ESKİŞEHİR TEKNİK ÜNİVERSİTESİ BİLİM VE TEKNOLOJİ DERGİSİ
C- YAŞAM BİLİMLERİ VE BİYOTEKNOLOJİ

Eskişehir Technical University Journal of Science and Technology
C -Life Sciences and Biotechnology

Estuscience – Life, 2026, 15 (1) pp. 15-31, DOI: 10.18036/estubtdc.1538875

RESEARCH ARTICLE

MARINE LITTER BASED ON FOREIGN ORIGIN ON THE COASTS OF THE CANAKKALE STRAIT AND BOZCAADA ISLAND (NORTH AEGEAN SEA)

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Abstract

In this study, marine litter (ML) according to foreign origin was investigated on the coasts of the Çanakkale Strait and Bozcaada Island (Northern Aegean Sea), where there is an extreme amount ship traffic in both regions, as they are important transition and pre-transition zones. As a result of this study, which was carried out daily at two stations between January and March 2021, a total of 28 pieces of foreign origin marine litter were identified as belonging to 10 countries by reading their barcodes. While the proportional distributions of ML density based on countries were found to be 8.00% for each of Switzerland, Mexico, Philippines, and Italy, 7.00% for each of Belgium and Tanzania at the station of Meteoroloji (Çanakkale Strait), they were found to be 33.0% for Greece, 13.0% for each Switzerland and Russia, 7.00% for each of Germany, Hungary and Tanzania at the station of Ayazma (Bozcaada Island). In particular, the fact that a large majority (33.0%) of the ML of foreign origin at the station located in the North Aegean Sea originates from Greece revealed that this ML may be originated from ship traffic, but also mostly originate from water current systems.While plastic was the most common ML in view of material type, the most common ML was mixed packaging wastes in view of usage area in both stations. It is needed to make and implement effective action plans as a solution to ML. It is recommended to include new actions in ML action plans in force regarding ML which is thought to originate from ships because ships crossing cause marine pollution.

Keywords

Çanakkale,
Foreign origin,
Marine litter,
Coast,
Plastic

Time Scale of Article

Received : 26 August 2024
Accepted : 05 September 2025
Online date : 27 January 2026

1. INTRODUCTION

Marine litter (ML) is defined “as any anthropogenic persistent, manufactured or processed solid material discarded, disposed or abandoned in the coastal and marine environment” [1]. ML is an environmental, aesthetic, health, and economic problem and one of the most prominent threats for the ocean. ML is originated from sea-based and land-based sources. Sea-based ML resources are known to be related to shipping, cruise, ferries, fishing and research vessels, drilling wells, aquaculture facilities, and offshore oil and gas platforms. Shipping activities are one of the major sources of sea-based ML. The land-based ML source is the transportation of litter on the coastal and inland to the sea because of high winds, large waves, storms and river flows [2,3].

Plastic material is the most common material among marine litter [4-8]. Although more than 80% source of marine plastic litter comes from land-based activities, its significant amount of marine plastic litter comes from sea-based activities. 94% of the plastic materials in the land reaches to the

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ocean and then ends up on the sea floor. There is now on average an estimated 70 kg of plastic in each square kilometer of seabed [9,10]. It was reported that 275 million metric tons (MT) of plastic waste was produced in 192 coastal countries in 2010, and between 4.80 and 12.7 MT million entered the ocean [11,12]. Plastic consumption in the world has been increasing rapidly since the 1950s [13]. While total annual production of plastics was 365.5 million tons worldwide in 2018, it has approached 390.7 million tons in 2021 [14].

In a recent review, a study on macro marine litter in the Marmara Sea was reported [15]. In this study, coastal areas of Marmara Sea, including Çanakkale Strait, were surveyed for buried macro marine litter during the period of 12-28 August 2018 [16]. In the literature review, a survey for macro marine litter was conducted on the shores of Çakalburnu lagoon in the Aegean Sea in the period of November 2020 and August 2021 [7].

Few studies exist on marine litter on the coasts of the Çanakkale Strait except for two studies carried out on the beaches around the Sea of Marmara, which also contained three stations on the Çanakkale Strait [16] and entirely on the coasts of the Çanakkale Strait in the period of May 2017-May 2018 [8]. Besides a study was carried out on an artificial breakwater area along the Strait in 2021 and 2022 to find out the extent of litter accumulation, type of litter as produced materials and use purposes [17]. However, there are no studies on ML on the coasts of Bozcaada. On the other hand, there are not many studies on foreign origin of ML. Therefore, this study, which is represented with one station each in the Dardanelles and the North Aegean Sea, gains a special importance and provides important data. Thus, this research aimed to evaluate the abudance, some characteristics and composition of foreign origin of ML in both the Çanakkale Strait and Bozcaada coasts. It is expected that this study will form a source for future studies.

2. MATERIALS AND METHODS

2.1. Study Area

The Çanakkale Strait is only means of transportation that does not have an alternative, which provides access to the Black Sea in connection with the Aegean Sea and Marmara Seas. The Çanakkale Strait is international waterway that separates the continents of Asia and Europe and connects the Aegean Sea and the Marmara Sea. Bozcaada is located in the northern Aegean Sea. Both areas are transition zones of maritime trade. Therefore the ship traffic is quite intensive in the study area. The number of ships passing through the Çanakkale Strait in 2021 is 43.342, of which 24.668 are non-stop ships [18]. There are 3 anchorage areas at the place connecting the Dardanelles Strait to the Aegean Sea, and 3 anchorage areas in the north, south and west parts of Bozcaada [19]. Meteoroloji station (coast of the Çanakkale Strait) and Ayazma station (coast of the North Aegean Sea) were chosen as the study areas (Figure 1). The sampling stations and their characteristics are given in Table 1.

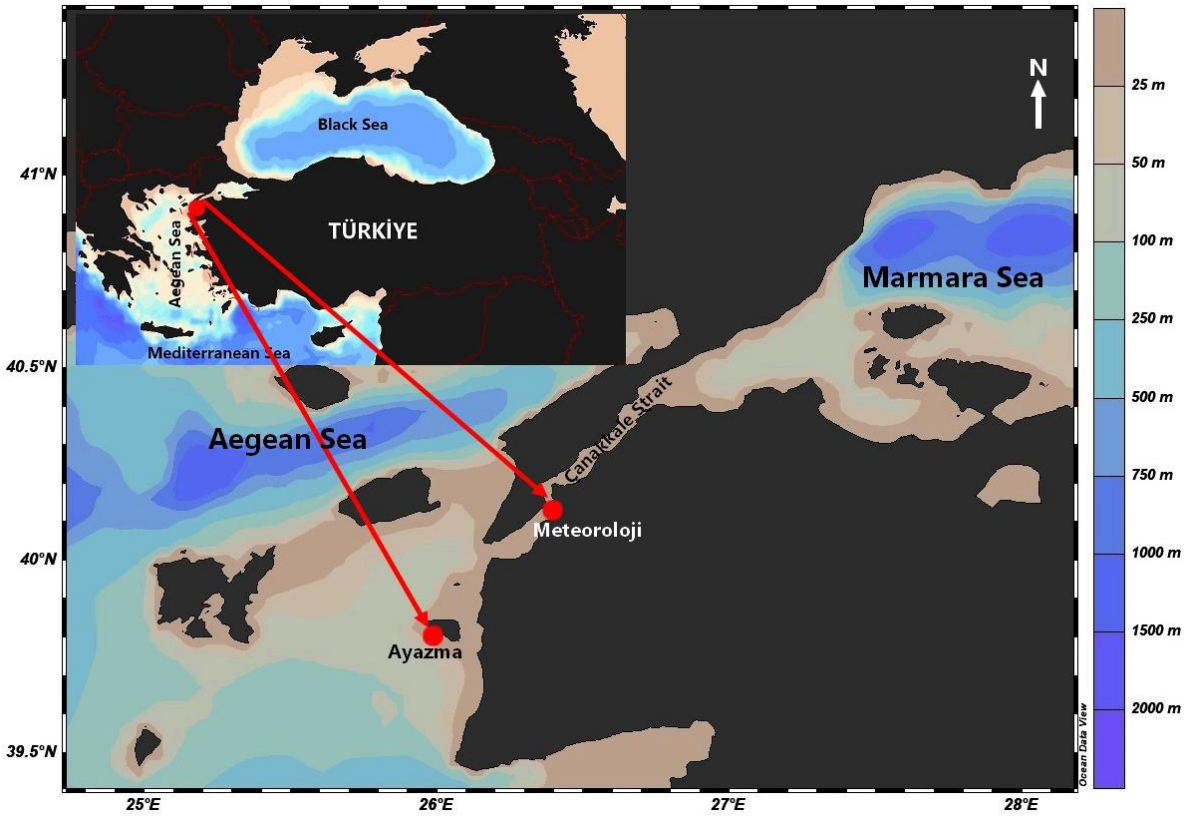

Figure 1. Sampling stations on the coasts of the Çanakkale Strait and Bozcaada.

Table 1. Various characteristics of two stations along the sandy beaches.

Station Name	Location	Total length of beach	Type of beach	Nearest town	The nearest ship crossing distance	Estimated traffic density (2021ship/year)
Meteoroloji	40° 08'29.60'' N 26° 23'56.86'' E	290 m	95% sandy 5% gravel	100 m	0.47 nm	43.342
Ayazma	39° 48'43.72'' N 26° 00'33.68'' E	750 m	95% sandy 5% gravel	450 m	0.87 nm	43.582

2.2. SAMPLING METHOD

In the study, ML samplings were daily performed for foreign origin marine litter (FOML) every day on same hour at two stations between January and March 2021. They were collected in the shore entrance area located between the terrestrial vegetation border and waterline(between Coastline and Coastal Edge Line). Samples were collected along a 100 m transect running parallel to the beach at both stations. In each sampling, foreign origin litter items larger than 2.50 cm were collected, counted, weighed, and categorized [1,20,21]. When a barcode or label was detected, the information was recorded to identify the items are foreign. FOML items were categorized according to material types and field of usage. Length, shape, colour and fragmentation distribution of the collected litter were detected.

3. RESULTS

A total of 28 items of foreign origin marine litter FOML were collected. The dates, countries and numbers of FOML found during research period are presented in Table 2. FOML distributed on four categories of materials and three of usage area (Table 3).

Table 2. Detection dates and numbers of foreign origin marine litter (FOML).

Station	Date	Total Item	Country
Meteoroloji (Cost of Çanakkale)	07.01.2021	1	1 Unknown
	12.01.2021	1	1 Belgium
	21.01.2021	3	1 Tanzania, 2 unknowns
	25.01.2021	2	1 Switzerland, 1 unknown
	26.01.2021	4	1 Philippines, 1 Italy 2 unknowns
	28.01.2021	1	1 Mexico
	10.02.2021	1	1 Unknown
Ayazma (Cost of Bozcaada)	02.01.2021	1	1 Germany
	03.01.2021	1	1 Switzerland
	06.01.2021	3	3 Unknowns
	15.01.2021	2	1 Greece, 1 Hungary
	16.01.2021	3	1 Tanzania, 1 Greece, 1 Russia
	19.01.2021	2	1 Greece, 1 Russia
	09.02.2021	1	1 Greece
	10.02.2021	1	1 Scwitzerland
	16.02.2021	1	1 Greece
Total		28	

Table 3. Compositions and used areas of foreign origin marine litter (FOML).

	Category	Meteoroloji		Ayazma	
		items/m^2	g/m^2	items/m^2	g/m^2
Materials	Plastic	0.0164	0.1791	0.0141	0.4359
	Metal	0.0015	0.0522		
	Glass	0.0015	0.3731		
	Composite			0.0051	0.1987
Used Areas	Mixed Packaging Wastes	0.0179	0.5970	0.0179	0.6218
	Fisheries Wastes	0.0015	0.0075		
	Medical Wastes			0.0013	0.0128
Mean FOML Density		0.0194	0.6044	0.0192	0.6346

At beaches both Çanakkale and Bozcaada, the total FOML observed in the study was classified according to both countries and, material types, usage types, lengths, shapes, colours and fragmentation states (Table 4).

In the study, a total of eight colours were found overall of the collected litter (blue, green, mixed, pink, red, transparent, white and yellow) based on colour (Table 4). The most abundant colour was transparent (25%) and the least common colors were pink (3.57%) and yellow (3.57%). Collected ML were categorized in two shapes (flat and cylindrical) and overall, most dominant shape was flat (64.29%) (Table 3). When we look at the sizes of the FOML their proportions were equal between 10 cm and 20 cm and larger than 20 cm (42.86%) (Table 4). The results indicated that 82.14 % of the ML was unfragmented and 15% fragmented.

Table 4. The distribution of the FOML in total by material type, used type, size, colour, shape and fragmentation.

Material Type	Item	Total	%
	Plastic	22	78.57
	Glass	1	3.57
	Metal	1	3.57
	Composite	4	14.29
Used Type	Mixed Packaging	26	92.86
	Medical Wastes	1	3.57
	Fishing Wastes	1	3.57
Size	<10	4	14.29
	10-20	12	42.86
	>20	12	42.86
Colour	Blue	3	10.71
	Green	4	14.29
	Mixed	4	14.29
	Pink	1	3.57
	Red	2	7.14
	Transparent	7	25.00
	White	6	21.43
	Yelow	1	3.57
Shape	Flat	18	64.29
	Cylindrical	10	35.71
Fragmentation	Piece	5	17.86
	Whole	23	82.14

During the study, distribution of FOML in terms of density (items/m^2) and weight (g/m^2) between two stations are presented in Figure 2 and Figure 3, respectively. At the end of this research, weight and all numbers of FOML collected during the study were 900 g and 28 items, respectively. Thirteen (13) of them were found at the Meteoroloji station and 15 of them were at the Ayazma station. It can be inferred that from the countries by reading the barcodes of foreign origin marine litter, Tanzania and Switzerland originating litter are in both stations. The highest amount of FOML was found ML of Greece origin as density in the Ayazma station, Mexican originas weight in the Meteoroloji station. These litter have been thought to originate from shipping activities Mexico originated ML was heavier due to being glass bottle compared to plastic. The reason for the second highest FOML weight in Ayazma was accumulation of more ML (Figures 2 and 3).

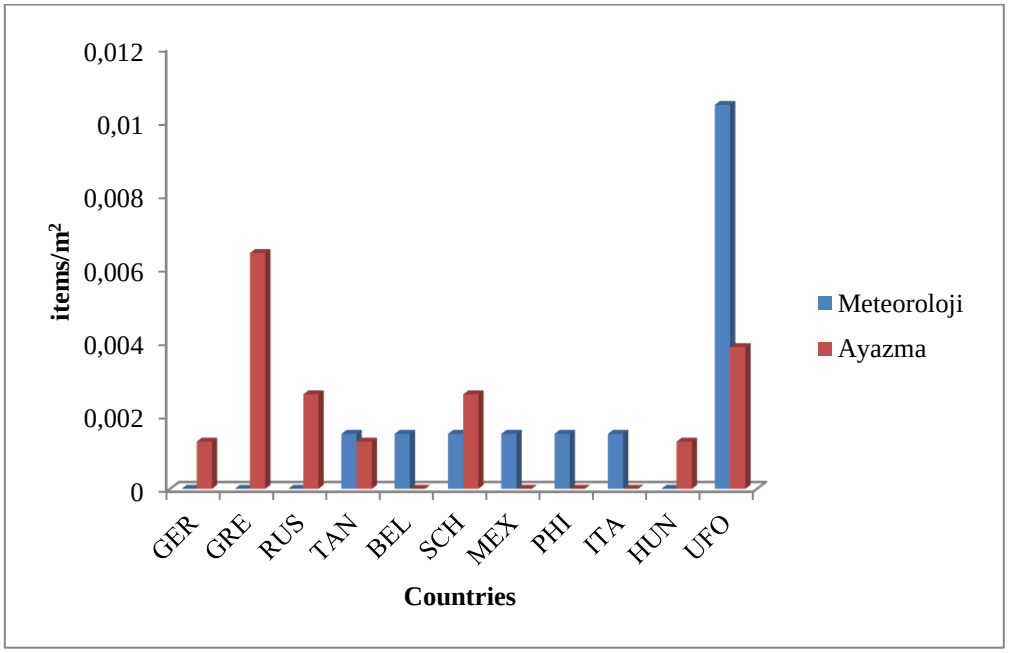

Figure 2. Distribution of foreign origin litter (FOML) density according to country between two stations (items/m^2).

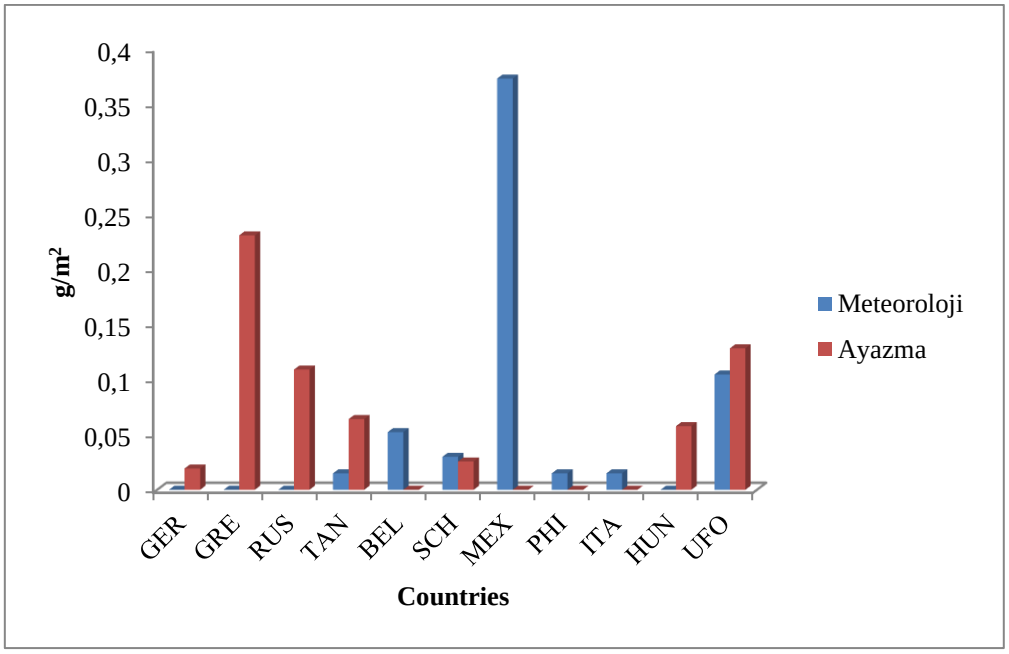

Figure 3. Distribution of foreign origin litter (FOML) weight according to country between two stations (g/m^2).

Proportional distribution (%) FOML density (items/m^2) and weight (g/m^2) on the coasts of the Çanakkale Strait and Bozcaada (North of Aegean Sea) are presented in Figure 4 and Figure 5, respectively.

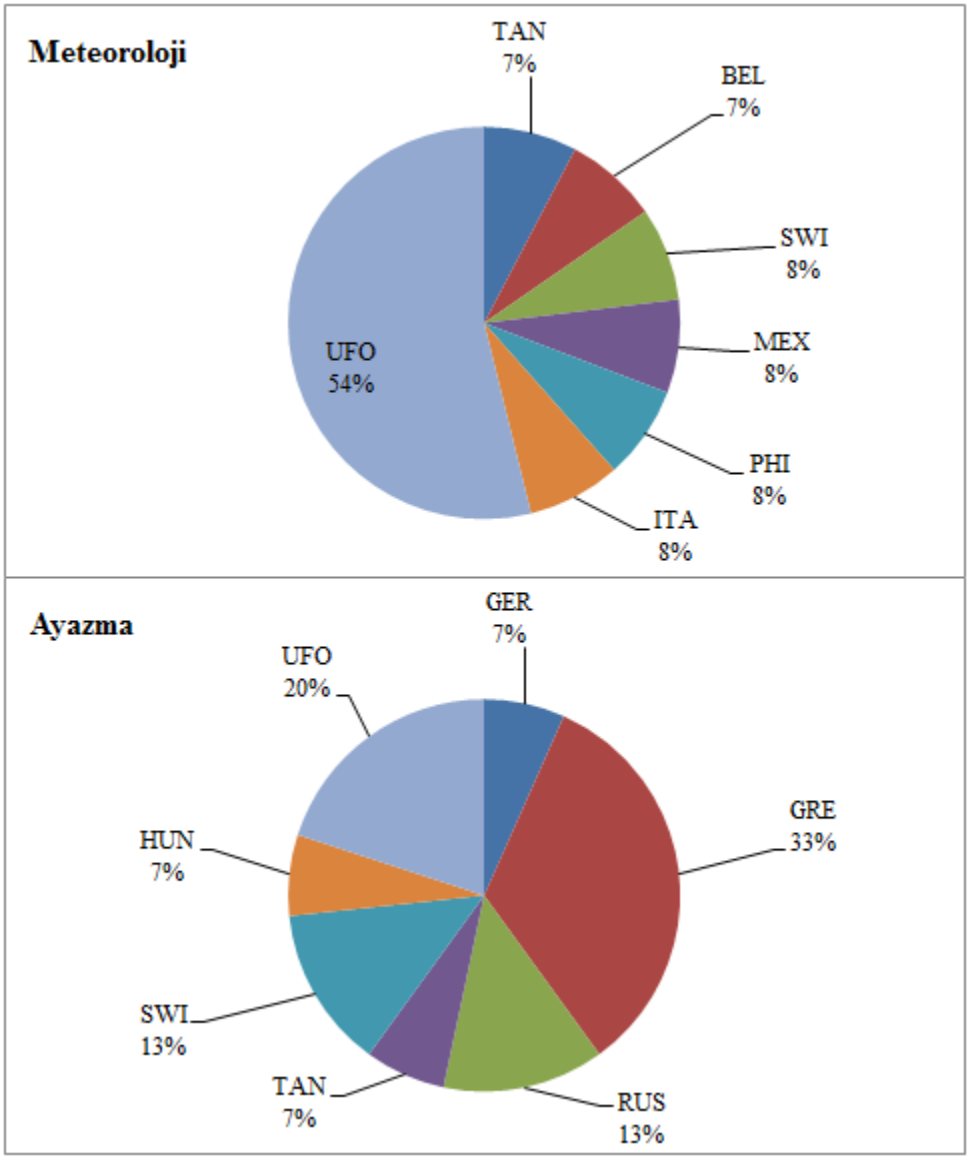

Figure 4. Proportional distribution of FOML density (items/m^2) in different countries between two stations according to countries (BEL: Belgium; TAN: Tanzania; SWI: Switzerland; PHI: Philippines; ITA: Italy; MEX: Mexico; GER: Germany; GRE: Greece; HUN: Hungary; RUS: Russia; UFO: Unknown Foreign Originated).

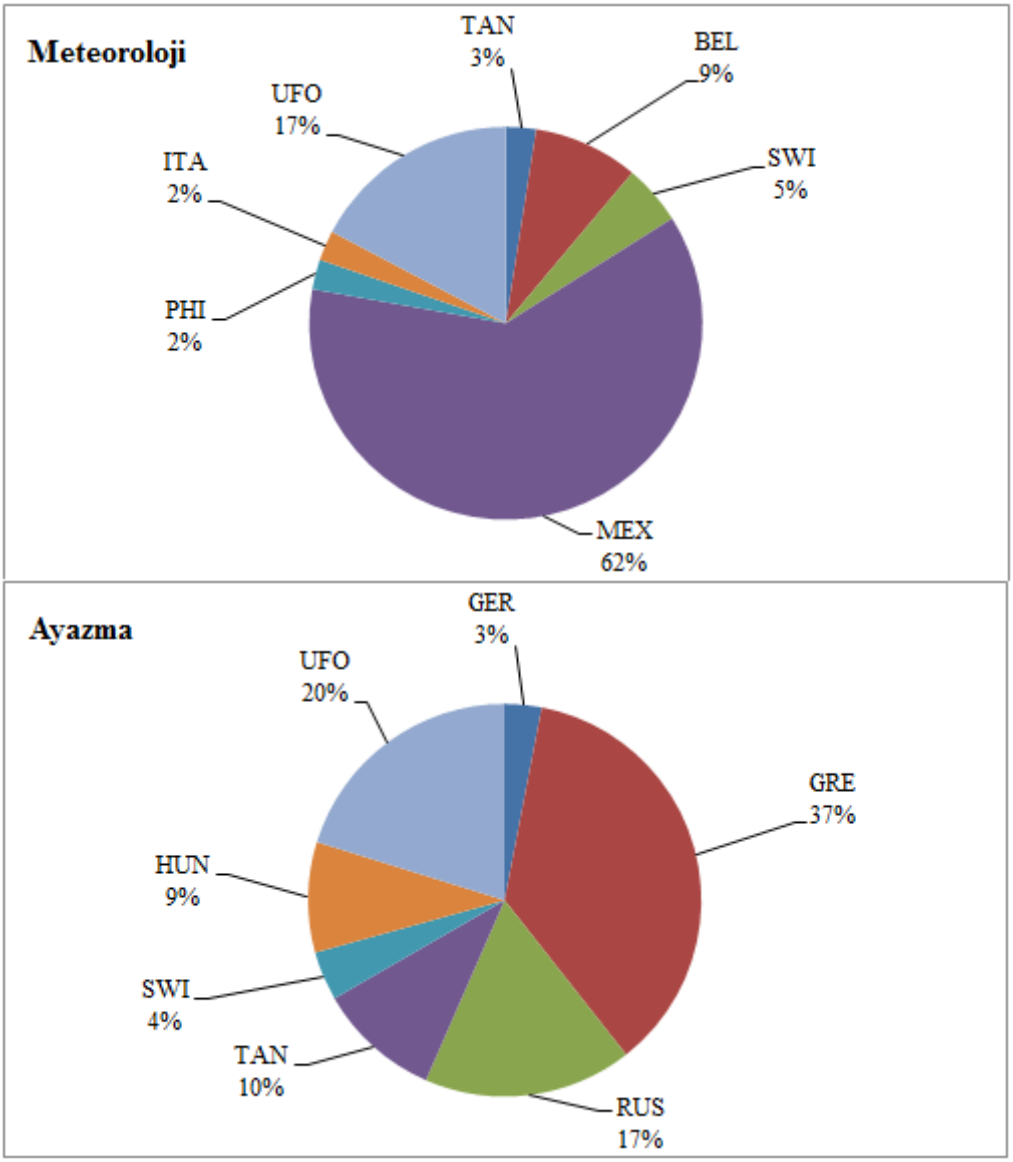

Figure 5. Proportional distribution of FOML weight (g/m^2) in different countries between two stations according to countries (BEL: Belgium; TAN: Tanzania; SWI: Switzerland; PHI: Philippines; ITA: Italy; MEX: Mexico; GER: Germany; GRE: Greece; HUN: Hungary; RUS: Russia; UFO: Unknown Foreign Originated).

Distribution of the FOML proportions (%) and material type to density (items/m^2) and weight (g/m^2) on the coasts of the Bozcaada (North of Aegean Sea) and Çanakkale Strait are presented in Figure 6 and Figure 7, respectively. During the study the most common FOML material in terms of density was plastic at both stations. Plastic rate was 84.0% in Meteroloji and 73.0% in Ayazma. Plastic was followed by glass (8.00%) and metal (8.00%) in Meteoroloji station and by composite (27.0%) in Ayazma station (Figure 6).

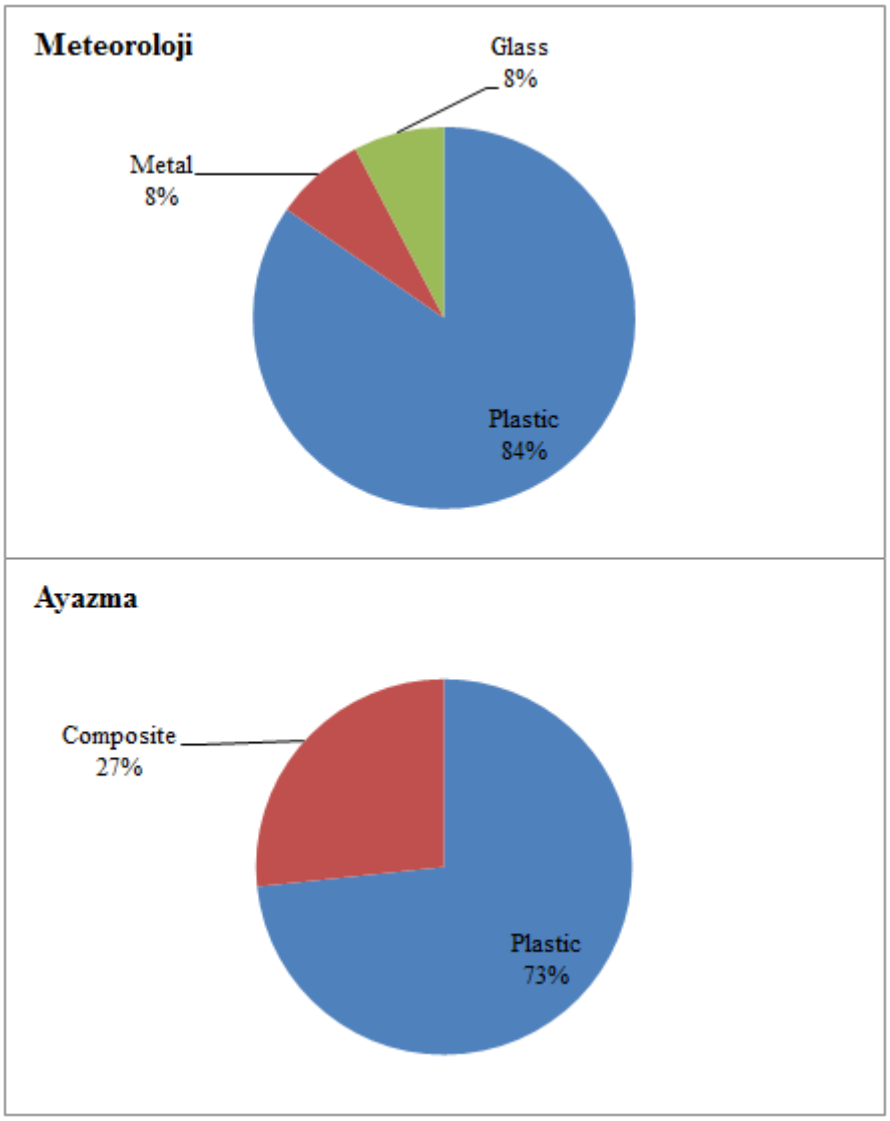

Figure 6. Distribution (%) of FOMLs to material types in terms of density (items/m^2) in both stations.

The most common FOML material in terms of weight was glass (62%) in Meteoroloji station. Glass material was followed by plastic (29%) and metal (9%) in Meteoroloji station and by composite (31%) in Ayazma station (Figure 7).

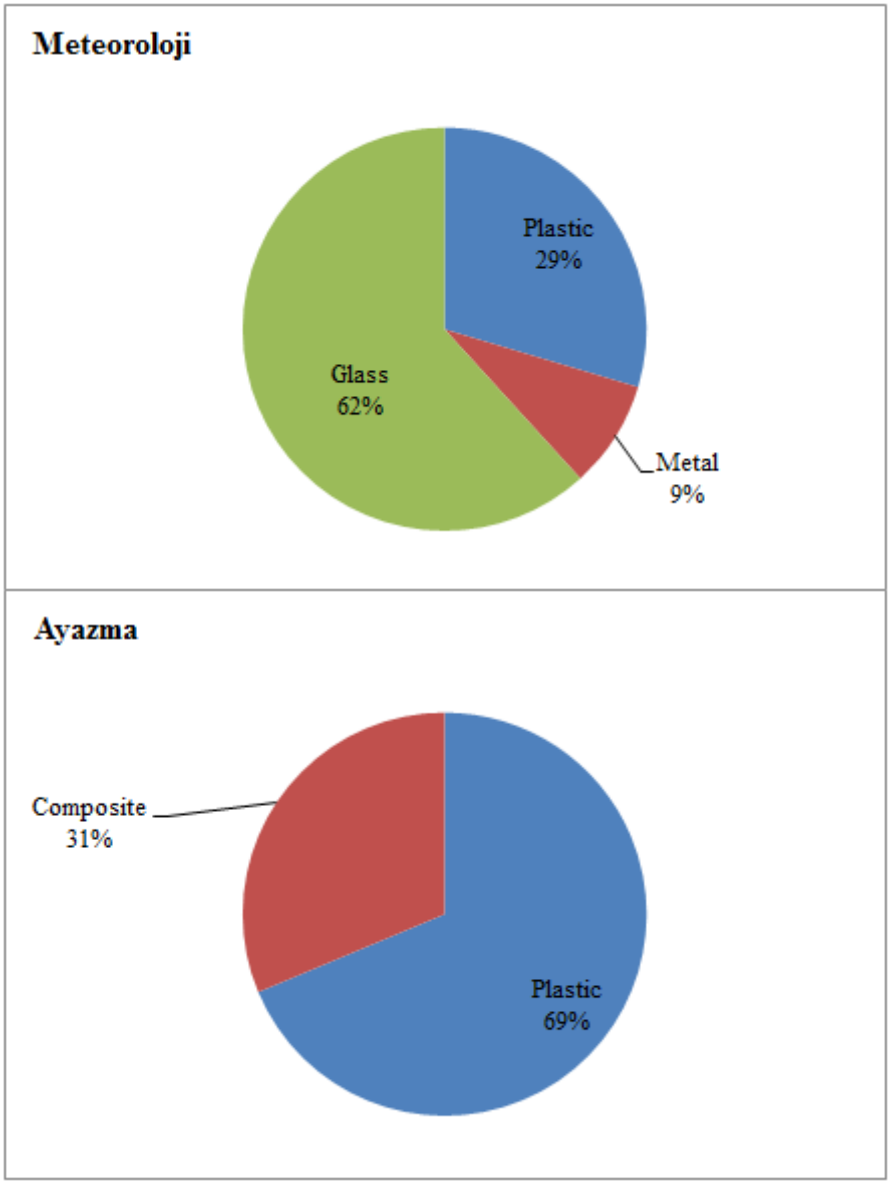

Figure 7. Distribution (%) of FOML to material types in terms of weight (g/m^2) in both stations.

Proportional distribution of the FOML density (items/m^2) and weight (g/m^2) according to usage fields on the coasts of the Çanakkale Strait and Bozcaada (North of Aegean Sea) are presented in Figure 8, Figure 9 respectively. The distribution of the FOML according to usage is researched. According to usage fields, the most abundant litter in terms of both density and weight was mixed packaging waste (MPW). MPW rate was 92.0% in the Meteoroloji and 93.0% in the Ayazma in terms of density. MPW was followed by fishing wastes (8.00%) in Meteoroloji station and by medical wastes (7.00%) in the Ayazma station (Figure 8). MPW rate was 99.0% in Meteoroloji and 98.0% in Ayazma in terms of weight. MPW was followed by fishing wastes (1.00%) in Meteoroloji station and by medical wastes (7.00%) in Ayazma station (Figure 9).

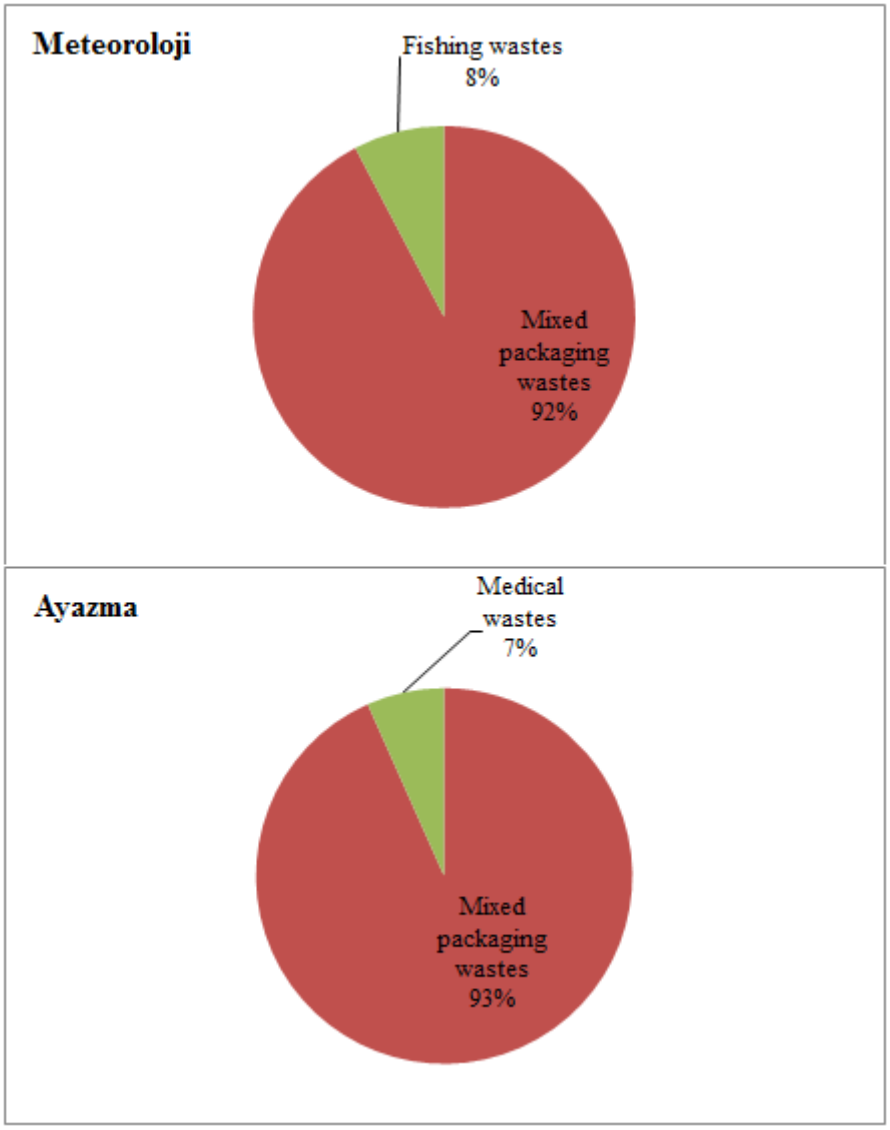

Figure 8. Distribution (%) of FOML to usage fields in terms of density (items/m^2) in both stations.

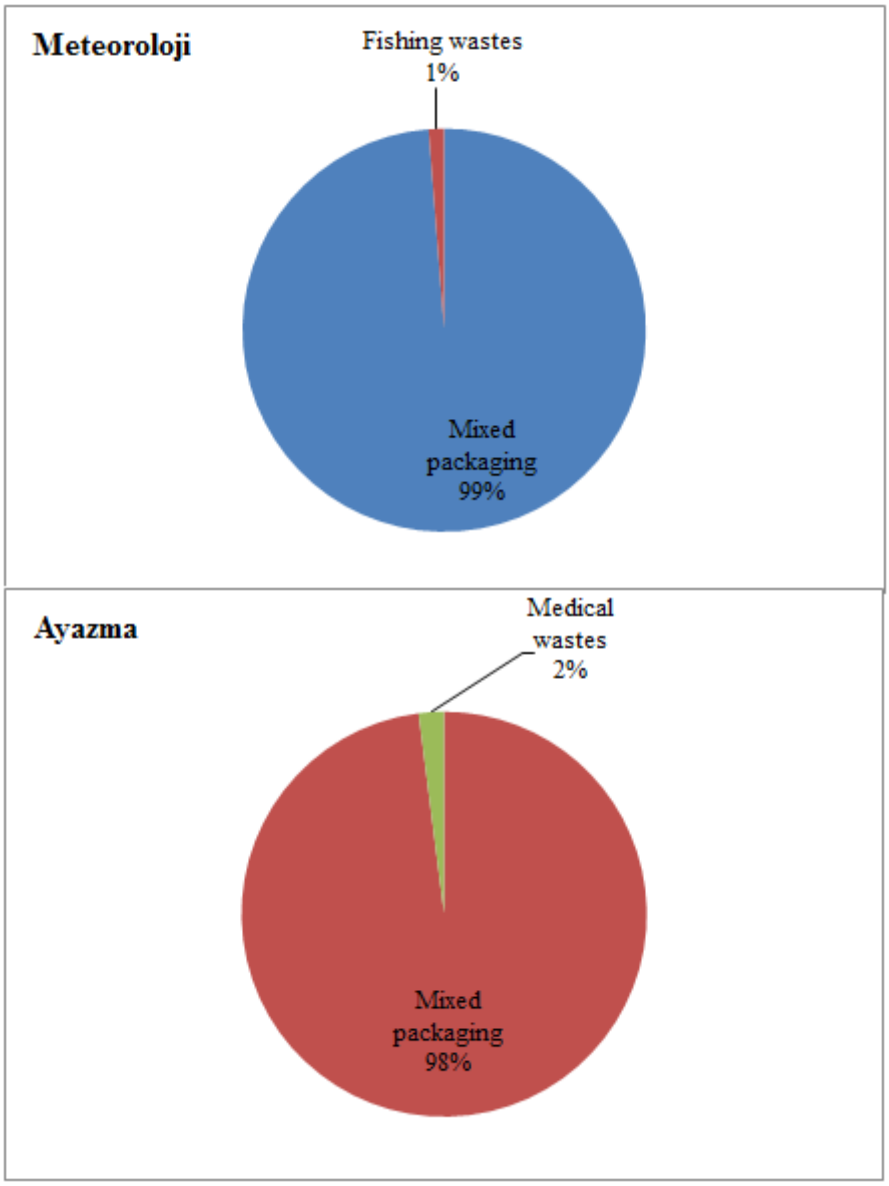

Figure 9. Distribution (%) of FOML to usage fields in terms of weight (g/m^2) in both stations.

4. DISCUSSION

The result of this study determined foreign origin marine litter and their material types, usage, length, colour and shape on the beaches Çanakkale Strait and Bozcaada in the period of January and March 2021.

28 foreign origin marine litter were identified in this study. From the barcodes of 18 of them, it is clear from which country their originate. It can be inferred that these litter are not very old, because their barcodes can readability and they remain intact without fragmentation. From here we can understand that this litter probably mixed with the sea from ships and reached the land with the effect of wind and current. These findings suggest that the litter was detected is source of marine based. Since it is probably caused by shipping activities. The average number of ships passing through the Dardanelles Strait between 2006 and 2022 is 45,402 [18]. The Çanakkale Strait faces intense danger of marine

litter originating from ships because there is a heavy national and international maritime traffic.

A significant proportion of marine plastics come from shipping activities. Their presence has been widely reported in coastal areas where there is heavy international maritime traffic. The shipping industry is a likely source of recently arrived plastic bottles from a various parts of Africa, Asia, Europe, and North, Central, and South America. It is possible that the recent increase can be attributed in large part to merchant shipping [22-23].

A survey of international litter on a beach in a protected area on the Amazon coast supported the conclusion that international international litter comes from ships operating in the region [24]. The same can be said for this research.

As a result of this study, it is understood that most of foreign origin marine litter found the beaches consists of bottles and food packaging materials.

Few studies exist about foreign origin marine litter. Therefore many comparisons haven't been made. There were 6 items (6 different country) FOML recorded in the Meteoroloji station (coast of Çanakkale Strait) and 12 items (6 different country) recorded in the Ayazma station (coast of North Aegean Sea). 10 different countries were found. The number of foreign countries (25) recorded in the Western Black Sea [25], (9) recorded in coastal area of the Cilician Basin [26], (25) recorded Sinop Sarıkum Lagoon [27], (7) recorded in Adana Akyatan Lagoon Coast of the East Mediterranean [28] and (15) recorded for Çanakkale Strait [8].

In addition, it is known that plastic material are proportionally higher in researches on all marine litter [8,16,17,24-26, 29-35]. Also packaging wastes are proportionally higher in researches on all marine litter [8,17,25,26,28,30,32,36-38]. In this study, plastic and packaging wastes were found the most in foreign marine litter.

5. CONCLUSIONS

This study reveals that the coasts of the Dardanelles (Çanakkale Strait) and Bozcaada Island (Northern Aegean Sea) are significantly affected by passing ships. The findings highlight the importance of taking action to reduce marine litter of foreign origin. The research demonstrated that both stations were subject to pollution from ships. This can be attributed to the presence of anchoring areas located offshore of Ayazma Station in Bozcaada, as well as in the section connecting the Çanakkale Strait to the Aegean Sea. As a result, international shipping activities have a direct impact on the coastal environment, primarily through ship-generated litter. Plastics were identified as the dominant litter category, accounting for 90.95% by density and 53.76% by weight. In terms of usage categories, mixed packaging wastes (MPW) represented the largest proportion, comprising 82.14% by density and 49.38% by weight.

Based on these results, several recommendations have been proposed to strengthen coastal management practices. First, it is suggested that public institutions—such as municipalities, coast guards, and governorships—enhance the frequency of inspections within the scope of their respective legal authorities. Raising public awareness is also a key priority, which can be achieved through educational programs on marine litter aimed at reducing waste generation at its source. Placing informational materials in high-traffic areas (shopping malls, ferries, and sea buses) represents a complementary measure to support awareness-raising efforts.

Furthermore, the implementation of regular marine and coastal monitoring programs is essential for assessing environmental conditions and informing evidence-based policy decisions. To mitigate waste originating from maritime activities, it is recommended that multilingual brochures (in at least six

foreign languages) be distributed to vessels in order to prevent the disposal of packaging waste into the sea. Moreover, marine litter action plans should explicitly incorporate measures targeting ship-based waste.

In addition, the effective management of marine litter pollution requires stricter regulation as well as systematic monitoring of industrial plastic discharges from coastal facilities. Seasonal monitoring programs—particularly during periods of intensified shipping and tourism activity—would enable timely detection and intervention. Equally important is the development of public awareness campaigns emphasizing the environmental and health risks associated with marine litter, thereby encouraging community engagement and behavioral change. Collectively, these recommendations enhance the practical relevance of our findings and provide a robust framework for the development of sustainable coastal management policies.

Finally, it is essential to prioritize the proper disposal and recycling of marine litter as part of precautionary measures. At the 73rd Marine Environment Protection Committee (MEPC) meeting, Decision MEPC.310(73), titled "Action Plan to Address Marine Plastic Litter from Ships", was adopted. It was emphasized that various research initiatives and regulatory developments are being undertaken at the international level to reduce marine plastic litter originating from ships. In addition, the protection of the marine environment requires the strengthening and periodic review of international conventions on marine plastic litter, to be developed on a global scale in cooperation with the relevant sectors [9].

ACKNOWLEDGEMENT

The authors thanks to Ahmet Hulusi Yenici, Uğur Yenici, Fikret Çakır and Barış Özalp for their help.

CONFLICT OF INTEREST

The author stated that there are no conflicts of interest regarding the publication of this article.

ETHICS APPROVAL

Ethics committee approval is not required for this study.

CRediT AUTHOR STATEMENT

Elif Yenici: Conceptualization, Methodology, Formal analysis, Investigation, Data Curation, Writing–Original Draft, Writing – Review & Editing, Visualization, Project administration.

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