Abundance and composition of floating microplastics in the central-western Mediterranean Sea

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Numerical models predict some of the highest concentrations of floating plastic in the world to occur in the Mediterranean Sea [1]. Here we present the results of a large-scale survey of neustonic microplastics in Mediterranean waters, confirming model predictions and providing detailed information about their occurrence, abundance, distribution and polymeric composition.

74 neuston samples were collected during two consecutive cruises carried out in the Mediterranean Sea between May and June 2013 (Fig. 1). Samples were all collected using a 200 µm Neuston net which was towed for ~ 5 minutes at a speed of 1.5-2 knots. Samples were fixed with 80% EtOH and stored for laboratory analysis. A mechanical flowmeter was used to measure the trawl length. In the laboratory, samples were sorted at the stereomicroscope. All plastic particles were hand-picked using laboratory tweezers and separated into seven size classes by sequential sieving through a series of stacked stainless steel meshes. All particles in each size category were counted, dried, weighed on an electronic balance and classified according to 5 shape and 7 colour categories. Because of the high risk of air-borne contamination, all synthetic fibres were subsequently excluded from density calculations.

Plastics particles were found in all samples collected with an average concentration of 1.25 ± 1.62 particles/m^2 and 703.16 ± 1573.95 g/km^2 throughout the study area. Most of the collected particles (93.2%) were classified as hard-plastic fragments (i.e. secondary microplastics), while pellets, films and foam constituted only a small fraction of the total. Transparent and black/grey were the most common colors, followed by white, blue/green, brown, orange/red and yellow. The vast majority of the particles (98.6%) were classified as microplastics *sensu stricto* – i.e. items smaller than 5 mm. Conversely to what was previously reported in the literature [2], no clear indication about the loss of smaller size fractions was found. The number of particles steadily increased with decreasing size. 26.4% of the particles were smaller than 300 µm and more than half of all collected items (50.8%) were smaller than 500 µm.

Plastic concentrations showed a very high spatial heterogeneity, spanning two or three orders of magnitude across the study area (Fig. 1) and likely reflecting the influence of diverse factors governing plastic distribution at sub-basin scales. Maximum concentrations (9.23 particles/m^2 and 10.63 kg/km^2) were found in a sample collected in the Corsica Channel, while the lowest concentration (0.04 particles/m^2) was observed in the Southern Adriatic Sea. On the whole, plastic was significantly ($p = 0.002$) less abundant in the Adriatic (0.83 ± 1.05 particles/m^2; 485.07 ± 1153.07g/km^2;

n = 30) than in the rest of the Mediterranean Sea (1.54 ± 1.87 particles/m^2; 851.85 ± 1803.66 g/km^2; n = 44). The same pattern was observed for plastic pellets, which were almost exclusively found in the Corsica channel and in the transect between Balearic islands and Sardinia.

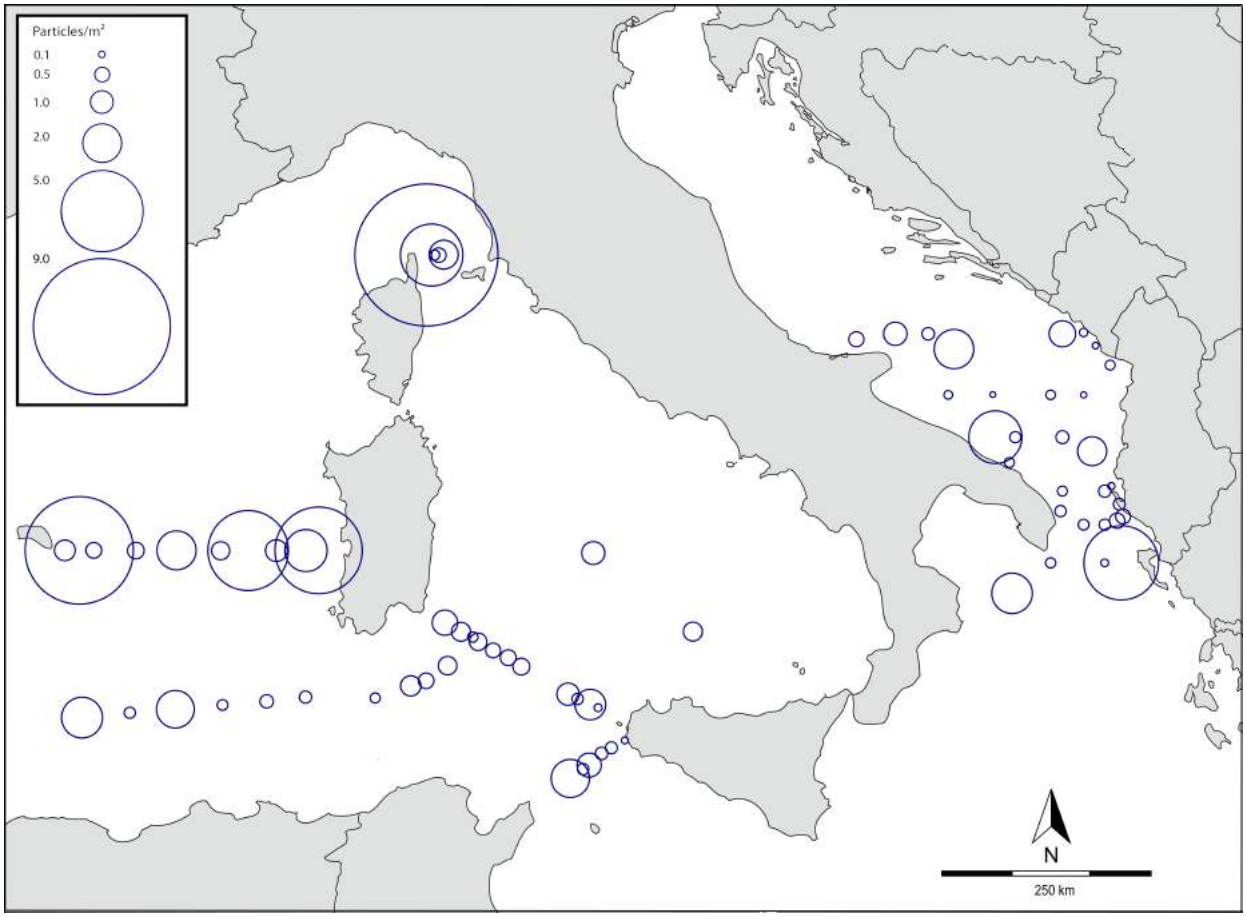

Fig. 1 Map of the study area showing the location of all sampling stations and measured microplastic concentrations expressed as number of items/m^2.

When testing for the effect of environmental variables on plastic concentrations, no significant correlation was found with depth, surface temperature or salinity ($p > 0.05$), whereas a negative correlation ($r_s = -0.2687$, $p = 0.020619$) was found between wind forcing and microplastic abundance. Hence plastic concentrations obtained from net tows carried out with wind-induced friction velocities in water $u^*_w > 0.6$ cm/s (n = 30; 40.5% of the tows), were corrected using a one-dimensional column model [3], which increased our mean plastic concentration to 1.84 ± 2.14 items/m^2 throughout the study area.

A sub-set of 4050 items (> 700 µm) was chemically characterized through FT-IR analysis. Sixteen different classes of synthetic polymers were identified. More than half of all particles (52%) were classified as polyethylene (PE), followed in abundance by polypropylene (PP) (16%), synthetic paints (7.7%), polyamides (PA) (4.7%), polyvinyl chloride (PVC) (2.6%), polystyrene (PS) (2.8%), Nylon (1.9%) and polyvinyl alcohol

(PVA) (1.2%). Other polymer classes encountered less frequently included: epoxy resin (polyepoxide), poly(ethylene terephthalate) (PET), polyisoprene (synthetic rubber), poly(vinyl stearate) (PVS), ethylene-vinyl acetate (EVA), cellulose acetate, paraffin wax and polycaprolactone (PCL), a biodegradable polyester, which was found in seven different samples throughout the study area. The molecular characterization revealed also that 4.4% of all analyzed particles did not consisted of plastic but were rather made of cotton, chitin, cellulose and other non-synthetic materials, suggesting a potential bias when visually sorting for microplastics.

Geographical differences in the relative proportions of different polymers were also observed, demonstrating for the first time a certain degree of spatial heterogeneity in microplastics composition and likely reflecting the influence of diverse factors governing plastic distribution at sub-basin scales. The composition of western Mediterranean samples was more homogeneous and markedly characterized by a higher occurrence of low-density polyolefins (polyethylene and polypropylene). In contrast, Adriatic samples appeared to be more heterogeneous and rather characterized by a higher presence of high-density polymers such as paint chips, PVC, PVA, PS and PAs, probably suggesting a closer link with pollution sources.

On the whole, our results demonstrate the pervasiveness of plastic pollution in the entire Mediterranean basin and provide further evidence that in this basin, microplastics abundances are amongst the highest in the world. We estimate that during our survey, between 2.2 and 4.0 x 10^{12} particles and between 933.4 and 2675.4 tonnes of plastic were floating in the Mediterranean basin, providing further evidence about the magnitude of the problem for the entire Mediterranean region.

Literature:

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