Note

Plastic litter in sediments from the coasts of south Tuscany (Tyrrhenian Sea)

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A B S T R A C T

This study estimated the total loads of plastic litter (macro-meso- and micro-plastics) in sediments from a wide stretch of marine and coastal environment of Tyrrhenian Sea. The prevailing category of debris was microplastic. The results obtained, in terms of average amount of microplastic per kilogram of dry sediment, are in agreement with data reported by various Authors internationally. The study area resulted to be uniform for plastic items levels. Particularly evident was the influence of a flood, occurred in November 2012 in Talamone, on sediments collected at the harbour of this locality: in this area, a difference in levels and quality of plastic debris, attributable to periods before and after the flood, was observed in sediments. In addition to focusing on the effect of this phenomenon, this study gives an important overview, for what concerns the presence of plastic litter, of a significant naturalistic area.

The presence of plastic particles on the surface of the sea is a fact known since the 70s of the last century (Carpenter and Smith, 1972); the widespread use of plastic (mainly disposable) products, together with poor materials degradability, has contributed to the environmental problem that is generating much interest by the scientific community nowadays (Barnes et al., 2009). Considering the wide spread of waste, including plastics, at sea, the European Union has chosen the "Marine Litter" as one of the eleven descriptors to evaluate the marine environmental status (De Lucia et al., 2014) established under the Marine Strategy Framework Directive (MSFD - Directive 2008/56/EC), and on which put in place initiatives to reach the "Good environmental status" (GES) by 2020 (Galgani et al., 2010). From what above reported, is evident the need of gathering as much information and data as possible to learn about the real state of health of our seas, and develop strategies aimed at the containment of contamination. This study has considered several sites, along southern Tuscan coast of Tyrrhenian Sea in order to determine total loads of microplastics in sediments and to evaluate the statistical significance of some possible factors involved with the observed variability. The study area was chosen because of its ecological relevance and geographical features. The whole investigated area, between Talamone and Marina di Capalbio (province of Grosseto), falls, in fact, in a coastal stretch that can be considered uniform in morphology (mostly sandy, except for Talamone promontories) and for currents influence.

The aim of this study was an assessment of plastic litter presence in marine and coastal environments; moreover, comparing the results of samples of different origin, to evaluate the influence of variables as sediment kind (river/sea), human presence and influence of an exceptional event as the flood that occurred in November 2012 in Talamone.

Samples were collected outside Talamone harbour (Fig. 1). The area is characterized by low coast, consisting of sandy loam and/or silty clay deposits, carried by Osa and Albegna rivers, and other streams. This area is subject to marine erosion, but a substantial change of its morphology occurred in November 2012, following an exceptional flood event that has moved massive amounts of sediment, along the coast of Talamone, causing a significant bathymetric shift in some accumulation zones (increase between 30 and 50 cm in sea bottom bedding, M. Renzi, pers. com.).

The Osa River flows in the province of Grosseto and emerges into Tyrrhenian Sea.

The Albegna River flows into the Tyrrhenian Sea in Albinia. The "Middle Albegna" is a heritage site; it is both safeguarded as a Special Protection Area (SPA, International code number: IT51A0021) and proposed as a Site of Community Importance (pSCI).

The Capalbio and Fiora River area is characterized by sandy beaches and a dense Mediterranean scrub. The territory is part of a WWF Oasis, and this means that the natural environment is protected and safeguarded. However, the large influx of tourists during the summer months has significant environmental impact. Another important factor, in determining a pollution input, is the contribution of the Fiora River, whose mouth opens in this stretch of sea. The Fiora River, even if not included in the protected areas system, is a site of regional interest (SRI), both SCI (Site of Community Importance), and SPA (International code number: IT51A0019).

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http://dx.doi.org/10.1016/j.marpolbul.2017.04.008

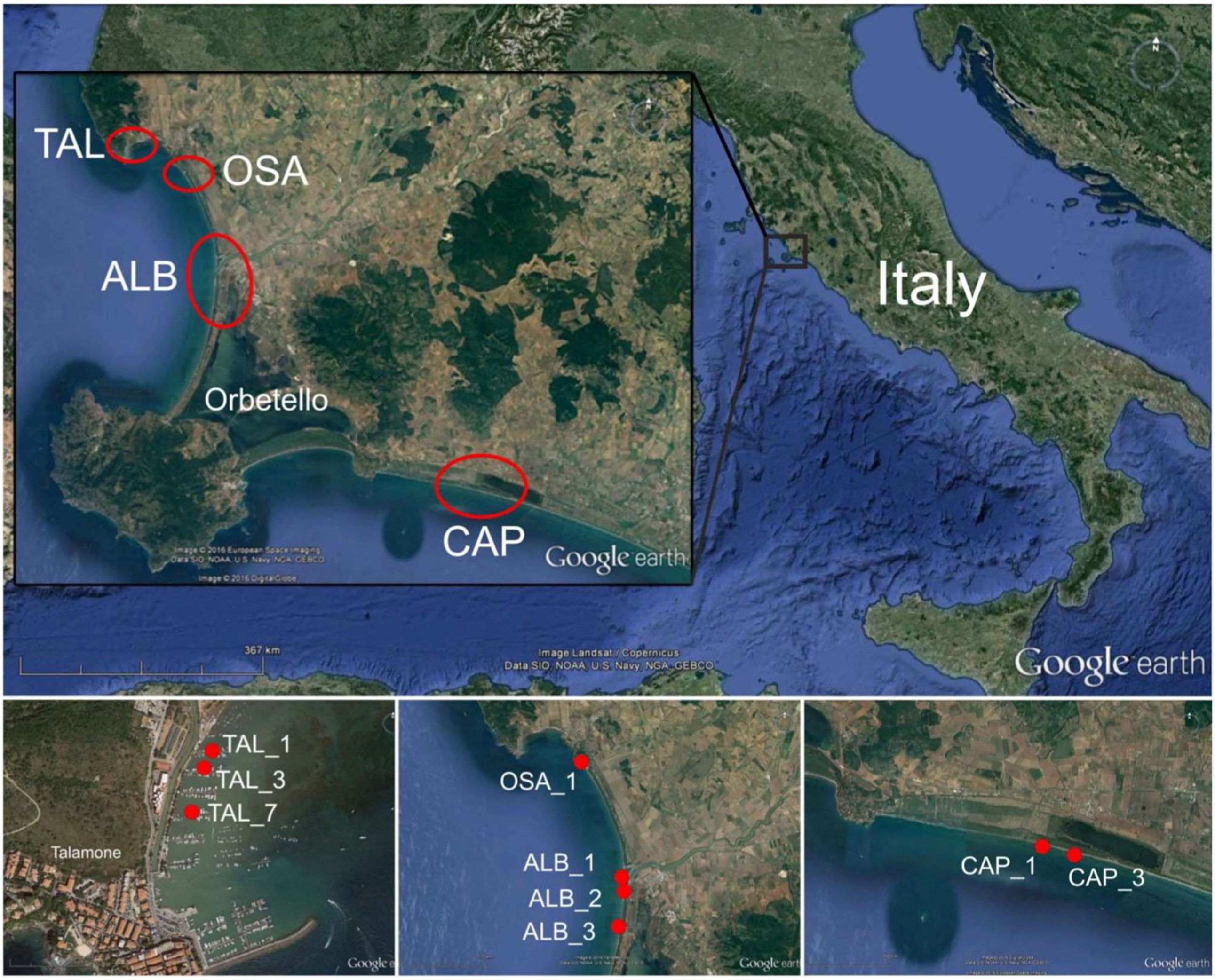

Fig. 1. Sampling sites.

The sampling stations selected are shown in Fig. 1. Sampling sites were chosen inside a wide area of great ecological relevance. According to study aims, sampling stations were chosen to guarantee representative samples of every particular location.

A list and a brief description of the sampling points are reported below:

- Talamone: 3 stations, from which 6 samples, (3 surficial, 0–50 cm, and 3 deep, 100–150 cm) were collected. This sampling is part of a BsRC larger survey, carried out with the support of a research vessel, and was performed with a stainless steel vibrocorer 3 m long.
- Osa and Albegna mouths: 4 sampling points (2o replicates of river mouth and 2 replicates of sandy shore). A manual bucket has been used for sampling, with a 2 L grab volume. Samples were taken at a depth of 0–50 cm in submerged areas and on the surface in those emerged, always in the first 10–15 cm thick.
- Capalbio: 4 samples were taken (2 replicates from sandy shore and 2 from submerged beach). Equipment and procedures are the same described for Osa and Albegna sites.

All samples were treated according to the procedure described below, which refers to "DeFishGear Protocols for sea surface and beach sediment sampling and sample analysis" (http://mio-ecsde.org/wp-content/uploads/2016/08/Beach-litter_monitoring-methodology.pdf), with some adaptation, and already described in Fastelli et al. (2016) Blăsković et al. (2017) and Guerranti et al. (2017).

Sediments were broken up with a mortar, and then each passing fraction was collected from the sieve and weighed separately. Fractions collected on 4-2-1 mm sieves were placed on a Petri dish and examined dry as described later, while those passing through the sieve 63 μm mesh, and lower, have been extracted with a NaCl solution, and then filtered through a Büchner funnel. Filters were left to dry and examined under a stereo microscope. The elements identified were classified by assigning size classes and according to shape and colour categories, respectively proposed by Alomar et al. (2016) and Galgani et al. (2013), and yet used in previous monitoring studies (Table 1; Fastelli et al., 2016).

Univariate (*t*-test and F-test) and multivariate statistics (*nm*-MDS, ANOSIM one-way test) was performed on results in order to verify the significance of some factors potentially involved, such as location, major or minor distance from river mouth and time trend (limited to Talamone). Multivariate statistics were performed by the use of the Primer software's routines (Plymouth, UK).

Table 2 and Figs. 2 and 3 report the results achieved, divided for sampling points/areas and for plastic items size classes. Microplastics dominate the analyzed sediments although mesoplastics are fairly represented. Filaments are the most common shape category in each sample analyzed (> 88% in each case); fragments represent almost the totality of items recovered other than filaments (< 9% in each sample). Items from 4 shape categories (filaments, fragments, films and foam) were found in sediments from Capalbio and Talamone, while in

Table 1
Plastic litter classification followed in the analyses of sediment samples (from Fastelli et al., 2016).

Colour	Shape	Dimension
White (W)	Filament (FI)	> 2.5 cm (MacroPs)
Clear (C)	Film (FILM)	2.5 cm–5.1 mm (MesoPs)
Red (R)	Fragment (FR)	≤ 5.0 mm (MicroPs)
Orange (O)	Granule (G)	
Blue (BE)	Pellet (P)	
Black (BK)	Foam (FO)	
Gray (GY)	Unrecognized plastic piece (UN)	
Brown (BN)		
Green (GN)		
Pink (P)		
Tan (T)		
Yellow (Y)		

Table 2
Number of micro-, meso- and macroplastics items for sampling site; mean ± SD for kg of dry sediment analyzed.

Site	MicroPs	MesoPs	MacroPs
Talamone (surficial)	62 ± 24	26 ± 23	0
Osa	286 ± 37	6 ± 8	0
Albegna	453 ± 424	12 ± 13	0
Capalbio	466 ± 297	26 ± 26	5 ± 10

Albegna and Osa samples filaments, fragments and films were recovered. With regard to size classes, in most samples, plastics reached maximum size between 5 and 10 mm. The minimum dimensions were nearly always between 0.5 and 1.0 mm.

Plastic colours vary widely, including white, clear, blue, black, pink, red, green, pink, orange, green and gray. The most frequent colours found in each sample are black, blue and clear. The maximum amount, as number of microplastics for kilogram of dry sediment, was found in Albinia sandy shore (1069 items/kg), while the minimum in a Talamone harbour surficial sample (42 items/kg).

Multivariate statistical analysis was performed on measured amount of micro, *meso* and macroplastics sediment concentrations, divided in their main components to test the relevance of some factors potentially capable of interfering with the distribution of plastic (i.e. major of minor distance from the river mouth, geographical localization of sampling sites, level of human pressure). Statistically significant differences in levels of plastic items concentrations of samples of different origin were not evidenced (ANOSIM test not significant), leading to consider the all the area analyzed as homogeneous.

Statistics carried out on Talamone samples shows significant lower levels on average in surface sediments (ascribable to sedimentary contribution post flood occurs in 2012) than in deep ones (representative of the state before the flood) in microplastics (*t*-test significant $p = 0.017$; F-Test resulted not significant), suggesting an effect of “dilution” due to this event (Fig. 3). Data relating to the depth 100–150 cm, which are attributable to the period before the flood, show higher plastic items content than those of the bathymetry 0–50 cm, which settled after alluvial event.

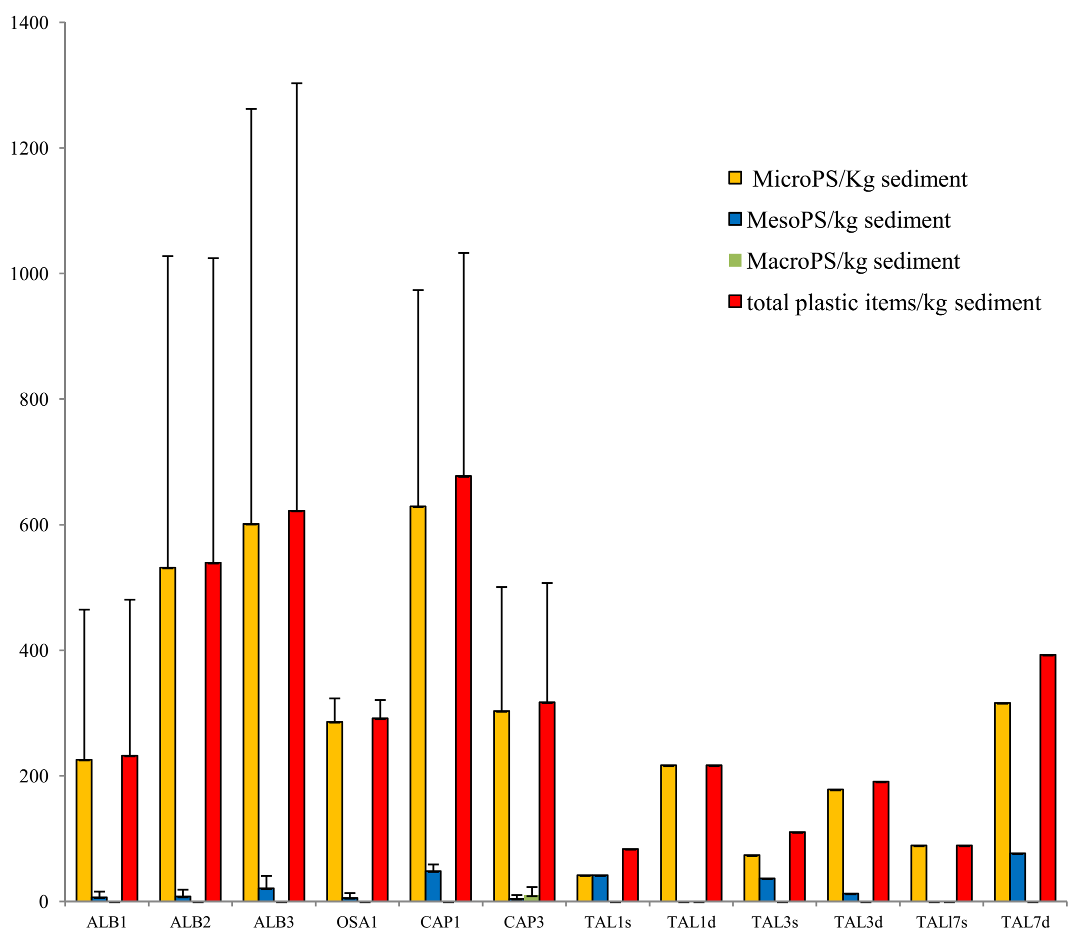

Fig. 2. Detailed results on plastic litter presence in each sampling point, divided for plastic items size. For Albegna, Osa and Capalbio mean ± standard deviation of two replicates are reported; for Talamone the results are referred to three single sampling points, divided in a surficial and a deep samples.

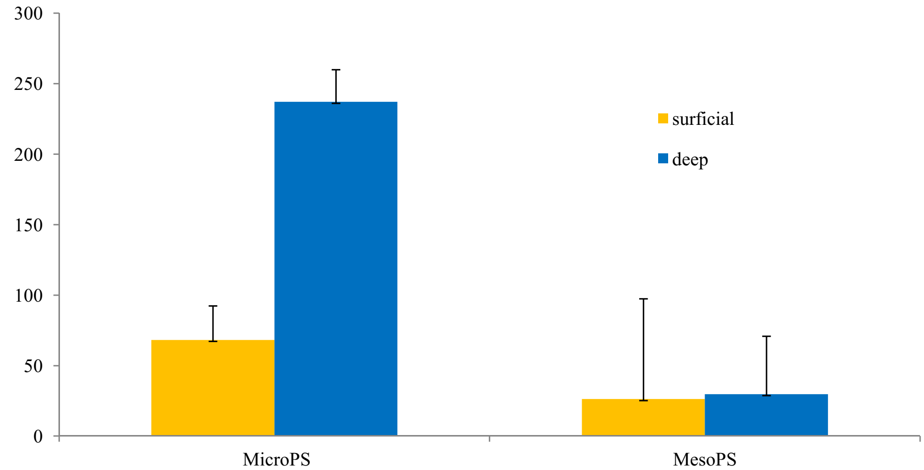

Fig. 3. Comparison between surface and deep sediments collected in Talamone (means ± standard deviation; items/Kg sediment dry weight).

It has been observed that colour mode turns from clear in deep sediments to blue in surface ones, that can be interpreted as a different origin of the plastic materials (from river in the case of surficial sediments, due to the alluvial event) or due to the different and type-related processes of degradation by salt water and sunlight.

There are several difficulties in comparing the results reported in the available literature, due to the adoption of different methodologies in data collection, classification and reporting of the marine litter, as well as different units of measurement (Alomar et al., 2016). Anyway the results obtained in this work lies within the wider international range (e.g. Claessens et al., 2011; Liebezeit and Dubaish, 2012; Fastelli et al., 2016; Munari et al., 2016; Pasquini et al., 2016; Blăsković et al., 2017). As regards the sandy shore, Poeta et al. (2014) report the results of a survey made on a nearby sandy shore few southern on Tyrrhenian coast: even if analyses done had different purposes and no microplastic sorting was made, the article points out the large prevalence of plastic materials within marine litter on sandy shores. Overall, the levels measured for sandy shores in this study are similar to those found in Germany (Spiekeroog and Kachelotplate, reported by Liebezeit and Dubaish, 2012), while they are significantly higher compared to all other. For what concerns samples from marine environments, the values found in this study are similar to what reported in literature above listed. Finally, the amount of microplastic found in Talamone harbour are in line with those reported for similar environments in Belgium (Claessens et al., 2011).

Based on the results achieved the studied area appears homogeneous, in terms of plastic litter presence: this common characteristic can be potentially due to common and/or similar sources of plastic litter environmental input or due to local movement and consequent remixing of plastic fragments.

For what concerns the samples from Talamone and the qualitative and quantitative difference between sediments attributable to periods before and after a consistent flood, some hypothesis can be made. Talamone harbour is an area characterized by scarce mixing and high deposition rates; to: the alluvial event could have somewhat diluted/dispersed the plastic material previously present in the area. Another possible cause of this difference can be a negative time trend in the plastic load transported by the river, due to an increased attention to the problem of plastic litter abandoned in the environment.

More detailed studies are necessary to better understand biological and ecological impacts related to marine litter. This study aimed therefore to give a first contribution to the characterization of the area, to understand how much is affected by this kind of pollution, also considering the sites of great naturalistic interest located within.

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