Microplastic and associated polyaromatic hydrocarbons in surface waters feeding Beyşehir Lake in Türkiye

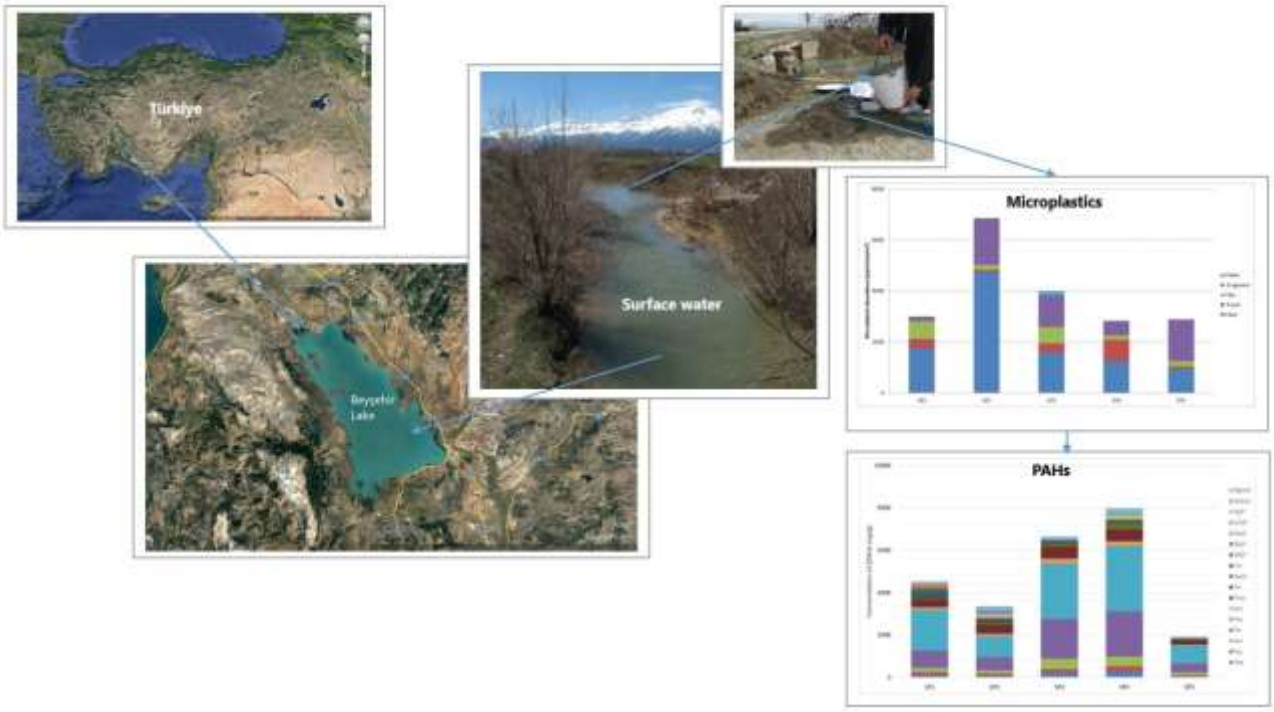
Muhammed Ulvi[1], Senar Aydin[1*]

[1]Necmettin Erbakan University, Engineering Faculty, Environmental Engineering Department, Konya, Türkiye

[*]Corresponding author:

E-mail: sozcan@erbakan.edu.tr, senarozcan@gmail.com, tel: 00905336189306

GRAPHICAL ABSTRACT



ABSTRACT

The detection of microplastics, defined as tiny plastics particles having a size from 1 µm to 5 mm, in aquatic environments has become a serious concern worldwide. Microplastics may be introduced either directly to water bodies or indirectly to the aquatic systems. In particular, microplastics may interact with persistent organic pollutants and inorganic contaminants and they transfer these pollutants to organisms in the aquatic environment. In this study, microplastics and their sorbed polyaromatic hydrocarbons (PAHs) in the surface water feeding Beyşehir Lake in Türkiye were investigated. The abundance of microplastics in the surface water was determined in the range of 2830-6860 particles/m^3. While five shapes (fiber, foam, film, fragment, pellet) of microplastics were determined in surface waters, fiber and fragment form microplastics were predominantly observed. The detected polymer types were cellophane, polyethylene, polypropylene. The transparent/white color microplastics were the most dominant (42-81%). The total concentration of the seventeen PAHs associated with microplastics in surface waters ranged from 1924 to 7970 ng/g. According to the diagnostic ratios of the PAH isomers (fluoranthane/pyrene < 1 and phenanthrene/antracene >10), the source of the PAHs all surface waters can be pyrogenic and petrogenic origins. These findings

indicate that high concentrations of microplastics and PAHs sorbed microplastics were carried into the lake by the surface waters feeding Beyşehir Lake. These pollutants may pose a risk to the use of water for irrigation and potable purposes and to aquatic organisms in the lake.

Keywords: Microplastics, PAHs, surface waters.

1. Introduction

Approximately 300 million tons/year of plastic is produced worldwide, and only 20% of the waste plastic is recycled or incinerated (Plastics Europe, 2019). Most of the plastic waste is spread with the environment as a result of poor waste management. Plastic wastes that are exposed to various degradation processes such as mechanical abrasion, photo-oxidation, thermal degradation, biodegradation, hydrolysis and chemical degradation in environments constitute microplastics with a size of less than 5 mm (Yang et al., 2022; Cole et al., 2011; Wang et al., 2021). These microplastics are called secondary microplastics. Primary microplastics are specially produced in small sizes. Microplastics are a serious environmental problem due to their resistance to degradation, common, permanent and toxic nature. They can be ingested by many organisms living in aquatic environments. Additives added to plastics during the production process to achieve durability, flexibility and UV resistance also increase the toxicity of microplastics (Priya et al. 2022). Also, microplastics have high adsorption capacities due to their large surface areas. Microplastics can accumulate organic compounds, heavy metals and other harmful substances in the aquatic environment on their surfaces up to 10-100 times the amount in the environment (Naqash et al., 2020). Urbanization and population increases have significant effects on increasing microplastic pollution (Yang et al., 2022). In current studies, microplastic types have been identified in different environments and their sources and distribution have been reported to be related to human activities (Koutnik et al., 2021).

Microplastics have been frequently detected in aquatic environments such as seas, lakes, oceans, rivers, and wetlands in the literature (Malli et al., 2022). Determination of microplastics in fish, molluscs, zooplankton, mammals and birds an indication that microplastics have reached the aquatic organisms (Fu et al., 2020). Microplastic pollution in aquatic environments has been most studied in

the seas. In addition, studies in fresh waters are limited (Wang et al., 2022). However, detection of microplastic pollution in freshwater systems such as rivers, lakes and estuaries is important as it provides information about the flow of microplastics into the oceans and seas (Ziajahromi et al., 2017). The concentrations of microplastics in freshwater are close to sea level in some areas and 80% of plastics in the seas originate from rivers (Alimi et al., 2018). In addition, microplastics increase the cytotoxicity of Ag^{+} even at low concentrations in long-term exposure (Sun et al., 2020), and that it can cause liver damage (Shen et al., 2022). For these reasons, microplastic pollution in fresh water has recently been investigated (Li et al., 2023).

Polycyclic aromatic hydrocarbons (PAHs) are ubiquitous environmental contaminants. The sources of PAHs can be of petrogenic and pyrogenic origin as the combustion of fossil fuels, industrial processes or motor vehicles. Sixteen PAHs are included in the United States Environmental Protection Agency (US EPA) list of priority pollutants due to the potential of these compounds to be carcinogenic, mutagenic, potent immunosuppressant or toxic (Jimenez-Skrzypek et al., 2021). It has been previously reported that microplastics can adsorb PAHs and therefore transfer these pollutants to organisms in the aquatic environment (Tan et al., 2019).

The occurrence and abundance of microplastics in the surface water in Konya, Türkiye were examined for the first time. The purpose of this study is (i) to determine the abundance, composition and morphological properties of microplastics in surface water feeding Beyşehir Lake in Türkiye, (ii) to identification the concentrations and types of seventeen PAHs associated microplastics, (iii) to evaluate the source of the PAHs in the surface water environment.

2. Materials and methods

2.1. Chemicals and reagents

All chemicals used were of analytical grade. The 16-PAHs mixed standard, including acenaphthene, acenaphthylene, anthracene, benzo[a]anthracene, benzo[a]pyrene, benzo[b]fluoranthene, benzo[ghi]perylene, benzo[k]fluoranthene, chrysene, dibenz[ah]anthracene, fluoranthene, fluorene,

indeno[123-cd]pyrene, naphthalene, phenanthrene, pyrene were obtained from Accustandard (New Haven, CT, USA). Benzo[j]fluoranthene was obtained from Dr. Ehrenstorfer. The residue grade solvents used, acetone, n-hexane, cyclohexane, ethyl acetate, petroleum ether (40-60 °C), silica gel 60 (0.063–0.200 mm) and other chemical reagents (Na_2SO_4, H_2O_2, $FeSO_4$, $ZnCl_2$) were obtained from Merck. A nylon filter with a 0.45 µm pore diameter was obtained from Sartorius (Göttingen, Germany). Deionized water was obtained from a Millipore Milli-Q Plus water purifier (Merck, MA, USA).

2.2. GC-MS conditions for PAH analysis

The determinations of PAHs were carried out by gas chromatograph (GC, Agilent 6890 N, Agilent Technologies, CA, USA) equipped with mass selective detector (MSD, Agilent 5973). GC, equipped with programmed temperature vaporizing (PTV) injector, DB-5 MS 5% phenylmethyl siloxane fused silica capillary column (30 m length, 0.25 mm i.d. and 0.25 µm film thickness) and helium was used as carrier gas. PTV temperature program was 80 °C, 12 °C/s to 350 °C and hold at 350 °C for 2 min. Injections were performed by an Agilent 7683 B Series auto injector. The temperature of the ion source and mass spectrometer transfer line were maintained at 180 °C and 280 °C, respectively. The temperature program was 60 °C for 4 min, 15 °C/min to 160 °C, 3 °C/min to 300 °C, hold at 300 °C for 10 min. The selected ion mode was used for analyses of PAHs and the m/z values of PAHs were selected according to Ozcan et al. (2010).

2.3. Sample collection and pretreatment

Beyşehir Lake catchment area covers an area of 4167 km^2 and is located 75 km from the city of Konya. It is the largest freshwater lake and drinking water reservoir in Central Anatolia, Türkiye. The water of the lake is used for irrigation and domestic purposes (Şener et al., 2010). Also, some fish species present in this lake (Altındağ and Yiğit, 2005). The lake is located within the borders of two national parks and it has been a first-degree Specially Protected Area since 1991. However, the lake has faced many threats such as urbanization, sewage discharge, exotic fish entry, excessive water withdrawal due to inappropriate water policy, and expansion of aquatic macrophytes in the lake

ecosystem during low water level periods (Bucak et al., 2018). Surface water samples were taken from five streams feeding Beyşehir Lake. Location map of sampling points is presented in Figure 1. Duplicate surface water samples were collected at a depth of about 10 cm below the surface water using prewashed stainless-steel bucket. A total of 36 L of water was collected at each sampling site.

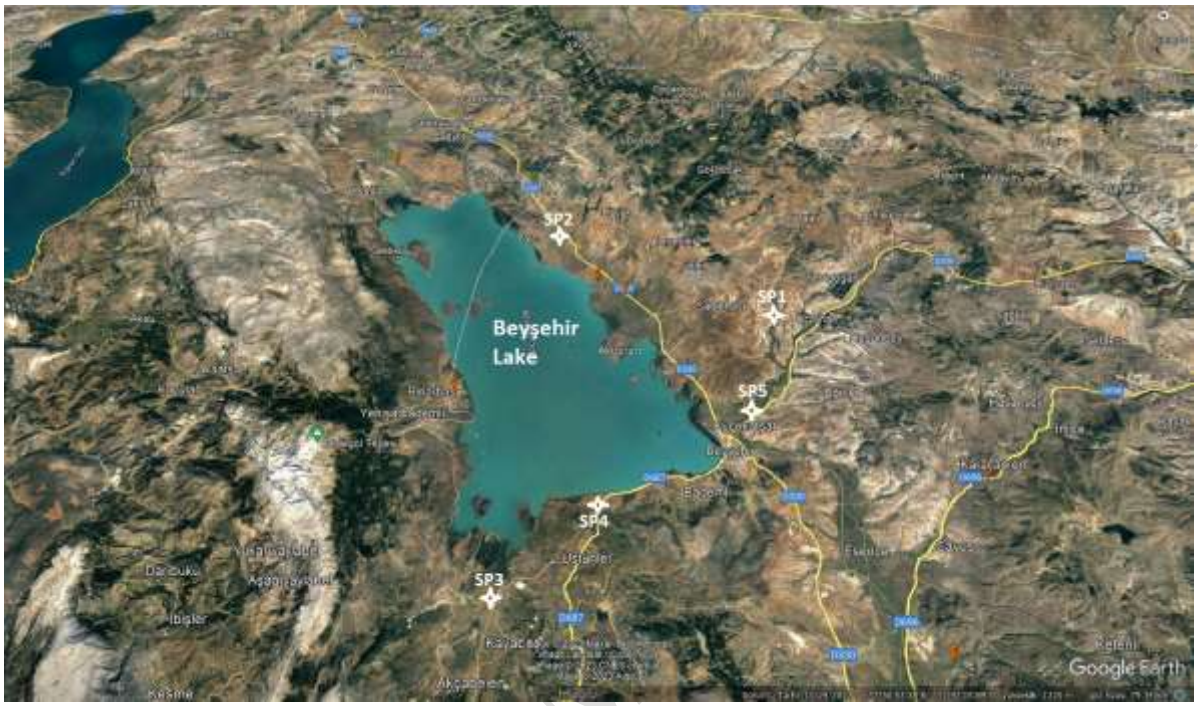


Figure 1. Location map of sampling points (SP) (SP1: Kuruçay-Hoyuklu-Yazı stream; SP2: İlmen stream; SP3: Derebucak stream; SP4: Büyükköprü stream; SP5: Beyşehir stream)

Samples were filtered through stainless steel sieves with mesh size of 5 mm and 20 μm. The materials retained on 5 mm sieve were discarded. The materials collected in the 20 μm sieve were transferred into the beaker. Then, the samples were stored at 4 ◦C until further analyses.

2.4. Determination of microplastics in surface water

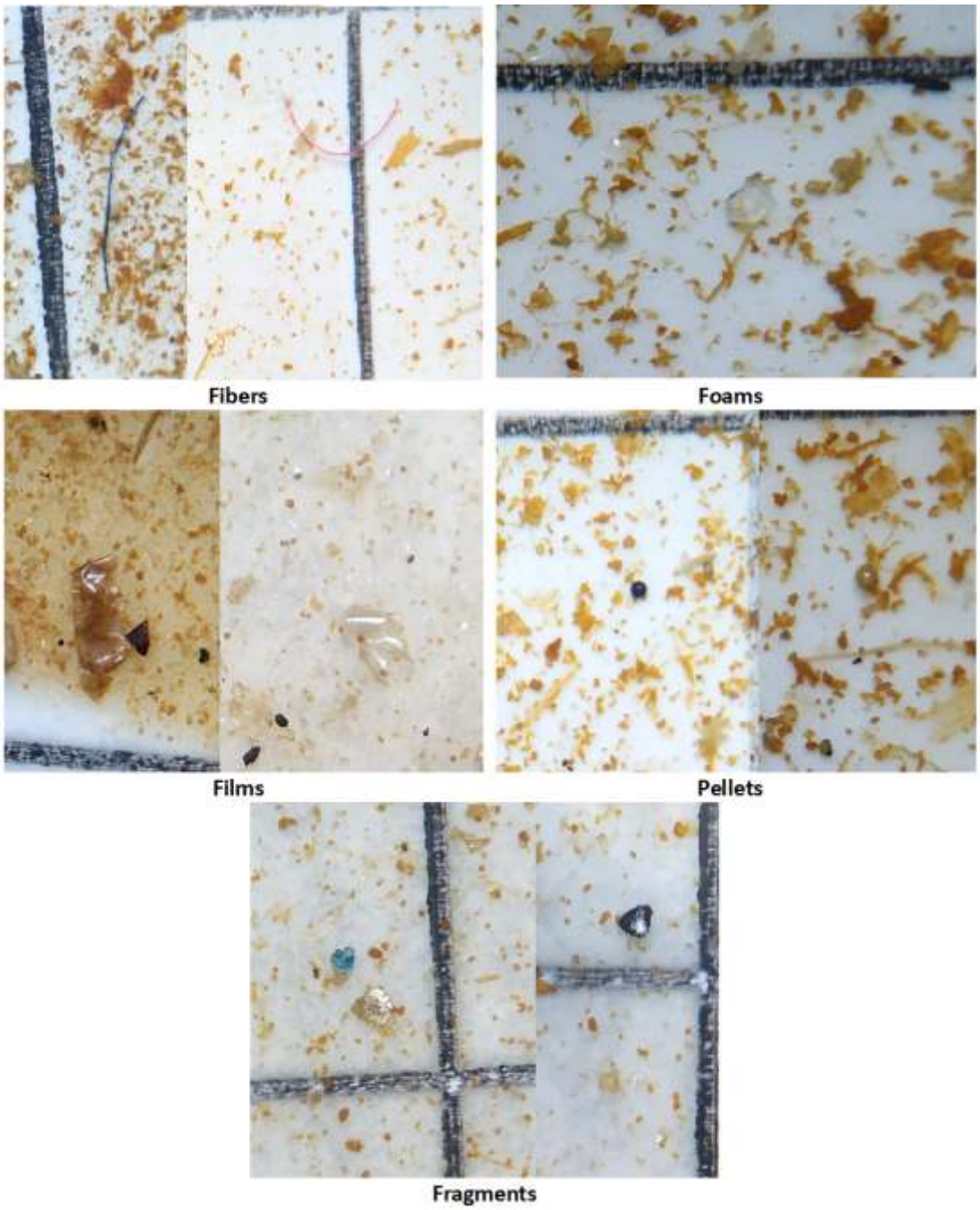
The microplastic samples were processed using the modified NOAA protocol (Masura et al., 2015). The solid materials transferred into the beaker were subjected to wet peroxide oxidation in the presence of a Fe(II) catalyst to digest organic material. 20 mL of aqueous 0.05 M Fe(II) solution and 20 mL of 30% hydrogen peroxide as fenton reagent catalysts were added to the beaker containing the 20 μm size fraction of collected solids. The solution was placed in a water bath at 75 ^{o}C. As soon as

gas bubbles are observed at the surface, the beaker was removed from the water bath and it was left overnight to eliminate any organic residues under the fume hood. Afterwards, the wet peroxide oxidation mixture is subjected to density separation in saturated $ZnCl_2$ solution to isolate the plastic debris through flotation. For that, 100 mL saturated $ZnCl_2$ solution was added to the beaker containing wet peroxide oxidation mixture. The beaker was covered loosely with aluminum foil and it was waited for the separation of high-density microplastics for 24 hours. The supernatant including floating solids was then filtered through gridded filter paper (Whatman GF/A, 47 mm Ø with 0.45 μm pore size) using a glassware filtration unit. Filter was transferred in sterile glass petri dishes. It was kept in the desiccator until dry for identification and characterization analysis. The filter paper was observed under a microscope (Nikon Eclipse) with a camera (Nikon DS-L4 and NIS-Elements software). The number, color and morphology of microplastics on each filter were recorded during visual examination. Eventually, the chemical structure of the plastics was evaluated using Fourier Transform Infrared Spectrometer (FTIR, Thermo Fisher Scientific Nicolet iS20). Microplastics were characterized morphologically as in Figure 2.

2.5. Determination of PAHs in associated microplastics in surface water

Surface waters collected at each sampling site were filtered through stainless steel sieves with mesh size of 5 mm and 20 μm. The materials collected in the 20 μm sieve were transferred into the beaker. Then, density separation was performed with saturated $ZnCl_2$ solution as described in section 2.4. The supernatant including floating solids was filtered through nylon membran filter (Whatman, 47 mm Ø with 0.45 μm pore size) using a glassware filtration unit. Filter was transferred in sterile glass petri dishes. It was kept in the desiccator until dry. Afterwards, the dried microplastics were weighed and transferred to flask. It was extracted using a 15 mL mixture of n-hexane:petroleum ether (1:1, v:v) for 15 min of sonication. The ultrasonic extraction of PAHs was repeated three times and the extracts were then combined. The volumes were adjusted to exactly 1 mL using a rotary evaporator. The extracts were transferred onto the top of the 2% deactivated silica gel column for purification and fractionations were carried out consecutively using 70 mL n-hexane and 3 x 20 mL n-

147 hexane:ethyl acetate (1:1, v:v). Then, the volumes of the elutions were reduced to 1 mL and a
148 quantitative analysis of the PAHs were performed using GC/MS as described in section 2.2 (Tan et
149 al., 2019, Ogata et al., 2009).
150



151

152 **Figure 2.** Visual morphology classification of microplastic used for all the samples

153

154 **3. Results and Discussion**

3.1. Abundance, morphological characteristic, color and polymer type of microplastics

Abundance and morphological characteristics of microplastics are presented in Figure 3. Microplastics were determined in all surface waters. The abundance of microplastics in samples ranged from 2833 to 6861 particles/m^3.

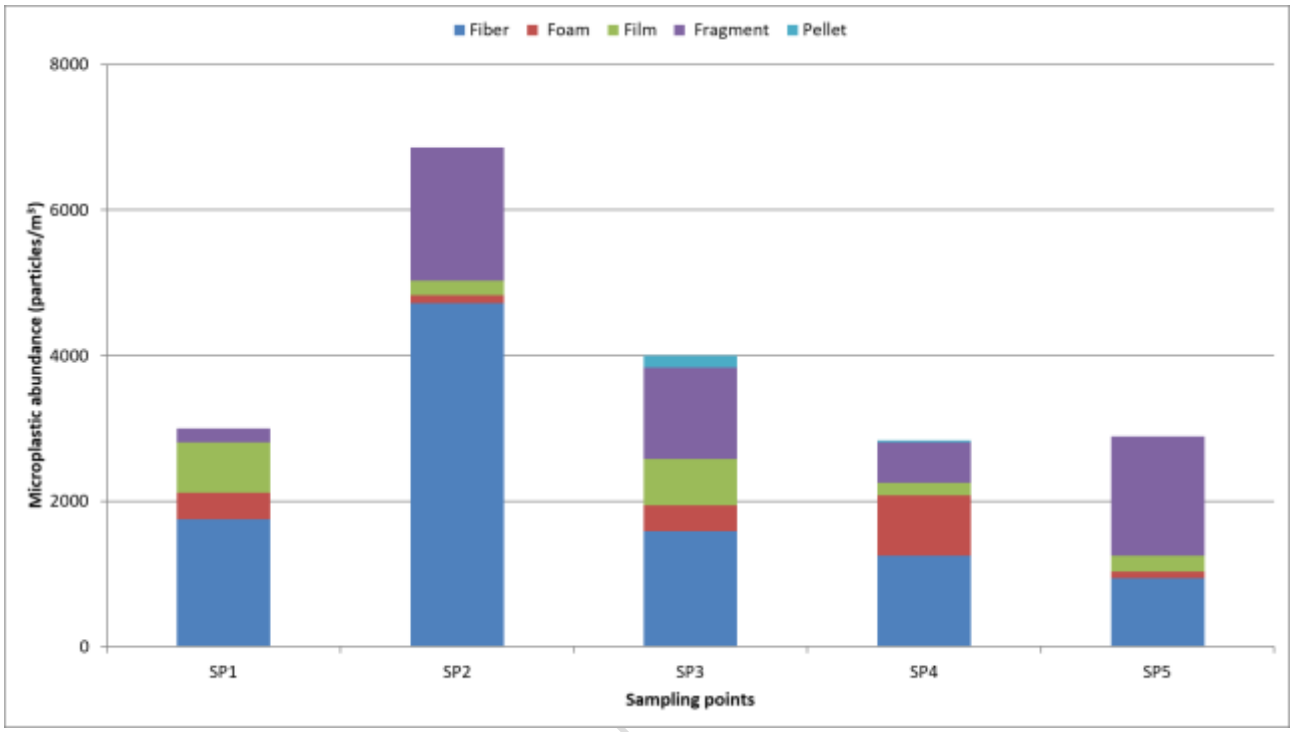


Figure 3. Abundance and morphological characteristics of microplastics determined in surface waters

While the highest microplastic amount was found in samples from İlmen stream (SP2), the lowest microplastic amount was determined in samples taken from Büyükköprü stream (SP4). This situation can be explained by the intensity of human activities around the İlmen stream and the degradation and fragmentation of randomly discharged plastic waste. The abundance of microplastic in the surface waters was quite low compared to study results in China (Ma et al., 2020). However, much higher MPs abundance was observed, compared to that reported in other countries listed in Table 1.

Table 1. Comparisons of abundance, morphological shapes and polymer types of microplastics detected in surface waters

Country	Abundance (particles/m^3)	Morphological characteristic	Polymer types	References
China	10300-87500	Fiber, fragment	PE, PP	Ma et al., 2020
Viet Nam	0.35-2522	Fragment, film, foam, fiber, pellet	PE, PP, polyester, PS, PA, poliolefin	Strady et al., 2021
Portugal	58-1265	Fiber, fragment, film, foam	PE, PP, PS, PET	Rodrigues et al., 2018
China	400±100	Film, Fiber	PE, PP, PVC	Lv et al., 2019
Netherlands	213.147	-	Isopiren, PE, PET, PP, PS, PVC	Mughini-Gras et al., 2021
South Africa	93.07±36.78	-	PP, PE, PET, PS, PVC, selefon	Preston-Whyte et al., 2021
Thailand	80±65	Fragment, fiber, pellet, film	PP, PS, PE, selefon, poliüretan, polibütilen	Ta and Babel, 2020
Indonesia	9.37±1.37	Fragment, fiber, granül, foam	PE, PP, PS, polyester, selefon	Cordova et al., 2020
Italy	0.9±4-13±5	Foam, fiber, pellet, fragmant, pul	PE, PP, PS, PVC, PU	Campanale et al., 2020
Türkiye	**2830-6860**	**Fiber, fragment, film, foam, pellet**	**Selefon, PP, PE**	**This study**

The shapes of the microplastics determined in the surface waters can be divided into fiber, foam, film, fragment, pellet. The relative proportions of different morphological shapes of microplastics are presented in Figure 4.

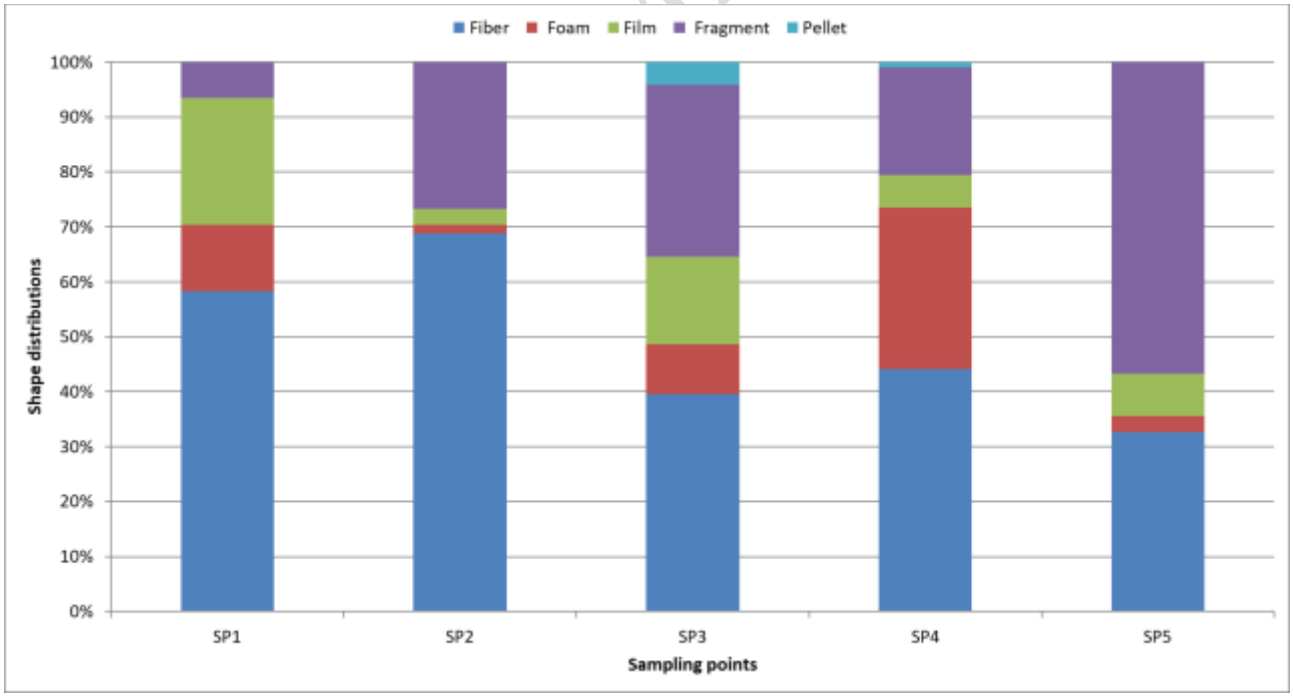


Figure 4. Distribution of different morphological shapes of microplastics determined in surface waters

As shown, fiber and fragment form microplastics were predominantly observed at all sampling points. Fiber form microplastics were the most frequent shape (33-69%) of the microplastics detected in surface waters. The other most abundant forms were fragments (7-57%), film (3-23%), foam (1-29%). Pellet forms were the least detected shape, and were detected less than 4% in only two surface waters. Fiber and fragment are also found in abundance in other studies carried out in surface waters (Strady et al., 2021; Ta and Babel, 2020; Rodrigues et al., 2018; Campanale et al., 2020). For example, microplastics determined predominantly characterized by fibers, accounting for 84.0%, followed by fragment (12.6%), in China's second largest urban lake, East Lake (Shi et al., 2023). Sulistyowati et al. (2022) determined fragment form microplastics predominantly (64.15%), followed by foam (20.40%), fiber (13.43%), and granule (1.99%) in surface water samples, the dominant forms in the estuary and coastal water were fragments of 53.31% and fiber of 34.3% (Cordova et al., 2020). Fiber was the most abundant shape (68.1-78.9%) followed by fragment, accounting for (31.2-19.3%) in Pearl River Estuary of Guangzhou, China (Ma et al., 2020). Morphological features of microplastics give information about their sources in the environment. Microplastics in the form of fibers in surface waters can mainly be caused by sewerage from clothes washing, decomposition of fishing nets and ropes, surface runoff and atmospheric deposition. While fragments found in surface waters may originate from decomposition of larged-size plastic wastes, film form may be caused by agricultural activity (Vivekanand et al., 2021; Jiang et al., 2023).

The distribution of microplastic colors determined in surface waters are given in Figure 5. The microplastics were categorized by colors as transparent, white, blue, black, green, yellow, brown, pink and grey. It is seen that the transparent/white color (42-81%) is dominant in the color distribution of the detected microplastics in surface waters. While, blue microplastics were ranged from 14 to 26% in samples, black microplastics were ranged 4 to 11%. Green microplastics were detected between 1% and 23% in four samples. Yellow, brown, pink and gray colored microplastics were detected in lower amounts than other colors. The results obtained agree with the results of the studies in the literature. Jiang et al. (2023) were determined different colors of microplastics (45-51% for

white/transparent, 13-25% for black, and 29-37% for multicolored) in the irrigation water. Shi et al., (2023) found eight kinds of colors of microplastics, including colorless, black, green, blue, red, brown, purple and yellow. The colorless MPs were predominantly determined in most samples. White and transparent microplastics were presented the highest percentage in river water (Ta and Babel, 2020). Transparent particles were presented the most common ones (mean value of 56 %), followed by black (mean value of 35 %) and colored microplastics (mean value of 11 %) in surface waters (Campanale et al., 2020). Generically, plastic base material is white and coloration of plastic products are conducted. The colors of colored plastic products may fade due to photodegradation and weather conditions in the natural environment. The high proportion of colorless or white/transparent microplastics in surface waters may be explained by this situation. White, black color microplastics may be originated from vehicles, colored plastic wastes may be originated from plastic packaging materials.

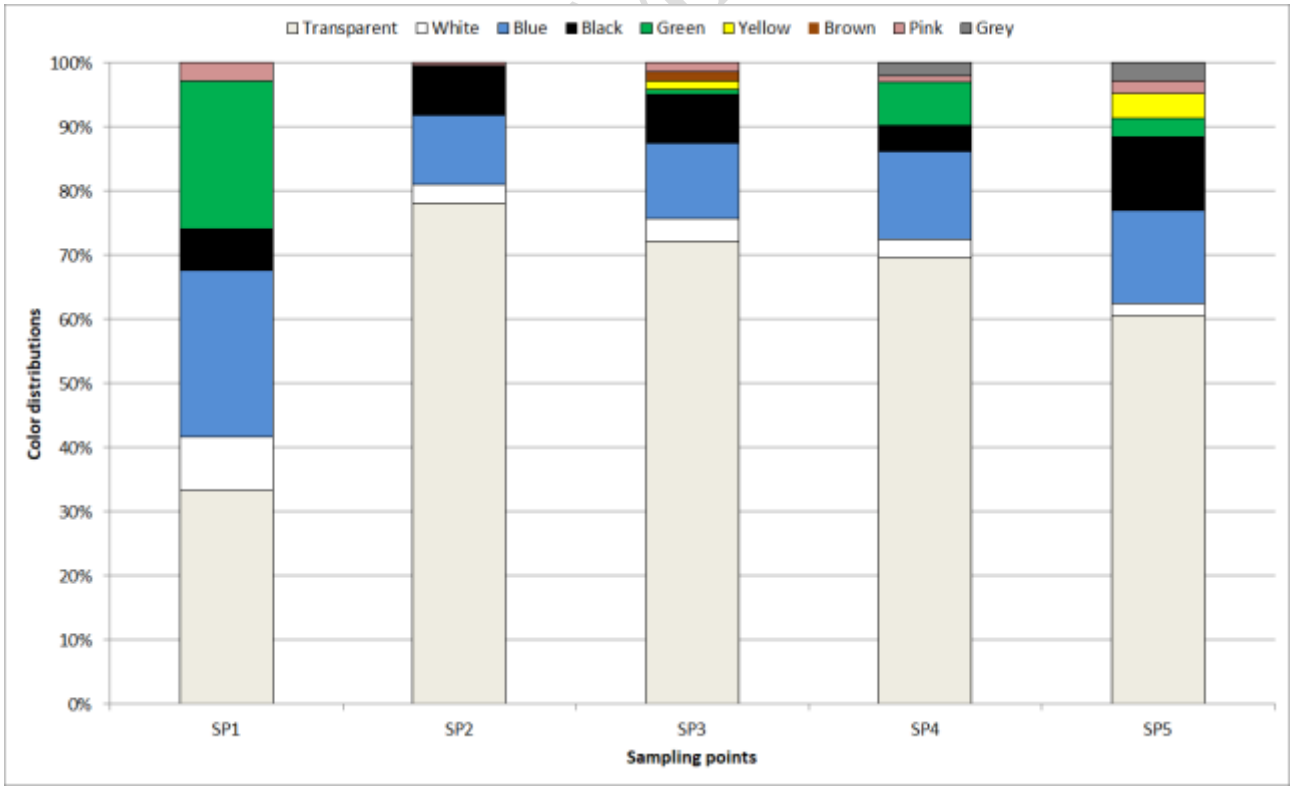


Figure 5. Distribution of microplastic colors determined in surface waters

A total of two polymer types were identified, which included cellophane and poly(ethylene:propylene:diene). The most common detected plastic polymer was cellophane. While cellophane polymer was detected in the all samples, poly(ethylene:propylene:diene) was detected in one samples as a result of FTIR analysis. The distribution of plastic ploymer types in surface waters is similar to other published data in freshwater. Yan et al., (2019) were detected the most common polymer types as polyamide (26.2%) and cellophane (23.1%) in river water. The most abundant polymer types in the surface water samples was poly(ethylene:propylene:diene) and cellophane was found the most abundant polymer in the sediment and fish samples (Zhang et al., 2020). Castillo et al., (2016) and Peng et al., (2017) detected as dominant poly(ethylene:propylene:diene) in seawater and sediment, respectively. Poly(ethylene:propylene:diene) was detected as 7% in seawater (Sathish et al., 2020). Cellophane, an organic cellulose-based polymer, is widely used in cigarette and food packaging and toothbrushes. Although cellophane is considered biodegradable, its long existence until it degrades can threaten marine ecosystems, especially the food chain. (Zainuddin et al., 2022). Poly(ethylene:propylene:diene) is a copolymers and is used in tires, conveying belts, electrical insulates, fuel storage tanks and coating for steel pipes (Castillo et al., 2016). Polyethylene and polypropylene are generally considered to be common microplastic contaminants of surface waters. This is due to their low density compared to other plastic polymers (Athulya and Chandrasekaran, 2023).

3.2. PAHs associated with microplastics

Microplastics have hydrophobic property. Microplastics exposed to different degrees of weathering and degradation in nature have a large surface area. This causes organohalogenous pollutants as PAHs to be adsorbed by microplastics and transported with them to the environment (Tan et al., 2019). Individual and total concentrations of target 17 PAHs associated on microplastics from surface sampling point are given in Table 2.

Table 2. Concentrations of 17 polycyclic aromatic hydrocarbons (PAHs) associated on microplastics from different surface sampling point

PAHs (ng/g)	SP1	SP2	SP3	SP4	SP5
Nap	107.3	85.28	208.5	279.1	56.12
Acy	148.5	102.2	190.9	256.7	47.19
Ace	201.9	149.3	482.6	451.6	138.1
Flu	814.5	626.6	1890	2139	413.6
Phe	1927	990.2	2611	3088	870.6
Ant	114.0	96.18	221.6	199.4	19.49
Fluor	37.15	77.42	36.97	49.73	15.54
Pyr	319.4	350.9	526.9	508.5	182.5
B[a]A	83.33	93.95	159.9	261.8	29.42
Chr	94.44	91.65	39.98	16.28	17.19
B[b]F	252.7	80.46	78.21	123.7	28.61
B[k]F	141.5	42.10	23.48	73.19	4.63
B[a]P	89.45	25.22	5.14	3.45	9.30
I[cd]P	57.61	37.11	2.21	16.67	5.88
D[ah]A	44.27	209.8	47.56	74.14	18.59
B[ghi]P	26.24	186.0	113.7	246.3	16.46
B[j]F	57.59	113.9	5.38	182.7	50.79
∑PAHs	**4517**	**3358**	**6644**	**7970**	**1924**

SP: Sampling Point

Nap: naphthalene, Acy: acenaphthylene, Ace: acenaphthene, Flu: fluoranthene, Phe: phenanthren, Ant: anthracene, Fluor: fluorene, Pyr: pyrene, B[a]A: benzo[a]anthracene, Chr: chrysene, B[b]F: benzo[b]fluoranthene, B[k]F: benzo[k]fluoranthene, B[a]P: benzo[a]pyrene, I[cd]P: indeno[1,2,3-cd]pyrene, D[ah]A: dibenz[a,h]anthracene, B[ghi]P: benzo[ghi]perylene, B[j]F: Benzo[j]fluoranthene

The total PAH concentrations associated with microplastics in the surface waters was ranged from 1924 ng/g (SP5) to 7970 ng/g (SP4). Distribution of PAHs in microplastics is shown in Figure 6.

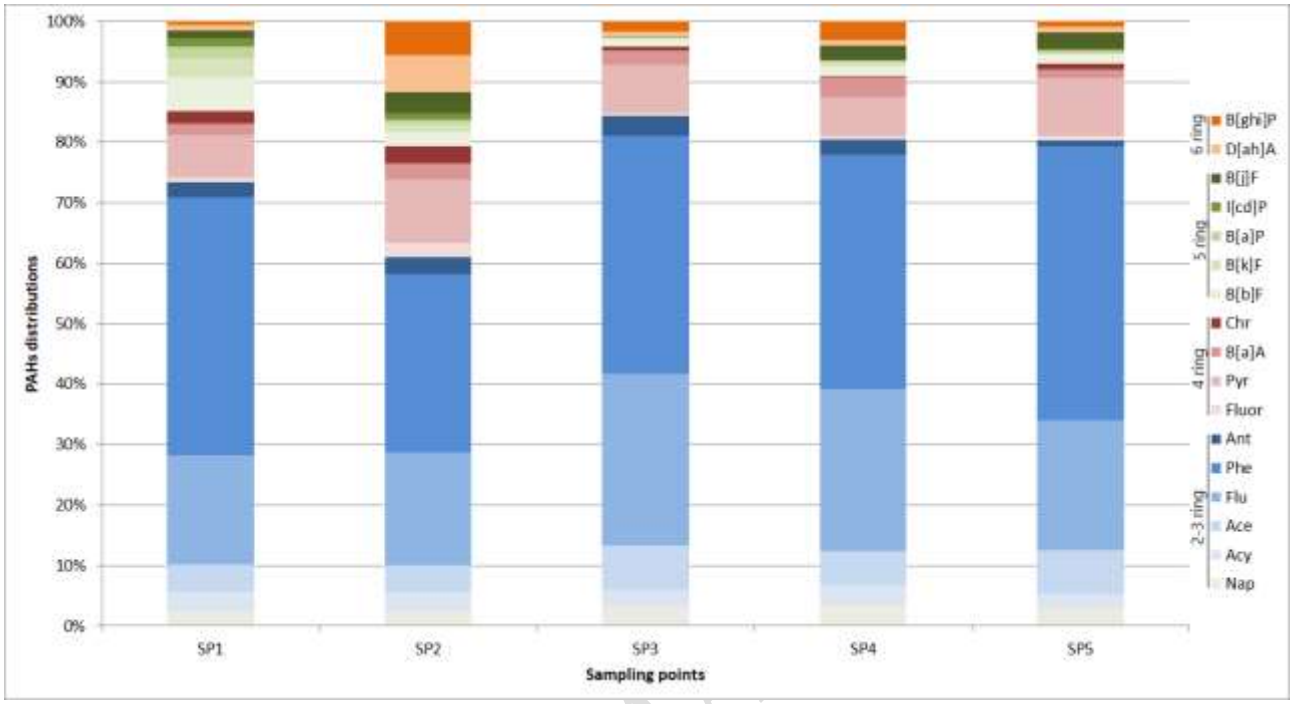


Figure 6. Distribution of PAHs in microplastics from the surface waters

Low molecular weight PAH compounds (with 2 to 4 rings) were dominantly determined than high molecular weight PAH compounds (5 and 6 rings) in surface waters. While phenanthrene and fluoranthene accounted for 29-45% and 18-28% of total PAHs, other compounds formed below 10% of total PAHs. Phenanthrene was the most abundant PAH with concentration of 870.6-3088 ng/g at all sampling points. Recent studies reported that PAHs sorbed to microplastics has been detected on surface waters, seas worldwide. Tan et al (2019) reported that the total concentration of the associated PAHs on microplastics in the surface waters of the Feilaixia Reservoir in China was determined between 427.3 and 282.4 ng/g. The total concentration of 16 PAHs affiliated with microplastics in surface waters of Bohai and Huanghai Seas were reported in the range of 3400-119000 ng/g (Mai et al., 2018). Hirai et al. (2011) reported that total PAHs concentrations ranged from 1 to 9300 ng/g in the plastic fragments in marine plastics debris from the Pasific Ocean. The total concentration of

PAHs in microplastics ranged from 104 to 3595 ng/g in the southwestern coast of Taiwan (Chen et al., 2020). PAHs associated with microplastics can pose some adverse ecotoxicological effects to the environment due to the intentional or accidental ingestion of microplastics by aquatic organisms. In addition, the presence of many hydrophilic compounds such as pharmaceuticals and personal care products sorbed to microplastics, apart from PAHs, cause of concern for human and ecosystem health.

3.3. Potential sources of PAHs in microplastics

The potential sources of PAHs at each sampling site were evaluated by using concentration diagnostic ratios of specific PAH congeners. Anthropogenic sources of PAHs can be classified as petrogenic and pyrogenic. While petrogenic PAHs are low molecular weight compounds, pyrogenic PAHs compounds are higher weight compounds (Ozcan et al., 2009; Hirai et al., 2011). If fluoranthene/pyrene ratio is greater than 1, the source of PAH compounds is of pyrogenic origins from incomplete combustion of fossil fuels. If phenantrene/anthracene ratio is higher than 10, the source of PAH compounds is of petrogenic origins (Tan et al., 2019; Lozoya et al., 2016). In this study, the phenantrene/anthracene ratio in all the samples was determined >10. Also, fluoranthene/pyrene ratios is lower than 1. Therefore, the main sources source of the PAHs carried on microplastics were mainly contributed by petrogenic sources. This is confirmed by the presence of a higher abundance of low molecular weight compounds (3-4 ring congeners) in all the samples. If benzo[a]anthracene/(benzo[a]anthracene+ chrysene) ratio is between 0.4 and 0.6, the source of PAHs is fossil fuels burning processes. If the ratio is between 0.6 and 0.9, the source of PAHs is traffic originating compounds from diesel engines (Ozcan et al., 2009). According to this evaluation, the sources of PAHs at sampling points 1 and 2 are due to pyrogenic sources, and at sampling points 4 and 5, they are due to traffic/exhaust. Tan et al (2019) reported that the main source of the PAHs carried on microplastics in the surface water was the incomplete combustion of fossil fuels. Mai et al. (2018) identified petroleum sources PAHs extracted from microplastics obtained from Bohai and Huanghai Seas. Lo et al. (2019) and Chen et al. (2020) reported mainly 3-4 ring PAH congeners in

the microplastics in Hong Kong and Taiwan and they reported that PAHs were mainly contributed by petrogenic sources.

4. Conclusions

With the results of the study, the presence of microplastics in surface waters in Turkey was detected for the first time. Microplastics in the surface water feeding Beyşehir Lake in Türkiye were found in the range of 2830-6860 particles/m^3. Fiber, foam, film, fragment, pellet shapes of microplastics were determined in surface waters. Fiber and fragment were the most common shapes. Three kinds of polymer (cellophane, polyethylene, polypropylene) were identified. The results confirmed that there is microplastic transport to the lake by the surface water flows feeding the Beyşehir Lake. Additionally, the concentration levels of pyrogenic and petrogenic sourced PAHs transported to the lake as sorbed to microplastics by surface waters is quite high. As it is known, PAH compounds are primary pollutants and some of them are known as carcinogens and mutagens. This is a concern for the lake water used for irrigation and domestic purposes and even for the aquatic organisms in the lake. This pollution situation should be taken into account in the use of lake water.

References

Alimi O.S., Budarz J.F., Hernandez L.M. and Tufenkji N. (2018), Microplastics and nanoplastics in squatic environments: aggregation, deposition, and enhanced contaminant transport. *Environmental Science Technol*ogy, **52**, 1704-1724.

Altındag A. and Yigit S. (2005), Assessment of heavy metal concentratıons ın the food web of lake Beysehir, Turkey. *Chemosphere*, **60**, 552-556.

Athulya P.A. and Chandrasekaran N. (2023), Interactions of natural colloids with microplastics in aquatic environment and its impact on FTIR characterization of polyethylene and polystyrene microplastics. *Journal of Molecular Liquids*, **369**, 120950.

Bucak T., Trolle D., Tavşanoğlu Ü.N. Çakıroğlu A.İ., Özen A., Jeppesen E. and Beklioğlu M. (2018), Modeling the effects of climatic and land use changes on phytoplankton and water quality of the largest Turkish freshwater lake: Lake Beyşehir. *Science of The Total Environment*, **621**, 802-816.

Campanale C., Stock F., Massarelli C., Kochleus C., Bagnuolo G., Reifferscheid G. and Uricchio V.F. (2020), Microplastics and their possible sources: the example of Ofanto river in Southeast Italy. *Environmental Pollution*, **258**, 113284.

Castillo A.B., Al-Maslamani I. and Obbard J.P. (2016), Prevalence of microplastics in the marine waters of Qatar. *Marine Pollution Bulletin*, **111**, 260-267.

Chen C.F., Ju Y.R., Lim Y.C., Hsu N.H., Lu K.T., Hsieh S.L., Dong C.D. and Chen C.W. (2020), Microplastics and their affiliated PAHs in the sea surface connected to the southwest coast of Taiwan. *Chemosphere*, **254**, 126818.

Cole M., Lindeque P., Halsband C. and Galloway T.S. (2011), Microplastics as contaminants in the marine environment: a review. *Marine Pollution Bulletin*, **62**, 2588-2597.

Cordova M.R., Riani E. and Shiomoto A. (2020), Microplastics ingestion by blue panchax fish (Aplocheilus sp.) from Ciliwung Estuary, Jakarta, Indonesia. *Marine Pollution Bulletin*, **161**, 111763.

Fu Z., Chen G., Wang W. and Wang J. (2020), Microplastic pollution research methodologies, abundance, characteristics and risk assessments for aquatic biota in China. *Environmental Pollution*, **266**, 115098.

Hirai H., Takada H., Ogata Y., Yamashita R., Mizukawa K., Saha M., Kwan C., Moore C., Gray H., Laursen D., Zettler E.R., Farrington J.W., Reddy C.M., Peacock E.E. and Ward M.W. (2011), Organic micropollutants in marine plastics debris from the open ocean and remote and urban beaches. *Marine Pollution Bulletin*, **62**, 1683-1692.

Jiang J.J., Hanun J.N., Chen K.Y., Hassan F., Liu K.T., Hung Y.H. and Chang T.W. (2023), Current levels and composition profiles of microplastics in irrigation water. *Environmental Pollution*, **318**, 120858.

353 Jimenez-Skrzypek G., Hernandez-Sanchez C., Ortega-Zamora C., Gonzalez-Salamo J., Gonzalez-
354 Curbelo M.A. and Hernandez-Borges J. (2021), Microplastic-adsorbed organic contaminants:
355 Analytical methods and occurrence. *TrAC Trends in Analytical Chemistry*, **136**, 116186.
356 Koutnik V.S., Leonard J., Alkidim S., DePrima F.J., Ravi S., Hoek E.M.V. and Mohanty S.K. (2021),
357 Distribution of microplastics in soil and freshwater environments: global analysis and framework
358 for transport modeling. *Environmental Pollution*, **274**, 116552.
359 Li W., Li X., Tong J., Xiong W., Zhu Z., Gao X., Li S., Jia M., Yang Z. and Liang J. (2023), Effects
360 of environmental and anthropogenic factors on the distribution and abundance of microplastics in
361 freshwater ecosystems. *Science of The Total Environment*, **856**, 159030.
362 Lo H.S., Wong C.Y., Tam N.F.Y. and Cheung S.G. (2019), Spatial distribution and source
363 identification of hydrophobic organic compounds (HOCs) on sedimentary microplastic in Hong
364 Kong. *Chemosphere*, **219**, 418-426.
365 Lozoya J.P., de Mello F.T., Carrizo D., Weinstein F., Olivera Y., Cedres F., Pereira M. and Fossati
366 M. (2016), Plastics and microplastics on recreational beaches in Punta del Este (Uruguay): Unseen
367 critical residents? *Environmental Pollution*, **218**, 931-941.
368 Lv W., Zhou W., Lu S., Huang W., Yuan Q., Tian M., Lv W. and He D. (2019), Microplastic pollution
369 in rice-fish co-culture system: a report of three farmland stations in Shanghai, China. *Science of*
370 *the Total Environment*, **652**, 1209-1218.
371 Ma J., Niu X., Zhang D., Lu L., Ye X., Deng W., Li Y. and Lin Z. (2020), High levels of microplastic
372 pollution in aquaculture water of fish ponds in the Pearl River Estuary of Guangzhou, China.
373 *Science of the Total Environment*, **744**, 140679.
374 Mai L., Bao L.J., Shi L., Liu L.Y. and Zeng E.Y. (2018), Polycyclic aromatic hydrocarbons affiliated
375 with microplastics in surface waters of Bohai and Huanghai Seas, China. *Environmental Pollution*,
376 **241**, 834-840.
377 Malli A., Corella-Puertas E., Hajjar C. and Boulay A.M. (2022), Transport mechanisms and fate of
378 microplastics in estuarine compartments: A review. *Marine Pollution Bulletin*, **177**, 113553.

Masura J., Baker J., Foster G. and Arthur C. (2015), Laboratory methods for the analysis of microplastics in the marine environment: recommendations for quantifying synthetic particles in waters and sediments. Siver Spring, MD, NOAA Marine Debris Division, 31pp. (NOAA Technical Memorandum NOS-OR&R-48). DOI: http://dx.doi.org/10.25607/OBP-604.

Mughini-Gras L., van der Plaats R.Q.J., van der Wielen P., Bauerlein P.S. and Husman A.M.D. (2021), Riverine microplastic and microbial community compositions: a field study in the Netherlands, *Water Research*, **192**, 116852.

Naqash N., Prakash S., Kapoor D. and Singh R. (2020), Interaction of freshwater microplastics with biota and heavy metals: a review. *Environmental Chemistry Letter*, **18**, 1813-1824.

Ogata Y., Takada H., Mizukawa K., Hirai H., Iwasa S., Endo S., Mato Y., Saha M., Okuda K., Nakashima A., Murakami M., Zurcher N., Booyatumanondo R., Zakaria M.P., Dung L.Q., Gordon M., Miguez C., Suzuki S., Moore C., Karapanagioti H. K. and Thompson R.C. (2009), International Pellet Watch: Global monitoring of persistent organic pollutants (POPs) in coastal waters. 1. Initial phase data on PCBs, DDTs, and HCHs. *Marine Pollution Bulletin*, **58**, 1437-1446.

Ozcan S. and Aydın M.E. (2009), Polycyclic aromatic hydrocarbons, polychlorinated biphenyls and organochlorine pesticides in urban air of Konya, Turkey. *Atmospheric Research*, **93**, 715-722.

Ozcan S., Tor A. and Aydın M.E. (2010), Determination of polycyclic aromatic hydrocarbons in waters by ultrasound-assisted emulsification-microextraction and gas chromatography-mass spectrometry. *Analytica Chimica Acta*, **665**, 193-199.

Peng G., Zhu B., Yang D., Su L., Shi H. and Li D. (2017), Microplastics in sediments of the Changjiang Estuary, China. *Environmental Pollution*, **225**, 283-290.

Plastics Europe, E. (2019), Plastics-the facts 2019. An analysis of European plastics production. https://plasticseurope.org/wp-content/uploads/2021/10/2019-Plastics-the-facts.pdf.

Preston-Whyte F., Silburn B., Meakins B., Bakir A., Pillay K., Worship M., Paruk S., Mdazuka Y., Mooi G., Harmer R., Doran D., Tooley F. and Maes T. (2021), Meso and microplastics monitoring

in harbour environments: a case study for the Port of Durban, South Africa. *Marine Pollution Bulletin*, **163**, 111948.

Priya K.L., Renjith K.R., Joseph C. J., Indu M.S., Srinivas R. and Haddout S. (2022), Fate, transport and degradation pathway of microplastics in aquatic environment-A critical review. *Regional Studies in Marine Science*, **56**, 102647.

Rodrigues M., Abrantes N., Gonçalves F., Nogueira H., Marques J. and Gonçalves A. (2018), Spatial and temporal distribution of microplastics in water and sediments of a freshwater system (Antuã River, Portugal). *Science of the Total Environment*, **633**, 1549-1559.

Sathish M.N., Jeyasanta I. and Patterson J. (2020), Occurrence of microplastics in epipelagic and mesopelagic fishes from Tuticorin, Southeast coast of India. *Science of the Total Environment*, **720**, 137614.

Shen R., Yang K., Cheng X., Guo C., Xing X., Sun H., Liu D., Liu X. and Wang D. (2022), Accumulation of polystyrene microplastics induces liver fibrosis by activating cGAS/STING pathway. *Environmental Pollution*, **300**, 118986.

Shi M., Zhu J., Hu T., Xua A., Mao Y., Liu L., Zhang Y., She Z., Li P., Qi S. and Xing X. (2023), Occurrence, distribution and risk assessment of microplastics and polycyclic aromatic hydrocarbons in East lake, Hubei, China. *Chemosphere*, **316**, 137864.

Strady E., Dang T.H., Dao T.D., Dinh H.N., Do T.T.D., Duong T.N., Duong T.T., Hoang D. A., Kieu-Le T.C., Le T.P.Q., Mai H., Trinh D.M., Nguyen Q.H., Tran-Nguyen Q.A., Tran Q.V., Truong T.N.S. Chu V.H. and Vo V.C. (2021), Baseline assessment of microplastic concentrations in marine and freshwater environments of a developing Southeast Asian country, Viet Nam. *Marine Pollution Bulletin*, **162**, 111870.

Sulistyowati L., Nurhasanah, Riani E. and Cordova M.R. (2022), The occurrence and abundance of microplastics in surface water of the midstream and downstream of the Cisadane River, Indonesia. *Chemosphere*, **291**, 133071.

Sun C., Zhang W., Ding R., Wang J. and Yao L. (2020), Mechanism of low concentrations of polystyrene microplastics influence the cytotoxicity of Ag ions to Escherichia coli. *Chemosphere*, **253**, 126705.

Şener Ş., Şener E., Nas B. and Karagüzel R. (2010), Combining AHP with GIS for landfill site selection: a case study in the Lake Beyşehir catchment area (Konya, Turkey). *Waste Management*, **30**, 2037-2046.

Ta A.T. and Babel S. (2020), Microplastic contamination on the lower Chao Phraya: abundance, characteristic and interaction with heavy metals. *Chemosphere*, **257**,127234.

Tan X., Yu X., Cai L., Wang J. and Peng J. (2019), Microplastics and associated PAHs in surface water from the Feilaixia Reservoir in the Beijiang River, China. *Chemosphere*, **221**, 834-840.

Vivekanand A.C., Mohapatra S. and Tyagi V.K. (2021), Microplastics in aquatic environment: Challenges and perspectives. *Chemosphere*, **282**, 131151.

Wang Y., Zhou B., Chen H., Yuan R. and Wang F. (2022), Distribution, biological effects and biofilms of microplastics in freshwater systems - A review. *Chemosphere*, **299**, 134370.

Wang X., Bolan N., Tsang D.C.W., Sarkar B., Bradney L. and Li Y. (2021), A review of microplastics aggregation in aquatic environment: influence factors, analytical methods and environmental implications. *Journal of Hazardous Materials*, **402**, 123496.

Yan M., Nie H., Xu K., He Y., Hu Y., Huang Y. and Wang J. (2019), Microplastic abundance, distribution and composition in the Pearl River along Guangzhou city and Pearl River estuary, China. *Chemosphere*, **217**, 879-886.

Yang, S., Zhou, M., Chen, X., Hu, L., Xu, Y., Fu, W. and Li C. (2022), A comparative review of microplastics in lake systems from different countries and regions. *Chemosphere,* **286**, 131806.

Zainuddin A.H., Aris A.Z., Zaki M.R.M., Yusoff F.Md. and Wee S.Y. (2022), Occurrence, potential sources and ecological risk estimation of microplastic towards coastal and estuarine zones in Malaysia. *Marine Pollution Bulletin*, **174**, 113282.

455 Zhang D., Cui Y., Zhou H., Jin C., Yu X., Xu Y., Li, Y. and Zhang C. (2020), Microplastic pollution
456 in water, sediment, and fish from artificial reefs around the Ma'an Archipelago, Shengsi, China.
457 *Science of the Total Environment*, **703**, 134768.
458 Ziajahromi S., Neale P.A., Rintoul L. and Leusch F.D. (2017), Wastewater treatment plants as a
459 pathway for microplastics: development of a new approach to sample wastewater-based
460 microplastics. *Water Reserch*, **112**, 93-99.