

Baseline

Artificial polymer materials debris characteristics along the Moroccan Mediterranean coast

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ABSTRACT

A monitoring program was carried out in autumn 2015 along the Mediterranean coast of Morocco, at sites including urban, village and remote/rural beaches. Artificial Polymer Materials (APM) represented 70.64% of all collected items and included plastic (16 categories), foamed plastic (3) and other APM materials (2). Plastic items represented the dominant debris with 5356 items, i.e. 94.53% of all APM debris, foamed plastics presented 191 items (i.e. 3.37%) and other APM summed 119 items, i.e. 2.1% of all APM. Urban areas presented 49.63% of all APM recollected items with cigarette butts representing 32% of total APM items. Village areas presented 40.43% of total APM recollected items with cigarette butts representing 14.1%. Remote and rural beaches recorded 9.94% of total APM items and no cigarette butts were observed. Despite the efforts of local administrations, which introduced litter bins and enforced mechanical and manual cleaning operations, debris were essentially related to beachgoers.

Any manufactured or processed solid waste material entering into the marine environment from different sources is defined as marine litter or marine debris (UNEP, 2005). Litter is observed along shorelines (Coe and Rogers, 1997; Santos and Friedrich, 2009), pelagic, benthic marine and lake systems all around the World (Galgani et al., 2000; Thiel et al., 2011). Such systems are deeply threatened by litter in different ways (Anfuso et al., 2015; Krelling et al., 2017).

Accumulation of marine litter in coastal areas menaces the associated ecosystem services that include leisure, recreation, aesthetic and cultural aspects (Hastings and Potts, 2013; Botero et al., 2017; Rangel-Buitrago et al., 2017 and 2018). Litter items carry a risk of minor cuts or abrasion injuries to beachgoers (Sheavly and Register, 2007; Williams, 2011) and especially deter recreational beach usage giving rise to related economic problems because of the loss of tourism revenues linked to low beach aesthetic attractiveness (Smith et al., 1997; Ogi and Fukumoto, 2000; Krelling et al., 2017). These issues are of great relevance today since coastal tourism is one of the world largest industries and beaches constitute a key factor in this market (Houston, 2013).

In line with the Barcelona Convention requirements, this paper provided a first step for the characterization of beach litter and especially Artificial Polymer Material (APM, Table 1) content and characteristics at 14 sites, arbitrary spaced to cover different beach types (i.e. urban, village, rural and remote) along the 512 km long

Mediterranean coast of Morocco. Usually one site per beach was established but, at largest beaches (i.e. Tangier, Martil and Saïdia), two sites were established. This constitutes a pioneer investigation for the development of monitoring capacity of Morocco marine coastal ecosystems and, consequently, a baseline for the implementation of adequate environmental policies and protocols. The study area is a microtidal environment subject to winds blowing from West to East directions and waves essentially approaching from West and East (El Mrini, 2011; Anfuso et al., 2016; Fig. 1). The littoral includes cliffed (80%) and sandy (20%) sectors comprising both natural and tourist areas of great economic value. In 2016, Morocco recorded the visit of c. 10 million international tourists, who brought in some US\$ 6.548 billion, i.e. 11.4% of the national GDP, the largest country tourist income in North Africa (World Tourism Organization [UNWTO], 2017).

Survey methodology followed the UNEP (Cheshire et al., 2009) and the UNEP/MAP (2016a). Litter items were recorded along a 100 m wide sector generally located in the central part of the beach and extended from the strandline to beach landward boundary, usually dunes, cliff base or a seawall or other anthropogenic structure (EA/NALG Protocol, 2000). The observer virtually covered the whole beach sector surface since he moved along shoreline parallel transects spaced 5 m apart. All litter items larger than 2.5 cm in the longest linear dimension were collected: light items were brought to the laboratory for accurate weighing and heavy objects were weighed in the field. The survey was

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Table 1
 Category codes for Artificial Polymer Material (APM) items according to UNEP “Operational Guidelines for Comprehensive Beach Litter Assessment” (Cheshire et al., 2009) and “Guidance on Monitoring of Marine Litter in European Seas” (Galgani et al., 2013).

Material composition	UNEP Code	Litter items	
Artificial Polymer Materials (APM)	Plastic (PL)	PL01	Bottle caps & lids
		PL02	Bottles < 2 L
		PL03	Bottles. Drums, jerry, cans & buckets > 2 L
		PL04	Knives, forks, spoons, straws, stirrers, (cutlery)
		PL05	Drink package rings, six-pack rings, ring carriers
		PL06	Food containers (fast food, cups, lunch boxes & similar)
		PL07	Plastic bags (opaque & clear)
		PL08	Toys & party poppers
		PL10	Cigarette lighters
		PL11	Cigarette butts
		PL12	Syringes
		PL13	Baskets, crates & trays
		PL16	Sheeting (tarpaulin or other woven plastic bags, palette wrap)
		PL19	Rope
		PL21	Strapping
		PL24	Other: Plastic pieces
Foamed Plastic (FP)	FP01	Foam sponge	
	FP03	Foam buoys	
Other APM	FP04	Foam (isolation & packaging)	
	OT02	Sanitary (nappies, tampon applicators)	
	RB02	Footwear (flip-flops)	

carried out in autumn from November 01st to December 18th 2015 to have an overview of APM debris characteristics and distribution in a period where no beach cleaning operations were carried out. The litter amount was expressed as number of items and weight per unit of beach length (i.e. 100 m of beach front). Density of items was expressed as total number and weight (in gr or kg) of collected items per square meter of beach surface, i.e. an area which alongshore length was constant (100 m) and cross-shore length varied from place to place, ranging from 41 m in Sfiha beach to 104 m in Tangier-Municipal beach. Values of density recorded at different beaches are comparable among them because the whole beach area was surveyed at each site and, further, litter cross-shore and longshore distribution was homogeneous along each sector, i.e. it was not observed any anomalous litter concentration at

mean sea level or at any other specific place.

A total of 108,051 m² of sandy beach surface was analyzed. An amount of 8021 items, including 45 different categories of litter were removed, counted and classified for a combined weight of c. 194 kg. Median debris abundance was 4.94 items m⁻¹, ranging from 12.21 items m⁻¹ at Marina Smir beach to 2.06 items m⁻¹ at Jebha. Median debris weight was 84.85 g m⁻¹ or 1.23 g m⁻², ranging from 460.8 g m⁻¹ (8.26 g m⁻²) at Oued Laou beach (due to the great abundance of glass and ceramics) to 23.7 g m⁻¹ (0.24 g m⁻²) at Saïdia-City beach. Median debris density was 0.08 items m⁻², ranging from 0.153 items m⁻² at Marina Smir beach to 0.02 items m⁻² at Nador-Boqueronesa beach. Such values are somewhat lower than mean average value (1 item m⁻²) established considering many studies carried out along the Mediterranean Sea (Galgani et al., 2013), but lower than ones observed in Slovenia with a median value of 1.25 items m⁻² (0.81–3.45 items m⁻²) and median weight of 4.45 g m⁻² (2.84–19.2 g m⁻², Laglbauer et al., 2014) and comparable to those registered in the Ionian Sea ranging from 156 to 455 items per 100 m and 0.08–0.91 items m⁻² (Prevenios et al., 2017).

Artificial Polymer Materials represented 70.64% (5666 items) of all collected items; their abundance is driven by input, great persistence and high floatability (Topçu and Öztürk, 2010). The second largest category were “metal debris” (16.97%; 1361), followed by “glass and ceramics” (4.99%; 400), “paper and card board” (4.09%; 328), wood (2.64%; 212), “cloth” (0.49%; 39) and “rubber” (0.12%; 10). Specifically, metal debris consisted of cans, foil wrappers, bottle caps and lids; glass and ceramics included bottles, glass fragments and construction material (brick, cement, pipes); paper and card board included paper fragments and cartons and tetrapack; wood consisted of < 50 cm fragments; cloth category included clothing/rags and other textiles and rubber included balloons and tires (Nachite et al., 2018).

Composition and percentages of different categories reflected results obtained at many coastal areas around the World, e.g. Nagelkerken et al. (2001), Derraik (2002), Claereboudt (2004), Santos and Friedrich (2009), Ryan et al. (2009), Nakashima et al. (2011), Viehman et al. (2011), Khairunnisa et al. (2012), Smith (2012) and Williams et al. (2017) and in the Mediterranean (UNEP/MAP, 2016b). Wood content was lower respect to other studies carried out in Oman (Claereboudt, 2004; Cheshire et al., 2004) and in China (Zhou et al., 2011), where they were respectively attributed to pieces of fishing boats and unspecified land-based sources.

A total amount of 21 APM categories of UNEP list were encountered and included plastic (PL, 16 categories), foamed plastic (FP, 3) and other APM materials (2, Table 1, Cheshire et al., 2009). PL represented the dominant debris in this study with 5356 items, i.e. 66.77% of collected debris and 94.53% of total APM debris, FP represented 191 items

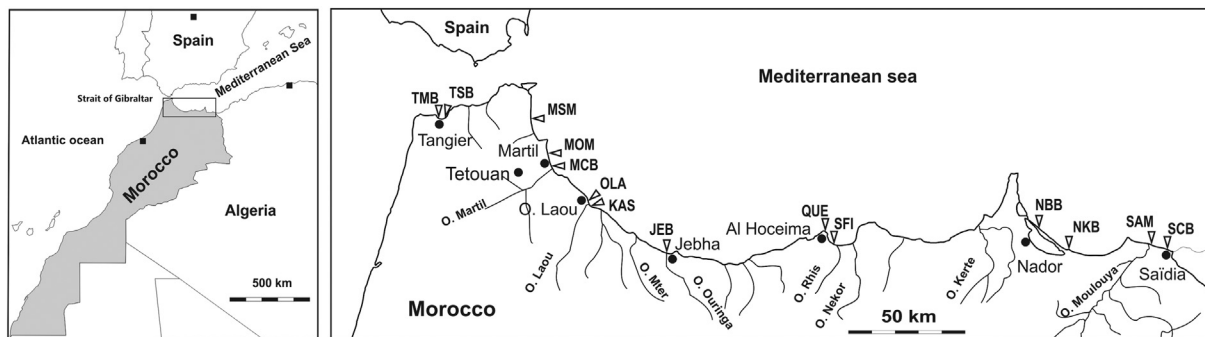


Fig. 1. Location of surveyed beaches along the study area. TMB: Tangier-Municipal Beach (sampled area: 10,400 m²), TSB: Tangier-Sanea beach (7978 m²), MSM: Marina Smir (7983 m²), MOM: Martil-Oued Maleh (8980 m²), MCB: Martil-City beach (6460 m²), OLA: Oued Laou (5580 m²), KAS: Kaa Asrasse (4870 m²), JEB: Jebha (9100 m²), QUE: Quemado (4880 m²), SFI: Sfiha (4060 m²), NBB: Nador-Boqueronesa beach (10,200 m²), NKB: Nador-Kariat Arekmane beach (8470 m²), SAM: Saïdia-Marina beach (9410 m²), SCB: Saïdia-City beach (9680 m²).

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