

# Marine Litter: Composition in Eastern Aegean Coasts

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Received 17 April 2014; revised 20 May 2014; accepted 23 June 2014

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## Abstract

In this study, 28 trawl operations were carried out from four different bays (Gulf of Kuşadası, Gulf of Güllük, Gulf of Gökova and Marmaris) in eastern Aegean Sea between December 2008 and March 2011. Sampled litters were separated by materials: glass, plastic, metal, wooden and others. Totally, as percentage, plastic material comprises the biggest group (48%) and it is followed by metal (25%), glass (12%), others (12%) and wooden (3%). Also regional litter densities were calculated for regions as 1692.0 item/km<sup>2</sup> for Marmaris, 796.0 item/km<sup>2</sup> for Gulf of Güllük, 175.0 item/km<sup>2</sup> for Gulf of Kuşadası, and 58.0 item/km<sup>2</sup> for Gulf of Gökova.

## Keywords

Marine Pollution, Aegean Sea, Gulf of Kuşadası, Gulf of Güllük, Gulf of Gökova, Marmaris

**Subject Areas:** Environmental Sciences, Hydrology

## 1. Introduction

Ocean litter—also commonly referred to as “marine debris”—is a persistent and growing worldwide problem [1]. “Marine litter” is described by [2] as: “items that have been made or used by people and deliberately discarded or unintentionally lost into the sea and on beaches including such materials transported into the marine environment from land by rivers, draining or sewage systems or winds”. Marine habitats are contaminated with man-made items of litter from the poles to the equator and from shorelines, estuaries and the sea surface to the depths of the ocean [3]. Contingent on their sources and driving forces, waste materials may be distributed in large distances and depths at sea [4].

Marine litter dispersion and deposition are strongly influenced by ocean currents, tidal cycles, regional-scale

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topography, including sea-bed topography and wind [5]. The very slow rate of degradation of most marine litter items, mainly plastics, together with the continuously growing quantity of the litter and debris disposed, is leading to a gradual increase in marine litter found at sea and on the shores [6]. Many of these items are highly buoyant, allowing them to be carried in currents for thousands of miles, endangering sensitive marine ecosystems and wildlife along the way [7]. Litter in the sea affects marine fauna through entanglement, or ingestion of such materials by animals [8]. The accumulation of such debris can inhibit the gas exchange between the overlying waters and the pore waters of the sediments, and the resulting hypoxia or anoxia in the benthos can interfere with the normal ecosystem functioning, and alter the make-up of life on the sea floor [9].

Marine litter threatens oceans and coasts, marine life, economy, safe navigation, and human health and safety [10]. Such litter can be harmful to wildlife and to human health [1] [11], medical and sanitary waste, and pieces of broken glass or metal, constitute a health hazard and can seriously injure people, directly or indirectly, discarded fishing nets can be a safety risk to boaters and divers [12], it has the potential to transport organic and inorganic contaminants [13] [14], can present a hazard to shipping and can be aesthetically detrimental [15]. Ghost fishing by loss of fishing gears causes economic losses [16] and cleaning of fishing gear from litters that causes time spent on fishing activities [17]. Ocean litter has been shown to affect at least 267 species worldwide, including sea turtles, seabirds and marine mammals [18].

Eastern Aegean coasts have been used by Greece and Turkey since the beginning of time. Coastal range between Greece Islands and Turkish coasts is not wide in many places. For example, the distance between Samos Island and Gulf of Kuşadası is only 1.58 km. Many activities such as industrial shipping, fishing, and yachting are made in this coastal area. Due to intensive use of the area, coast pollution observed frequently, and seabed is occupied by litters come from both countries.

This study aims to learn the composition of marine litter found on the seabed of Eastern Aegean coasts and determine the litter sources and to find a way of conservation and prevention methods for natural life and human benefits. This is the first attempt to present the marine litter in eastern Aegean coasts of Turkey.

## 2. Material and Method

### 2.1. Study Locations

Trawl operations has been done in Marmaris, Gulf of Gökova, Gulf of Güllük and Kuşadası (**Figure 1**). Selected study locations are also four important tourism regions for Turkey. Especially in summer times, lots of foreign and native tourists go for holiday to these regions (It means that increasing of tourism traffic) and they make a pressure on these cities and their vicinities for 5 months. So we decided to work in these highly “under pressure” tourism regions.

### 2.2. Sampling and Method

Study was done in legal and prohibited areas for fishing activities. Trawling method which had been used by previous studies was considered the most suitable method for sampling [19]-[21]. From December of 2008 to March of 2011, 28 trawl operations were done in Gulf of Kuşadası, Gulf of Güllük, Gulf of Gökova and Marmaris. Trawl ship is 26 m long and demersal trawling vessel. The trawl net which was used in study was a “Mediterranean Type Traditional Trawl Net”. One trawl operation was taking 2 hours with speed of 2.5 knots. Trawl net horizontal mouth width was measured as 32 meters. Trawling area’s depths change from 9 to 210 meters. All litters was separated by materials as plastic, metal, wooden, glass and others, than counted for each hauls. Litter sources were estimated after materials were grouped.

### 2.3. Data Analysis

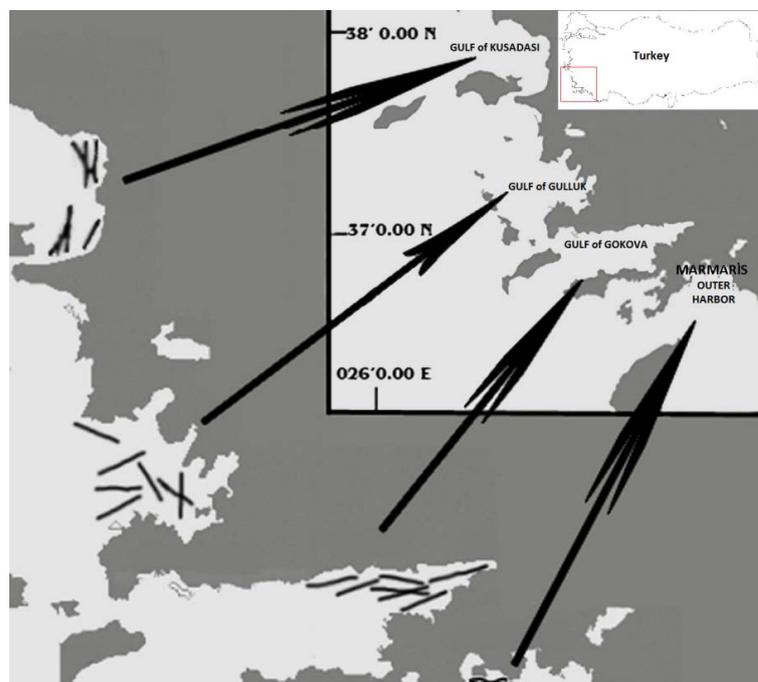
Litter densities, for each region, have been calculated with equation below [22]:

$$“D = n/A”$$

where “*D*” is the density of litters per km<sup>2</sup>, “*n*” is the number of litters collected and “*A*” is trawled area (km<sup>2</sup>).

## 3. Results

Totally, 806 waste materials were collected. Surface of the one trawled area has been calculated as 0.29632 km<sup>2</sup>.



**Figure 1.** Study Area.

Litter concentrations were ranged between 58.0 and 1692.0 item/km<sup>2</sup>. Sources of litters were determined as domestic, fishing, recreational, yachting and rivers (**Table 1**).

Plastic material was found the highest value in all hauls as 47.89% (386 items) in total percentages. Plastic is followed by metal 25.19% (203 items), glass 12.53% (101 items), and other materials by 11.54% (93 items) and wooden 2.85% (23 items) (**Figure 2**).

Litter counts are shown in **Table 2**. Marmaris was found as the most polluted region (1692.0 item/km<sup>2</sup>), followed by Gulf of Güllük (796.0 item/km<sup>2</sup>), Gulf of Kuşadası (175.0 item/km<sup>2</sup>) and Gulf of Gökova (58.0 item/km<sup>2</sup>).

## 4. Discussion

### 4.1. Litter Transfer, Accumulation and Effects

Marine pollution, in recent years, impends and damages the natural life. Litters which transport easily to distant localities by local currents and global currents do not influence only one locality. In shallow coastal areas, the abundance of marine debris is generally much greater than on the continental shelf or on the deep seafloor, with the exception of some accumulation zones in the open sea [23]. Greater abundance of marine debris has been found in bays than in open coastal areas, which is a result of the influence of hydrodynamics [24] [25]. In bays, it is more difficult for litter disposed locally to be transported away from the point of disposal, due to weaker currents, and thus it is more likely to accumulate on the bottom. Furthermore, in open coasts, wave action may transfer a large portion of the marine debris from shallow areas to the shore [2].

Marine pollution leads to:

- Nanopolystyrene beads can inhibit photosynthesis and cause oxidative stress in algae [26].
- Marine debris can also cause habitat destruction by affecting water quality and causing physical damage to sensitive ecosystems. Coral reefs, sea grass beds and their bottom-dwelling species are very susceptible to the impacts of marine debris [27].
- Detent the selectivity with choking off access of meshes in fisheries and curling to fishing gears cause to losing time and fishing amounts when doing clearing processes [3].
- Marine mammal species entangle in and ingest many different types of debris, including derelict fishing gear and plastics [28].

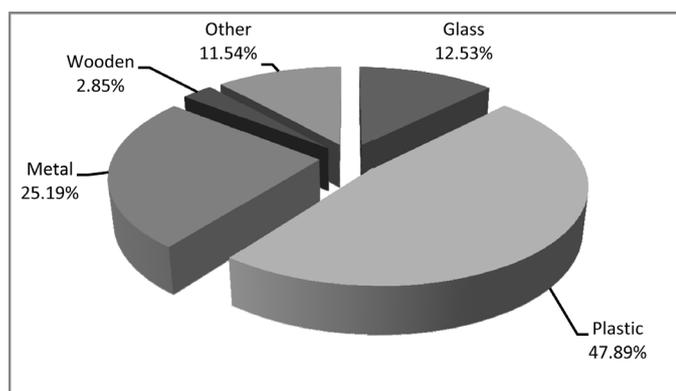
**Table 1.** Materials: by groups, item varieties and litter sources.

Groups	Items	Sources
Metal	Barrel, Anchor, Cans, Fridge, Fire extinguisher, Chains, Coasters, Chairs, Guy (Steel Robes), Fishing hooks, Knives, Door handles, Tabor, Frames, Bucket, Bicycle	Fishing Yachting Domestic By Rivers
Glass	Bottles, Glass cases, Glass	Yachting Recreation
Wooden	Logs, Twigs, Cabinets, Vessel Parts	Domestic Fishing By Rivers
Plastic	Fender, Mug, Fishing line, Feeding bag, Bottle, Basket, Tent, Jack, Nylon, Buckle, Seat sponge, Snorkel, Mask, Flippers, Sea-Beds, Canoe, Bag, Shoe, Rosary, CD's, Cable, Condom, Socks, Tires	Domestic Yachting Recreation By Rivers
Others	Fabric, Porcelain, Lamp Shade, Robe, Saddle, Swim-Wear, Fishing Nets, Tires, Papers, Mobile Phones, Television, Radio, Books, Photograph Papers, Video Camera, Hats, Heater, Kettle, Headphones, Clocks, Plaque, Purses, Socks (Wool)	Domestic Recreation By Rivers

**Table 2.** Litter counts (per 1 km<sup>2</sup>).

Material (item/km <sup>2</sup> )	Gulf of Kuşadası	Gulf of Güllük	Gulf of Gökova	Marmaris Outer Harbor
Glass	17.0	10.0	0.00	314.0
Plastic	128.0	469.0	34.0	672.0
Metal	30.0	81.0	7.0	567.0
Wooden	0.0	10.0	17.0	51.0
Other	0.0	226.0	0.00	88.0
Total	175.0	796.0	58.0	1692.0

\*One trawled area was calculated as 0.29632 km<sup>2</sup> per operation.

**Figure 2.** Distribution and percentage of litters.

- Lost fishing gear and gear parts are the most hazardous types of marine litter's pollution for marine life [29].
- Litter found in an off-shore fishing bank, has caused a serious economic loss to fishermen in fisheries [30].
- Marine debris washing ashore can be also be an aesthetic problem on beaches and may cause economic losses to tourism because it discourages swimming, boating and fishing activities [31].

#### 4.2. Reasons of Pollution in the Study Locations

Plastic and synthetic materials are the most common types of marine debris [32] [22]. Almost every packaging and covering processes are done with plastic or other materials derived from it.

In Turkey, despite presence of marine pollution prevention law [33], there is a serious situation emanates from absence of enough inspection mechanisms. Pollution from ships is clearly touched in [34]. Also Turkey has signed the protocol. Turkish seas have dense marine traffic such as fishing activities, container ships and daily tours especially during summer times. Without solid litters, also bilge water discharges contribute to pollution.

Regions which are studies carried out, are known by all over the world as very famous tourism regions. Besides, these regions are used excessively by shipping, yachting, daily tours, fish aquaculture systems and fishing activities. Without these factors, a few rivers and hotels discharge their waters to these regions.

South Aegean area is a favorite region for many indigenous and foreign tourists especially in summer times. So, population increases in coastal regions and makes pressure on seas. Besides, this region which includes some of the important Mediterranean harbors, does not only polluted by territorial litters but also it is polluted by blue tours, fishing and shipping activities.

Marmaris is known all over the world. There are so many hotels and inhabitants in this region. Especially in summer time, nearly 8.5 million tourists visit south-west of Turkey's coasts. Outer harbor is effected heavily from daily tours and yachting. Without this, also marine traffic has a big role in litter pressure on here. 2399 ships (Commercial and Personal ships) had come to only Marmaris region in 2010 [35]. In 1992 and 2007, there were two floods in Marmaris. For this reason, so many goods and other items (cans, plastic bottles, wooden etc.) passed to marine environment from territorial area (Table 2).

Gulf of Güllük is the biggest center of fish aquaculture systems in Turkey. There are too many fish aquaculture systems and hotels in this region. In addition to these factors, there is a big lagoon (Gulf of Güllük Lagoon) and fresh water source (Sarıçay River) in this gulf. Because of these situations, a great pressure exists on Gulf of Güllük. Except "plastic" material group, "other" material group litter numbers have considerable counts in this region. Fish aquaculture systems' wastes (Especially feeding bags, robes, and plastic materials), fishing activities (Trawling, loglines, longnets etc.), currents, and submerged illegal (refugee) boats had made it variable and high amounts (Purses, pants, fabrics, photograph papers etc.) (Table 2).

Gulf of Kuşadası is one of the biggest harbors in Mediterranean area. City reclines along with the coast. Great touristic passenger ships, fishing activities (Longline, trawling, purse-seining etc.) and domestic litters are sources of marine litters of Gulf of Kuşadası. During the sampling, especially, fishing and domestic plastic litters (plastic spoon, forks, bottles, plates etc.) have been found higher than other groups (Table 2).

Gulf of Gökova has the lowest litter density compared with the other areas. Because, daily tour ship owners are very sensitive, there is no broadly fishing activity and too much residential area and gulf is a close area towards most winds. So terrestrial litter transfer is weaker than the other regions by winds (Table 2).

Some of previous studies which have been done in Mediterranean, Aegean Sea and Turkish coasts of Black Sea are shown on Table 3.

### 4.3. Outputs and Suggestions

Most of countries and associations (USA, Australia, UK, Korea, EU, etc.) make studies on for prevent marine pollution [6]. Marine pollution studies in Turkey are insufficient for making decision in management.

In accordance with the study, for the lowest marine pollution or completely removing:

- Increasing natural awareness.
- Local and national briefing about dimensions of pollution in seas.
- Increasing inspections and applying sanctions.
- Working with universities for orientated work on decreasing existent of pollution.
- Instead of widely used plastic material, necessitate to using easy recycling material.

**Table 3.** Previous studies.

Material (%)	Eastern Mediterranean [25]	Western part of The Turkish Black Sea [21]	This Study
Glass	2.09	0.8	12.53
Plastic	60.6	92.5	47.89
Metal	25.73	2.1	25.19
Wooden	-	1.7	2.85
Other	11.55	6.6	11.54

- Especially, working with bottom hauling gears owner's, consciousness of marine pollution was raised and told them to dump the litter taken out from sea bottom by hauling gear not back at the sea but to the land.
- Taking precautions for drifted territorial litter source with river currents and sewers before reaching to marine environment.
- Recycling centers should not be built near coasts and their numbers should be increased.

Monitoring of marine pollution is an advantage for decreasing environmental and socioeconomic damages. So management plans can be made easily according to polluted regions. Raising awareness on preventing marine pollution should be the main subject of studies.

World seas and oceans are not only considered with their offers also we have to respect them as habitat of living organisms.

## Acknowledgements

Thanks for obtaining materials during the sampling period, typing and statistical analyzing processes to Sercan YAPICI, Özde ÖZKAN and Uğur KARAKUŞ and valuable shipmasters and crews of AKYARLAR, ÖMER EFE and DEVLET-3 trawl ships.

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