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RESEARCH PAPER

An Assessment of Sea Surface and Seabed Macro Plastic Density in Northeastern Mediterranean Sea

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ABSTRACT
Increasing plastic usage pose a significant threat to the marine environment. Many studies have been conducted to examine the amount and environmental impacts of plastic waste across the world. This study was carried out to investigate the density and quality of plastics on the sea surface and seabed of İskenderun Bay. 35 different seabed sampling and 25 different sea surface sampling were conducted by using İskenderun Technical University R/V ISTE-1 vessel. A total of 1 661 581 m^2 and 465 511 m^2 swept from the seabed and sea surface were scanned, respectively. As a result of these scans, the amount of plastic waste density per unit area of the seabed was found as 0.126 g / m^2 ± 0.011 (p: 0.95), and the amount of plastic waste density per unit area of sea surface was calculated as 0.052 gr ± 0.011 (p: 0.95). Scuba dives conducted in river mouths showed plastic deposition pits at the seabed. Major surface current systems and dominant southern winds were found to be effective in the sea surface distribution of plastic materials.
Keywords: plastic density, İskenderun Bay, Turkey, plastic pollution

INTRODUCTION

Plastics are used for several sectors including but not limited to agriculture, automotive, packaging, construction, electrical and electronics. As a result of the increasing demand for the plastic products, global plastic production has been increased more than 20 times in the last century and reached to 360 million tons in 2018. On the other hand, only 32.5% of collected plastic waste was effectively recycled (Plastic Europe, 2019). Consequently, plastic waste management and its potential impacts on the environment become an important global concern; since, they can remain in the marine environment for a long time without being destroyed (Yılmaz et al., 2002).

Plastic wastes reaching to marine ecosystems increase the existence pollution pressure on marine creatures. Plastic waste could lead to physical damage on the body or could be directly ingested by marine organisms (Gregory, 2009). Plastic wastes, which remain in the marine environment for a certain period, turn into micro plastics and accumulate on the bodies of marine organisms (Teuten et al., 2009). This condition pose a risk for many living beings that are not directly exposed to plastic pollution due to the food chain (Farrell & Nelson, 2013; Bakir et al., 2014).

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In marine systems, the structure of plastics can change or become heavier due to the adhesion of polluting organisms. This condition lead to the sedimentation of plastic waste on the seabed which in turn destroy the living area of marine organisms by covering the sediment (Barnes et al., 2009). In another point of view, plastic waste cause damage to the fish nets propellers and adversely affect the national truism activities which lead to national economic loss (Yılmaz et al., 2002).

İskenderun Bay is an economically important bay of Northeastern Mediterranean coasts of Turkey in terms of port operations, sea traffic, industrial facilities and fishing. According to studies conducted in the region, plastic wastes are caught together with fishes in almost every fish nets (Demirci, 2003; Mazlum et al., 2019). As a result of these type of anthropogenic activities, there has been a significant increase in plastic pollution in recent years (Gündoğdu & Çevik, 2017; Yılmaz et al., 2017).

As a result of those negative impacts on the environment and economy, there are many studies conducted to estimate the plastic waste amount in the Mediterranean Sea (Cózar et al., 2015; Ruiz-Orejón et al., 2016; Munari et al., 2017; Portman & Brennan, 2017; Pedrotti et al., 2016; Kaandorp et al., 2020). Compared to the other parts of Mediterranean Sea, studies conducted in the NW Mediterranean was quite limited (Bingel, 1987; Güven et al., 2017; Gündoğdu & Çevik, 2017; Castro-Jiménez et al., 2019).

Previous studies on plastic waste density have focused mainly on plastic waste concentrations on the sea surface and their regional variations. Different from previous studies, this study was focused on the determination of both seabed and sea surface plastic waste density at İskenderun and Antakya Bays. Also, regional differences in the plastic waste density and factors creating this the differences were examined. Lastly, this study will provide up-to-date information regarding to the quantity and quality of macro plastic pollution in İskenderun Bay.

MATERIAL AND METHODS

Monitoring studies were carried out in İskenderun and Antakya Bays (Northeastern Mediterranean) to determine the density of waste plastic material on the seabed and sea surface. Sampling was carried out using RV İSTE-1 on 10-11 February, 4 April, 9 April, 11 April 9 October at Samandağ, İskenderun, Dörtyol, Konacık and Samandağ, respectively. Map indicating the study basis was shown in Figure 1. During sampling, necessary precautions (low hauling speed and time) were taken to prevent sea creatures from being caught during sampling. Trawl operations were carried out for the collection of plastic material from Collected waste materials were divided into three as pet bottle-cap, sachet bag parts and other materials. Divided waste materials were dried at room temperature. After drying, the plastic material was weighed with a balance with an accuracy of 0.001

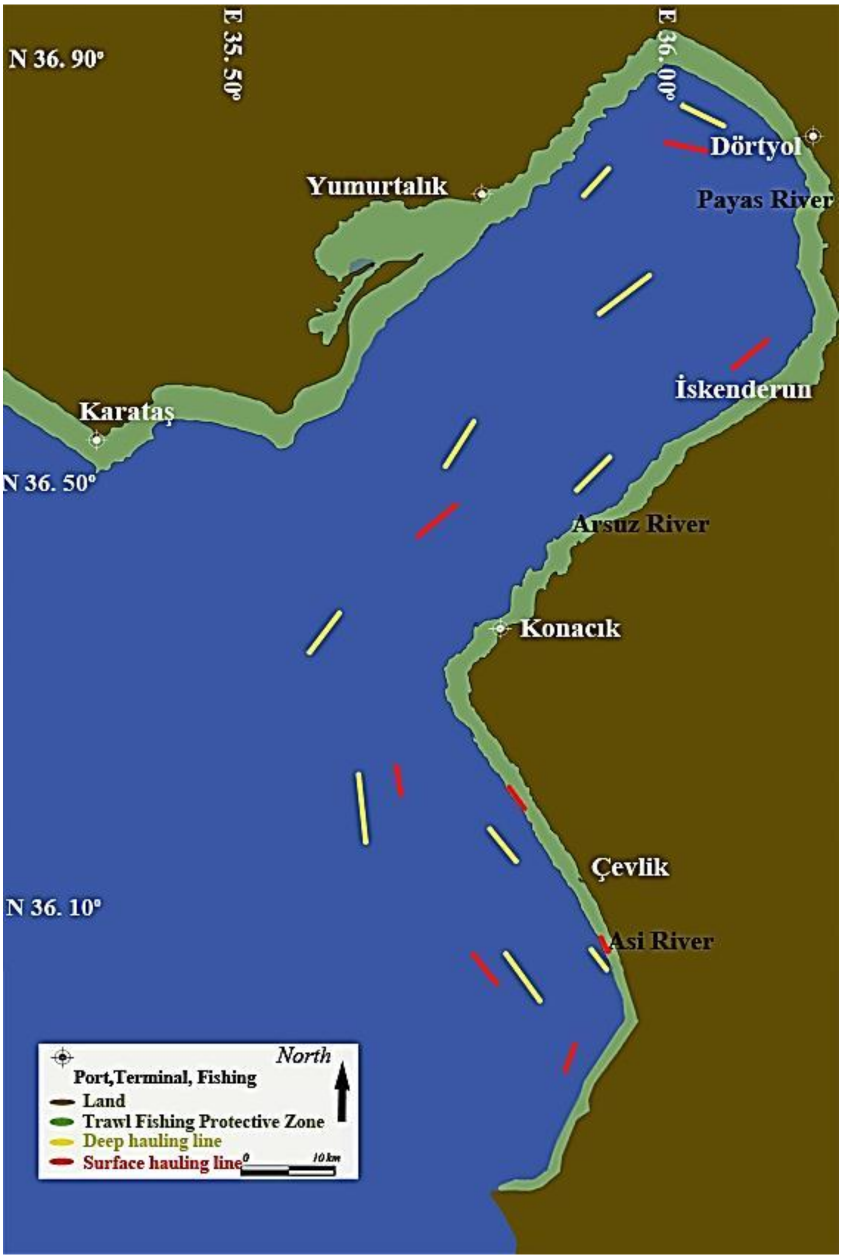

Fig.1. Sampling Locations

Sampling from the seabed was carried out with two different methods according to the characteristics of the sampling area. In the first method, otter trawl operations were carried out in the commercial fishing area. Otter trawl has 32 meter ball rope and has a total length of 38 meter. The mouth of the trawl net is 12 meter and the length is between 0.6-1.5 meter. The mesh size of the trawl mouth size is 44 mm.

Trawl hauling time was determined as 60 minutes and speed was tried to be kept constant at 3 knots. In the second method, beam trawl operations were conducted for closed trawl fishing coastal zone to avoid ecosystem destruction. The beam trawl has a 2.40 meter framed trawler device, the hauling speed was arranged as 3.7 knots for 15 minutes.

Results obtained from trawl operations were used for the estimation of the plastic amount per unit area in accordance with the below formulas (Pauly, 1987; Sparre & Venema, 1998; Demirci, 2003).

$a = t \times v \times h$
a: Area scanned in each trawl operation (m^2),
v: Trawling speed (m/min),
h: Witdh of the scanned area (m),
t: Trawling time (min)
$b = C/a$
b: plastic amount per unit area (gr/m^2)
C: Amount of plastic collected in each trawl haul (gr)
a: Area scanned in each trawl operation (m^2),

The density of plastic material on the sea surface was sampled from the shipboard by framed trawl like sampling device (24 mm mesh size) from the shipboard. In Iskenderun Bay, usage of beam trawl was banned by Ministry of Agriculture and Forestry (MAF, 2020). For this reason, fishing gear which is similar to the framed trawl was designed for this study.

During sea surface sampling, 3.5 meter width area was scanned in each hauling period. Hauling speed and duration were planned as 2.5 knot and 20 minutes, respectively. One way ANOVA analysis was conducted to evaluate the significant difference in the collected waste material depending on depth and location.

RESULTS and DISCUSSION

In this study, 35 different sampling in the seabed were made in İskenderun and Antakya Bays. Among them, 6 samplings were carried out with a commercial trawl net; whereas, 29 samplings were made with framed like troll sampling device.

The total area dredged on the seabed was 1 661 581 m^2 and total dredging time was 1 184 minutes. During sampling period, total of 150.61 kg (dry weight) plastic materials were removed and plastic material per unit area was estimated as 0.126 ± 0.011 g / m^2 (p:0.95).

Plastic bags accounted for the majority of the collected material, accounting for approximately 45% of the total collected material (Figure 2). In order to increase the accuracy of the study, textile products, plastic sponges and car tires were not included in the collected plastic materials. Because of the fact that textile and sponges dry very late naturally, they are really heavier, likewise, car tires are rarely encountered in the region, but increase the error factor in weight prediction.

The origin of the collected plastic material was examined. A significant part of plastic waste (47.8 %) has remained anonymous; whereas, the origin of 52.2 % of collected plastic material was estimated. 47.7 % of plastic waste whose origin could be estimated was local based. On the other hand, it was determined that 52.3% of the collected wastes are of foreign origin, which is commonly found in Çevlik (Antakya Bay).

Results of this study showed no statistically significant difference in the collected plastic waste amount depending on depth. In fact, the plastic material was accumulated in certain locations as a result of local deep water systems (Fig 3). In addition, SCUBA diving was conducted around the river discharge zones; since, seabed sampling using trawl or framed trawl is quite different and may be harmful to the benthic biodiversity in these areas. Underwater images obtained from SCUBA diving showed that plastic material was accumulated at the pits which were formed by river mouths.

In addition to the seabed sampling, 25 different sea surface sampling was carried out in İskenderun Bay. The total area swept on in sea surface was 465 511 m^2 and total dredging time was 536 minutes. During the sampling period, a total of 17.138 kg (dry weight) plastic material was removed and plastic material per unit area was estimated as 0.052 ± 0.011 g / m^2 (p:0.95). A significant portion of the plastic waste collected from the sea surface was similar to the pieces of plastic bags on the seafloor (Figure 2). The majority of other plastic material section was consist of plastic case and sack pieces.

Plastic materials extracted from the sea surface consisted of very small (3-5 cm wide) particles that were broken down by natural or anthropogenic causes. Therefore, its origin could not be determined.

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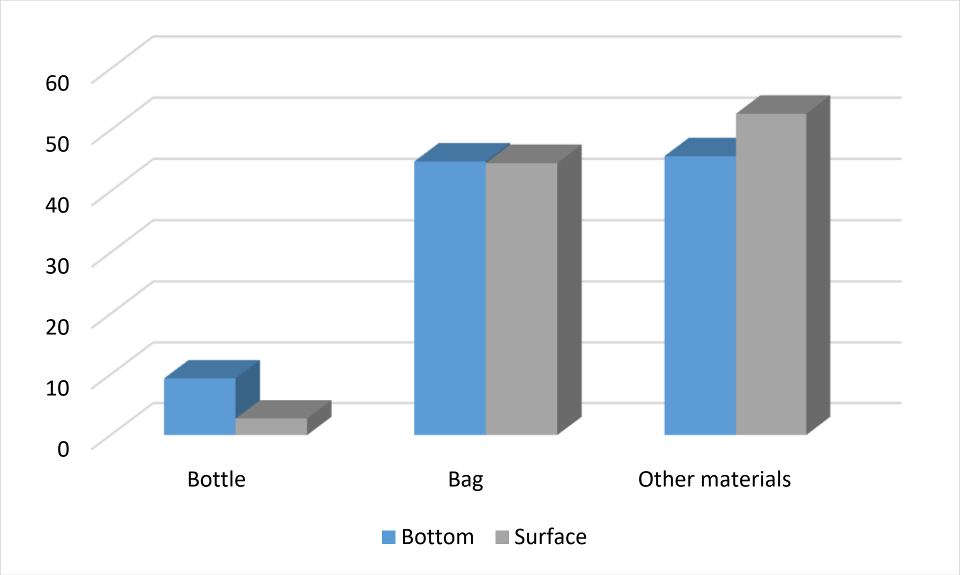

Fig 2. Composition of plastic material collected from the seabed and surface

Sea surface distribution of plastic materials was characterized by main surface current systems and dominant southern winds. Surface currents sort plastic waste on line which makes it easier the collection of plastic waste from the sea surface (Fig. 3). Secondly, plastic waste materials were accumulate near the coastal area as a result of the dominant southern winds in summer; whereas, the opposite situation is applicable in winter months. Even though seasonal wind direction impacts the plastic accumulation locations, plastic waste amount on the sea surface remains unchanged. In other words, the seasonal variation in the amount of plastic waste was found to be statistically insignificant.

Previous studies conducted in the Mediterranean Sea were focused on the plastic material waste density in the sea surface. Cozar et al. (2015) investigated the plastic waste density in the sea surface of the Mediterranean basin scale and found that plastic waste density was different on different sub basin coast depending on the local factors. Galgani et al. (2000) reported the mean plastic waste density in Lyon cost, Corsica and the Adriatic Sea as 1.4 number/ha, 2.3 number/ha, 3.8 number/ha, respectively. Koutsodendris et al. (2008) found that the density of plastic waste in the Ionian Sea was varying from 0.7 number/ha to 4.4 number/ha. On the other hand, information regarding the macro plastic waste density in the Northeastern Mediterranean was insufficient and out of date.

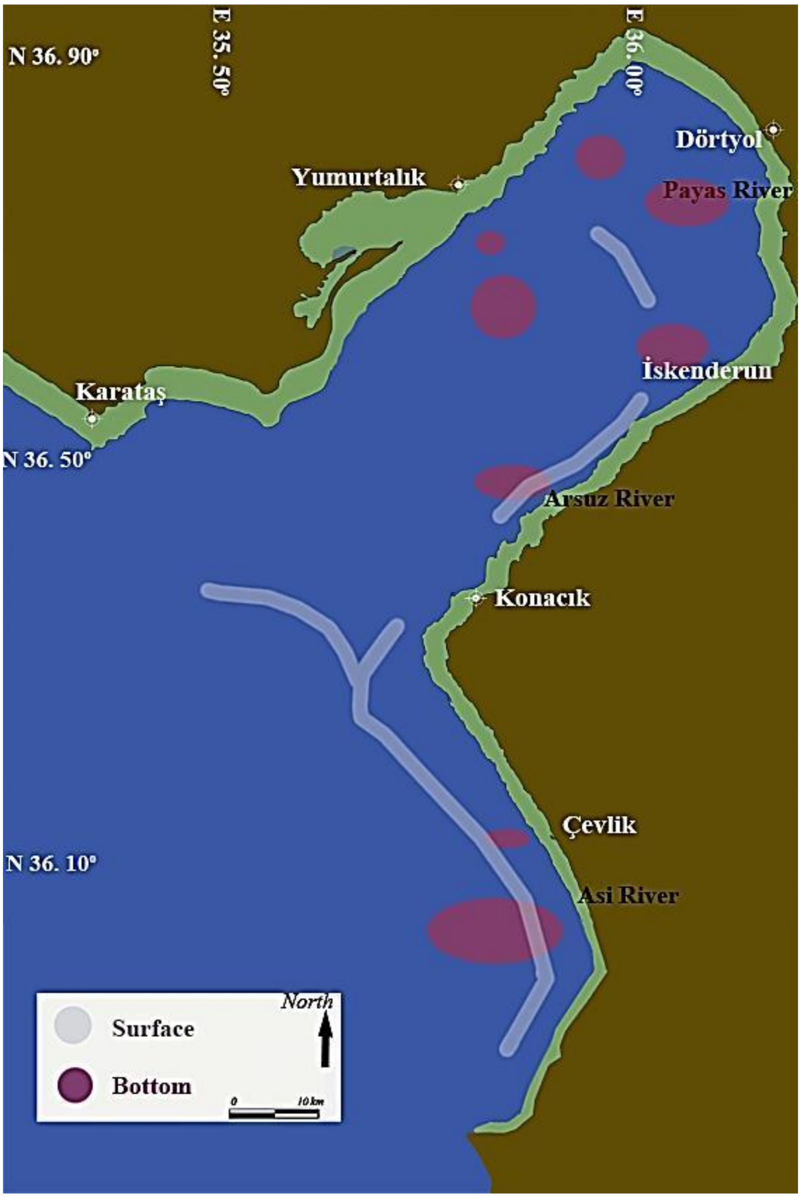

Fig. 3. Areas where the waste density in the research area is observed to be higher than other areas

Yılmaz et al.(2002) and Bingel et al. (1987) estimated the plastic amount in the sea surface of İskenderun Bay as 15.1 tons and 94.6 tons, respectively. Recently, Büyükdeveci and Gündoğdu (2021) estimated the mean bentic litter density of İskenderun Bay as 450.94 item/km^2. In this study, the amount plastic waste material per unit area was estimated to be 0.126 g/m^2 at the bottom and 0.052 g/m^2 at the surface. Studied area is approximately 3 000 km^2. When estimated plastic waste material per unit area and total scanned area were combined with each other, it may be concluded that approximately 400 tons of plastic waste material was distributed at the seabed and 150 tons of plastic material were distributed at the sea surface. Even though, these estimates were numerically low in number, plastic material covers a much greater area in terms of volumetric density.

Previous studies conducted in the region did not contain measurement at the outside of the trawl hunting area and, they did not take the impact of the Asi River on the plastic waste density into account. Therefore, the estimated plastic waste amount in this study is greater than previously reported ones.

Rivers carry several types of pollution sources including wastewater, urban runoff, agricultural runoff, waste leakage into the marine environments. This pollution load coming from surface rivers alters the psychochemical and biological balance in the receiving environments (Kılıç et al. 2018). Likewise, human presence and activities increase the plastic waste amount in the receiving marine environments (Barnes et al., 2009; de Lucia et al., 2014). Gündoğdu & Çevik (2017) reported the highest plastic waste accumulation at the outlet of Seyhan River. Kılıç et al. (2018) showed that the organic pollution load coming from the Asi River increases the primary production at the receiving environment. Similarly, this study showed the highest plastic waste density downstream of the Asi River.

Previous studies conducted in the Northeastern Mediterranean coast of Turkey had reported different locations as the highest plastic waste contamination locations. According to Bingel et al. (1987) and Gündoğdu & Çevik (2017) claimed that İskenderun Bay and Mersin Bay as the most polluted location of Northeastern Mediterranean coast of Turkey in terms of plastic waste density, respectively. This study showed that local current and dominant wind systems are effective in the distribution of plastic waste density at both sea surface and seabed.

Plastic materials which are unable to move actively transferred on sea surface via local current and wind systems (Avşar, 1999; Yılmaz et al., 2002). As a consequence, plastic material accumulation points were found to be changing from inshore to offshore waters as a result of dominant wind flows. Prevailing southern winds observed during summer months carry the plastic waste closer to the coast; while, they were transported to open waters in the winter months. Bingel et al. (1987) also reported the increasing plastic waste density at the coastal zone of İskenderun Bay during the dominant southern wind period.

Yılmaz et al. (2017) determined that the main sources of plastic pollution in the İskenderun Bay as wastes coming from rivers, streams, ship discharges and transported waste coming from neighboring countries via main coastal current systems. In this study, more than 50% of collected plastic materials were from foreign origin at the Çevlik coastline. Likewise, Yılmaz et al. (2002) reported that 32% of collected plastic waste material in the İskenderun were foreign origin. Therefore, it can be concluded that the transportation of foreign origin plastic waste into Turkey’s coast is an important issue in terms of plastic waste deposition.

Commercial trawl fishers were collect marine waste from the bottom of the sea while hunting; however, they had to discharge it back to the sea; since, there was no marine waste collection practice in the fisheries ponds (Şimşek, 2018; Yılmaz et al., 2019). Therefore, if the necessary infrastructures for the collection of marine litter were established in fisheries ports by public institutions, a commercial fishing activity could be useful alternative for waste collection.

This study showed that winds and dominant current systems were effective in the distribution of plastic waste on the sea surface. In fact, plastic waste forms visible waste accumulation sites in the certain locations of seabed and sea surface. Therefore, these concentrated waste regions should be prioritized in the rough plastic waste removal studies when their collection and purification are easy and not expensive. The collection of plastic materials from the marine ecosystem before they are transformed into microplastics is an important issue to minimize and eliminate environmental damage.

Quantitative analysis conducted in the marine ecosystems is hard since they rely on many environmental factors which are not available or hard to determine. Therefore, the amount of plastic waste reported in this study may have been overestimated or underestimated. However, this estimation is important since it is the first recorded study covering the outside of trawl fishing area. Therefore, it reflects the comprehensive assessment of plastic density in the study area.

CONCLUSION

This study was conducted to determine both seabed and sea surface plastic waste density and factors affecting the temporal variations. 35 different sea bath sampling and 25 different sea surface sampling were conducted using trawl or framed trawl. Underwater imaging showed peaks of plastic waste accumulation on the seafloor. Also, the sea surface distribution of plastic materials was characterized by major surface current systems and dominant southerly winds. This study has shown that collecting plastic waste from predominant locations before it turns into microplastic will help reduce marine ecosystem damage.

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CONFLICT OF INTEREST

The authors declare that there is not any conflict of interests regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/ or falsification, double publication and/or submission, and redundancy have been completely observed by the authors.

LIFE SCIENCE REPORTING

No life science threat was practiced in this research.

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