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PROOF RESEARCH PAPER

The Influence of Land Use on Coastal Litter: An Approach to Identify Abundance and Sources in the Coastal Area of Cilician Basin, Turkey

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Abstract

The Cilician Basin located in the Northeastern Mediterranean is a region that is affected by a diversity of anthropogenic pressures and is further expected to suffer from negative economic, environmental and social impacts of coastal litter. To provide a baseline for litter management plans, the standing crop of coastal macro-litter was sampled on 13 beaches following MSFD guidelines. Environmental predictors characterizing beach use and potential land based litter point sources in the vicinity of the beaches were related to litter densities to identify litter sources. The average litter density was 0.92 ± 0.36 items/m^2. Litter items resulting from convenience food consumption and smoking made up more than half of the total litter collected, while agricultural, industrial, fishing activities together contributed only 6% of the total number of items. Plastic items on average constituted more than 80% of the dominant material type. Percentages of the litter transported with currents from neighbouring countries (transboundary litter) varied from 0 – 4.23% between beaches. Direct deposition on the beaches was identified as the main method for transport of items to the coastal environment. Our results show poor local awareness and underline the need for educational programs that can help reduce coastal litter.

Keywords: Beach litter, MSFD, marine litter, litter classification, functional litter groups.

Introduction

Marine litter, defined as "any persistent solid material that is manufactured or processed and directly or indirectly, intentionally or unintentionally, disposed of or abandoned into the marine environment" (UNEP/MAP 2011), is recognized as one of the most prevalent pollution problems of our time (Sheavly & Register 2007). While the majority of marine litter is observed to sink and remain on the sea floor as benthic litter, litter ending up on the sea shore represents a rather small fraction of the total marine litter (estimated as 15% of all marine litter) (Cheshire et al. 2009). However, due to its diverse economic, ecological and social impacts, coastal litter is the most commonly assessed litter pool.

Macro-litter beach surveys are cheap and easy to implement (MSFD GES Technical Subgroup on Marine Litter 2011). They are understood as a primary tool to derive information on the state of litter pollution of the adjacent marine environment. Coastal litter surveys can focus on the standing crop of litter on a coastline or on coastal litter fluxes. While the latter helps to understand seasonal or annual changes in litter loads, the former serves as a snapshot of the level of pollution in a region. In order to standardize coastal litter surveys and hence make gathered data comparable, the European Marine Strategy Framework Directive (MSFD) has introduced in Descriptor 10 a coastal litter sampling methodology which is to be applied by all its contracting parties. Results of these surveys form an important baseline for the determination of Good Environmental Status (GES), which is aimed to be achieved in all European Seas by 2020 (MSFD GES Technical Subgroup on Marine Litter 2011).

Turkey as an associated member of the EU is seeking to harmonize national legislation with EU legislation, including the implementation of the MSFD. However, only a limited number of studies have been carried out in the Turkish coastal environment to date (Topçu et al. 2013; Balas et al. 2003; Tudor et al. 2002; Gabrielides et al. 1991). Identification of the baseline of litter pollution, i.e. the standing crop of litter on Turkish beaches is urgently needed to evaluate the state of litter pollution and develop successful management plans.

To reduce or avoid negative impacts of coastal litter, the identification of litter sources is also indispensable. Despite the international pressure for

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standardizing coastal litter surveys and the crucial role of identifying the litter source, a sound and easily applicable methodology for litter source determination is lacking worldwide. Hence, information on litter sources is in general either absent or insufficient. In literature, the term 'litter source' is used ambiguously (Cheshire et al. 2009). It either refers to the spatial component of a source, i.e. to the point of emergence of a litter item (*origin*) or to the last type of usage or activity, where an item was employed (*function*) (Williams et al. 2003).

The Cilician Basin is a densely populated and multi-use region where agricultural, touristic, fishing and industrial activities co-dominate. Especially in the west of the region, human settlements are mostly confined to a narrow strip along the coast. This consists to a high extent of summer residences for domestic tourists, which leads to a remarkable increase in coastal inhabitants during the summer months (Ozhan 2005; Güler et al. 2012). These conditions cause a high emergence of litter, potentially leading to a diversity of adverse effects on the economy, society and the environment in the region. For instance, coastal litter was identified as the main complaint of both foreign and domestic beach visitors in the region, possibly triggering economic losses in the tourism industry by negatively affecting the aesthetic beauty and safety of the beaches (Birdir et al. 2013). To evaluate the level of pollution in the Cilician Basin, this study aimed to gather data on the standing crop of litter and to identify likely sources of the encountered litter. In this study 13 sites in the Cilician Basin in the Eastern Mediterranean were surveyed in April 2014 using the coastal litter sampling design proposed by the MSFD (Galgani et al. 2013). The detected sources of coastal litter can be used as a basis for regional litter management plans.

Materials and Methods

Sources of marine litter were assessed both in terms of function and origin by also taking into account transboundary litter items and secondary uses of items. Therefore, the relationship between environmental predictors and litter densities was assessed using Multivariate Adaptive Regression Splines (MARS) (Friedmann 1991). MARS fits non-linear relationships between predictors and a response variable and has been shown to perform better than earlier techniques such as generalized linear models (GLM) and generalized additive models (GAM) in the detection of environmental relationships of species (Leathwick et al. 2006).

Sampling Sites

The sampling region comprises the Turkish coast of the Cilician Basin in the Northeastern Mediterranean. 13 sites in the region each featuring a minimum length of 100 m and sand (n=12) and small gravel (n=1) as substrate types were selected as sampling sites (Figure 1). All sampling sites were easily accessible and hence suitable for future comparative studies on litter development.

Coastal Litter Sampling

The sampling was carried out in April 2014 prior

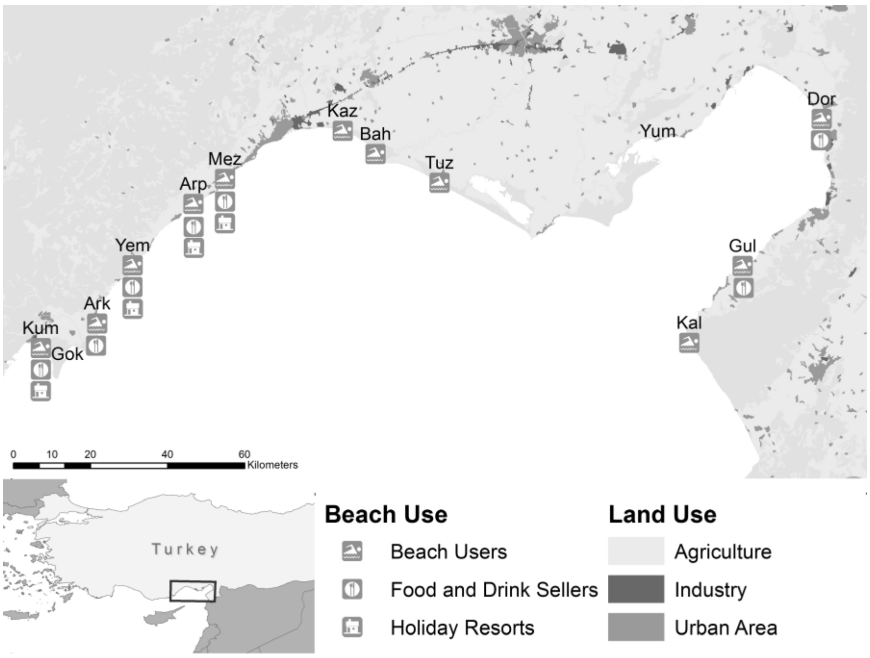

Figure 1. Overview of land-use in the Cilician Basin and the beach-use of the sampling beaches.

to the start of the tourism season in order to avoid data distortion through local beach clean-ups. All beaches experienced similar weather conditions, with no storms or heavy rainfalls occurring in the week before sampling. Coastal macro-litter, i.e. items of artificial or processed material greater than 2.5 cm in the longest linear dimension, were sampled following the MSFD guidelines (MSFD GES Technical Subgroup on Marine Litter, 2011). Accordingly, a 100 m length stretch of a site of interest was sampled from the shoreline to the back beach and assessed both in terms of litter abundance and litter weight (wet weight, accuracy 0.005 kg, items of the same category were weighed together). Due to the expected high abundance of cigarette butts, these were only sampled within a 10 m subunit, determined at one edge of the 100 m sampling unit (Cheshire *et al*., 2009). In case of the presence of legible location identifiers, the country of origin, when different to Turkey, was documented. The respective items are understood as transboundary litter items.

To allow comparability with other publications on coastal litter surveys, litter abundance was expressed as number of items per meter of shoreline [items/m], number of items per square meter [items/m^2] and weight per square meter [g/m^2]. Litter densities [items/m^2] were related to the beach cleanliness categories of the Clean-Coast-Index (very clean, clean, moderate, dirty, extremely dirty) (see Alkalay *et al.* (2007) for a detailed description).

Litter Classification

Each litter item was attributed to a function, also taking into account secondary uses of items. In the study region, secondary usage mainly applied to cut plastic bottles (used as funnels) and old tires with punched holes for rope attachments (used as fenders). Previous studies reported difficulties when broad and overlapping categories, like "recreational boating" and "tourism", were included (Tudor et al. 2004; Kordella et al. 2013). These impede a clear attribution of frequently encountered items such as plastic bottles and convenience food wrappers, which are likely to emerge during more than one of these activities. By splitting these widely used *function* categories into more distinct categories such as "Rapid Consumption", "Personal Use" and "Recreation" a clear attribution of items was facilitated. In total, twelve distinct function categories were identified based on the last activity or type of usage, where an item was employed (Table 1, *see supplementary material for detailed list).*

The material type of each litter item was reported according to MSFD categories (Cloth, Foamed Plastic, Glass and Ceramics, Metal, Paper and Cardboard, Plastic, Rubber, Wood) (MSFD GES Technical Subgroup on Marine Litter 2011). In case of an item being composed of more than one type of material, the predominant material type was used for categorization.

Litter *Origin* Determination

Land-use Parameters

Eight land-use parameters were recorded to characterize the environment of the sampling sites (Table 2). These environmental predictors are considered as a proxy of potential land-based point sources of litter emergence, i.e. litter *origin* (Cheshire et al. 2009).

The use of the beach by beach goers, the presence or absence of food or drink sellers as well as of weekend houses or holiday resorts within the direct vicinity of the beach was recorded on site. The straight line distances between the sampled stretch of the beach and the nearest river mouth were extracted online from the *GeoData – v.6.0* database of the Turkish Ministry of Forest and Water Management (resolution 1:250,000; available on *geodata.ormansu.gov.tr*). Air-line distances were measured between the center of the sampled stretch and the closest border of industrial areas (CORINE Land Cover (CLC) 1.2.1) and of commercial ports (CLC 1.2.3) according to the CORINE data set (2006) of the European Environmental Agency using ArcGIS 10.1. Information on the extent of agricultural (CLC 2) and populated sites (CLC 1.1 and 1.4.2) was extracted over an 8 km radius of each sampling site. Taking into account topography and distribution of natural sites, this radius was considered to be representative for the characterization of the immediate beach environment in the Cilician Basin. The radius size may differ for other study regions.

Multivariate Adaptive Regression Splines (MARS)

The above defined eight land-use parameters were related as predictors to *function* densities using Multivariate Adaptive Regression Splines (MARS) (Friedmann 1991). MARS is an adaptive non-parametric regression technique using piecewise linear segments to describe non-linear relationships between a response variable and a set of predictors. In one of its implementations, MARS can be used to select parameters which have a strong effect on the response variable. Accordingly, in this study MARS is used to identify a set of environmental predictors (i.e. *origins*), that is likely to have strong functional links with the obtained *function* densities.

The function 'earth' in the R package *earth* (default setting) was used for MARS construction (Milborrow 2014; R Core Team 2012). Thereby, a two-stage forward/backward procedure is automatically applied: In the forward stage all predictors are considered for the description of the response variable. In the backward stage predictors are dropped gradually. The final set of predictors is automatically chosen based on their contribution to

Table 1. Function categories for litter item classification

Function	Abbr.	Explanation
Agriculture	*Ag*	Packaging for fertilizer and pesticides, material for storage and transport of seeds and seedlings, tools and material used during the operation of agricultural fields
Fishing	*Fish*	Nets, ropes, lures and other fishing related items
Smoking	*Smo*	Cigarettes, cigarette butts and cigarette/filter/tobacco packages
Domestic and Household	*Dhr*	Cleaning and washing material, kitchen utensils, food storage containers and packages, light bulbs
Construction	*Con*	Construction material and waste, tools and equipment
General Packaging	*Genp*	Material and items for transport or storage of any kind of good
Rapid Consumption	*Rapd*	Take-away/convenience food wrappers and containers, drink containers
Medical and Personal Hygiene	*Hyg*	Pharmaceutical, cosmetic and care products and containers, protections against venereal diseases, handkerchiefs, diapers
Industrial	*Inds*	Chemical and engine oil containers, industrial scrap
Personal Use	*Per*	Stationary items, clothes, shoes, bags, glasses and sun glasses, hair-ribbons, hairbrushes
Recreation	*Rec*	Toys, beach use related cosmetics and toys, fireworks, balloons
Unclassified	*Un*	Pellets and unidentifiable pieces of items

Table 2. Description of the predictors used for the Multivariate Adaptive Regression Splines as proxies for land-based litter origins

Predictor	Type	Description	Unit	Source
Beach User	Beach Usage	Usage of the beach by beach users	Presence/ Absence	Own observation
Food and Drink Seller		Existence of food and drink sellers on or in the direct vicinity of the beach		
Holiday Resorts		Presence of holiday resorts and weekend houses in the direct vicinity of the beach		
Agricultural Area	Beach Environment	Agricultural area within an eight km radius around the sampled stretch	m^2	CORINE Land Cover Data (EEA 2006)
Inhabited Area		Urban area within an eight km radius around the sampled stretch		
Industrial Site		Airline distance between the sampled stretch and the closest industrial site	m	
Commercial Port		Airline Distance between the sampled stretch and the closest commercial port		
River		Airline distance between the sampled	m	Turkish Ministry of Forest

the accuracy of the data fit, assessed by the generalized cross-validation (GCV) criterion. Friedmann (1991) introduced the GCV as a trade-off between the goodness-of-fit against model complexity, with lower values representing a better data fit. R^2 is reported as coefficient of determination. Due to the limited number of data points it was not tested for interactions between the land-use parameters.

Two MARS runs were performed for each *function*. In the first run, all sampling sites (n=13) were included. A distinctive sediment composition at Dortyol (*Dor)* with pebbles rather than sand as the dominant grain type is expected to cause a change in accumulation patterns and enhances breaking of fragile items. Therefore, litter densities are affected by different inherent factors and hence may not be comparable to the other sampling sites. Considering this fact, a second run was performed excluding *function* densities obtained at *Dor* (n=12). Final model selection was based on the GCV values, with lower values representing a better data fit.

Results

Litter Abundance

In total 17,024 items were collected from the 13 beaches. The average litter density was 0.92 ± 0.36 items/m^2. The average weight was 7.43 ± 2.68 g/m^2. According to the Clean-Coast-Index (CCI) (Alkalay et al. 2007) three of the sampled beaches were clean or very clean, two were moderate and eight were found to be dirty or extremely dirty (Table 3).

Litter Composition

Plastic represents the majority of litter on all 13 beaches. On 11 of the sampled beaches, plastic items account for more than 73% of all litter items. The

Table 3. Observed litter densities on the sampled beaches and their respective Clean-Coast Index (Alkalay *et al.*, 2007)

Beach name	BeachID	Items/m^2	Item/m	g/m^2	CCI	Density [Items/M^2]											
						Ag	Fish	Smo	Dhr	Con	Genp	Rapd	Hyg	Inds	Per	Rec	Un
Kum Mahallesi	Kum	0.51	7.90	3.35	Dirty	0,005	0,020	0,284	0,009	0,006	0,019	0,097	0,013	0,002	0,005	0,003	0,051
Göksu Delta	Gok	0.02	0.55	0.42	Very clean	0,000	0,001	0,000	0,000	0,000	0,002	0,006	0,000	0,000	0,000	0,000	0,009
Arkum	Ark	0.70	15.45	8.70	Dirty	0,021	0,026	0,077	0,033	0,026	0,027	0,210	0,051	0,009	0,032	0,009	0,176
Yemişkum	Yem	0.96	15.98	2.73	Dirty	0,002	0,007	0,592	0,012	0,013	0,031	0,170	0,023	0,002	0,006	0,007	0,094
Arpaçbahşiş	Arp	1.31	18.63	4.08	Very dirty	0,003	0,010	0,898	0,021	0,017	0,056	0,142	0,033	0,004	0,002	0,006	0,115
Mezitli	Mez	0.70	5.27	4.00	Dirty	0,001	0,014	0,316	0,011	0,024	0,096	0,140	0,025	0,001	0,005	0,004	0,069
Kazanlı	Kaz	0.47	13.42	8.86	Moderate	0,015	0,017	0,023	0,017	0,026	0,063	0,152	0,019	0,002	0,010	0,006	0,116
Baharlı	Bah	0.43	17.53	6.14	Moderate	0,004	0,013	0,002	0,015	0,018	0,033	0,142	0,024	0,014	0,015	0,007	0,145
Tuzla	Tuz	0.67	25.33	8.06	Dirty	0,004	0,058	0,079	0,026	0,025	0,081	0,194	0,032	0,005	0,006	0,002	0,157
Yumurtalık	Yum	0.13	2.10	2.09	Clean	0,001	0,009	0,025	0,004	0,004	0,012	0,025	0,005	0,002	0,005	0,000	0,042
Dörtyol	Dor	5.15	60.4	38.30	Very dirty	0,024	0,192	0,998	0,058	0,280	0,366	2,284	0,114	0,027	0,032	0,039	0,733
Gülcihan Köyü	Gul	0.68	12.92	6.94	Dirty	0,000	0,028	0,111	0,020	0,016	0,054	0,212	0,062	0,000	0,006	0,004	0,163
Kale Köyü	Kal	0.24	4.96	2.92	Clean	0,000	0,008	0,001	0,040	0,004	0,015	0,075	0,008	0,000	0,001	0,001	0,090
Mean ± se		0.92±0.36	15.42±4.25	7.43±2.68													

second most common material after plastic varies between the beaches and ranges from *Glass and Ceramics* (four beaches), to *Paper and Cardboard* (three beaches) to *Foamed Plastic* (three beaches) (Table 4). An outstandingly high percentage of metal (9.8%) was observed in *Tuzla*.

Litter items resulting from Rapid Consumption (*Rapd*) were the dominant litter function on five of the 13 beaches. Smoking related items (*Smo*) contributed to the majority of litter found on four beaches. On four beaches the most abundant litter category was *Unclassified Items* (*Un*). In general, *Un*, *Smo* and *Rapd* together compose a minimum of 62.6% (*Kaz*) and a maximum of 89.3% (*Yem*) of the total litter density on the study beaches. Fisheries (*Fish*), Agricultural (*Ag*) and Industrial (*Inds*) waste contribute in average to only 5.8% of the total amount of litter. Recreational (*Rec*) and Personal Use (*Per*) items do not constitute more than 5% on any of the beaches (Figure 2, Table 3).

In total, 89 transboundary litter items were collected and the percentages of the litter transported with currents from neighbouring countries (transboundary litter) varied from 0 – 4.23% between beaches. Foreign litter items (identified by writing on the labels) featured Arabic (41 items), English (39 items), Greek (2 items), Russian (2 items), Hebraic, Lebanese, Italian, Thai and Georgian (1 item respectively). All items with English writing were cigarette packets.

Land-based Litter Origin

GCV values of the MARS results (Table 5) were lower, representing a better fit for each *function* density, when the beach exhibiting pebbles as

Table 4. Mean (± Standard error) and percentage in terms of abundance and weight of each material type observed on the 13 beaches

Material	Abundance		Weight	
	Items/m^2	%	g/m^2	%
Clothes	0.009±0.003	1.0	23.18±21.48	22.4
Foamed Plastic	0.069±0.046	7.5	0.64±0.18	0.6
Glass and Ceramics	0.130±0.110	14.2	70.19±66.71	67.9
Metal	0.024±0.010	2.6	0.48±0.26	0.5
Paper and Cardboard	0.032±0.011	3.5	0.65±0.26	0.6
Plastic	0.647±0.194	70.3	7.68±1.57	7.4
Rubber	0.005±0.002	0.5	0.26±0.08	0.3
Wood	0.003±0.001	0.4	0.31±0.17	0.3

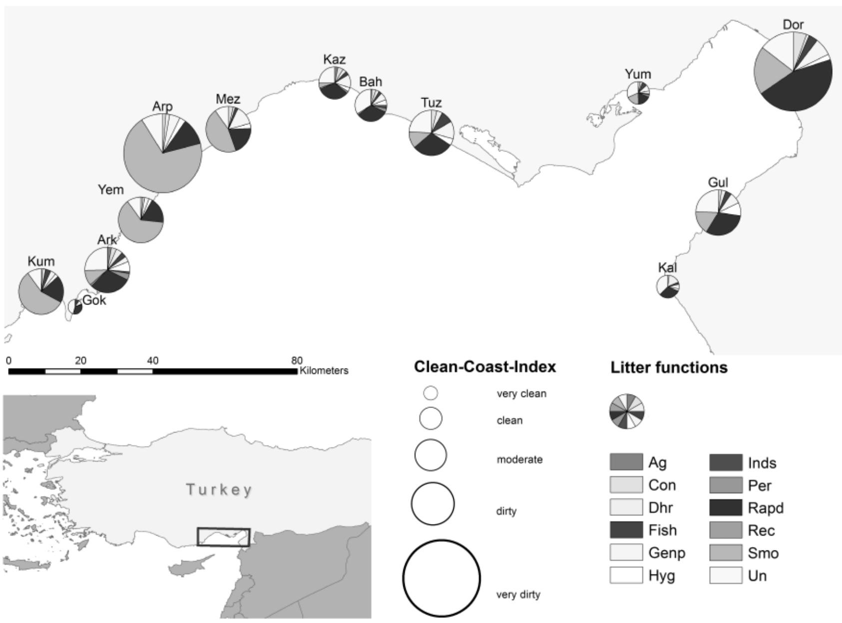

Figure 2. Composition of coastal litter in the Cilician Basin according to functions. The sizes of the charts vary according to the pollution status of the beach, expressed using the Clean Coast Index (Alkalay et al. 2007), with bigger charts referring to higher litter densities. (Ag: Agriculture, Con: Construction, Dhr: Domestic and Household, Fish: Fishing, Genp: General Packaging, Hyg: Medical and Personal Hygiene, Inds: Industrial, Per: Personal Use, Rapd: Rapid Consumption, Rec: Recreation, Smo: Smoking, Un: Unclassified).

Table 5. Overview of MARS model outputs. Selected environmental predictors and their effect on the response variable are reported for each response variable. R^2 is reported as coefficient of determination

Response variable	Selected Predictors	Effect	GCV	R^2
Ag litter density	-	-	$4.62 \cdot 10^{-5}$	-
Con litter density	Agricultural area Beach user – absence	Positive Negative	$5.53 \cdot 10^{-5}$	0.769
Dhr litter density	Distance to port Beach user – absence	Positive Negative	$1.27 \cdot 10^{-4}$	0.652
Fish litter density	-	-	$2.40 \cdot 10^{-3}$	-
Genp litter density	Agricultural area	Positive	$6.78 \cdot 10^{-4}$	0.513
Hyg litter density	Holiday resort – presence Food seller – presence	Negative Positive	$2.50 \cdot 10^{-4}$	0.720
Inds litter density	-	-	$1.88 \cdot 10^{-5}$	-
Per litter density	-	-	$8.17 \cdot 10^{-5}$	-
Rapd litter density	Beach user – absence	Negative	$2,77 \cdot 10^{-3}$	0.629
Rec litter density	Beach user – absence	Negative	$8.61 \cdot 10^{-6}$	0.404
Smo litter density	Holiday resort – presence	Positive	$3.82 \cdot 10^{-2}$	0.707
Un litter density	Holiday resort – presence Beach user – absence	Negative Negative	$2.00 \cdot 10^{-3}$	0.734

substrate type (*Dor*) was excluded from the analysis. Hence, the analysis based on 12 sampling sites excluding *Dor* was accepted as final MARS output.

All three predictors characterizing beach usage have been shown to affect litter. Lower densities of *Rapid Consumption*, *Recreation*, *Domestic and Household*, *Construction*, and *Unclassified* litter items are related to beach user absence. Among them, the absence of beach users explains around 60% of the variance in *Rapid Consumption* litter between the sampling sites ($R^2 = 0.629$). The density of *Smoking* related litter was positively linked with the presence of holiday resorts, which explained more than 70% of the variance in the data ($R^2 = 0.707$). Densities of *Medical and Personal Hygiene* items were lower when holiday resorts were present, and higher in the presence of food and drink sellers ($R^2 = 0.720$). Furthermore, the presence of holiday resorts was related to lower densities of *Unclassified* litter items. With increasing agricultural area, *Construction* and *General Packaging* densities increased. *Domestic and Household* related litter density increased with increasing distance to the port. None of the eight environmental predictors explained the density variation in *Ag*, *Fish*, *Inds* and *Per* litter densities. The distance to river mouths, the distance to industrial sites and the area of inhabited sites were not related to litter densities in the region.

Discussion

Litter surveys on the standing crop of coastal litter were performed covering 13 sampling sites in the Cilician Basin in April 2014 to provide baseline data for the litter pollution in the region. Density values of litter [items/m^2] are considered for the discussion of the findings, since density rather than abundance determines the harm caused by the litter. Even though weight was recorded for a better comparison with other studies, this might be misleading since it underestimates the impact of lighter items. For example, smoked cigarette butts form toxic leachates once in contact with water, exhibiting an lethal concentration (LC50 – concentration of a substance in water that kills 50% of the test organisms) of only one cigarette butt per liter for some marine fish species (Slaughter et al. 2011). Together with items of Rapid Consumption (*Rapd*), Smoking (*Smo*) related items comprised more than half of the coastal litter in the region. High shares of *Smo* and *Rapd* are reported for other touristic areas, similar to the Antalya region and the Balearic Islands (Tudor et al. 2002; Martinez-Ribes et al. 2007). Hence, *Rapd* and *Smo* items are frequently considered as beach user items and illustrate the adverse effects of mass tourism on Mediterranean beaches. Agricultural, industrial, and fishing activities combined contributed to only 6% of the total number of items. The multi-usage of the region is thus not reflected in the coastal litter composition.

As expected, with an average of 70%, plastic was by far the most abundant material type in the Cilician Basin (Table 3). This result is in agreement with several other coastal litter studies. While in Europe an estimated 7% of the waste mass consists of plastic, it generally comprises 50 - 80% of coastal litter (Barnes et al. 2009). This accumulation is explained by the high durability and strength of plastic, which makes it long-lasting with decomposition times of several hundred years (Laist 1987). High abundances of foamed plastics in *Dortyol* (0.61 items/m^2), *Mezitli* (0.08 items/m^2) and *Kazanli* (0.06 items/m^2) are probably related to their proximity to commercial ports. Polyurethane foam is used for insulation and lining e.g. the inside of the cargo hold of vessels (Marine Division - Department of Trade 1976). A high share of metal (9.8%) was noted in *Tuzla*, consisting mainly of large tent pegs and pins. According to information from locals, these are remnants of a campsite set up by domestic tourists every summer on the beach until four years ago. This very distinct beach usage can be considered as a region specific litter source.

The level of pollution observed on the sampled beaches would theoretically deter more than 40% of the beach visitors from returning to a beach (Ballance et al. 2000). Remarkably lower litter densities are reported for beaches in the western Black Sea and in the Antalya regions, despite the fact that the latter region is a tourist hotspot in the Mediterranean Sea (Topçu et al. 2013; Balas et al. 2003) (Table 6). The high level of coastal litter in the study region adds to the findings of the *Report on the State of the Mediterranean Marine and Coastal Environment*, which identifies eight hotspots of pollution stress in the Cilician Basin (UNEP/MAP 2012). A loss of cultural ecosystem services provided by beaches, a decrease in ecosystem health and integrity, losses due to non-recurring tourists and high expenses for beach cleaning and maintenance activities are likely consequences of the reported high coastal litter abundance in the Cilician Basin (Barbier et al. 2011; Sheavly and Register 2007).

Information on the abundance of transboundary litter items is deemed of high value for the Cilician Basin, both as a basis for informing the public at large of the extent of the problem and for international discussion on responsibilities concerning pollution. Results from bottom trawl catches report high shares of transboundary litter in the region (Eryaşar et al. 2014; Yılmaz et al. 2002; Bingel et al. 1987). Similarly high numbers cannot be reported for the coast. Shares of transboundary coastal litter obtained in this study are 0 - 9.09% and hence partly higher than reported for the Turkish Black Sea Coast (e.g. in average 2.2% in autumn, Topçu et al. 2013). However, taking into account that highest shares of foreign items are observed on the cleanest beaches (*Gok* and *Kal*), while absolute numbers are extremely low (89 items among 17,024 items), a comparison of shares between studies might not be representative. More than half of the transboundary litter items featured Arabic writing suggesting Near Eastern origin. Accurate numbers of transboundary litter items are difficult to report. Due to the absence of location identifiers on many items, we might not have been able to consider all foreign items as such. On the other hand the presence of foreign writing does not necessarily relate to a foreign origin since e.g. foreign cigarette brands are widely sold in the study region. In any case this study can only serve as a snapshot of the density of transboundary litter in the Cilician Basin.

Together with the good condition in which the majority of items were encountered, the low abundance of transboundary litter items suggests a local *origin* of coastal litter in the study region (Corcoran et al. 2009). This facilitated *origin* determination, i.e. the assessment of the effect of land-use in the immediate surroundings of the sampling sites on the litter *function* densities. It should be noted that *origin* states where a litter item originates from, but does not determine how the item in question enters the coastal environment. This can be via waterways, breakwater or through direct deposition on the beach. However, some *origins* suggest a likely way of entrance. For instance, *origins* related to beach use are associated with a direct deposition of items on the coast. Thereby, direct deposition refers to the first emergence of items in the coastal environment and does not preclude a later relocation to other sites via currents and winds. For the Cilician Basin, *origins* related to beach use (beach user, food and drink sellers, holiday resorts) have been found influential on litter densities of several *functions*, including *Recreational* waste and the prevalent functions of *Rapid Consumption* and *Smoking* waste. In general, the prevalence of weekend and holiday homes in the Cilician Basin lead to visitors also being present during the low holiday-seasons. Since beaches are rarely used by hotel guests, frequent clean-ups are absent and supposedly undertaken with limited effort. The year-round effect of direct deposition on the beach in touristic areas is indicated by the dominance of cigarette butts on beaches in front of holiday resorts:

Table 6. Litter densities along the Mediterranean and the Turkish Black Sea coasts

Location	Density [items/m^2]	Items per meter shoreline [items/m]	Weight per meter shoreline [g/m]	Sampling Scheme	Reference
Turkey, Mediterranean, Cilician Basin	0.02 – 5.15	0.55 – 60.40	12.00 – 531.60	standing crop	*this study*
Turkey, Mediterranean, Antalya	-	0.18 – 7.43	-	litter flux	(Balas et al. 2003)
Turkey, Mediterranean, Samandağ	-	-	1251	standing crop	(Özdilek et al. 2006)
Israel, Mediterranean	0.005 – 2.23	-	-	litter flux	(Alkalay et al. 2007)
Turkey, Black Sea	0.09 – 5.06	1.70 – 197.25	-	litter flux	(Topçu et al. 2013)
Spain, Mediterranean, Balearic Islands	-	8.00 – 132.00	18 ± 8 – 75 ± 62 (mean ± sd)	litter flux	(Martinez-Ribes et al. 2007)
Spain, Mediterranean, Menorca	-	8.80	-	standing crop	(Barnes & Milner 2005)

As buoyant and non-persistent litter item, cigarette butts are widely agreed to be indicative of on-site litter deposition (Rech et al. 2014). The positive effect of food sellers on Personal Hygiene (*Hyg*) waste can be explained by the high abundance of disposable wet wipes and napkins: considered as *Hyg*, these items are often provided by convenience food sellers. *Hyg* density is furthermore negatively affected by the presence of holiday resorts in the surrounding areas of the beach. A probable explanation is that the majority of beach visitors in such a neighborhood are likely to return to their residences for personal hygiene purposes, contrary to visitors at beaches located farther from their dwelling places. Similar reasoning may explain decreasing *Domestic and Household* litter abundances when beach users are absent. Next to beach use, the size of agricultural area was shown to positively affect densities of *General Packaging* and *Construction* waste. This is presumably emerging during greenhouse operation and maintenance activities. Contrary to the suggestions of other studies, no effect of the inhabited area on litter densities was observed. This may be explained by the fact that in previous studies touristic use of beaches was related to proximities to urban centers (Martinez-Ribes et al. 2007; Ariza et al. 2008; Leite et al. 2014). In the Cilician Basin, beach use is observed both in urban and agriculturally affected areas, blurring clear relations. Additionally, no clear effect of the distance to river mouths was detected. Previous studies suggest that the effect of river mouths on the distribution of litter is observable on a smaller spatial scale (Özdilek et al. 2006; Rech et al. 2014). On the scale applied in this study, the effects of litter transport by river mouths are likely to be masked: Due to the numerous riverine inputs in the study region, all sampling sites were rather close to river mouths (0.1 – 7.1 km distance) and hence the study lacks a reference beach with no freshwater influence.

The coefficient of determination (R^2) of the MARS outputs reached maximum values of 0.77. Higher values are unlikely to be obtained as the environmental predictors employed serve as indicators for land-based litter origins only. According to OSPAR (2007), between 60 and 80% of all coastal litter worldwide can be attributed to land-based sources. This value matches the R^2 obtained in this study, suggesting that the unexplained variations in litter *function* densities are at least partly due to sea-based environmental parameters. i.e., MARS fails to explain variations in *Fishing* and *Industrial* litter densities using land-based parameters. This underlines that litter resulting from these activities is to a great extent attributable to diffuse sea-based litter *origin*. Some other detected relations are only weakly explained and require further investigations: with an increasing distance to ports, an increase in *Domestic and Household* waste was detected. Furthermore, a drop in *Construction* litter density was noticed, when beach users are absent. Both relationships may be due to the local incongruities of the respective litter function density and explanatory origin parameters in the study region. Likewise, the detected effects of beach use on the density of *Unclassified* litter items are difficult to interpret: In the present study, more than 70% of the *Unclassified* items consist of plastic pellets and nylon particles, which do not link back to any explicit origin. An extension of the study is further needed to explain the variations in *Agricultural* and *Personal Use* litter items. The encountered difficulties underline that a certain proportion of land-based litter items cannot be explained by origins in the immediate surroundings of the study sites, but travel longer distances before they reach the coastal environment. A potential remote source for all function categories might be illegal and poorly operated landfills since illegal waste dumping is still a commonly performed in the study region. In the provinces of Adana and Mersin, around 1500 tons of general waste are deposited at unofficial dumping sites daily. Wind-blown litter is expected to be a likely consequence (Altuntop et al. 2014). Even though it is desirable to include such landfills as point sources in the analyses, due to their illegal status, obtaining a comprehensive data set is unlikely in the near future. Potentially the inclusion of further study sites by extending the survey focus may help to reveal and better understand relationships between land-based litter point sources and the respective *function*s.

Conclusion

The results obtained in this study serve both as a scientific description of the state of litter pollution and as a source of information for stakeholders working for the establishment of successful litter management plans. In the Cilician Basin, beaches are exposed to high levels of litter pollution, with eight out of 13 beaches being classified as either dirty or extremely dirty according to the Clean-Coast Index (Alkalay et al. 2007). Beach use has been shown to remarkably contribute to the litter abundance on the beaches of the Cilician Coast, explaining among others the densities of the most prevalent litter functions (*Rapid Consumption* and *Smoking*). At the same time, beach users are the main group suffering from high coastal litter densities: Coastal litter has been identified as the main criticism of beach visitors at three beaches in the region (Birdir et al. 2013). As discussed for other regions worldwide, a major problem remains the lack of incentives for the reduction of littering (Hastings & Potts 2013). Hence, in order to achieve any reduction in coastal litter, the littering behaviour of beach users and coastal inhabitants must be addressed in management plans. The high number of domestic tourists in the study region, many being present all year-round, eases the establishment of target-group-specific education programs and awareness campaigns.

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References

Alkalay, R., Pasternak, G. & Zask, A., 2007. Clean-coast index—A new approach for beach cleanliness assessment. *Ocean & Coastal Management*, 50 (5-6), pp. 352–362. DOI:10.1016/j.ocecoaman.2006.10.002

Altuntop, E., Bozlu, H. & Karabıyık, E., 2014. *Evsel Atiklarin Ekonomiye Kazandirilmasi - TR62 (Adana, Mersin) Bölgesi*, Mersin, Adana: Cukurova Kalkinma Ajansi.

Ariza, E., Jiménez, J. & Sardá, R., 2008. Seasonal evolution of beach waste and litter during the bathing season on the Catalan coast. *Waste management*, 28 (12), pp. 2604–2613. DOI: 10.1016/j.wasman.2007.

Ballance, A., Ryan, P.G. & Turpie, J.K., 2000. How much is a clean beach worth? The impact of litter on beach users in the Cape Peninsula, South Africa. South African Journal of Science, 96 (5), pp. 210–213.

Balas, C.E. et al., 2003. Marine Litter Assessment for Antalya Beaches. In E. Özhan, ed. *Proceedings of the Sixth International Conference on the Mediterranean Coastal Environment, MEDCOAST 03*. Ravenna: MEDCOAST.

Barbier, E.B. et al., 2011. The value of estuarine and coastal ecosystem services. Ecological Monographs, 81 (2), pp.169–193. DOI: 10.1890/10-1510.1

Barnes, D.K.A. et al., 2009. Accumulation and fragmentation of plastic debris in global environments. *Philosophical transactions of the Royal Society of London. Series B, Biological sciences*, 364 (1526), pp. 1985–98. DOI: 10.1098/rstb.2008.0205

Bingel, F., Avsar, D. & Ünsal, M., 1987. A note on plastic materials in trawl catches in the North-Eastern Mediterranean. *Meeresforschung - Reports in Marine Research*, 31, pp. 227–233.

Birdir, S. et al., 2013. Willingness to pay as an economic instrument for coastal tourism management: Cases from Mersin, Turkey. Tourism Management, 36, pp. 279–283. DOI:10.1016/j.tourman.2012.10.020

Cheshire, A.C. et al., 2009. *UNEP / IOC Guidelines on Survey and Monitoring of Marine Litter*, United Nations Environment Program / Intergovernmental Oceanographic Commission. ISBN 978-92-807-3027-2.

Corcoran, P.L., Biesinger, M.C. & Grifi, M., 2009. Plastics and beaches: a degrading relationship. *Marine pollution bulletin*, 58 (1), pp. 80–84. DOI:10.1016/j.marpolbul.2008.08.022

Eryaşar, A.R. et al., 2014. Marine debris in bottom trawl catches and their effects on the selectivity grids in the north eastern Mediterranean. *Marine pollution bulletin*, 81 (1), pp.80–4. DOI:10.1016/j.marpolbul.2014.02.017

Friedmann, J.H., 1991. Multivariate Adaptive Regression Spline Models. *The Annals of Statistics*, 19 (1), pp.1–141.

Gabrielides, G.P. et al., 1991. Man-made garbage pollution on the Mediterranean coastline. *Marine Pollution Bulletin*, 23, pp.437–441. DOI:10.1016/0025-326X(91)90713-3

Galgani, F., Hanke, G., Werner, S., Oosterbaan, L., Nilsson, P., Fleet, D., Kinsey, S., Thompson, R.C., van Franeker, J., Vlachogianni, T., Scoullos, M., Veiga, J.M., Palatinus, A., Matiddi, M., Maes, T., Korpinen, S., Budziak, A., Leslie, H., Gago, J., Liebezeit, G., 2013. Monitoring Guidance for Marine Litter in European Seas. MSFD GES Technical Subgroup on Marine Litter (TSG-ML).

Güler, C. et al., 2012. Assessment of the impact of anthropogenic activities on the groundwater hydrology and chemistry in Tarsus coastal plain (Mersin, SE Turkey) using fuzzy clustering, multivariate statistics and GIS techniques. Journal of Hydrology, 414-415, pp.435–451. DOI:10.1016/j.jhydrol.2011.11.021

Hastings, E. & Potts, T., 2013. Marine litter: Progress in developing an integrated policy approach in Scotland. *Marine Policy*, 42, pp.49–55. DOI:10.1016/j.marpol.2013.01.024

Kordella, S. et al., 2013. Litter composition and source contribution for 80 beaches in Greece, Eastern Mediterranean: A nationwide voluntary clean-up campaign. *Aquatic Ecosystem Health & Management*, 16 (1), pp. 111–118. DOI: 10.1080/14634988.2012.759503

Laist, D.W., 1987. Overview of the Biological Effects of Lost and Discarded Plastic Debris in the Marine Environment. *Marine Pollution Bulletin*, 18 (6) pp. 319–326. DOI:10.1016/S0025-326X(87)80019-X

Leathwick, J.R., Elith, J. & Hastie, T., 2006. Comparative performance of generalized additive models and multivariate adaptive regression splines for statistical modelling of species distributions. *Ecological Modelling*, 199 (2), pp. 188–196. DOI:10.1016/j.ecolmodel.2006.05.022

Leite, A.S. et al., 2014. Influence of proximity to an urban center in the pattern of contamination by marine debris. *Marine pollution bulletin*, 81 (1), pp. 242–247. doi:10.1016/j.marpolbul.2014.01.032

Marine Division - Department of Trade, 1976. *Polyurethane foam and other organic foam materials*, United Kingdom.

Martinez-Ribes, L. et al., 2007. Origin and abundance of beach debris in the Balearic Islands. *Scientia Marina*, 71 (2), pp. 305–314. ISSN: 0214-8358

MSFD GES Technical Subgroup on Marine Litter, 2011. *Marine Litter Technical Recommendations for the Implementation of MSFD Requirements*, Luxembourg: European Union. DOI: 10.2788/92438

OSPAR, 2007. *OSPAR Pilot Project 2000-2006 on Monitoring Marine Beach Litter*, London.

Özdilek, H.G. et al., 2006. Impact of accumulated beach litter on Chelonia mydas L . 1758 (Green Turtle) hatchlings of the Samandag Coast, Hatay, Turkey. *Fresenius Environmental Bulletin*, 15 (2), pp. 95–103.

PAP/RAC, 2005. Coastal Area Management in Turkey, *Priority Actions Programme Regional Activity Centre*, Split. ISBN 953-6429-54-3

Rech, S. et al., 2014. Rivers as a source of marine litter - A study from the SE Pacific. *Marine Pollution Bulletin*. 82(1-2) 66-75. DOI: 10.1016/j.marpolbul.2014.03.019

Sheavly, S.B. & Register, K.M., 2007. Marine Debris & Plastics: Environmental Concerns, Sources, Impacts and Solutions. *Journal of Polymers and the Environment*, 15(4), pp.301–305. DOI 10.1007/s10924-007-0074-3

Slaughter, E. et al., 2011. Toxicity of cigarette butts, and their chemical components, to marine and freshwater fish. *Tobacco control*, 20 Suppl 1(Suppl 1), pp.i25–9. DOI:10.1136/tc.2010.040170

Topçu, E.N. et al., 2013. Origin and abundance of marine litter along sandy beaches of the Turkish Western Black Sea Coast. *Marine Environmental Research*, 85, pp.21–28. DOI:10.1016/j.marenvres.2012.12.006

Tudor, D.T. et al., 2004. Development of a " Matrix Scoring Technique " to determine litter sources at a Bristol Channel beach Development of a " Matrix Scoring Technique " to determine litter sources at a Bristol Channel beach. *Journal of Coastal Conservation*, 10 (1), pp. 119–127. DOI: 10.1652/1400-0350(2004)010[0119:DOAMST]2.0.CO;2

Tudor, D.T. et al., 2002. The use of multivariate statistical techniques to establish beach debris pollution sources. *Journal of Coastal Research*, 725 (36), pp. 716–725. ISSN 0749-0208

UNEP/MAP 2011. Assessment of the Status of Marine Litter in the Mediterranean. UNEP(DEPI)/MED WG.357/Inf.4

UNEP/MAP, 2012. *State of the Mediterranean Marine and Coastal Environment*, Athens.

Williams, A.T., Tudor, D.T. & Randerson, P., 2003. Beach litter sourcing in the Bristol channel and Wales, U.K. *Water, Air and Soil Pollution*, 143, pp. 387–408. DOI: 10.1023/A:1022808908500

Yılmaz, A.B., Başusta, N. & İşmen, A., 2002. İskenderun Körfezi'nin Güney-Doğu Kıyılarında Plastik Materyal Birikimi Üzerine Bir Çalışma. *E.U. Journal of Fisheries and Aquatic Sciences*, 19, pp. 485–488. ISSN 1300 - 1590