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Microplastic and tar pollution on three Canary Islands beaches: An annual study

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ABSTRACT

Marine debris accumulation was analyzed from three exposed beaches of the Canary Islands (Lambra, Famara and Las Canteras). Large microplastics (1–5 mm), mesoplastics (5–25 mm) and tar pollution were assessed twice a month for a year. There was great spatial and temporal variability in the Canary Island coastal pollution. Seasonal patterns differed at each location, marine debris concentration depended mainly of local-scale wind and wave conditions. The most polluted beach was Lambra, a remote beach infrequently visited. The types of debris found were mainly preproduction resin pellets, plastic fragments and tar, evidencing that pollution was not of local origin, but it cames from the open sea. The levels of pollution were similar to those of highly industrialized and contaminated regions. This study corroborates that the Canary Islands are an area of accumulation of microplastics and tar rafted from the North Atlantic Ocean by the southward flowing Canary Current.

1. Introduction

Plastic, due its properties such as durability, impermeability and low cost production, has become essential in our daily life. Microplastics (< 5 mm) and mesoplastics (5–25 mm) includes synthetic fibres, microbeads, preproduction resin pellets and fragments derived from larger plastics. These small pieces of plastic become one of the most common and persistent pollutants of the sea and beaches around the world (Derraik, 2002; Moore, 2008; Ryan et al., 2009; Cózar et al., 2014; Eriksen et al., 2014). In the early 1970s, scientists tried to alert society about this problem (Carpenter and Smith, 1972; Carpenter et al., 1972), but their warning was largely ignored. Now, almost five decades later, the reality is worse than expected; the size of plastic particles is getting smaller, their abundance is increasing, and their distribution is becoming global (Moore, 2008; Thompson et al., 2009). In the North Pacific Central Gyre, the mass of plastic was six times higher than plankton biomass (Moore et al., 2001). Cózar et al. (2014) reported 7000 to 35,000 tons of plastic in the total ocean and Eriksen et al. (2014) estimated that 5.125 trillion particles, weighing 268,940 tons, are currently floating at sea. However, the concentration of particles < 4.75 mm is 100 orders of magnitude lower than the total estimate, based on rates of fragmentation of plastic debris that has been dumped into the sea since the 70s, thus a significant portion of microplastics has disappeared. The question, "Where is all the plastic?" continues without answer. Here, we explore one possible answer, namely that the missing plastic has been deposited, accumulated, and buried as microplastic debris in beaches, marshes, and other coastal areas all over the world.

The southward flowing Canary Current brings plastic debris from the open North Atlantic Ocean to the coasts of the Canary Islands, mainly on the N and NE exposed beaches (Baztan et al., 2014). In the first evaluation of this phenomenon, Baztan et al. (2014), showed that the Canary Islands are highly polluted by microplastics, reaching values above 100 g per L of sand, on the most exposed areas (Fig. 1).

At Famara beach, the citizen science project, COASTAL (Communities-Based Observatories Tackling Marine Litter), is continuing its research. This effort includes the Famara Participative Observatory project that will provide long-term data on microplastic pollution in the region. In addition, it will be carrying out the important task of increasing awareness in the local population through the media social group "Agüita con el Plástico" (Baztan et al., 2015). Famara is also the beach chosen in Canary region to carry out the monitoring of microparticles on beaches (BM-6) established by the Marine Strategy Framework Directive (2008/56/CE) (CEDEX, 2016).

In order to better understand the condition that affects the microplastic, mesoplastic and other marine debris deposition in this area, we

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Fig. 1. Microplastic pollution in the Canary Islands. (a) Marine plastic debris along the high tide line in Famara beach, Lanzarote. (b) Detailed view of marine plastic debris.

aimed to determine:

1– The micro and mesoplastic accumulation on three beaches of the Canary Islands.
2– The types of debris found in the samples.
3– The temporal and spatial variability of marine debris accumulation.

2. Materials and methods

2.1. Study area

The study was conducted from September 2015 to September 2016, at three sandy beaches in the Canary Islands: Lambra (La Graciosa Island), Famara (Lanzarote Island) and Las Canteras (Gran Canaria Island) (Table 1, Fig. 2). The areas were selected because they are exposed to the predominant wind and swells (N-NE), have enough space to deposit plastic debris on the high tide line and are accessible to sampling (Fig. 2c, d and e).

Lambra is the most isolated of the three beaches, located on La Graciosa, a small-populated island located in the so-called "Chinijo archipelago". These islands are at the northernmost of the Canary Islands, and therefore the first to encounter the plastics flowing with the Canary Current. Famara is located on Lanzarote Island. The nearest town is Caleta de Famara, with less than 1000 inhabitants; this beach, however, receives a large number of tourists all year around. Las Canteras is an urban beach, located in a nucleus of population of more than 350,000 inhabitants. Due to the benign climate, Canteras is daily used by many thousands of tourists throughout the year.

Table 1
Summary of geographical and sedimentary conditions at each beach. Data from Alonso Bilbao (1993) and Mangas et al. (2008).

	Lambra beach	Famara beach	Las Canteras beach
Location	29° 16.763′N 13° 29.736′W	29° 6.917′N 13° 33.504′W	28° 7.854′N 15° 26.775′W
Total longitude (m)	600	6000	2949
Turistic pressure	Low	Medium	High
Beach cleaning	Once a month Macrolitter	Once a month Macrolitter	Twice a day Macro and microlitter
Orientation	N-NE	N	N
Exposure	Open to NE	Open to N-NW, partially protected to NE	Open to NW, partially protected to NE
Intertidal zone (m)	20	100	60
Sediment type	Medium sands	Fine sands	Fine sands
Median sediment size (mm)	0.433	0.228	0.125

2.2. Field work

We have applied a slightly modified TSG-ML sampling protocol. We collected 3 replicates (instead 5 recommended) separated by, at least, 5 m, on 1 cm layer (instead 5 cm) (MSFD GES Technical Subgroup on Marine Litter, 2013). The Spanish BM-6 report (CEDEX, 2016) did not report particles under the first centimeter of sand in the beaches studied. This finding supports our decision to limit our sampling to the upper layer (1 cm). Samples were collected, every 2 weeks, in the highest tide to avoid variability due to the tidal cycle. In a square of 50 × 50 cm (0.25 m^2) along the high tide line, sediments were collected from the top 1 cm of sand to exclusively collect the marine debris deposited by the last tide. At the same time, 3 L of seawater were added to each sample, mixed, and then the supernatant was filtered through a 1 mm mesh. This process was repeated three times to collect as much marine debris as possible. In Las Canteras, all sampling was done before the beach cleaning to avoid underestimation.

In the laboratory, samples were dried for 24 h at 60 ° C. For the samples containing remnants of vegetal debris (mainly composed of leaves, seeds, wood, seaweeds and seagrass), a density separation by ethanol (96%) was done to separate plastics and tar from organic material. Samples were dried again, sieved and separated in two sizes classes: large micro-debris (1–5 mm) and meso-debris (5–25 mm). After sieving each size class, the samples were weighted in a high precision balance (0.1 mg). The items in each sample were not counted, due to the large number of samples and the amount of particles present in them. In order to compare the number of items per m^2 with other studies, a short study was performed on three samples from each site to determine the relationship between number of items/weight in debris 1–5 mm. Ratios obtained in Lambra were 69.9 ± 16.3 items/g; in Famara, 52.7 ± 12.9 items/g; and in Las Canteras, 79.8 ± 8.1 items/g (Appendix A). We only used this data for comparison purposes because this relationship showed great variability between sites, and also between each sample studied.

2.3. Environmental variables

We analyzed the effect of environmental variables on monthly marine litter accumulation on each study site. The oceanographic data was provided by Puertos del Estado (2016) of the Government of Spain and included: significant wave height (m), wave direction in degrees (0 = N, 90 = E), peak wave period, primary swell wave height (m) and tidal coefficient. In addition, several meteorological variables were accounted: wind speed (km/h), maximum wind speed (km/h), wind direction in degrees (0 = N, 90 = E) and rain (L/m^2), as provided by Agencia Estatal de Meteorología (AEMET, 2016) of the Government of Spain.

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