Microplastic abundance in the mouths of rivers and streams reaching the Marmara Sea and the Bosphorus

Hanife Sari Erkan and Guleda Onkal Engin

***Abstract*—**In this study, the distribution, type, size and color of microplastics (MPs) in 9 stream mouths pouring into the Marmara Sea were investigated. Both sea surface water and deep sea sediment samples were collected to determine MP abundance at these stream (STR) stations. According to the results obtained, the spatial distribution of microplastics was determined. Higher MP abundance has been detected at the mouths of rivers where anthropogenic and industrial activities are intense. While the highest MP content was found in STR-3 (Ayamama Stream) in sea surface samples, STR-6 (Kağıthane Stream) was the station where the highest MPs were observed in deep sediment samples. On the other hand, while fragments were dominant type MPs in sea surface samples, filament type MPs were dominant in deep sea sediments.

***Keywords*—**Microplastic, stream, river, Marmara Sea, İstanbul Bosphorus.

I. Introduction

Microplastics (MPs) with dimensions less than 5 mm can be found in almost all seas and oceans and today are considered as a new pollutant parameter. Research on MPs in the aquatic environment continues to increase due to the ecological and environmental problems they create [1].

Marine ecosystems are exposed to acidification, climate change effects, illegal, unreportable and unregulated fishing activities, and other pollutions. In addition, MPs, having small diameters and low densities, can be taken by a number of different organisms (such as facial zooplankton, algae, fish) as food and show accumulation potential in living organisms due to their inability to degrade them. MP particles can reach aquatic systems from different sources [2]-[5]. Primary MPs consist of micro and nano beads or fibers such as plastic granules or pellets used in cosmetics, textile and medical industries, while secondary MPs are small particles separated from large plastic wastes from terrestrial sources by ultraviolet rays and physical processes after they reach the marine environment. Primary MP particles, generally, result from the outflow of washing machines and reach water media as they are unable to be held in wastewater treatment plants due to their small sizes [6]. MPs reach marine ecosystem from treated and untreated wastewater, urban runoff and atmospheric depositions, and it is known that 60-80% of marine pollutants are originated from petroleum-based plastics [1], [7].

Marmara Sea is exposed to various sources of pollution due to the concentrated urbanization on its coasts, land and sea tourism activities, opportunities offered by coastal regions such as increased industrial activities, sea transportation, and agricultural, municipal and industrial pollution coming from inner regions via rivers and streams [8], [9]. Marmara Sea just like other any water resource in the other parts of the world is exposed to MPs pollution as a disadvantage of the widespread use of plastic materials nowadays. MPs pollution poses an environmental threat in terms of marine life and ecosystem sustainability especially in the coastal regions of Marmara Sea where metropolitan cities, such as Istanbul, are located.

In our country, no comprehensive study was encountered determining and characterizing MPs in the marine environment spatially. As known, many streams and rivers are polluted as a result of agricultural, domestic and industrial activities carried out in the inner regions of Istanbul. Thus, this study was based on the investigation of MP pollution, which threatens many water resources, in the coastal areas in river and stream mouths entering the Marmara Sea and the Bosphorus.

II. Materials and Methods

A. Study Area and Samples Collection

The Marmara Sea (26 ° 07 'E, 41 ° 44' N: 030 ° 17 'E, 39 ° 46' N), which is an inland sea with a coastline of 933.3 km, is under environmental risk in many aspects due to its special condition. It is an internationally important waterway for trading and tourism, and therefore is exposed to various sources of pollution due to sea transportation and municipal, industrial and agricultural activities coming from the inner regions via rivers and streams. Sampling of surface waters and deep sea sediments took place in 9 stream mouth stations (STR) along the coastline of Istanbul on the Marmara Sea and the Bosphorus. The location details of the stations are shown in Fig. 1 and Table I. Most of sea surface water and deep-sea samples were taken from the Research Vessel named R/V Yunus-S of Istanbul University. The samples from STR-5 and STR-6 stations were collected using the sea surface cleaning boat which belongs to the Istanbul Environmental Management Industry and Trade (ISTAC) due to the fact that

Hanife Sari Erkan, Yildiz Technical University
Turkey

Guleda Onkal Engin
Yildiz Technical University
Turkey

the research vessel was unable to enter the estuary zone (Golden Horn).

Fig. 1 Google map view of the studied stations in this study

TABLE I
STATION LOCATIONS AND COORDINATES

Code	Station	Start coordinate	End coordinate
STR 1	Kusdili Stream	40°58'621"N	29°01'852"E
STR 2	Ayamama Stream	40°57'986"N	28°51'380"E
TR 3	Ambarli Stream	40°57'795"N	28°41'328"E
STR 4	Haramidere Stream	40°57'260"N	28°37'244"E
STR 5	Alibeykoy Stream	41°03'52"N	28°56'38"E
STR 6	Kagithane Stream	41°03'49"N	28°56'50"E
STR 7	Kucuksu Stream	41°04'680"N	29°03'748"E
STR 8	Goksu Stream	41°04'930"N	29°03'839"E
STR 9	Cayırbasi Stream	41°09'351"N	29°02'440"E

All samples were collected between September 7th and September 10th, 2020. Sea surface samples were taken using a manta trawl with a rectangular opening of 0.8 m x 0.4 m and a mesh size of 330 µm. During the sampling, manta trawl was towed starboard on the sea surface for 20 min. The outer side of the manta net was washed using sieved seawater ensuring a maximal concentration of the sample into the collector of the net. The sample collected in the collector was poured onto three stacked metal sieves with mesh sizes of 5 mm, 1 mm and 300 µm. Macro-plastic particles retained on the 5 mm sieve were discarded whereas the particles on the 1 mm and 300µm sieves were emptied into a clean labeled glass bottle using 96% of ethanol. On the other hand, deep sea sediment samples were collected by lowering the Van Veen grab into the water having depths changing between 5 m and 30 m at the STR station location. All samples were stored at – 20 °C for further analysis.

B. Sampling Processes

Isolation of MPs was conducted based on the protocol suggested by Masura et al. [10]. Visually detected plastic particles from the sea surface samples were collected in Petri glasses by rinsing distilled water using laboratory tweezers. The remaining constituents in the samples were dried for one night in the beaker at 80°C. After that, wet peroxide oxidation (WPO) was applied by adding 20 mL of $FeSO_4.7H_2O$ (0.05 M) and 20 mL of H_2O_2 (30%) and heated to 75 °C on the hot plate. The oxidation process was repeated several times until no natural material content remained in the sample. Then, the sample was then filtered using 0.45 µm glass-fiber filter paper for microscopic examination.

Deep sea sediment samples were dried using a water bath at 80 °C and then left for one night in the beaker at 80°C. The dry weight of the glass jars containing sediment samples was recorded. The sediment samples were then dissolved using 5 M NaCl solution and WPO was applied if the sample contains visible natural organic matter. After that, density separation was applied for the separation of MPs using NaCl (5 M) solution and a density separator. Extracted MPs from the samples were filtrated using a 0.45 µm filter paper for further examination using a stereo microscope.

III. RESULTS AND DISCUSSION

A. Abundance of MP isolated from sea surface water

MPs distribution in each STR stations is presented in Fig. 2. Fig. 2a shows abundance of MPs in all STR stations. As shown in Fig. 2a, the highest level of MPs was found for STR-3 (7456.28 MP/km^2) and the lowest MPs was obtained for STR-1 (350.04 MP/km^2). As seen from these results, MPs in STR-3 was 21 times higher than STR-1.

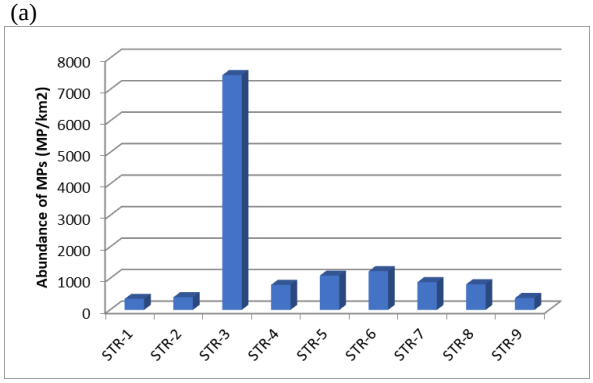
The obtained results showed that the variance in the distribution of MPs is affected by the spatial conditions. STR-3 (Ambarli Stream) station is a seaport surrounded by a warehouse for fuel storage and filling facilities which will have a high impact on the regional and international ship traffic. Moreover, the presence of different textile and electronic industries is no doubt an influencing factor in microplastic occurrence in this station. The last factor to be listed with STR-3 is the activity of the nearby wastewater facilities. The other stations with high MPs were STR-6 (Kagıthane Stream) and STR-5 (Alibeykoy Stream) located in the Golden Horn zone. The MP abundance of these stations was found 1226.99 and 1088.87 MP/km^2, respectively.

Isolated MPs were classified 5 categories among fragments, granule/pellet, film, foam, and filament shape. As can be seen from Fig. 2b, fragment is the dominant shape detected in all the STR stations for sea surface water samples (71.90±11.10%). Heat, ultraviolet (UV) radiations and oxidative decomposition are the main causes of degradation of macroplastics, causing them to become brittle and break into MPs fragments [11]. The average percentage of film and filament particles of all studied stations was found as 13.10±4.10 % and 11.35±9.22%, respectively. Remaining small percentage was composed of granule/pellet and foam particles.

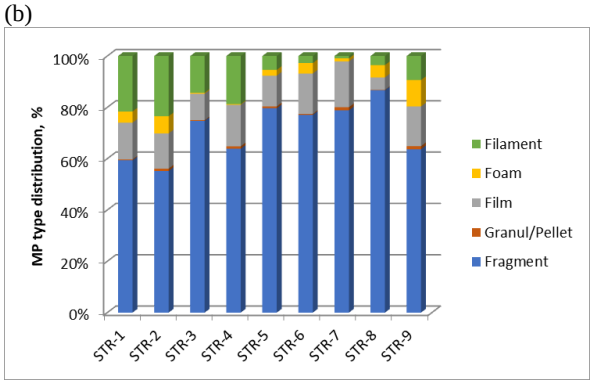
The size distribution of MPs is shown in Fig. 2c. In the study, two different size ranges were used as 0.3-1 mm and 1-5 mm. Fig. 2c shows a majority of MPs having a particle size between 1 and 5 mm with an exception in STR-4. Similar results were obtained by Eo et al. [12] and they found less abundance of small-size MPs. On the other hand, Enders et al.

[13] reported that MPs decrease in size when they increase in numbers.

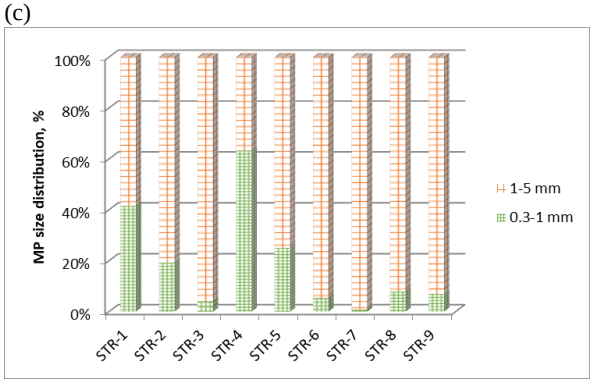
(a)



(b)



(c)



(d)

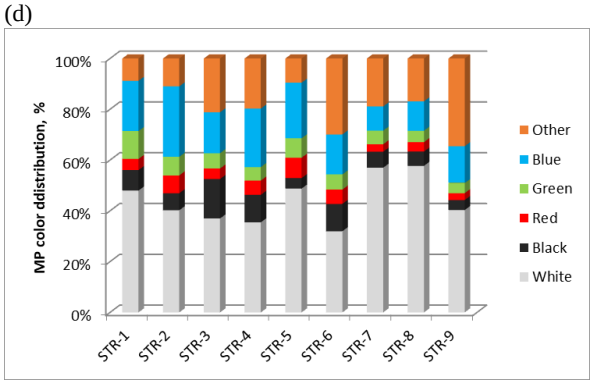


Fig. 2 Abundance of microplastics in seawater samples (a), type distribution (b), size distribution (c) and color distribution

The color distribution of MPs in STR stations was presented in Fig. 2d. Although different colors such as pink, grey, brown, orange, purple etc. have been observed in small percentage, MPs was mainly categorized into 6 color groups as white, black, red, green, blue and other. As can be seen from Fig. 2d, the dominant color was white in all stations (44.05±9.29%) and blue color was found the second main color with a percentage of 17.76±5.82%.

A. Abundance of MP isolated from deep sea sediment

The abundance of MPs and type, size and color distributions in deep sea sediments of the studied STR stations is presented in Fig. 3. As seen from Fig. 3a, the highest MP abundance was found in STR-6 station (22521.60 MP/kg). STR-2 was the second station that the higher abundance of MPs was observed (13294.66 MP/kg). The main reason for the detection of high concentrations of MPs at STR-5 and STR-6 stations pouring into the Golden Horn may be that there are many industrial establishments around these streams and heavy pollution is transported to the Golden Horn through these streams. Ayamama Stream (STR-2) is a stream located on the European side of Istanbul and it receives treated wastewater of Atakoy Advanced Biological Wastewater Treatment Plant. On the other hand, several industrial establishments such as textile, paper mill industry and logistic services were around Ayamama Stream throough which the waste load is carried to the Marmara Sea.

In parallel with the sea surface water samples, isolated MPs in the bottom sediments were also classified in 5 different categories as fragment, granule/pellet, film, foam and filament. Fig. 3b shows the MPs type distribution of all STR stations. In contrast to sea surface samples, filament was found the dominant type of MPs in deep sea sediment samples (37.71±20.48%). However, fragment was found the second dominant MPs shape with a percentage of 34.62±16.73%. The percentage of film shape was 26.69±13.07% in deep sea sediments. The total percentage of granule/pellet and foam was found lower 1% in all studied stations.

The size distribution of MPs is useful in providing hints that help to understand the potential sources of MPs [14]. MPs size distribution is presented Fig. 3c in deep sea sediment samples. Higher percentage of 1-5 mm size of MPs was found in STR-2, STR-3, STR-6, STR-7 and STR-9. In other stations, 0.3-1 mm size of MPs was comparatively more abundant.

Fig. 3d shows the color distribution of MPs. As seen in this figure, the blue color (43.28±14.20%) was dominant over white ones (22.60±12.67%). The rest of the color distribution was as follows: green (7.90±4.13%), black (7.49±6.69%), red (7.39±3.08%) and other (11.34±6.19%). Hartmann et al. [15] reported that the color distribution of MPs may be helpful in the determination of their sources. On the other hand, color of MPs is found to be related to their probability of being ingested by aquatic organisms. Abayomi et al. [16] declared that aquatic organisms tend to ingest MPs having similar color as their prey.

(a)

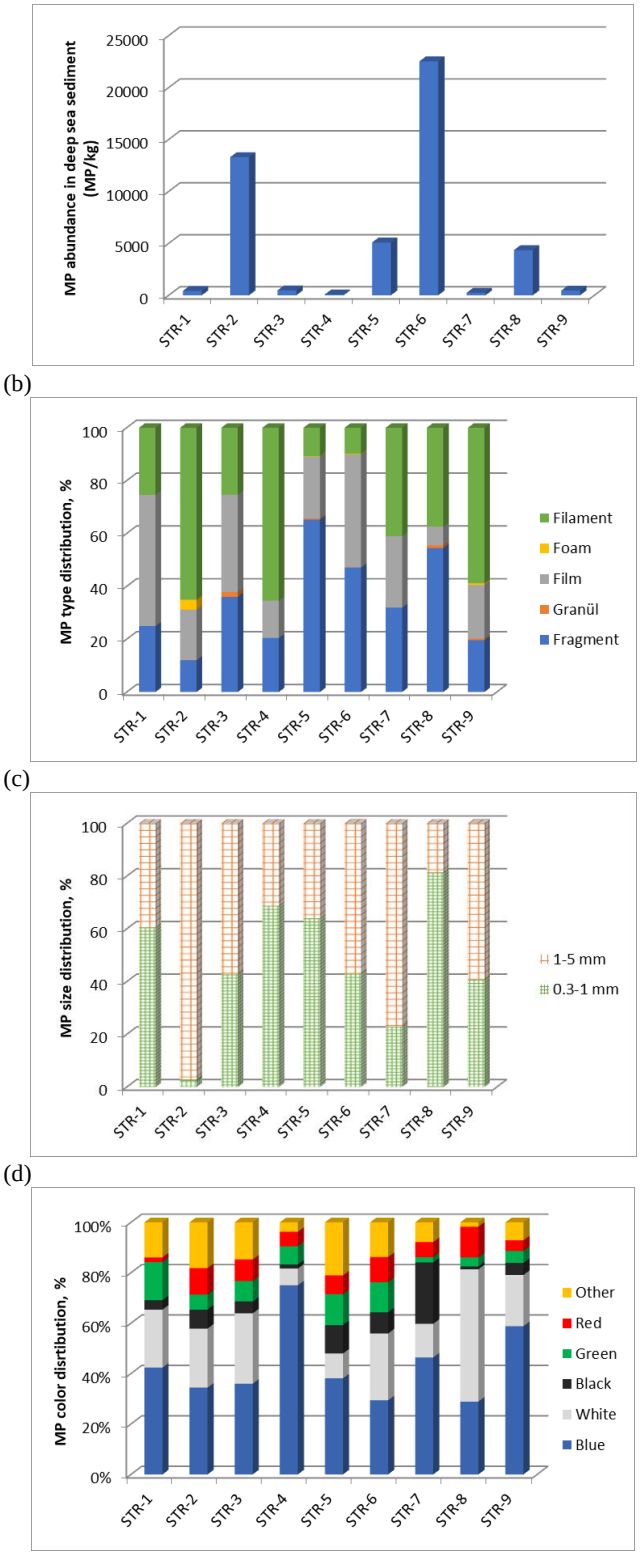


Fig. 3 Abundance of microplastics in deep sea sediment (a), type distribution (b), size distribution (c) and color distribution

IV. Conclusion

The abundance of microplastics in sea surface water and deep sea sediments of the Marmara Sea and the Bosphorus in Turkey was investigated in this study. Severe MPs abundance was found in both surface water and sediment samples. The obtained results showed that there is an urgent need for plastic management in streams pouring into the Marmara Sea.

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Hanife Sari Erkan completed her Ph.D in the Environmental Engineering Department in 2017 at YTU, Istanbul, Turkey. She became an associate professor in April 2020 at YTU. Her research areas include microplastics in wastewater and oceans. aerobic wastewater treatment, membrane bioreactors, electrochemical industrial wastewater treatment technologies.

Prof. Dr. Guleda Onkal Engin is holding a Ph.D from Chemical and Process Engineering of Imperial College, UK and is working for Environmental Engineering Department, Yildiz Technical University, Istanbul, Turkey. Her interests include aerobic/anaerobic wastewater treatment, micropollutant removal, microplastics pollution and watershed management.