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Abundance and characterization of microplastics in the coastal waters of Tuscany (Italy): The application of the MSFD monitoring protocol in the Mediterranean Sea

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ABSTRACT

Monitoring efforts are required to understand the sources, distribution and abundance of microplastic pollution. To verify the abundance of microplastics along the Tuscan coastal waters (Italy), water-column and surface samples were collected in two seasons across four transects at different distances to the coast (0.5, 5, 10 and 20 km), within the implementation of the European Marine Strategy Framework Directive. The results show an average concentration of 0.26 items/m^3 in the water-column samples and 41.1 g/km^2 and 69,161.3 items/km^2 of floating microplastics, with an increase with the distance to the coast The seasonality and the sampling area do not affect the abundance of microplastics. The most abundant size class is 1–2.5 mm as fragments and sheets suggesting that fragmentation of larger polyethylene and polypropylene items could be the main source of microplastics. These data represent the application of a harmonized protocol to make the data on microplastics comparable and reliable.

1. Introduction

Anthropogenic litter on the ocean surface, beaches and seafloor has become an urgent issue in recent decades worldwide, including the Mediterranean Sea that has been described as one of the most affected area in the world (Cózar et al., 2015; van Sebille et al., 2015). The Mediterranean Sea houses around 10% of the global coastal population along its shores (about 100 million people within the 10-km coastal strip) (CIESIN, 2012). To date, a lot of studies carried out in this basin have focused on beach litter (Karapanagioti et al., 2011; Munari et al., 2017; Portman and Brennan, 2017; Prevenios et al., 2018; Turner and Holmes, 2011), on the accumulation of marine debris on the coastal sediments (Alomar et al., 2016; Blašković et al., 2017; Cannas et al., 2017; Fastelli et al., 2016; Guerranti et al., 2017) and on the sea floor (Cannas et al., 2017; Galgani et al., 2000; García-Rivera et al., 2017; Guerranti et al., 2017; Koutsodendris et al., 2008; Mifsud et al., 2013; Ramirez-Llodra et al., 2013). Regarding the abundance of floating macro and mega debris in the Mediterranean waters, studies (Aliani and Molcard, 2003; Carlson et al., 2017; Di-Méglio and Campana, 2017; Faure et al., 2015; Fossi et al., 2017; Gajšt et al., 2016; Suaria and Aliani, 2014), showed densities between 0 and 194.6 items/km^2, with a maximum registered in the Adriatic Sea and Algerian Basin (Suaria and Aliani, 2014). Levels of microplastics have been detected in surface waters using surface net tows (Collignon et al., 2014, 2012; Cózar et al., 2015; Faure et al., 2015; Fossi et al., 2017, 2012; Gündoğdu and Çevik, 2017; Panti et al., 2015; Pedrotti et al., 2016; Suaria et al., 2016; van der Hal et al., 2017) even in areas with low human impact, confirming that floating debris is widespread in the Mediterranean Sea with concentration higher or in the same order of magnitude of those found in oceanic accumulation zones (Cózar et al., 2014; Suaria et al., 2016; van der Hal et al., 2017; van Sebille et al., 2015).

Very few specific studies have focused on the quantification of microplastics in the water column. At European level a single study on the Baltic Sea shows an average concentration of microliter of 0.40 items/l, where the highest concentrations are found in the near-bottom samples from the coastal zone and from near-surface waters (Bagaev et al., 2018) Any study has been published on the Mediterranean sea, apart from few data presented in Fossi et al. (2012).

The density and characteristics of the floating plastics and microplastics sampled in the Mediterranean sea are comparable to other

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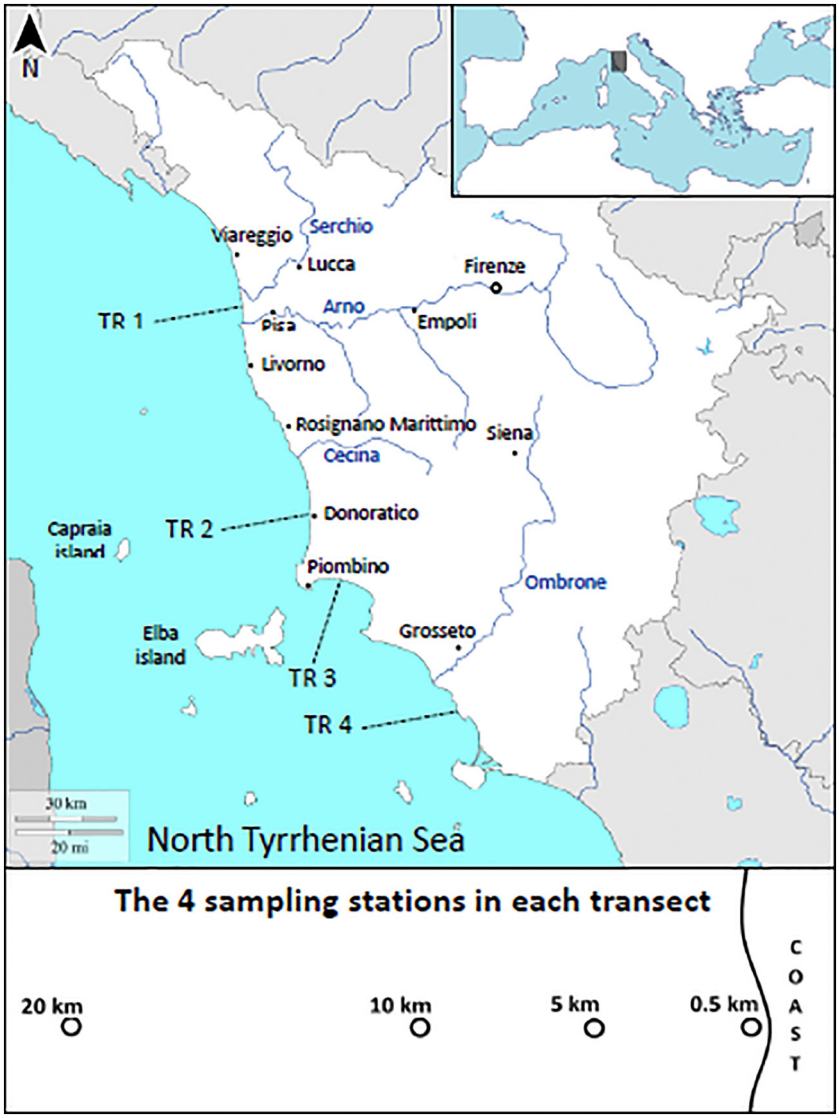

Fig. 1. Map of the study area along the Tuscany coast, in blue the rivers and in black the towns. Sampling plan with four different transects, each one with four stations located at increasing distance from the coast (0.5 km, 5 km, 10 km, 20 km). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

basins and oceans, but the issue about the total mass based on the size of the particles, based both on field and model observation, is still debated (Cózar et al., 2015; van Sebille et al., 2015).

Large plastic items and microplastics distribution vary across the Mediterranean Sea, depending on surface circulation and transient and seasonal formation of fronts, eddies and accumulation areas (Zambianchi et al., 2017). The surface flow temporal variability might play a role in driving marine litter accumulation pattern, as well as the costal kinematics and features influence the distribution of marine litter in the 10–50 km near-shore waters (Liubartseva et al., 2018; Ourmieres et al., 2018). A general tendency of floating litter to accumulate in the southern portion of the basin, and, in particular, a long-term accumulation in the southern and south-eastern Levantine basin, has been observed (Zambianchi et al., 2017).

Permanent structures which retain floating items have not been yet identified since the circulation variability in the basin alters their stable spatial distribution, but these oceanographic features led to consider the entire basin as a great accumulation region of microplastics with concentrations comparable to those found in of the great Subtropical Gyres (Cózar et al., 2015).

Other factors influencing the accumulation of plastic and microplastics items can be related to the distance from input sources (e.g. rivers, waste water treatment plants, urban sewage) as well as the distance to the coast (Pedrotti et al., 2016; Ryan et al., 2016).

The area investigated is characterized by a variety of anthropogenic pressures. On the northern area, there are two main possible pollution sources. The Leghorn commercial, touristic and maritime port is one of the largest Italian ports with 30 million tonnes of cargo and 600,000 twenty-foot equivalent unit and 2 million of people and the mouth of the Arno river, one of the largest Italian river, which during its 240 km of length cross several cities, agricultural sites and industrial area (Cincinelli et al., 2001; Cortecci et al., 2002). Some minor inputs can derive for the Piombino harbour and minor rivers (e.g. Ombrone) and city facing the Tyrrhenian sea (Guerranti et al., 2017; Guidi et al., 2018). Along all the Tuscany costs, maritime traffic for the Tuscan Archipelago islands and the presence of several touristic location makes the area highly anthropized and prone to the plastic and microplastic accumulation.

As underlined by the Barcelona Convention within the Regional Plan for Marine Litter (Barcelona Convention, 2013) “Marine pollution knows no border, pollution in one country affects all other 21 countries”; hence a regional approach is strictly needed. This awareness has