Abundance, size and spatial distribution of neustonic microplastic in the Ligurian Sea (NW-Mediterranean Sea)

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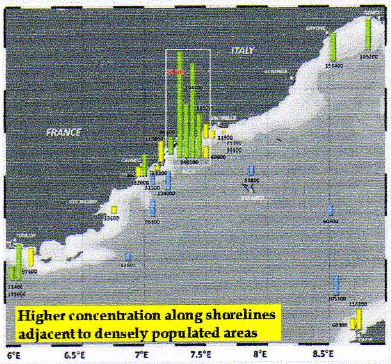
Marine debris has been defined as any manufactured or processed solid waste material that enters the marine environment from any source (Coe and Rogers, 1997). While plastics constitute a lower percentage of discarded waste, they are the most important part of marine litter, comprising sometimes up to 100% for floating items. Plastics have been considered an environmental and pollution threat to the marine environment whose importance will increase through the 21stcentury. In Mediterranean Sea more than 70% of plastic litter comes from land-based sources. Once in the marine environment debris may remain for many years. The Mediterranean Sea is one of the most affected by floating plastic debris however scientific investigation on the impact of microplastic is recent and results beginning to emerge. Here we report a study on the abundance, size and spatio-temporal distribution of microplastic and zooplankton carried out in summer 2013 in the Ligurian Sea. Surface floating microplastics abundance and area per square kilometer were calculated and compared to the size distribution and mean spatial trends of the neustonic plankton.

Methods: Surface floating plastic fragments and neustonic plankton were collected in July and August 2013 in the Ligurian sea (NW Mediterranean sea) in the framework of the participative science activities of ExpeditionMED association. Samples were collected using a Manta trawl net with 333µm mesh size (A). Back to lab, plastic particles and zooplankton were enumerated, sorted and measured by digital imaging analysis using a data acquisition system and the ZooScan (Gorsky et al, 2010.) (B-C). Fourier transform infrared spectroscopy (FTIR) and Thermogravimetric analysis (TGA) were used to specify absorption bands of plastic fragments and characterize microplastic particles.



Port & near Towns 2.44E+05 items/km²

Bays 6.29E+04 items/km²

Open sea 7.36 E+04 items/km²

Amount (items/Km²) & distribution of microplastics collected in Ligurian sea

Microplastic dynamics: Our results suggest that plastic fragments are widespread in the Ligurian Sea. Microplastics were present in all Manta tows, varying from 11900 to 578000 plastic debris per km² near Nice town. The average abundance of microplastics found in Ligurian Sea is higher than in Sardinian Sea with levels approximately seven times higher in the samples from the same survey in both sites (Fossi *et al.* 2012).The highest abundance is of the same order of magnitude as that found in the North Pacific Gyre.

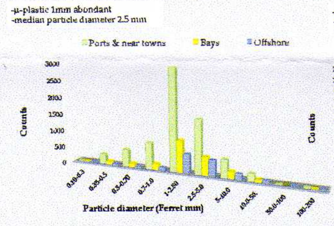
Microplastics and zooplankton abundance in the Mediterranean sea

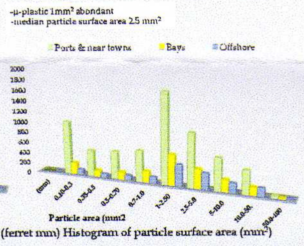
Microplastics (items / km²)			Zooplankton (items / km²)			Ref
Mean	Max	Min	Mean	Max	Min	
1.32E+05	5.78E+05	1.19E+04	2.15E+08	2.33E+09	6.94E+04	Our study
1.16E+05	8.92E+05	0.00E+00	NA	NA	NA	Collignon, 2012
6.20E+04	6.88E+05	0.00E+00	1.12E+08	9.86E+08	3.42E+06	Collignon, 2013

Microplastics (items /m3)

Location	Mean	Ref
Ligurian Sea	1.578	Our study
Ligurian Sea	0.116	Collignon, 2012
Ligurian Sea	0.940	Fossi et al, 2012
Sardinia Sea	0.130	Fossi et al, 2012
Sardinia Sea	0.150	de Lucia et al 2014

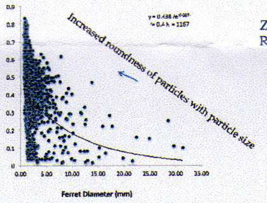
Microplastic size spectra and area (n=10540 ; small particles dominate)





Histogram of frequency distribution of particle diameter (ferret mm) Histogram of particle surface area (mm²)

Circularity & weathering: index of the roundness of microplastics

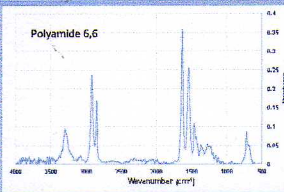


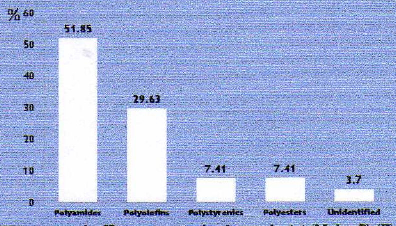
ZoosCan parameter circularity (4 π area*perimeter^{-2})
Ranges from 0 to 1 (1.0 indicating a perfectly circular object)

Average particle circularity =0.4 (N 1167 µ-plastics)

- smaller particles were more circular & larger particles were more irregular
- associated with mechanical breakdown and weathering
- increased residence time of particles at sea Gilfillan et al. (2009)
- California current system 0.49-0.47 Gilfillan et al. (2009)

Chemical characterization of microplastics: A data bank containing the spectra of main marine microplastics has been established. These spectroscopic results associated with the thermal data obtained using TGA and DSC revealed that the most frequent plastic types were polyamides (comprising 52 % of the plastic present), polystyrenics (different kinds of polystyrene and also copolymers of polystyrene), polyolefins (polyethylene and polypropylene) and polyesters. As shown by numerous recent studies, polyethylene, polypropylene and polystyrene were usually the most abundant types of debris (Frias *et al.* 2014, Cozar *et al.* 2014) but in that special case, the plastic predominantly recovered is polyamide. One likely explanation could be the introduction of some of these fibers via the sewage outlets onto shorelines and/or their re-suspension in water column





Chemical characterization of microplastic particles. As an example, IR spectrum of polyamide 6,6 (Nylon®) (E).

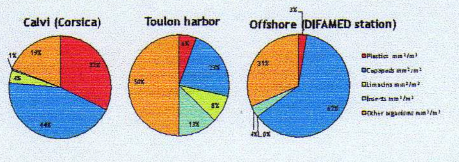
Microplastic & Zooplankton interactions

0.33 -average ratio between total abundance / m² of microplastics and mesozooplankton
Copepods were the most abundant organisms in the surface layer but neustonic mollusks and cladocerans were also abundant.
If we give the ration in surface area of plastic occupied by plastic & plankton for each size class of plastic and plankton it increase considerably.

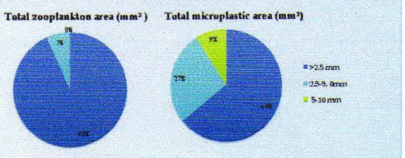
Size class	Ratio Plastic /Plankton (mm2/m2)
300-500µm	0.98
500-700µm	0.42
700-1000µm	1.88
1000-2500µm	6.48

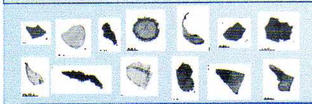
Ration plastic:plankton = possible environmental indicators to attest the good ecological state (DCMM)

Proportion of the abundance of microplastics and of zooplankton



Proportion of the total zooplankton & microplastics area for each size class

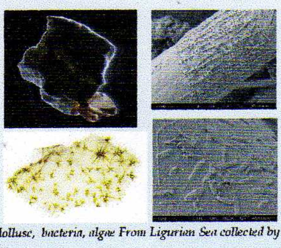




Microplastics same range size as zooplankton 300-2500µm (imaged by ZooScan)

Potential confusion for predators regarding planktonic prey of this size class
Microplastics enter the food chain

Microplastics rafting for species



Mollusc, bacteria, algae From Ligurian Sea collected by Manta trawl

Living fauna associated to & transported with microplastics
High amount of terrestrial insects (average 15000 ind km⁻²)

MICROPLASTIC New reservoir?
Ecosystem modification?
Abundance and ecological implications of microplastics for the biota need to be better assessed.

Coe J.M. and Rogers D.B. (eds.) 1997 Marine Debris. Sources, Impacts and Solutions. New York Springer-Verlag
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