

Man-Made Garbage Pollution on the Mediterranean Coastline

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Measurements of persistent litter on 13 beaches in Spain, Italy (Sicily), Turkey, Cyprus and Israel between 1988 and 1989 show that plastic items are the most abundant in the litter composition, followed by wood, metal and glass items. Remnants of fishing gear are rather rare. It appears that the quantity of litter on a beach is inversely related to its geographical distance to a population center and directly related to the number of visitors frequenting it. Seasonal fluctuations in coastal litter are caused by storm waves which wash the litter landward, leaving the beach clean during winter, and by bathers who pollute it during summer. Based on the nature of the garbage, there are indications that most Mediterranean coastal litter is land-based, in contrast to the reported marine-based litter on the western European shores.

The beach is susceptible to litter accumulation because floating garbage discarded at sea from ships is swept by winds and currents until it lands on the beach. Litter also reaches the beach from land by drainage of uncovered garbage dump sites as well as by people who come to the beach for recreation and leave their debris behind. The deleterious effect of litter on the coastal environment is twofold: (a) animals, mostly birds, get entangled in it, and (b) it causes aesthetic deterioration of the beach. In view of the recent intensive development of coastal oriented tourism, the aesthetic effect has not received proper attention. This is especially true of the Mediterranean Sea, which attracts tourists by the millions to its beaches, particularly from the cold and rainy European countries. In the last two decades, tourist arrivals to Mediterranean countries increased by 50-600%, and most of these tourists spend their time near the beach (Blue Plan, 1987). As littered beaches are a major deterrent to tourists, this problem is of great economic importance for the Mediterranean countries.

The Protocol for the protection of the Mediterranean Sea against pollution from land-based sources, which is related to the Barcelona Convention, stipulates that Contracting Parties undertake to eliminate pollution of, among others, persistent synthetic materials. To this end, parties should "elaborate and implement ... as appropriate the necessary programmes and measures". The information on man-made litter in the Mediterranean is rather limited. The presence of plastic beads on the shores of Lebanon and Spain was described by Shiber (1979, 1982, 1987) and floating garbage in the central and eastern Mediterranean by Morris (1980), Saydam et al. (1985) and McCoy (1988). Bingel et al. (1987) have reported on litter found on the sea bottom. In view of the meager information on litter in the Mediterranean Sea, IOC, FAO and UNEP initiated a pilot survey of the litter in the Mediterranean, in the framework of the MED POL activities. The survey was conducted in five Mediterranean countries: Spain, Italy (Sicily), Turkey, Cyprus and Israel. The purposes of this survey were, to determine the nature and quantity of the litter, to indicate the factors which control its distribution, and to determine its sources. The survey included some work on sea bottom as well as floating litter, but only the results of the beach survey are presented here.

Material and Methods

In all, 13 beaches were monitored in the five Mediterranean countries. These beaches do not undergo regular cleaning by local authorities. The beaches were sampled once a month (in one case more frequently) between mid 1988 and mid 1989. Several sampling transects were selected randomly on

each beach. The transect width varied from country to country (see Table 1), and its length was from the waterline to the back of the beach, defined by the foot of the cliff, dune or vegetated area. Litter pieces, larger than 1-2 cm, were collected from the transect and constituted a sample. The material was classified into categories (plastics, wood, Styrofoam, fishing gear, glass, metal and others), and the results were expressed as counts of litter pieces and/or weight per frontal meter of beach. A list of the beaches, their location, and information pertinent to the sampling procedure and beach characteristics are provided in Table 1.

Table 1. Monitored Beaches, Location, Sampling Procedure and Relevant Information

Name of beach	Location		No. of transects	Transect width (m)	Sampling period	Proximity to population center	Abundance of bathers
	Long.E	Lat.N					
San Lorenzo, Spain	03°26'	39°13'	2	1	Jun 88-Apr 89	25 km	low
Ficarazzi, Sicily	13°30'	38°06'	2	3	Oct 88-May 89	near	medium
Balestrate, Sicily	13°02'	38°03'	2	3	Oct 88-May 89	3 km	high
Eraclea, Sicily	13°17'	37°24'	2	3	Oct 88-May 89	20 km	low
Lara, Cyprus	32°19'	34°56'	11	1	Oct 88-May 89	isolated	very low
Makronissos, Cyprus	33°58'	35°02'	5	1	Oct 88-May 89	near	high
Erdemli, Turkey	34°20'	36°31'	3	100	Jun 88-May 89	isolated	low
Beit Yanai, Israel	34°54'	32°24'	6	5	May 88-May 89	50 km	high
Dor, Israel	34°56'	32°32'	5	5	May 88-May 89	30 km	high
Neveh Yam, Israel	34°57'	32°36'	6	5	May 88-May 89	20 km	very low
Carmel Beach, Israel	34°59'	32°45'	6	5	May 88-May 89	near	very high
Haifa Bay, Israel	35°04'	32°49'	6	5	May 88-May 89	near	medium
Akhziv, Israel	35°07'	33°04'	8	5	May 88-May 89	30 km	low

Results

Litter Composition

Figure 1 shows the relative abundance of the various litter categories in the surveyed countries. Plastic materials are by far the most abundant component, ranging between 49-71% by count and 25-71% by weight. The only exception is Sicily, where construction material is the most abundant component (by weight). The plastics fraction consists of fragments, sheets, bags and containers. The order of abundance of the other litter categories varied somewhat from country to country, but in general wood is second in abundance followed by metal and glass at 2-5% each, except for Cyprus where glass by weight was 22%. Most of the metal fraction consisted of cans and aerosol containers, and the glass consisted mostly of bottles and to a lesser extent light bulbs. The relative abundance of pieces of Styrofoam was 3.5-9.3% but only by count. Conspicuously rare was fishing gear - 2.8% was the highest recorded abundance, in Turkey. Under the category of "others", a large variety of items are found, including clothing, cartons, paper, foam rubber, toys, etc.

Litter Distribution in Space and Time

Table 2 provides the mean litter quantity on each of the studied beaches (except Erdemli, Turkey, where the whole beach was sampled) in terms of the number of litter pieces and weight per meter of frontal beach. The most contaminated beach is that of Ficcarazzi, Sicily and the least contaminated are Neveh Yam and Beit Yanai in Israel. A ranked Duncan test (Steel & Torrie, 1960) which was carried out on the data from Israel (Golik and Gertner, submitted for publication) show that there is a significant difference between the beaches of Akhziv and Carmel and that of Neveh Yam.

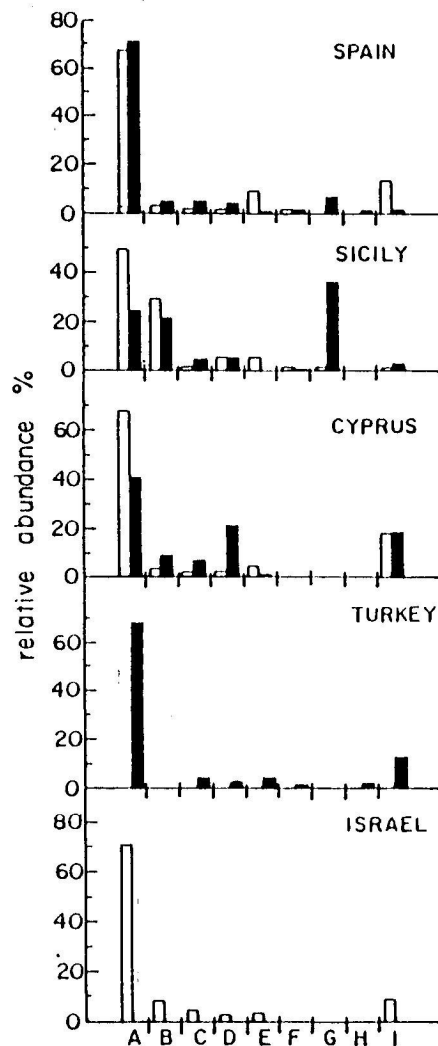


Fig. 1. Relative abundance of litter components (by counts and weight) in the studied countries. A - plastics, B - wood, C - metal, D - glass, E - Styrofoam, F - fishing gear, G - construction material, H - rubber, I - other.

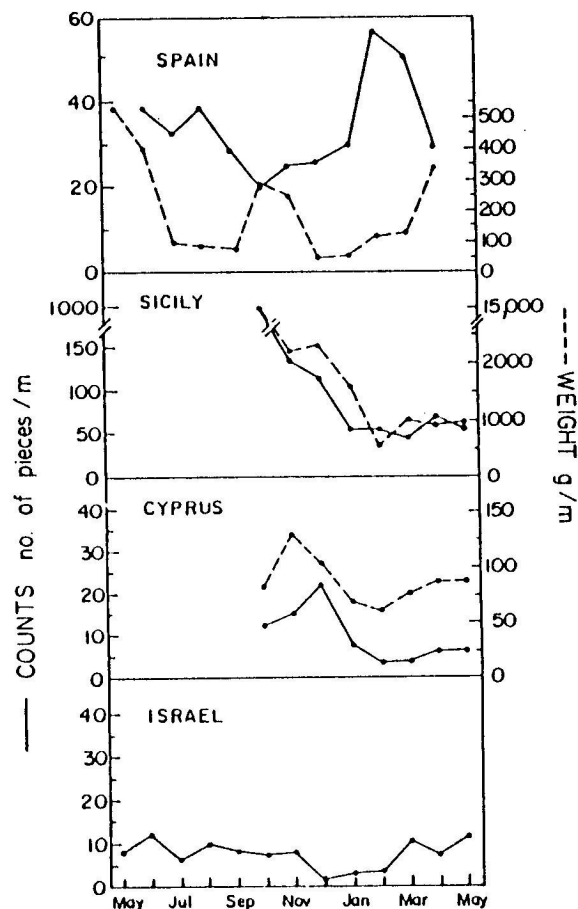


Fig. 2. Litter quantity (counts and weight) as a function of time. Values normalized to 1 m of beach front. Note differences in scales for the various countries.

Figure 2 shows the mean quantity of litter for each of the participating countries as a function of time. The results do not show a clear pattern which is common to all of the coastlines. Perhaps the only common pattern of behaviour is between Sicily, Cyprus and Israel, where a reduction in the quantity of litter occurs during the winter (December-February).

Discussion

Factors Controlling Litter Distribution

The high variability in the litter distribution in the field (see the standard deviation values in Table 2), and the differences between the sampling procedures employed in the various countries, make it difficult to relate the results to factors which control the geographical and temporal distribution of the litter. Nevertheless, some trends may be detected. Ficcarazzi, which is the most contaminated beach in Sicily, is in the vicinity of Palermo, the largest city in Sicily, whereas Eraclea, the cleanest beach, is located far away from a population center and is not frequented by many bathers. Similarly, in Israel there is a significant difference (statistically) between the beach of Carmel, which is near a population center (Haifa), and Neveh Yam, which is an isolated beach with only a few visitors. It seems that distance of a beach from a population center is one of the factors which control the quantity of litter on a beach. The results from Cyprus, however, show an opposite trend. Lara, which is an isolated beach, is twice as polluted as Makronissos, which is near a population center. This is probably due to the exposure of Lara to the predominantly westerly winds which cause marine-based garbage to accumulate on this particular beach.

Table 2. Mean litter quantity for the sampling period on the monitored beaches (normalized to 1 m frontal beach)

Name of beach	No. of samples	Mean number of pieces		Mean weight	
		pc/m	± SD	gr/m	± SD
San Lorenzo, Spain	18	33		159	
Ficcarazzi, Sicily	16	231	217	3137	2385
Balestrata, Sicily	16	54	22	1270	1117
Eraclea, Sicily	14	9	2	205	101
Lara, Cyprus	88	12		101	
Makronissos, Cyprus	35	7		51	
Beit Yanai, Israel	78	6	4	-	
Dor, Israel	64	7	4	-	
Neveh Yam, Israel	78	6	3.5	-	
Carmel Beach, Israel	84	8	4	-	
Haifa Bay, Israel	72	7	4	-	
Akhziv, Israel	96	9	6	-	

The observed decline in the quantity of litter on some of the coasts during winter is attributed to the influence of high waves which wash the garbage to the back of the beach and even beyond it landwards during storm periods, leaving the beach clean or relatively clean from litter. During the summer, bathers cause an increase in the garbage level.

Sources of Litter on the Mediterranean Coastline

The source of coastal litter is perhaps the most important issue of the litter problem because it has a direct bearing on the strategy which should be employed to control it. There are no clear and specific indicators of litter sources. However, a comparison of litter found on the Mediterranean beaches with that reported from other beaches in the world suggests that most of the coastal litter in the Mediterranean is land-based.

Dixon & Dixon (1981, 1983) report that litter investigations on the Atlantic coasts from Portugal to Jutland, Denmark, show that the most abundant discarded containers on the beach were those of household detergents and lavatory cleansers. As these materials are not normally brought to the beach by visitors who come there for bathing and recreation, the conclusion was that these were discarded from ships at sea. This conclusion is further supported by the containers' labels which indicated that most of them were alien to the beach on which they were found.

Although no actual count of discarded containers on the Mediterranean beaches was carried out in this study, it is the feeling of the authors, based on observations in the field, that most of the containers (plastic, metal and glass) were used for beverages, food and cosmetics (mostly suntan lotion). These are typical of garbage left behind by people who come to the beach for picnics and recreation. The other components of the litter: plastic handbags, pieces of clothing, toys and foam rubber mattresses, indicate the same. The conclusion that most of the litter on the Mediterranean beaches is land-based is further supported by the scarcity of remnants of fishing gear which is a typically marine-based component.

The hypothesis that most of the coastal litter in the Mediterranean is land-based needs further investigation and proof. If it is confirmed, the implication is that the responsibility for clean beaches lies mostly with those who come to enjoy the beaches and the local authorities that govern these beaches.

This IOC/FAO/UNEP study was undertaken within the framework of the MED POL activities and was supported through the MED Trust Fund.

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