



First report of occurrence, distribution, and composition of microplastics in surface waters of the Sea of Marmara, Turkey

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ABSTRACT

Plastic is produced today in large quantities and used for many purposes. At the end of use, a large part of it gets into the environment, often into the sea and there it is fragmented into the smallest fragments, so-called microplastic (MP). MPs pose a serious challenge to the marine environment such as the sources and properties of MP particles, their impact on marine organisms, and the challenges of environmental pollution. This work, carried out in the fourteen sites in the area, is the first reference to the detection of MP distribution at surface waters in the Sea of Marmara, Turkey. As a result of this study, the average level of MP in the surface was determined to be 1.263 item/m². The results were higher compared of the most other adjacent regions and show that the Sea of Marmara started to face that problem.

1. Introduction

Plastic is an indispensable part of today's world and is used in a variety of areas of industry and daily life. If plastic is not properly disposed of and released into the environment, it causes not only a recreational problem. The waste is entered into aquatic environments in different ways, such as runoff, rain, and wind. In the process, the plastic disintegrates into microplastic, whereby the particles become so small that even microorganisms can absorb them. As a result, MPs already reach the base of food web and are transported across the various trophic levels, right through to end consumers, including humans.

Plastic pollution in the seas tends to increase rapidly. The pollution caused by plastic in both the oceans and seas in recent years is closely related to both marine scientists and society.

Total plastic produced since 1950's have reached 311 million tons in 2014 (PlasticsEurope, 2014). Recent research indicates that plastics and wastes in coastal areas are expected to reach 99.5 million tons in 2010 and 4.8 to 12.7 million tons in the oceans (Jambeck et al., 2015). Tons of plastic parts in the oceans and seas pollute surface waters. MPs whose diameters are < 5 mm are defined as industrial products, the larger ones being called mesoplastic and macroplastic.

All the plastics seen in seawater, bottom mud, and organisms are divided into two groups; the first group is used directly as cosmetic, synthetic yarn and pellet. The second group is formed as a result of macroplastics being affected by environmental conditions, physical,

chemical, and biological events (Browne et al., 2007).

MPs are increasing rapidly in the marine environment as a result of shipping, industrial and agricultural activities, local governments discharging their wastes directly to rivers and streams, especially the coastal cities where settlement is concentrated (Derraik, 2002).

The Mediterranean is considered with the highest plastic pollution among the world's seas, and in recent researches it is reported that values up to 1934 particles/km² (Suaria et al., 2016), also van der Hal et al. (2017) are reported 1,518,340 particles/km² on the Israeli coast. Regarding the researches in across of surface waters around Turkey, it was reported some of these values in the eastern Mediterranean coast as 16,339–520,213 particles/km² to be between (Güven et al., 2017).

Gündoğdu and Çevik (2017) surveyed 4.75 km² area for micro and mesoplastic levels in surface waters in a study conducted in 7 stations in İskenderun and Mersin gulfs in the eastern Mediterranean with an average of 0.376 particles/m² reported. Similarly, in İskenderun Bay, 541 particles/m² (mean size 2.77 mm) were measured and in Mersin Bay 0.683 particles/m² (mean size 3.01 mm). In the qualitative evaluation carried out in the same research, 15 different types of colour, 5 different types of micro- and mesoplastic are revealed.

The plastics that are found in surface waters in the world's waters are generally young materials and their background is ~60 years old (Thompson et al., 2009). However, microplastic can occur in the marine environment either by primary or secondary sources (Cole et al., 2011) and they are also constantly accumulated by the sea creatures in

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different stages (Von Moos et al., 2012). For these reasons, it is necessary to constantly investigate and monitor the marine life and sedimentary levels of plastics, particularly surface and sea water, especially of micro and meso-plastics.

This study covering the entire Sea of Marmara will be the first to show the current situation in order to determine the MP concentration in the Sea of Marmara surface waters, which is the rising problem of our time. The first present results obtained within the scope of this project, which was taken as a long-term program, show that the Sea of Marmara started to face the problem.

2. Material and method

2.1. Study area

Sea of Marmara (26° 07' E, 41° 44' N: 030° 17'E, 39° 46'N), with 933.3 km coastline, is an inland sea within Turkey. The Sea of Marmara is a unique inland sea located in the mainland within Turkey property as a whole and the Turkish Straits, composed of the Bosphorus (Boğaziçi) and the Dardanelles (Çanakkale Strait), which connect it to the Black Sea and Mediterranean Sea via Aegean Sea, respectively. The occupation surrounding the entire watershed of Sea of Marmara is 22,841,211 people, which constitutes 28.3% of the entire population of Turkey (TÜİK, 2018).

Sea of Marmara has several competing uses including industrial, tourism, commercial, and recreational activities. In the Marmara Basin industry is more concentrated in the eastern half, including Istanbul and Kocaeli provinces. Along the Sea of Marmara, there are numerous heavy industrial facilities engaged in production in the field that include petrochemical, plastic, textile, fibre, marble, automotive and parts, non-ferrous metal industry, paint and varnish industry, iron-steel industry, leather industry, meat-fish-milk industry, textile industry, pharmaceutical industry and chemical industry. Inside the Sea of Marmara, there are several shipyards, metallurgy factories, and power plants. In addition, Sea of Marmara basin is the fastest growing region in entire Turkey (Garipağaoğlu, 2016).

2.2. Study sites

In this study, fourteen of eighteen planned sampling sites for surface layer were studied. Four stations could not be performed due to the dense jellyfish (*Aurelia aurita*) proliferation (since Manta-Trawl lost its function) of that one was cancelled before hauling after visual inspection (MP05) and three were after performing the hauls (MP03; MP17; MP18). The locations of the surface layer sampling sites are selected in such a way that will characterize the entire area, considering the distribution of population, current and dominant wind conditions, ship traffic, coastal topography and runoff from those are located two in Bosphorus, two in Dardanelles and fourteen in the Sea of Marmara. The station locations are given in Fig. 1 and related information is given in Table 1.

2.3. Sample collection

Surface samples were taken from various sites in the Sea of Marmara, Turkey (Fig. 1 and Table 1) in the summer of 2017. In the stations where the research was carried out, trawls were taken from the surface using Manta-Trawl Net to evaluate qualitatively and quantitatively the MPs, following Ryan et al. (2009). Samples were collected using a manta Trawl (60 × 20 cm frame with a tor length of 260 cm) with a mesh size of 333 µm. The trawls were run through the ship for 20 min at speed set to 2 knots.

All specimens were taken in clean glass jars and fixed in 5% formaldehyde solution and then moved to qualitative and quantitative analyses at the Faculty of Marine Sciences and Technology, Department of Marine Science and Limnology of Çanakkale Onsekiz Mart

University. All obtained data are recorded and processed in MAREM database (Artüz, 1990).

2.4. Sample preparation

The samples brought to the laboratory were washed with pure water from steel sieves (10 mm and 100 µm) then 32% H₂O₂ was applied to the samples to remove the organic substances in the environment, and cleaned. All samples taken into Petri dishes and dried for 24 h at 60 °C in a drying oven then dry weight were determined and in part confirmed with the hot needle test, which involved the application of a heated needle tip to each plastic to confirm that it would melt (Karlsson et al., 2017). Against any airborne and/or peripheral contamination in the laboratory, all the process were realised strictly in the sterile cabinet class II.

2.5. Microplastic identification

All suspected microplastic samples were counted and measured according to their groups under the Zeiss Stemi 508 microscope, taking their colour, size, and shape into consideration and photographs were taken. They were then counted and further classified as type (films, filaments, fragments, granules, and foam), shape (elongated, flat, irregular, and spheroid), size, and their colouration documented. The microplastic specimens were characterized by a single bounce diamond attenuated total reflectance (ATR) module on a Fourier-transform infrared (FTIR) spectrometer (Nicolet Nexus 6700) equipped with a liquid nitrogen cooled mercury-cadmium-telluride (MCT) detector. The Spectra were collected at a resolution of 4 cm⁻¹, and 64 interferograms were co-added in the range of 500–4000 cm⁻¹. The chemical identity of the microplastics was also checked by differential scanning calorimetry (DSC) on a Perkin Elmer Diamond DSC under a nitrogen atmosphere. The microplastics were cut into small specimens of about 10 mg weight and sealed in aluminium pans. Then, they were scanned between 0 and 200 °C with a heating and cooling rate of 10 °C·min⁻¹.

2.6. Statistical analyses

To verify significance differences between plastic particle numbers between the stations, types, shapes, and size classes statistical analyses were performed with one-way ANOVA test at significance level 0.05 (transformed for homogenization of variances) by using the SPSS statistical package software, version 25.

2.7. Descriptive measurements

Area, distance, and volume measurements were calculated, on the base of the beginning and ending coordinates and manta-trawl dimensions. Wind direction and speed were measured in-situ with the automated onboard meteorological weather terminal of the boat (MarPro 1.2) and the current measurements of the hauling stations are transferred from the MAREM Database as also in-situ measurements of the 0.5 m depth (surface) which measured within the main project with 3 axis Doppler current meter (Multiprobe Sonde-ADCP) simultaneously with the hauls.

3. Results

3.1. Microplastic concentration in the environment

In the present study, during the hauls ~118.32 m³ surface water was swept, with a traced area of 1183.2 m² and 1494 particles in total, with a total mass (dry weight) of 2.471 g were detected. The average density per m² was calculated to be 1.26 ± 130.5 particles (mean ± SD) with the average density of 12,626,774.85 particles per km² and 12.63 items per m³. The minimum size of the collected

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