. 55–57, 2019, doi: https://doi.org/10.1016/j.tifs.2018.12.009.

[17] G. F. Schirinzi, I. Pérez-Pomeda, J. Sanchís, C. Rossini, M. Farré, and D. Barceló, "Cytotoxic effects of commonly used nanomaterials and microplastics on cerebral and epithelial human cells," *Environ. Res.*, vol. 159, pp. 579–587, 2017, doi: https://doi.org/10.1016/j.envres.2017.08.043.

[18] Q. Wang *et al.*, "Effects of bisphenol A and nanoscale and microscale polystyrene plastic exposure on particle uptake and toxicity in human Caco-2 cells," *Chemosphere*, vol. 254, p. 126788, 2020, doi: https://doi.org/10.1016/j.chemosphere.2020.126788.

[19] M. S. Bhuyan, "Effects of Microplastics on Fish and in Human Health," *Front. Environ. Sci.*, vol. 10, no. March, pp. 1–17, 2022, doi: 10.3389/fenvs.2022.827289.

[20] L. M. L. Nollet, *Food Analysis & Properties Series Editor*. 2021. [Online]. Available: https://www.crcpress.com/Food-Anal

[21] C. Campanale, C. Massarelli, I. Savino, V. Locaputo, and V. F. Uricchio, "A detailed review study on potential effects of microplastics and additives of concern on human health," *Int. J. Environ. Res. Public Health*, vol. 17, no. 4, 2020, doi: 10.3390/ijerph17041212.

[22] L. G. A. Barboza, A. Dick Vethaak, B. R. B. O. Lavorante, A. K. Lundebye, and L. Guilhermino, "Marine microplastic debris: An emerging issue for food security, food safety and human health," *Mar. Pollut. Bull.*, vol. 133, no. June, pp. 336–348, 2018, doi: 10.1016/j.marpolbul.2018.05.047.

[23] Y. Deng, Y. Zhang, B. Lemos, and H. Ren, "Tissue accumulation of microplastics in mice and biomarker responses suggest widespread health risks of exposure," *Sci. Rep.*, vol. 7, no. October, pp. 1–4, 2017, doi: 10.1038/srep46687.

[24] A.-A. AL-Dabag, "Effect of Recirculation Ratio, Organic Loading and Suspended Solids Loading on the Efficiency of the Trickling Filters With Plastic Media," *Al-Rafidain Eng.*, vol. 22, pp. 147–157, 2013.

[25] H. Tong, Q. Jiang, X. Hu, and X. Zhong, "Occurrence and identification of microplastics in tap water from China," *Chemosphere*, vol. 252, p. 126493, 2020, doi: https://doi.org/10.1016/j.chemosphere.2020.126493.

[26] I. V. Kirstein, A. Gomiero, and J. Vollertsen, "Microplastic pollution in drinking water," *Curr. Opin. Toxicol.*, vol. 28, pp. 70–75, 2021, doi: 10.1016/j.cotox.2021.09.003.

[27] Y. Picó, I. Manzoor, V. Soursou, and D. Barceló, "Microplastics in water , from treatment process to drinking water : analytical methods and potential," 2022, doi: 10.20517/wecn.2022.04.

[28] M. Abduljabbar, "The Situation Of Water Treatment Plant In Mosul City," *Journal, Al-rafidain Eng.*, vol. 24, no. 2, p. 8, 2020.

[29] D. Kossay K. Al-Ahmady and Z. A. Znad, "The Optimum Conditions For Fluoride Removal From Drinking Water Using Nalgonda Method (Flocculation And Sedimentation)," *AL-Rafdain Eng. J.*, vol. 22, no. 2, pp. 38–47, 2014, doi: 10.33899/rengj.2014.87315.

[30] Y. Xu, Q. He, C. Liu, and X. Huangfu, "Are Micro- or Nanoplastics Leached from Drinking Water Distribution Systems?," *Environ. Sci. Technol.*, vol. 53, no. 16, pp. 9339–9340, 2019, doi: 10.1021/acs.est.9b03673.

[31] K. Moraczewska-Majkut and W. K. Nocoń, "Microplastic in tap water – preliminary tests,"

Desalin. Water Treat., vol. 275, no. December 2021, pp. 116–121, 2022, doi: 10.5004/dwt.2022.28822.

[32] C. Sanz-lázaro *et al.*, "Microplastics in sediments of the Pantanal Wetlands , Brazil," no. October, 2022, doi: 10.3389/fenvs.2022.1017480.

[33] M. Zhang *et al.*, "Distribution Characteristics and Influencing Factors of Microplastics in Urban Tap Water and Water Sources in Qingdao, China," *Anal. Lett.*, vol. 53, no. 8, pp. 1312–1327, May 2020, doi: 10.1080/00032719.2019.1705476.

[34] L. Shao, L. Yaowei, C. Yang, and Z. Mengyuan, "Microplastic atmospheric dustfall pollution in urban environment: Evidence from the types, distribution, and probable sources in Beijing, China," no. May, 2022, doi: 10.1016/j.scitotenv.2022.155989.

[35] V. Hidalgo-Ruz, L. Gutow, R. C. Thompson, and M. Thiel, "Microplastics in the marine environment: A review of the methods used for identification and quantification," *Environ. Sci. Technol.*, vol. 46, no. 6, pp. 3060–3075, 2012, doi: 10.1021/es2031505.

[36] J. Dalmau-Soler, R. Ballesteros-Cano, N. Ferrer, M. R. Boleda, and S. Lacorte, "Microplastics throughout a tap water supply network," *Water Environ. J.*, vol. 36, no. 2, pp. 292–298, 2022, doi: 10.1111/wej.12766.

[37] L. J. W. Herv, "Fisher ' s Least Significant Difference (LSD) Test 1 Overview 2 Notations 3 Least significant difference," pp. 1–6, 2010.

[38] V. C. Shruti, F. Pérez-Guevara, and G. Kutralam-Muniasamy, "Metro station free drinking water fountain- A potential 'microplastics hotspot' for human consumption.," *Environ. Pollut.*, vol. 261, p. 114227, Jun. 2020, doi: 10.1016/j.envpol.2020.114227.

[39] M. Kosuth, S. A. Mason, and E. V. Wattenberg, "Anthropogenic contamination of tap water, beer, and sea salt," *PLoS One*, vol. 13, no. 4, pp. 1–18, 2018, doi: 10.1371/journal.pone.0194970.

[40] X. Zhang, T. Lin, and X. Wang, "Investigation of microplastics release behavior from ozone-exposed plastic pipe materials," *Environ. Pollut.*, vol. 296, p. 118758, 2022, doi: https://doi.org/10.1016/j.envpol.2021.118758.

[41] A. J. Whelton and T. Nguyen, "Contaminant Migration From Polymeric Pipes Used in Buried Potable Water Distribution Systems: A Review," *Crit. Rev. Environ. Sci. Technol.*, vol. 43, no. 7, pp. 679–751, 2013, doi: 10.1080/10643389.2011.627005.

[42] T. S. Gill, R. Knapp, S. W. Bradley, and W. L. Bradley, "Long term durability of crosslinked polyethylene tubing used in chlorinated hot water systems," *Plast. Rubber Compos.*, vol. 28, pp. 309–313, 1999.

[43] L. Feld, V. H. Da Silva, F. Murphy, N. B. Hartmann, and J. Strand, "A study of microplastic particles in danish tap water," *Water (Switzerland)*, vol. 13, no. 15, 2021, doi: 10.3390/w13152097.

[44] H. Zhao *et al.*, "Pollution status of microplastics in the freshwater environment of China: a mini review," *Water Emerg. Contam. Nanoplastics*, 2022, doi: 10.20517/wecn.2021.05.

[45] D. Eerkes-Medrano, R. C. Thompson, and D. C. Aldridge, "Microplastics in freshwater systems: A review of the emerging threats, identification of knowledge gaps and prioritisation of research needs," *Water Res.*, vol. 75, pp. 63–82, 2015, doi: https://doi.org/10.1016/j.watres.2015.02.012.

[46] D. N. Michler-kozma, L. Kruckenfellner, A. Heitkamp, K. P. Ebke, and F. Gabel, "Uptake and Transfer of Polyamide Microplastics in a Freshwater Mesocosm Study," *Water (Switzerland)*, vol. 14, no. 6, pp. 1–10, 2022, doi: 10.3390/w14060887.

[47] F. Liu, K. B. Olesen, A. R. Borregaard, and J. Vollertsen, "Microplastics in urban and highway stormwater retention ponds," *Sci. Total Environ.*, vol. 671, pp. 992–1000, 2019, doi: https://doi.org/10.1016/j.scitotenv.2019.03.416.

[48] R. Delta, Q. Liu, and Z. Lai, "Microplastics in Freshwaters and Drinking Water: Critical Review and Assessment of Data Quality," 2022.

[49] D. Lithner, A. Larsson, and G. Dave, "Environmental and health hazard ranking and assessment of plastic polymers based on chemical composition," *Sci. Total Environ.*, vol. 409, no. 18, pp. 3309–3324, 2011, doi: 10.1016/j.scitotenv.2011.04.038.

Appendix:

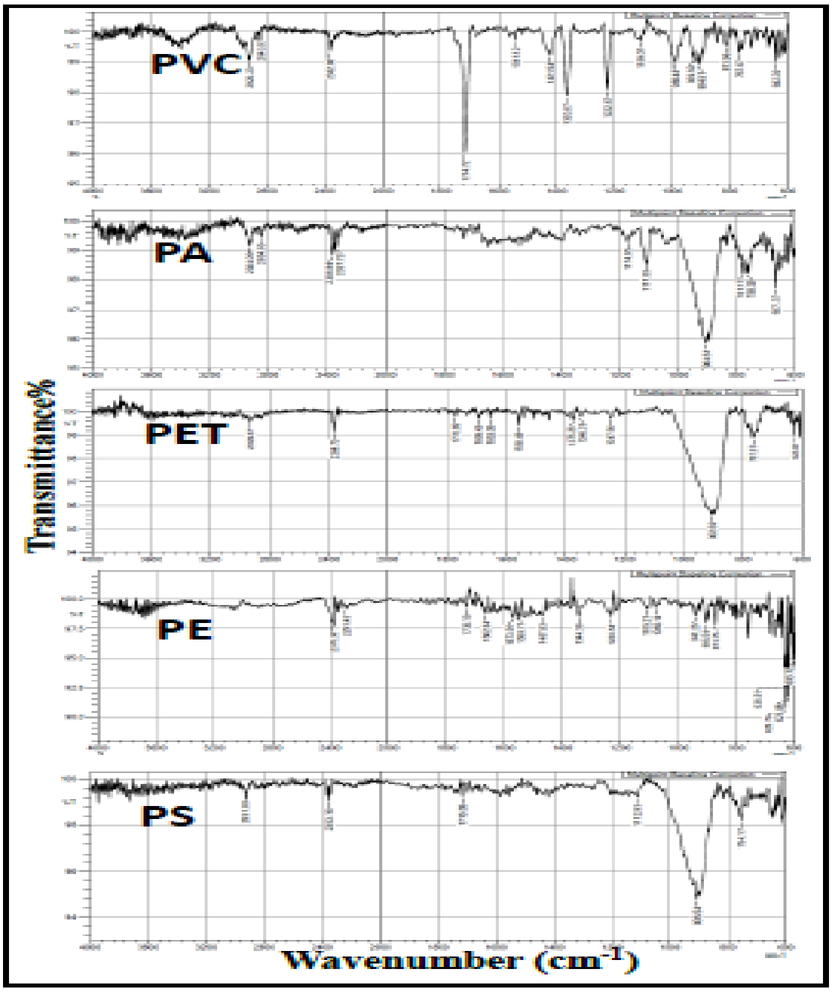

Fig (A-1): FTIR spectra of plastics obtained in this study

Table (A-1): Nomenclature list

Abbreviation	Description
MPs	Microplastics
AYJ- DWTP	Alayman aljadid drinking water treatment plant
AYQ- DWTP	Alayman alqadim drinking water treatment plant
FTIR	Fourier transform infrared spectroscopy
SM	Stereomicroscope
PVC	Polyvinyl chloride
PA	Poly amide
PET	Polyethylene terephthalate
PE	Polyethylene
PP	Polypropylene
PS	Polystyrene
DI	Ductile iron
ANOVA	Analysis of variance
∆NMPs	Difference between sampling sites depending on the number of MPs
LSD	Least significant differences
t	t-value calculation from the distribution table
∝	Probability level
MSE	Mean square error taken from ANOVA table.
n	Repetitions number
MPs/L	Microplastic per Liter
RI	Potential risk index
Ei	Potential single risk index
Ti	The polymer toxicity coefficien
Ci/Co	Ratio between the measured and background concentrations of microplastics

تقييم الجسيمات البلاستيكية الدقيقة في مياه الصنبور في الجانب الأيمن من مدينة الموصل، العراق

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الملخص

فى السنوات الاخيرة أصبحت التلوث بالجسيمات البلاستيكية من المخاطر التي تشكل مصدر قلق في انظمة توزيع المياه. القليل من الدراسات التي وصفت اعداد الجسيمات و خصائصها. الدراسة الحالية ركزت على وفرة و خصائص و نوع البوليمر للجسيمات البلاستيكية الدقيقة في مياه الصنبور ضمن 16 موقع في الجانب الايمن من مدينة الموصل، متضمنة ثمانية مناطق مجهزة بمحطة معالجة مياه الشرب الايمن الجديد و ثمانية مناطق اخرى تزودت بالمياه من محطة الايمن القديم. يستخدم المجهر التشريحي لاكتشاف وفرة الجسيمات البلاستيكية ومظهرها من خلال التقاط صور للجسيمات البلاستيك. تم تطبيق مطيافية فوربيه لتحويل الأشعة تحت الحمراء (FTIR) لتمييز أنواع البوليمر. في هذه الدراسة ، أوضحت النتائج أن وجود الجسيمات البلاستيكية الدقيقة في مياه الصنبور لكل من شبكة توزيع مياه الايمن الجديد و شبكة توزيع مياه الايمن القديم تراوحت من 28 إلى 69 جسيمة لكل لتر، بمتوسط 45 ± 10 جسيمة لكل لتر. كانت الألياف والشظايا هي الشكل السائد للجسيمات البلاستيكية الدقيقة، وقدرت بنحو (89-91٪) من إجمالي الجسيمات. ان اللون الشفاف للجسيمات هو الأكثر وفرة. كان كل من البولي فينيل كلوريد (PVC) والنايلون بولي أميد (PA) أكثر البوليمرات شيوعًا للجسيمات البلاستيكية الدقيقة حوالي (39٪) و (21٪)، على التوالي. تم تطبيق التحليل الإحصائي عن طريق اختبار ANOVA. كان مؤشر مخاطر PVC مرتفعًا جدًا.

الكلمات الدالة :

الجسيمات البلاستيكية ، انواع الانابيب البلاستيكية، مطيافية الاشعة تحت الحمراء، المجهر التشريحي، ماء الصنبور.