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

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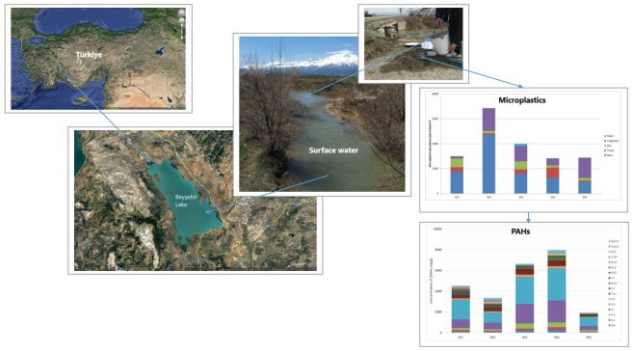
Graphical abstract



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 2,830-6,860 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 ones (42-81%). The total concentration of the seventeen PAHs associated with microplastics in surface waters ranged from 1,924 to 7,970 ng/g. According to the diagnostic ratios of the PAH isomers (fluoranthane/pyrene < 1 and phenanthrene/antracene >10), the source of the PAHs -in surface waters can be of 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 aquatic organisms in the lake as well as to the use the lake water for irrigation and for potable purposes.

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 in the environment such as mechanical abrasion, photo-oxidation, thermal degradation, biodegradation, hydrolysis and chemical degradation 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 for a specific application. Microplastics are a serious environmental problem due to their resistance to degradationand 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 to volume ratios. 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 increase 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 reported in the literature (Malli *et al*., 2022). Determination of microplastics in fish, molluscs, zooplankton, mammals and birds is an indication that microplastics have reached the aquatic organisms (Fu *et al*., 2020). Microplastic pollution in aquatic environments has

been often studied in the marine environment. Studies in fresh waters are limited (Wang *et al*., 2022). However, detection of microplastic pollution in freshwater systems such as rivers, lakes and estuaries are 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 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 thustransfer 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 was (i) to determine the abundance, composition and morphological properties of microplastics in surface water feeding Beyşehir Lake in Türkiye, (ii) to identify the concentrations and types of seventeen PAHs associated microplastics, and (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 membrane 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 4,167 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 are 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 water surface using a 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 sizes 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 (National Oceanic & Atmospheric Association) (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 matter. 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 °C. As soon as gas bubbles are observed at the surface, the beaker was removed from the water bath and 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 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 and 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.

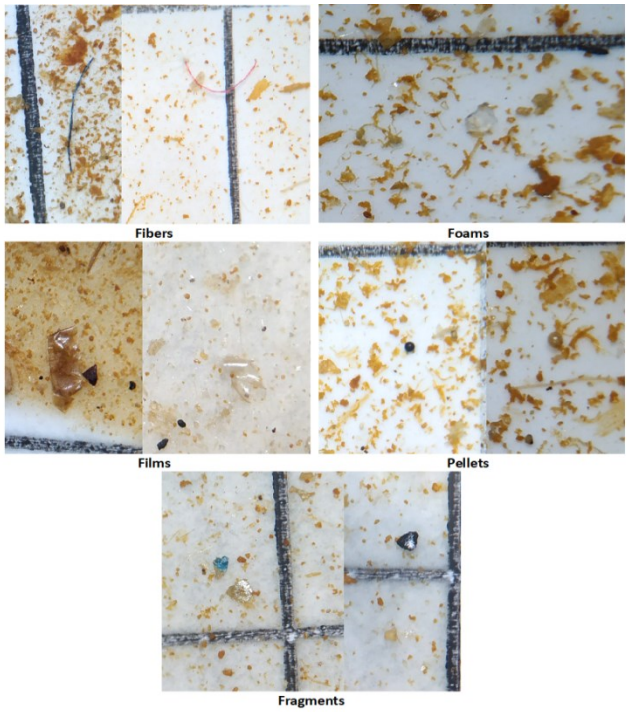


Figure 2. Visual morphology classification of microplastic used for all the samples

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 sizes 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 membrane filter (Whatman, 47 mm Ø with 0.45 µm pore size) using a glassware filtration unit. Filter was transferred in sterile glass petri dishes andkept in the desiccator until dry. Afterwards, the dried microplastics were weighed and transferred to flask, and then extracted using a 15 mL mixture of n-hexane:petroleum ether (1:1, v:v) for 15 min undersonication. The ultrasonic extraction of PAHs was repeated three times and the extracts were 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-hexane:ethyl acetate (1:1, v:v). Then, the volumes of the elution were reduced to 1 mL and a quantitative analysis of the PAHs were performed using GC/MS as described in section 2.2 (Tan *et al*., 2019; Ogata *et al*., 2009).

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 2,833 to 6,861 particles/m^3.

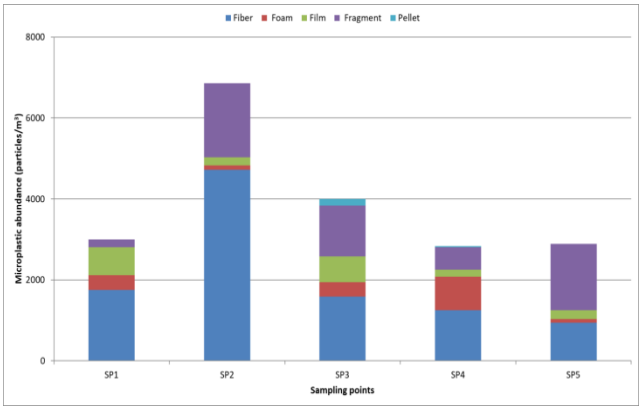


Figure 3. Abundance and morphological characteristics of microplastics determined in surface waters

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 microplastic 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/m³)	Morphological characteristic	Polymer types	References
China	10,300-87,500	Fiber, fragment	PE, PP	Ma *et al*., 2020
Vietnam	0.35-2,522	Fragment, film, foam, fiber, pellet	PE, PP, polyester, PS, PA, polyolefin	Strady *et al*., 2021
Portugal	58-1,265	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	-	Isoprene, PE, PET, PP, PS, PVC	Mughini-Gras *et al*., 2021
South Africa	93.07±36.78	-	PP, PE, PET, PS, PVC, cellophane	Preston-Whyte *et al*., 2021
Thailand	80±65	Fragment, fiber, pellet, film	PP, PS, PE, selefon, polyurethan, polybutylene	Ta and Babel, 2020
Indonesia	9.37±1.37	Fragment, fiber, granule, foam	PE, PP, PS, polyester, cellophane	Cordova *et al*., 2020
Italy	0.9±4-13±5	Line, fiber, pellet, fragment, foil	PE, PP, PS, PVC, PU	Campanale *et al*., 2020
Türkiye	2,830-6,860	Fiber, fragment, film, foam, pellet	Cellophane, 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.

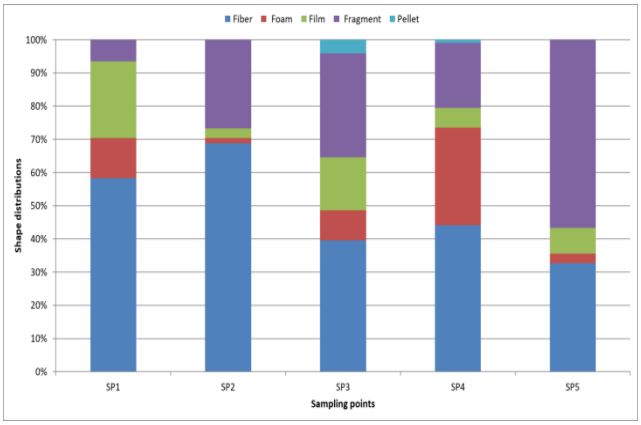


Figure 4. Distribution of different morphological shapes of microplastics determined in surface waters

As shown, microplastics of fiber and fragment forms 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 next most abundant forms were fragments (7-57%), film (3-23%), and 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 as fibers were 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 (64.1%), followed by foam (20.4%), fiber (13.4%), and granule (1.99%) in surface water samples, the dominant forms in the estuary and coastal water were fragments of 53.3% 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 large-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 predominant in the color distribution of the detected microplastics in surface waters, while blue microplastics were ranged from 14 to 26%, and black ones 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) 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 microplastics 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 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 andblack color microplastics may be originated from vehicles, colored plastic wastes may be originated from plastic packaging materials.

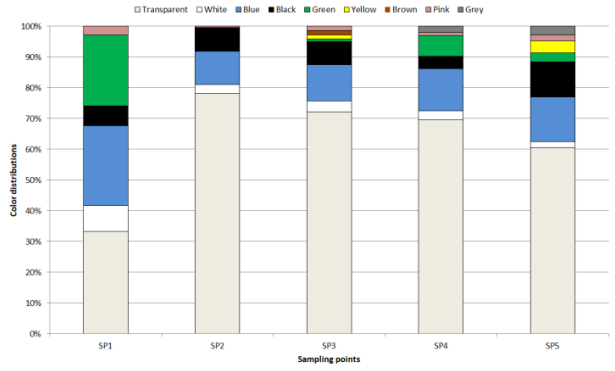


Figure 5. Distribution of microplastic colors determined in surface waters

A total of two polymer types were identified, which included cellophane and poly(ethylene:propylene:diene) EPDM rubber. The most common detected plastic polymer was cellophane. While cellophane polymer was detected in all samples, EPDM rubber was detected in one sample as a result of FTIR analysis. The distribution of polymer types in surface waters is similar to other published data in freshwater. Yan *et al*. (2019) 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 were EPDM rubber, and cellophane was found the most abundant polymer in sediment and fish samples (Zhang *et al*., 2020). Castillo *et al*. (2016) and Peng *et al*. (2017) detected as predominant EPDM rubber in seawater and sediment, respectively. EPDM rubber 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 degradationcan threaten marine eco-systems, especially the food chain. (Zainuddin *et al*., 2022). EPDM rubber is a copolymer 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 properties. Microplastics exposed to different degrees of weathering and degradation in nature have a large surface area. This causes halogenated organic pollutants as well 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 PAHs associated on microplastics in surface waters

PAHs (ng/g)	SP1	SP2	SP3	SP4	SP5
Nap	107	85.2	208	279	56.1
Acy	148	102	190	256	47.1
Ace	201	149	482	451	138
Flu	814	626	1,890	2,139	413
Phe	1,927	990	2,611	3,088	870
Ant	114	96.1	221	199	19.4
Fluor	37.1	77.4	36.9	49.7	15.5
Pyr	319	350	526	508	182
B[a]A	83.3	93.9	159	261	29.4
Chr	94.4	91.6	39.9	16.2	17.1
B[b]F	252	80.4	78.2	123	28.6
B[k]F	141	42.1	23.4	73.1	4.63
B[a]P	89.4	25.2	5.14	3.45	9.30
I[cd]P	57.6	37.1	2.21	16.6	5.88
D[ah]A	44.2	209	47.5	74.1	18.5
B[ghi]P	26.2	186	113	246	16.4
B[j]F	57.5	113	5.38	182	50.7
∑PAHs	4,517	3,358	6,644	7,970	1,924

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 1,924 ng/g (SP5) to 7,970 ng/g (SP4). Distribution of PAHs in microplastics is shown in Figure 6.

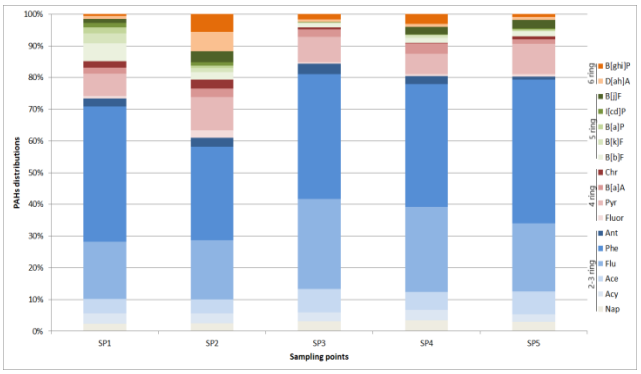


Figure 6. Distribution of PAHs in microplastics from the surface waters

Low molecular weight PAH compounds (with 2 to 4 rings) were predominantly 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 individual compounds formed below 10% of the total PAHs. Phenanthrene was the most abundant PAH with a concentration of 870-3,088 ng/g at all sampling points. Recent studies reported that PAHs sorbed to microplastics have 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 and 282 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 3,400-119,000 ng/g (Mai *et al*., 2018). Hirai *et al*. (2011) reported that total PAHs concentrations ranged from 1 to 9,300 ng/g in the plastic fragments in marine plastics debris from the Pacific Ocean. The total concentration of PAHs in microplastics ranged from 104 to 3,595 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 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, are 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 of petrogenic and pyrogenic origins. While petrogenic PAHs are low molecular weight compounds, pyrogenic PAHs are higher weight compounds (Ozcan *et al*., 2009; Hirai *et al*., 2011). If fluoranthene/pyrene ratio is greater than 1, the source of PAHs 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 ratio 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 Türkiye was detected for the first time. Microplastics in the surface water feeding Beyşehir Lake in Türkiye were found in the range of 2,830-6,860 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 carcinogenic and muteganic. 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.

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