A FIRST ASSESSMENT OF MICROPLASTICS IN THE SEA WATERS OFF THE PUGLIA REGION

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Abstract – Plastic materials persist in the marine environment with different timing depending on their nature but atmospheric agents contribute to their degradation into smaller fragments, the so called microplastics (MPs). To meet the objectives of the EU Marine Strategy Framework Directive (MSFD, 2008/56/EC), the Puglia Regional Agencies for the Prevention and Protection of the Environment (ARPA Puglia) performed a quantitative and qualitative analysis of the MPs on the basis of the data collected during 2015-2017 monitoring program. A total of 90 samples in 5 campaigns were collected using a manta net. The MPs average density of 0.469 n/m³ was calculated for the entire dataset, a value comparable with those previously reported for others Adriatic and Mediterranean waters. No significant statistical differences were detected among sampling sites, campaigns and distance from the coast. The results represent a first assessment of microplastics at Apulian regional scale, that can be useful for the implementation of predictive circulation models in order to estimate the fate of plastic litters released at the sea.

Introduction

The growing impact of plastics on ecosystems is now in the public domain as an emerging issue of global concern involving numerous actions worldwide, both in the field of research, in public awareness campaigns and in the field of environmental policies.

Plastic materials persist in the marine environment with different timing depending on their nature but atmospheric agents contribute to their degradation into smaller fragments, the so called microplastics (MPs). The common definition of MPs, as reported by Frias *et al.* (2019), is "*synthetic solid particles or polymeric matrices, with regular or irregular shape and with size ranging from 1 µm to 5 mm (5000 µm), of either primary or secondary manufacturing origin, which are insoluble in water*".

The Mediterranean Sea host numerous peculiar habitats and several endemic species, being a very studied basin. However, its position and geo-morphological conformation as well as the strong anthropization of the basin makes it more subject to plastic materials and MPs pollution. As predicted by van Sebille *et al.* (2015), the highest MPs concentrations are in Mediterranean and in North Pacific zones, while the largest microplastic quantity is in the North Pacific. The total quantity is much smaller in Mediterranean Sea compared to other cited zones because of the very small average particle size and much smaller basin size. It has been estimated by Eriksen *et al.* (2014) that of the 268 940 tons of plastics particles floating on the surface of the world's oceans, about 14.1 quintals of particle

Referee List (DOI 10.36253/fup_referee_list)
FUP Best Practice in Scholarly Publishing (DOI 10.36253/fup_best_practice)
Ilaria Dalle Mura, Enrico Barbone, Daniela Battista, Cosimo Gaspare Giannuzzi, Sergio Ranieri, Giuseppe Strippoli, Antonietta Zito, Nicola Ungaro, *A first assessment of microplastics in the sea waters off the Puglia region,* pp. 436-445 10.36253/979-12-215-0030-1.39

size between 0.33-1.00 mm and 53.8 quintals of particle size 1.01-4.75 mm have been found in the Mediterranean Sea.

In the field of environmental policies, the EU Marine Strategy Framework Directive (MSFD, 2008/56/EC) establishes a framework within which EU Member States shall act to achieve or maintain good environmental status (GES) of their marine waters. In particular it includes, among the eleven key descriptors of marine environmental status quality, the Descriptor #10 "*The properties and quantities of marine litter do not cause damage to the coastal marine environment*" focus on marine litter and its impact on the marine environment and biota (Galgani *et al.* 2013). About MPs, in Italy the related monitoring protocol drawn up by the SNPA (the National System for Environmental Protection) aims to determine the abundance and the quality of microplastics into the water column. In Italy, this monitoring protocol is performed at regional scale by the ARPAs (Regional Agencies for the Prevention and Protection of the Environment). ARPA Puglia performed a quantitative and qualitative analysis collecting data on MPs during 2015-2017 monitoring program. The aim of this study is to provide a first assessment at regional scale of microplastics into Apulian sea waters, to give an estimation of their abundance and quality in Southern Adriatic and Western Ionian Sea off the Apulian coast.

Materials and Methods

Puglia region is located in the south of Italy and it is the easternmost region. It overlooks two seas, the Southern Adriatic Sea to the north-east and the Western Ionian Sea to the south-west. The total coastline length is 985 km (Regional coastal plan – Puglia Region, 2011), representing the 14 % of the Italian coast overall development.

Six survey areas, representative of the Apulian marine waters, were chosen for the monitoring activities (CA, Foce Capoiale; FO, Foce Ofanto; BA, Bari Trullo; CB, Capo Bianco; PC, Porto Cesareo; PN, Punta Rondinella). In each survey area, a coastal-wide transect was identified. For each transects, three sampling stations were chosen at progressive distances from the coastline: 0.5, 1.5 and 6 nautical miles (NM). The planned survey areas with the relative transect and the coordinates of the three sampling stations are reported in Figure 1 and Table 1.

The sampling activities were performed during 2015-2017. The sampling was carried out twice in 2016 and 2017, in spring season (February-April) and autumn season (September-November), while in 2015 a single campaign was performed during the autumn season, for a total of 5 campaigns in three years. The MPs were sampled using a manta net with a mouth opening of 25 cm height and 50 cm wide. On the mouth of the manta net a flow meter was mounted, in order to measure the water volume filtered. At each sampling stations, the manta net was lowered slowly from the boat and towed for twenty minutes across a linear transect, in the opposite direction to the surface current and the wind. The linear transect starting point coincides with the sampling stations coordinates, as reported in Table 1. The end position was recorded with portable GPS in WGS 84 UTM 32 as DD°, DDDGG. The boat speed was constant and slow, around 1 or 2 knots, never exceeding 3 knots. The collected samples were fixed adding 70 % alcohol and stored in a refrigerator. A total of 90 samples were achieved during the five campaigns. The laboratory analysis of MPs was performed on the whole sample. As a first step, the sample was sieved through two sieves, of 5000 μm and 300 μm respectively, rinsing the container several times.

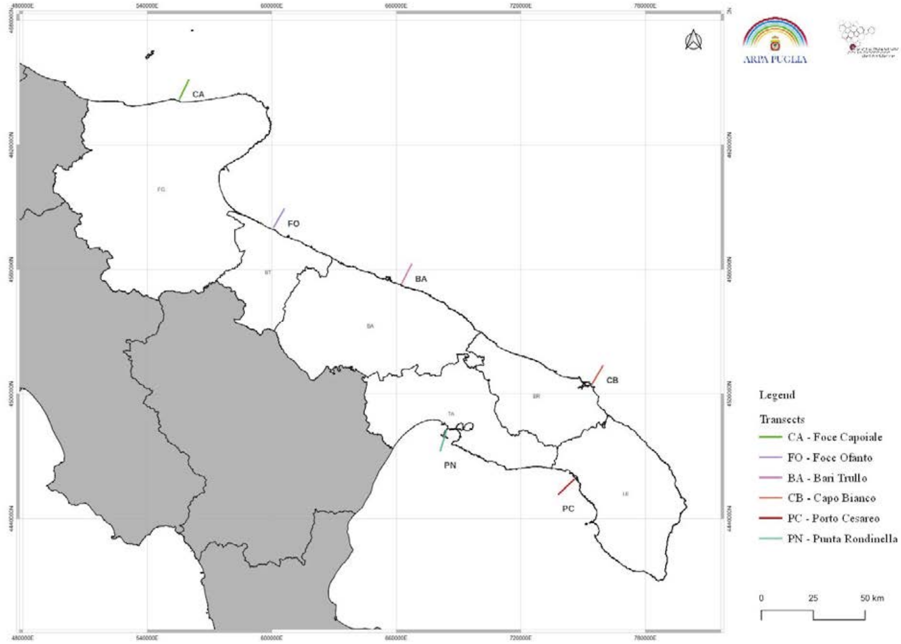

Figure 1 – Mapping of the six transects along the Apulian coasts.

Table 1 – Transects and sampling stations: identification code and geographical position.

Transects	Linear transect starting point	Lat.	Long.
CA	1CA01M	41.92963	15.67001
	1CA02M	41.94462	15.67997
	1CA03M	42.01132	15.72471
FO	3FO01M	41.36730	16.20593
	3FO02M	41.38175	16.21734
	3FO03M	41.44593	16.26803
BA	4BA01M	41.11583	16.93854
	4BA02M	41.13009	16.94867
	4BA03M	41.19636	16.99582
CB	6CB01M	40.65287	18.00848
	6CB02M	40.66689	18.02016
	6CB03M	40.73072	18.07377
PC	8PC01M	40.24308	17.88828
	8PC02M	40.23204	17.87222
	8PC03M	40.18166	17.79905
PN	9PN01M	40.47170	17.17270
	9PN02M	40.45584	17.16604
	9PN03M	40.38413	17.13597

Then, in a glass beaker the floating fragments were moved on a Petri dish with counting grid. The sorting phase involves the selection of the plastic materials only, separating for first organic residues (algae and plants, wood, etc.) with the aid of tweezers. Finally, MPs in the sample were counted and divided according to the shape (sphere, filament, fragment, sheet).

The MPs density was expressed as the number of particles per m^3 of sea water (n/m^3), according to different shape.

Most of the studies use a manta net for sampling, sometimes with mesh opening and vacuum of different sizes, pulled to the surface for a defined time and the samples are in all cases sieved in the laboratory in order to collect the microplastics (Frias *et al.* 2019, Suaria et al., 2016, Cózar et al., 2015, Zeri et al., 2018). In most of the studies the manta net is equipped with a flowmeter, however the GPS position of the beginning and the end of the transect is recorded. Consequently, some researchers show the data as the number of particles per m^3 of sea water (n/m^3; Fossi et al., 2016) while others as number per m^2 (n/m^2; Fossi et al., 2012). The data returned in the different articles are comparable to each other and with this study by standardizing them with mathematical formulas. Therefore, in order to compare the obtained results with the literature ones, MPs data were expressed as number per m^2 (n/m^2) also (Table 2).

The differences in the density values of MPs (n/m^3) were tested using the non-parametric Kruskal-Wallis rank sum test.

Results

MPs average number calculated for the entire dataset was 0.469 +/- 0.06 n/m^3. MPs average number for the Southern Adriatic Sea, calculated for 4 of the 6 transects (CA, FO, BA, CB), was 0.529 +/- 0.08 n/m^3 while the Western Ionian Sea transects (PC, PN) one was 0.348 +/- 0.07 n/m^3 (Figure 2). Nevertheless, although the average number of MPs is lower in the Ionian Sea than in the Adriatic Sea, the difference is not statistically significant (KW χ^2= 1.3656, df = 1, p-value = 0.2426).

The transect CA shows the highest average number of MPs per m^3 (0.702 +/- 0.25 n/m^3) in the three-year period, followed by FO, BA and transects (Figure 3). PC and PN show similar values. No statistical differences were detected among transects (KW χ^2= 6.8738, df = 5, p-value = 0.2302)

Considering MPs average number for each survey (Figure 4), the 2015 campaign highlighted the highest value (Autumn 2015: 0.646 +/- 0.21 n/m^3). Lowest mean value resulted for the 2016 Spring campaign (0.325 +/- 0.09 n/m^3), while Autumn 2016, Spring and Autumn 2017 mean values ranged from 0.430 ± 0.2 n/m^3 (Autumn 2017) to 0.501 +/- 0.10 n/m^3 (Autumn 2016). No statistical differences were detected among sampling periods (KW χ^2= 2.1424, df = 4, p-value = 0.7096)

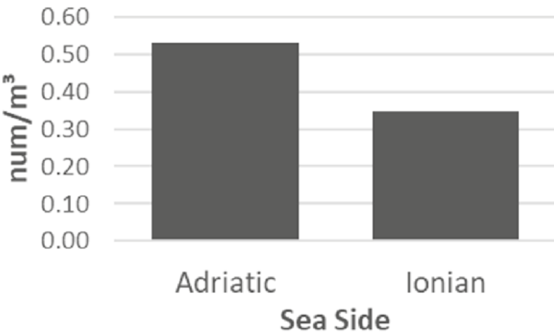

Figure 2 – MPs' average number calculated for the Southern Adriatic and Western Ionian Sea (+1 Standard Error).

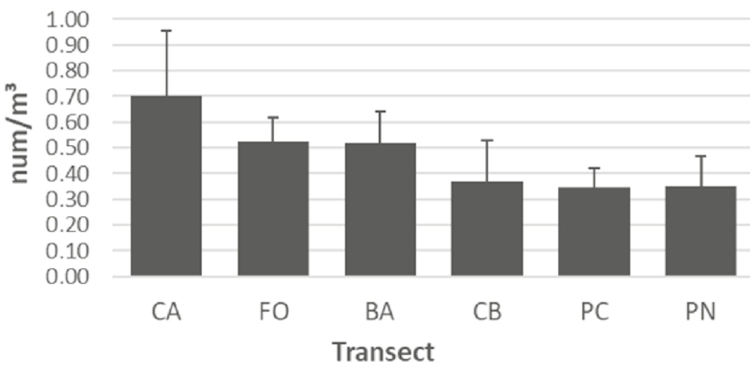

Figure 3 – MPs' three-year average number calculated for each transects (+1 Standard Error).

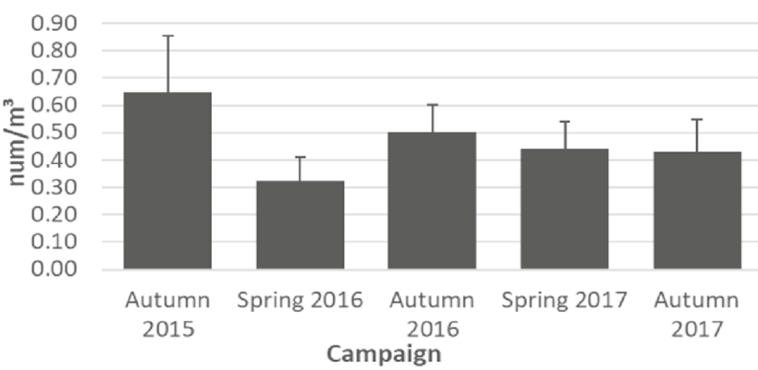

Figure 4 – MPs' average number calculated for each the five campaigns (+1 Standard Error).

MPs average numbers per transects and surveys are reported in Figure 5. The highest MPs average number was recorded in 2015 campaign along CA transect (0.331 ± 0.72 n/m³). None distribution pattern was highlighted. Since the samples were taken at 3 different distances from the coast (0.5, 1.5 and 6 NM), the possible distribution of microplastics as a function of this factor was investigated (Figure 6). Although highest value of MPs average number was detected close to the coast (0.5 NM, 0.520 ± 0.13 n/m³) no statistical differences were detected among coast distance (KW $\chi^2 = 1.2733$, df = 2, p-value = 0.529). Figure 7 shows average number of MPs per transects and surveys, as a function of distances from the coast. CA and BA transects show a decreasing gradient from the coast offshore, while FO transect don't show any trend. Instead, CB shows the highest values at the greatest distance from the coast (6 NM), PC at the lowest distance (0.5 NM) and for PN the highest value was found at the intermediate distance of 1.5 NM.

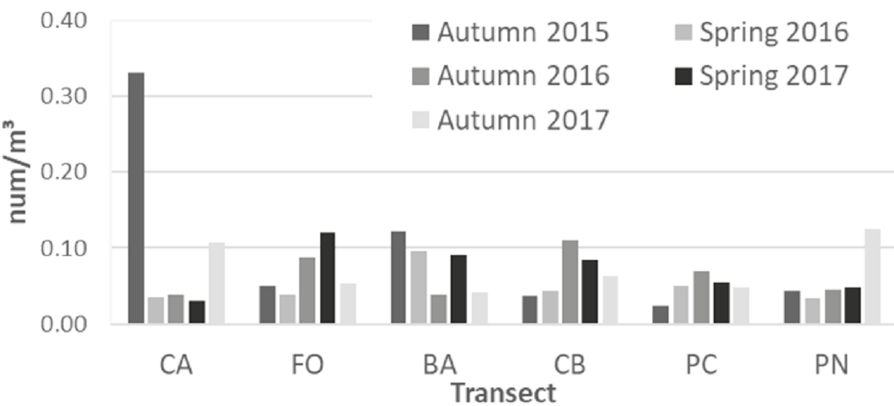

Figure 5 – MPs' average number for the 6 transects during the five campaigns (+1 Standard Error).

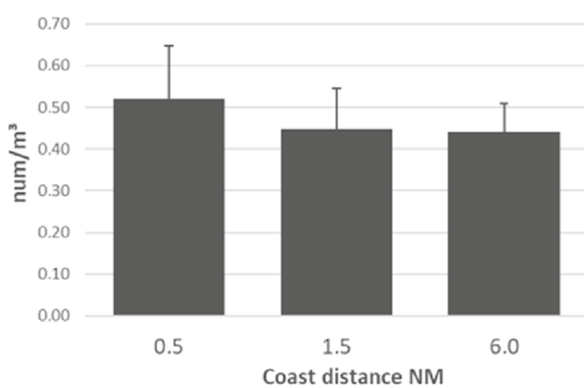

Figure 6 – MPs average number in the 6 transects as a function of distances from the coast (0.5, 1.5 and 6 NM) (+1 Standard Error).

With regard to the MPs qualitative analysis, the most common shape detected during the three-year monitoring program was “fragment” (68.9 %) followed by “sheet” (23.5 %), “filament” (4.9 %) and “sphere” (2.6 %) (Figure 8). In the end, the comparison among the results of the present study and the data from literature is reported in Table 2.

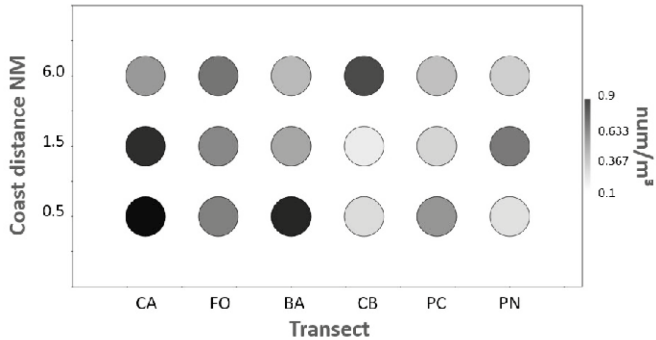

Figure 7 – MPs average number as a function of the distance from the coast per transects and campaigns.

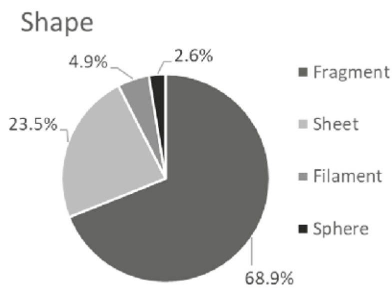

Figure 8 – Most common shape detected during the 2015-2016-2017 campaigns.

Table 2 – Literature data on floating microplastic densities for the Mediterranean Sea.

Source	**Region**	**Year**	**n. or item/m³**	**n. or item/m²**
Fossi et al., 2016	Ligurian Sea	2011-'12-'13	0.310	
Panti et al, 2015	NW Sardinia	2012-'13	0.170	
de Lucia et al., 2014	W Sardinia	2012-'13	0.150	
Suaria et al., 2016	W & Central Med. Sea	2013	1.000	0.400
Fossi et al., 2012	Ligurian/Sardinian Sea	2011		0.310
Ruiz-Orejón et al., 2016	W & Central Med. Sea	2011–'13		0.147
Cózar et al., 2015	Med. Sea	2013		0.243
Pedreotti et al., 2014	Ligurian Sea	2013		0.103
Gajšt et al., 2016	Adriatic Sea	2014		0.472
Zeri et al., 2018	Adriatic Sea	2014–'15		0.315
This study	Apulian sea waters	2015-'17	0.469	0.117

Discussion

As evidenced by recent studies (Cózar *et al.,* 2015), the Mediterranean Sea is a potentially accumulation zone at global scale but the patchy plastic distribution suggests that the variability of surface circulation hampers the formation of stable plastic retention areas into the basin. Regardless, the Mediterranean Sea is one of the marine regions in the world most impacted by plastic waste and it present a gradual increase in the concentration of marine litter mainly due to its basin conformation (van Sebille *et al*., 2015).

Within the Mediterranean Sea, Adriatic Sea is a semi-closed basin, with a limited recirculation of water and with highly anthropized coasts (by tourism and industry), with the presence of numerous rivers and streams that can be a path of contamination of coastal waters. In this study, the MPs average number calculated for the entire dataset was 0.469 n/m^3 and 0.117 n/m^2, values comparable with those previously reported for the Adriatic and Mediterranean waters (Fossi et al., 2016; Panti et al, 2015; de Lucia et al., 2014; Suaria et al., 2016; Fossi et al., 2012; Ruiz-Orejón et al., 2016; Cózar et al., 2015; Pedreotti et al., 2014; Gajšt et al., 2016; Zeri er al., 2018). As far as the Ionian Sea is concerned, only the portion relating to the Gulf of Taranto was taken into consideration. Nevertheless, in this study the average number of MPs is lower in the Ionian Sea than in the Southern Adriatic Sea, but the difference is not statistically significant.

As concern the investigated areas, no significant statistical differences were detected among transects, campaigns and coast distance, but the obtained results need to be confirmed in the next monitoring surveys. However, considering the whole Apulian sea waters, data from 2015/2017 three-year monitoring highlighted the highest value for the CA transect.

Although not confirmed by the statistical test, CA and BA transect shows higher values close to the coast while FO transect shows similar value at different distances from the coast. Since CA and FO are close to river mouths, it could indicate the presence of important plastics flows from land to the sea. The different position of the two transect, respectively in the north and in the south of Gargano promontory, can suggest the influence of such a geomorphological structure as a driver for the distribution and circulation of plastics in the Adriatic.

Conclusion

The results from the 2015/2017 three-year monitoring of microplastics (MPs) in the Apulian sea waters give first scientific data on distribution and relative density of MPs for the Southern Adriatic and the Western Ionian seas.

Although not significant differences have been found among the sampling sites and periods, some signals suggest the continuation of monitoring in order to achieve a larger data set to be analysed.

Nevertheless, the information now available can be useful for the implementation of predictive circulation models in order to estimate the fate of plastic litters released at the sea.

Acknowledgements

We would like to thank all the collaborators of ARPA Puglia who took part in the monitoring campaigns.

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