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RESEARCH ARTICLE **ARAŞTIRMA MAKALESİ**

High level of micro-plastic pollution in the Iskenderun Bay NE Levantine coast of Turkey

Türkiye'nin kuzeydoğu Levant kıyısındaki İskenderun Körfezi'nde yüksek düzeyde mikroplastik kirliliği

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Abstract: Microplastic pollution is a global problem. The Mediterranean Sea, especially, has high pressure of pollution as it is enclosed by highly populated and industrialized countries. In this study, we have determined the level of microplastic pollution in the Iskenderun Bay, located in the Northeastern Levantine coast of Turkey. The average level of microplastic has been determined to be 1,067,120 particles/km^2 at fourteen stations. The highest level has been determined at the M4 station in the middle of the bay (with 1820 items; 2,888,889 particles/km^2), and the lowest level has been found at the M11 station (62 items; 98,412 particles/km^2). As a result of this study, it was determined that the microplastic pollution level in the Iskenderun Bay is higher than the other regions of the Mediterranean Sea.

Keywords: *Microplastic, Marine litter, Levantine Sea, Iskenderun Bay*

Öz: Mikroplastik kirliliği, küresel bir problem haline gelmiştir. Özellikle Akdeniz, çevresinde bulunan endüstrileşmiş ve yüksek nüfuslu yerleşimlerden kaynaklı, yoğun bir kirlilik baskısı altındadır. Bu çalışmada, Türkiye'nin Kuzeydoğu Levant kıyısında bulunan İskenderun körfezindeki mikroplastik kirliliğinin düzeyi araştırılmıştır. 14 istasyonda yapılan çalışmada ortalama mikroplastik partikül miktarı, 1,067,120 partikül/km^2 olarak tespit edilmiştir. En yüksek mikroplastik miktarı körfezin orta noktasına denk gelen M4 nolu istasyonda tespit edilmiştir (1820 partikül; 2,888,889 partikül/ km^2). Sonuç olarak İskenderun körfezindeki mikroplastik kirliliği miktarı Akdeniz'in diğer bölgelerine göre oldukça fazla bulunmuştur.

Anahtar kelimeler: *Mikroplastik, Deniz çöpleri, Levant denizi, İskenderun Körfezi*

INTRODUCTION

Because of their durability, light weight, and low cost, plastics have become an industrial product (Osborn & Stojkovic, 2014). However, the durability of plastic also results in its persistence in the marine environment (Bouwmeester et al., 2015). It is estimated that about 10% of the plastic produced in the world enters the ocean (Barnes et al., 2009). According to Jambeck et al. (2015), the quantity of plastic litter that reached our oceans in 2010 was approximately 8 million tons. For example, till 2025 the quantity of plastic is expected to enter the marines and oceans annually—double compared to the quantity that entered the ocean in 2010 (Jambeck et al., 2015). Although marine plastic litter can originate from fisheries or marine-related activities, the majority of marine plastic litter is thought to be generated from land-based activities (GESAMP 2001a, 2001b), accounting for about 80% of marine plastic litter (Andrady, 2011; Derraik, 2002; UNEP, 2005). 92% of the total amount of plastic in marine ecosystem is in the form of microplastics (MPs) (Eriksen et al., 2014; Suaria et al., 2016; Thompson, 2016).

According to many researchers, the Mediterranean Sea consists of the highest amount of plastic litter in the world (Eriksen et al., 2014; Lebreton et al., 2012). Due to the industrial facilities surrounding it, the Levantine coast of Turkey, especially the Iskenderun Bay, is very significantly polluted. A significant portion of this pollution is plastic litter (Gündoğdu & Çevik, 2017; Güven et al., 2017). Gündoğdu and Çevik (2017) in their preliminary study stated that the average quantity of MPs particles in surface water samples of north part of the bay was 225,400 particles/km^2.

This study reveals the facts about pollution caused due to the MPs in entire Iskenderun Bay. The results obtained from this study provide a broad perspective on the situation of the Iskenderun Bay in terms of pollution caused by the MPs. In this

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way, this study is different from the previous studies done by Gündoğdu and Çevik (2017) and Güven et al. (2017).

MATERIALS AND METHODS

Study Area

Sampling was performed in February 2017 in the Iskenderun Bay at fourteen stations (Figure 1). The stations were chosen by taking the whole picture of Bay. Sampling was performed in conditions where the wind speed was below force 2–4 miles/h and the wave sizes were under 10 cm. Through this, the effect of wind and waves was minimized.

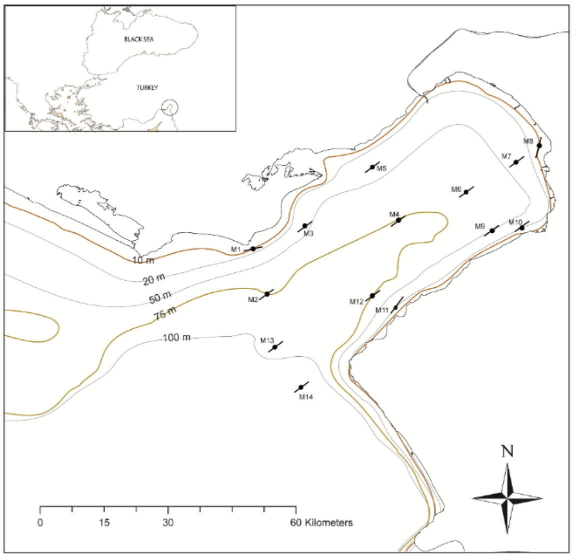

Figure 1. Study area and sampling stations

Survey Methods

Samples were collected using a "Manta Trawl" net attached to a frame sized 0.6 m × 0.25 m with a length of 260 cm and mesh size of 333 µm. To avoid affecting particle distribution, the net was towed at the side of the boat. During the tow, the speed of the boat was kept at 2 knots, and the tow took 20 minutes. The depth of filtering was set to filter through the water mass 15 cm below the surface.

Microplastic Separation

The separation of MPs was carried out as indicated by Masura et al. (2015).

i) Wet sieving

Samples were sieved through stainless steel sieves with 5 mm and 300 µm mesh size, and all the materials left above the sieve were transferred to a beaker using distilled water.

ii) Wet Peroxide Oxidation

20 ml 30% hydrogen peroxide and 20 ml of 0.05 M Fe(II) solution (prepared by adding 7.5 g of FeSO4°7H20 (= 278.02 g/mol) to 500 mL of water and 3 mL of concentrated sulfuric acid), were added to the sample. The mixture was placed on a hot plate set to 75°C and the reaction was allowed to continue until all organic material disappeared.

iii) Density seperation

After the full dissolution of the organic matter was observed, 6g NaCl for each 20 ml was added and stirred in at 75°C. After this, the whole mixture was placed in a density separator and kept there overnight.

iv) Microscopic examination

After density separation was completed, the solution was sieved again and then examined under the microscope with regard to size, color, and shape.

MPs classification was performed under a SZX 16 microscope. A wide zoom range between 0.7x and 11.5x was used. The classification of MPs was done according to Doyle et al. (2011) and Hidalgo-Ruz et al. (2012). Microscopic examination was repeated three times to make sure all plastic particles were fully identified. To avoid contamination, the laboratory was cleaned with deionized water, and all the materials used were washed for 3 times with the same. All analytic process was done in a sterile fume hood, and the processes were finished as quickly as possible. During the study, covered materials and glass sample containers were used.

The quantity of MPs was given as particles per km^2. A one-way ANOVA test was used to determine whether there is a difference in (ln(x+1)-transformed for homogenization of variances) plastic particle numbers between the stations, shapes, types, and size classes. All analyses were performed at significance level 0.05 using the SPSS v22 software.

RESULTS

In this study, MPs sampling was performed at fourteen stations. In fourteen stations, a line with a total length of 8.64 km was traced, and a surface area of 9.5 km^2 was swept. Average quantity of MPs was determined as 1,067,120 items/km^2 (Total N = 9412). Size range of plastic particles was determined to be 55 µm – 4.9 mm (Table 1; Figure 2). Most frequent size group of MPs was 0.1-0.3 mm (n = 2729, 29%)

Table 1. Number of MPs according to stations, shape, types, and size classes

		Stations*														
		M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	M13	M14	Total
Type**	Fibril	463	261	138	341	123	59	53	21	80	24	82	85	90	102	1922
	Film	557	318	20	132	36	133	70	5	378	4	20	86	52	50	1861
	Foam		1				32									33
	Fragment	511	611	195	1249	199	719	126	36	609	110	190	488	244	210	5497
	Pellet	1			98											99
Size*	<01 mm	200	606	68	560	96	64		6	25	61	79	204	48	28	2045
	01-03 mm	461	414	143	736	107	124	62	27	38	41	64	272	114	126	2729
	03-05 mm	72	65	54	279	52	58	81	18	158	21	34	80	69	86	1127
	05-1 mm	248	37	56	156	56	170	64	10	575	2	70	88	79	82	1693
	1-5 mm	551	69	32	89	47	527	42	1	271	13	45	15	76	40	1818
Shape**	Elongated	463	261	138	319	123	59	53	21	82	24	82	85	90	102	1902
	Flat	560	324	60	417	67	248	135	19	523	16	68	217	92	70	2816
	Irregular	505	489	155	983	168	604	61	22	462	98	142	355	204	190	4438
	Spheruloids	4	117		101		32						2			256
Color*	Black	178	117	75	242	45	18	4	13	55	36	62	72	53	23	993
	Blue	87	48	98	252	71	93	8	3	48	24	29	129	21	42	953
	Brown	12			5		4				5	5	2	9		42
	Cream	19						1						1		21
	Gray	76	11		40	6	40	11	5	35	23	12	6	31	12	308
	Green	22	44	2	56	2	25	3	1	25	1	2	1	6	5	195
	Orange	16		1		1	16			14		9		8		65
	Pink						5			6					1	12
	Purple		1					1		9				2		13
	Red	12	22	3	14	15	15	1		10		9		5	8	114
	Transparent	882	882	136	903	168	562	156	28	652	34	89	252	183	237	5164
	White	177	66	38	307	50	155	64	11	197	15	74	197	66	32	1449
	Yellow	51			1		10		1	16		1		1	2	83

*Number of MPs were found statistically significantly different ($p<0.05$; one-way ANOVA)
** Number of MPs were not found statistically significantly different ($p>0.05$; one-way ANOVA)

It was determined that MPs were of 5 different types and 13 different colors (Table 1; Figure 2; Figure 3; Figure 4).
Most frequent type of MPs were plastic fragments (n = 5497; 64.6%), and the most dominant color was transparent (n = 5164; 54.9%). It was determined that the number of MPs types were not statistically and significantly different (one-way ANOVA, $p > 0.05$; Table 1).
With regard to shape, MPs had 4 different shapes (elongated, flat, irregular, and spheroids), and the most frequent shape was irregular (n = 4438, 47.2%; Figure 2; Figure 3; Figure 4; Table 1). MPs shapes were found to be statistically significantly different in terms of number (one-way ANOVA, $p < 0.05$; Table 1).

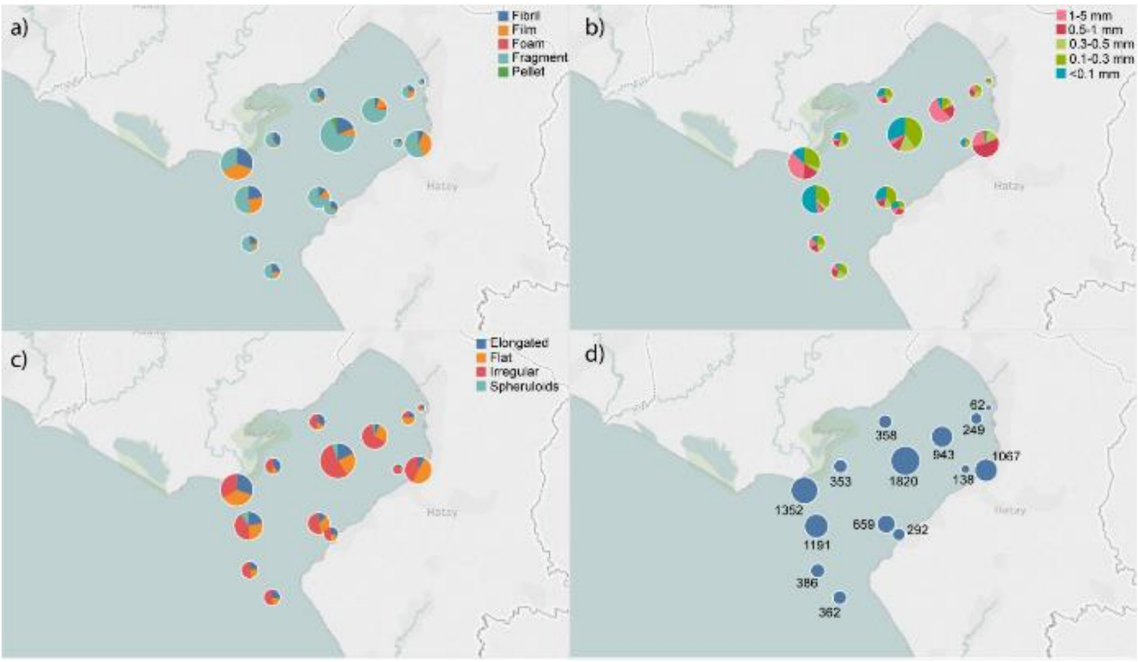

Figure 2. MPs (a) type, (b) size, (c) shape, and (d) concentration of 14 stations in İskenderun Bay

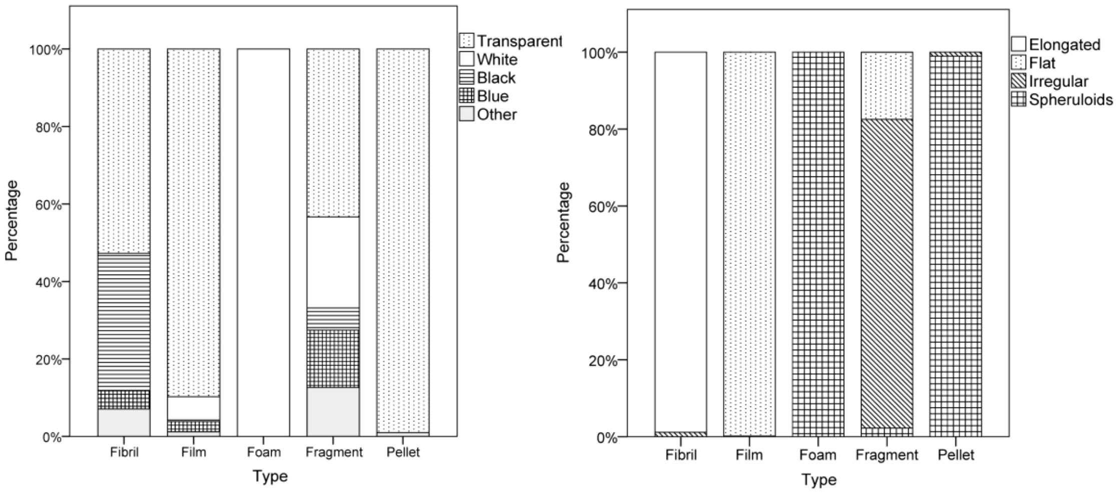

Figure 3. Types, colors, and shapes of the MPs from İskenderun Bay

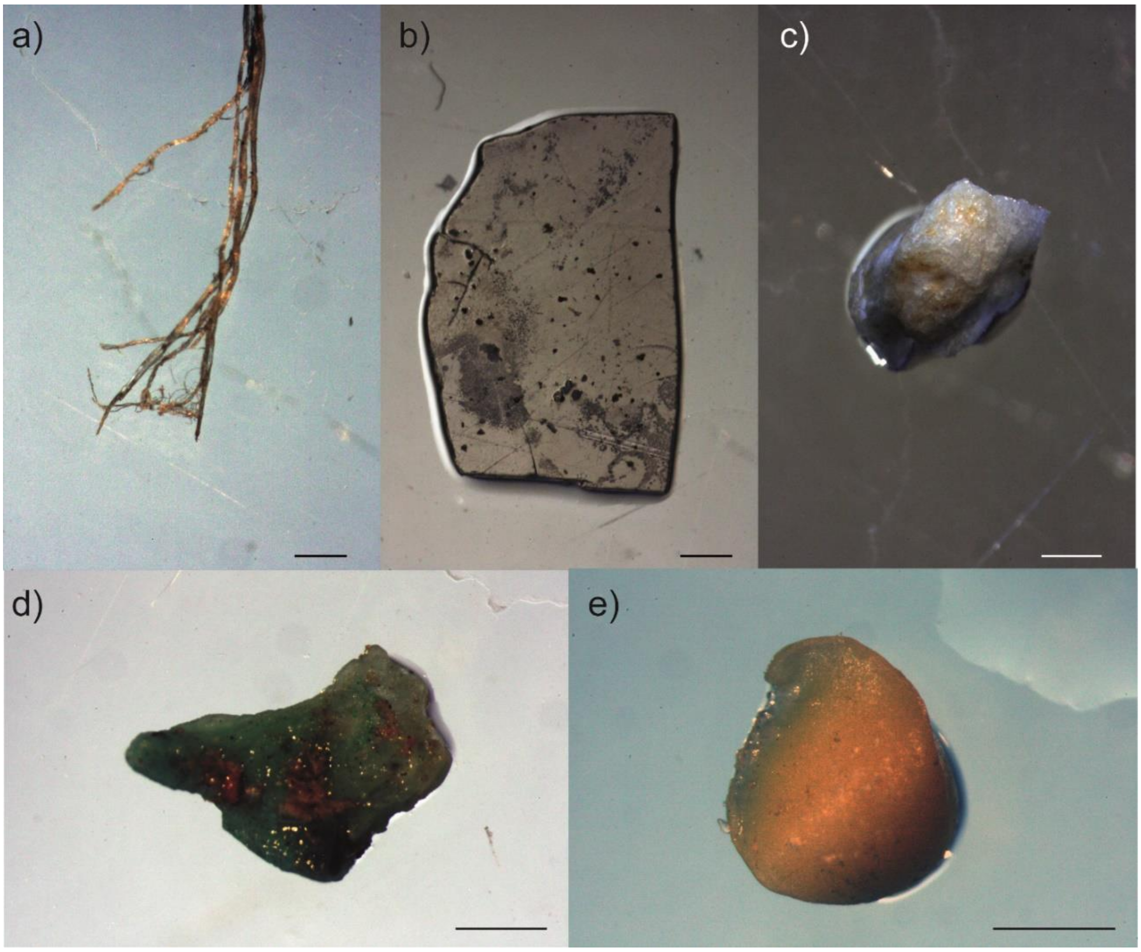

Figure 4. Plastics with different shapes (a) fibril/elongated, (b) film/flat, (c) foam/spherical, (d) fragment/irregular, (e) pellet/spherical

DISCUSSION

In this study, the presence of MPs was established. MPs are highly abundant in the Iskenderun Bay. The highest number of MPs was found at the M4 station (Table 1, Figure 2). The amount of plastic at this station was almost two to three times higher when compared to that of the other stations except for stations M1, M2, and M9. This difference is statistically significant (one-way ANOVA, $p < 0.05$). Doyle et al. (2011) and Desforges et al. (2014) stated that the number of MPs increases in the presence of the currents. From this point of view, it is thought that M4's location, in the middle of the currents of the bay, can be the reason behind high levels of MPs because of the current cyclone (Doyle et al., 2011). The second station with high concentration of MPs is the M1 station. According to de Lucia et al. (2014), there is a direct relationship between human activities (e.g. urbanization) and the concentration of the MPs. It can be said that M1's location being close to the mouth of the Ceyhan River may cause the MPs level be higher here. Ceyhan River passes through the most significant source of irrigation for the Çukurova agricultural area. While considering the state of the bay, it is thought that the reason for this station to have a statistically and significantly higher MPs content is due to the presence of the Ceyhan River.

Compared to other studies conducted in the Mediterranean Sea, the average amount of MPs found in this study (1,067,120 particles/km^2) is similar to the results found by van der Hal et al. (2017) in the Israeli Mediterranean coastal waters. (Table 2). However, the values found in this study are higher than those of other studies conducted at the Mediterranean Sea (Collignon et al., 2014; Cozar et al., 2015; Gündoğdu & Çevik, 2017; Güven et al., 2017; Kornilios et al., 1998; Ruiz-Orejon et al., 2016). The most important reason behind these differences is thought to be the effect of the Ceyhan River flowing to the bay, the season in which the sampling is conducted, and the seasonal dependent hydrographic conditions at the time of sampling. It is a widely known fact that marine currents vary seasonally. The main sources of this variability are the seasonal winds and the central Mediterranean current from the southern coast of the eastern Mediterranean. According to Uysal et al. (2008) in the Eastern Mediterranean, where the

Gulf of Iskenderun is also in the period that included the time of the sampling, the main currents continue counterclockwise, parallel to the shore. Following the Lebanese and Syrian borders, the northward currents follow the Turkish coast westwards.

The main stream flows into the İskenderun Gulf, while the others continue without entering the bay (Özsoy & Sözer, 2006). Therefore, it is thought that these plastics can be transported by seasonal discharge to the bay, and the amounts and distributions in the bay can be derived from the current.

Table 2. A comparison of the results found in this study and other studies regarding the MPs pollution in the Mediterranean Sea

Location	Sampling Time	Mean MPs (item/m²)	References
Mediterranean, Surface (Cretan Sea)	July 1997	0.119	Kornilios et al.(1998)
NW Mediterranean	July-August 2010	0.116	Collignon et al.(2012)
Mediterranean (Ligurian/Sardinian Sea)	June-July 2011	0.310	Fossi et al.(2012)
Mediterranean (Bay of Calvi)	August 2011- August 2012	0.062	Collignon et al.(2014)
Mediterranean, Surface	May 2013	0.250	Cozar et al.(2015)
Mediterranean, Surface (Central and Western Part)	May-July 2011 – April June 2013	0.147	Ruiz-Orejon et al. (2016)
Mediterranean, Surface (Central/Western Part)	May-June 2013	0.400	Suaria et al.(2016)
Mediterranean (NE Levantine)	October – November 2016	0.376	Gündoğdu and Çevik(2017)
Mediterranean (NE Levantine)	July-August 2015	0.163-0.520	Güven et al.(2017)
Israeli Mediterranean coasts	Summer 2013 and Spring 2015	1.518	van der Hal et al.(2017)
Mediterranean (NE Levantine)	February 2017	1.067	This study (2017)

The percent of MPs types were, in general, found to be similar to other studies (Cozar et al., 2015; Faure et al., 2015; Gündoğdu and Çevik 2017; Moore et al., 2001; Moret-Ferguson et al., 2010; Ruiz-Orejon et al., 2016)

The most frequent type of MPs in this and those other studies is plastic fragments. According to Hidalgo-Ruz et al. (2012), as plastic fragments can be part of any plastic product, it is expected that the plastic fragments are high in both this study and other studies.

Table 3. The comparison of the percentage of different MPs types in the total sample

Location	Average concentrations (%)					Source
	Fragments	Pellets/ Granules	Filaments/ Fibrils	Films	Foams	
N. Pacific	59%	0%	11%	29%	1%	Moore et al. (2001)
N. Atlantic 30°N	91%	5%	2%	1%	1%	Moret-Ferguson et al. (2010)
Mediterranean	87%	1.8%	2.3%	5.9%	2.3%	Cozar et al. (2015)
W Mediterranean	77%	1%	2%	15%	5%	Faure et al.(2015)
W Mediterranean	87.2%	-	1.7%	3.9%	5.5%	Ruiz-Orejon et al. (2016)
NE Mediterranean	60%	0.2%	7%	30%	3%	Gündoğdu and Çevik(2017)
NE Mediterranean	64%	0.3%	21.6%	13%	0.5%	This Study

Results of our study show that the size of MPs is mostly in the 0.1-0.3 mm range (Table 1; Figure 2b). The number of MPs particles, defined as particles with 0.1-0.3 mm size, is determined to be 2729 particles (29%).

This presence is similar to the ratio reported by Hidalgo-Ruz et al.(2012). Hidalgo-Ruz et al.(2012) stated that most MPs were found in the size classes 0.5 to 1 mm.

MPs show a great variety with regard to color as well as shape. Among the 68 studies reviewed by Hidalgo-Ruz et al. (2012), the most dominant colors were white (or colors related to white) and transparent and the most dominant type of MPs were fragments. The findings regarding MPs shapes and color in this study support this (Table 1; Figure 2; Figure 3).

Plastic pollution is quite a new phenomenon. Although it is a new phenomenon, all aquatic ecosystems are at a concerning level (Thompson, 2016). The results of this study show that pollution caused by MPs is at a concerning level for the Iskenderun Bay.

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