Marine Pollution Bulletin 62 (2011) 377–381

Contents lists available at ScienceDirect

Marine Pollution Bulletin

journal homepage: www.elsevier.com/locate/marpolbul

Occurrence, distribution and characteristics of beached plastic production pellets on the island of Malta (central Mediterranean)

Andrew Turner *, Luke Holmes

School of Geography, Earth and Environmental Sciences, University of Plymouth, Drake Circus, Plymouth PL4 8AA, UK

ARTICLE INFO

Keywords:
Plastic production pellets
Malta
Beaches
Infra red spectroscopy
Photo-oxidation

ABSTRACT

The distribution, abundance and chemical characteristics of plastic production pellets on beaches of the island of Malta have been determined. Pellets were observed at all locations visited and were generally most abundant (>1000 m^{-2} at the surface) on the backshores of beaches with a westerly aspect. Most pellets were disc-shaped or flattened cylinders and could be categorised as white, yellow, amber or brown. The polymeric matrix of all pellets analysed by infrared spectroscopy was polyethylene and the degree of yellowing or darkening was associated with an increase in the carbonyl index, hence extent of photo-oxidation or aging. Qualitatively, pellets are similar to those reported for other regions of the Mediterranean in surveys spanning three decades, suggesting that they are a general and persistent characteristic of the region.

1. Introduction

Plastic production pellets, or resin pellets, have been reported in marine waters and on beaches worldwide (Gregory, 1977, 1983; Khordagui and Abuhilal, 1994; Kuriyama et al., 2002; Ivor do Sul et al., 2009; Ashton et al., 2010). Sources of pellets are both marine- and land-based and include spillages during handling and transfer and losses during transportation. Although, in many places, pellets represent the most abundant form of beached litter on a number basis, their size (a few mm in diameter) and colour (commonly white, off-white or translucent) means that they are not as aesthetically significant as other larger, but less abundant forms of debris and waste. The main cause for concern of both suspended and beached pellets, however, is the effects resulting from their ingestion by animals, birds and fish that mistake them for food (Ryan, 1987; Graham and Thompson, 2009); ingested pellets can adversely affect foraging ability and feeding stimulus and can cause internal physical damage (e.g. intestinal blockage). Pellets are also able to act as a carrier and, potentially, a bioaccessible source of toxins such as organic micropollutants and trace metals, although the significance of this role is currently unclear (Endo et al., 2005; Ashton et al., 2010).

Despite the importance of the Mediterranean Sea as both a tourist destination and shipping route, studies of the occurrence and characteristics of beached plastic pellets in this region are relatively few and appear to be confined to the western and eastern coasts. Specifically, Shiber (1979, 1987) provided a qualitative account of pellets from some Spanish and Lebanese beaches that were collected more than two decades ago; more recently, Karapanagioti and Klontza (2007) described pellets collected from the Greek island of Lesvos that were subsequently employed as a sorbent for a study of phenanthrene uptake. On previous visits to the Maltese islands in the central Mediterranean, we observed an abundance of plastic production pellets on many beaches. In the present study, therefore, we undertake a systematic, quantitative analysis of the abundance and distribution of pellets on the beaches of Malta and employ various analytical techniques to ascertain the chemical characteristics of the pellets. Such information will improve our understanding of the sources, histories and ages of pellets in the region, and the persistence and potential effects of stranded microplastics more generally.

2. Materials and methods

2.1. Sample locations

Of the 190 km of coastline on the Maltese islands, sandy beaches comprise only 2.4% and are located largely to the north of the archipelago (Deidun et al., 2003). The tidal range around the islands is about 20 cm at springs and beaches are typically characterised by a narrow swash zone and extensive backshore. The main natural beaches on the island of Malta were sampled systematically in the present study and are coded S1-S8 in Fig. 1. Also shown are three locations where qualitative analyses and observations were made; namely, Ramla Bay, a sandy beach on the island of Gozo, and Slugs Bay and Pembroke, rocky shorelines on the island of Malta.

* Corresponding author. Tel.: +44 1752 584570; fax: +44 1752 584710.
E-mail address: aturner@plymouth.ac.uk (A. Turner).

0025-326X/$ - see front matter © 2010 Elsevier Ltd. All rights reserved.
doi:10.1016/j.marpolbul.2010.09.027

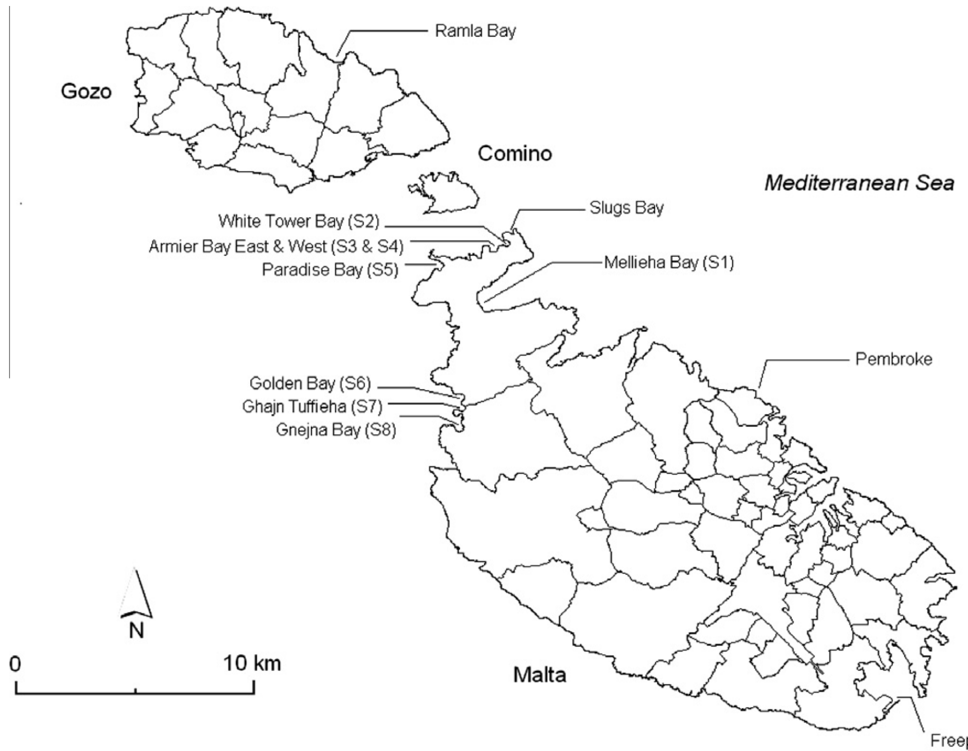

Fig. 1. The Maltese Islands, showing the locations of beaches that were sampled (S1-S8) and other sites visited or mentioned in the text.

2.2. Sampling

At each beach studied (S1–S8), plastic production pellets were counted and categorised according to shape and colour in at least eleven 1 m^2 quadrats that were randomly stratified to encompass all morphological zones except dune systems (where occasional visual inspections were made). Although pellets were present to variable depths on a given beach, only those visible at the surface of the sand were counted and categorised systematically. The primary diameters or heights of randomly selected samples were measured using a pair of callipers as the pooled contents from each beach were transferred to a polypropylene centrifuge tubes using a pair of plastic tweezers. Virgin polyethylene pellets, analysed as a baseline, were supplied by Algram Ltd, Plymouth.

2.3. Sample characterisation

In the laboratory, randomly selected pellets from each beach were weighed on a five figure Salter ER182A electronic balance, and the polymeric composition of each sample was determined by Fourier transform-infrared (FTIR) spectroscopy. Thus, transmission spectra were acquired using a Bruker IFS 66 spectrometer coupled with an MTec 300 photo-acoustic cell. Spectra were recorded as an average of 64 scans in the range 4000–400 cm^{-1} at a resolution of 8 cm^{-1}. A qualitative evaluation of the age of different types of pellet based on colour (and including the virgin pellets as a baseline) was ascertained from the keto-carbonyl and hydroperoxide indices. Here, the carbonyl peak, integrated between 1729–1696 cm^{-1}, and the hydroperoxide peak, integrated between 3455–3433 cm^{-1}, were compared with the methylene peak, measured at 3445 cm^{-1} and serving as a reference (i.e. unaffected by photo-oxidation; Artham et al., 2009).

The surface areas of 200 mg pellet composites, grouped according to colour (see below), were determined by BET nitrogen adsorption using a Micromeritics Gemini 2360. Concentrations of various metals (Al, Fe, Mn, Cr, Cu, Zn) associated with individual pellets sampled from S7 (n = 20) and the virgin pellets (n = 5) were determined by inductively coupled plasma-mass spectrometry using a Thermoelemental Series II benchtop instrument after 16 h sample digestion in 5 ml of dilute aqua regia (three parts of 2 M HCl to one part 1 M HNO_3; both VWR AnalaR).

3. Results and discussion

3.1. Occurrence and general characteristics

The abundance of surficial pellets per m^2 was greater (typically by at least an order of magnitude) on the backshore of each beach, where wave action occurs during storms, than in the swash zone or on the immediate strandline. Backshore pellets usually co-existed with, and were sometimes embedded within, accumulations of other debris, including string, wood, leafy deposits of *Posidonia oceanica*, larger fragments of plastic and other small pieces of litter. Pellets were also encountered in the cracks and grooves of rocks and walls at the backs of the narrower beaches, but were never observed in dune systems of the broader beaches that were inspected suggesting that wind transportation of these contaminants is not important.

Most pellets were disc-shaped, although cylindrical pellets were common on some beaches (with a relative abundance up to about 10%) and cube-shaped pellets were occasionally observed. The primary diameter or height of 40 randomly selected pellets averaged 3.4 mm (SD = 0.7 mm; range = 1.9–5.6 mm), while subsequent gravimetric analysis revealed an average pellet mass of 27 mg (SD = 6.9 mg; range = 16–61 mg). All pellets analysed by FTIR (n = 30) were polyethylene.

At the rocky shorelines visited (Slugs Bay and Pembroke) we observed high densities of pellets (up to several thousand per m^2), of similar characteristics to those described above, embedded in tar deposits (Fig. 2). Dissection of the tar revealed heterogeneous