BEACH LITTER OCCURRENCE IN SANDY LITTORAL: CASE STUDY – THE ROMANIAN BLACK SEA COAST

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Abstract. The paper presents the results of seasonal marine litter surveys carried out during the period 2014 – 2017 within 9 sectors of sandy beaches situated in Mangalia (7 sectors), Tuzla (1 sector) and Eforie Sud (1 sector) at the Romanian littoral of the Black Sea. These border seaward five marine protected areas: *The submerged sulphurous springs from Mangalia* (ROSCI0094), *Aurora Cape* (ROSCI0281), *The Marine area from Tuzla Cape* (ROSCI0273), *The Submerged Beach from Eforie Nord - Eforie Sud* (ROSCI0197) and ROSPA00076 Marea Neagra. The MarineLitterWatchAPP for Iphone/Ipad and Android developed within the PERSEUS FP7 project was used during both surveys from 2014 and 2015, conducted in the framework of the Marine Litter Watch Campaigns initiated by the project as well as during those carried out in 2016 and 2017 within the national program PN 16 45 05 01. Out of the twenty five litter types monitored, plastic/polystyrene and cigarettes buts and filter made up the highest contribution with more than 50% in all years. The results of surveys performed on the same beach from Mangalia (Mangalia 3 and Mangalia 4 sectors) evinced higher litter amount in 2016 and 2017 than in the previous years (2014 and 2015). Touristic activities and urban development proved to be the major sources of waste, since plastic and cigarettes were the most present items found in all locations.

Key words: plastic, cigarettes buts and filter, MarineLitterWatchAPP, Marine Strategy Framework Directive, marine protected areas

1. INTRODUCTION

The study aims to provide data on the distribution, amount and categories of marine litter collected in the period 2014 –2017 on the front beaches of five marine protected areas of the southern Romanian littoral. The results will contribute at designing the conservation and protection measures of habitats and species of the MPAs (Sites of Community Interest of Natura 2000 network) that are in the custody of The National Research and Development Institute for Marine Geology and Geoecology since 2011. The marine areas are directly threatened by the accumulation of litter on the beaches that may enter their waters and thus preventing the achievement of GES (Good Environmental Status) for the Descriptor 10 of the MSFD (The Marine Strategy Framework Directive 2008/56/EC). The MSFD is the pillar European legislation concerning the waste monitoring, management and setting targets for achieving GES of marine waters, which represents a major contribution to the Integrated Marine Policy of the European Union.

Apart of the MSFD, the waste problematic (including the beach litter) is widely regulated at different levels, resulting in a series of obligations undertaken by Romania in respect with the national, regional (e.g., Bucharest Convention) and European (The Habitats and Birds Directives, The Waste Framework Directive 2008/98/EC, The Packaging and Packaging Waste Directive 94/62/CE, The Waste Shipment Regulation) legislation. Moreover, Romania ratified a series of international Conventions referring also in their body text to marine litter (e.g., MARPOL Annex V, The Basel Convention, the Bonn Convention, and UN Convention on Biological Diversity). The ambitious 2015 Circular Economy Action Plan adopted by the European Commission (COM (2017) 33)) integrates all specific European regulations concerning the wide spectrum of waste, establishing a concrete programme of action, with measures covering the whole cycle: from production and consumption to waste management and the market for secondary raw materials.

At the Romanian littoral, there is already a consistent data collection on beach litter distribution and amounts, thanks

to NGOs activities (i.e., http://litoral.marenostrum.ro/) and other research institutes (Golumbeanu *et al.,* 2017). Evidences on beach-litter in other regions of the Black Sea have also been brought out in several papers (Guneroglu, 2010; Topçu *et al.*, 2013; Simeonova *et al.*, 2017; Terzi and Seyhan, 2017). The distribution and amount of litter on the Black Sea seabed were documented by many authors (Ioakeimidis *et al.*, 2014; Aytan *et al.*, 2016; Topçu and Öztürk, 2010; Suaria *et al.,* 2015; Moncheva *et al.*, 2016; BSC, 2007). These studies were conducted according to different methodological approaches of beach-litter data based on measurements of quantities or fluxes, considering various litter categories, and sampling on transects of variable width and length parallel or perpendicular to the shore (Galgani *et al.*, 2015). As for example, in one study (Topçu *et al.*, 2013) there were used transects of 20 m length and density (items/m^2) to estimate the litter occurred on 10 beaches of the Turkish Western Black Sea Coast, while OSPAR guideline for litter classification was used at the Bulgarian coast (Simeonova *et al.,* 2017). The Marine Litter Watch App developed by the European Environment Agency (EEA, 2013) available for Android and iPhone devices was successfully implemented at the Romanian littoral with the occasion of several projects (e.g., MARLISCO, PERSEUS) to assess the beach litter distribution and amount along 100 m long transects within different beach sectors.

2. MATERIALS AND METHODS

9 sectors of beach situated in the southern part of the Romanian littoral (Fig. 1 and Table 1) in front of the following Marine Protected Areas (MPAs) - *The submerged sulphurous springs from Mangalia* (ROSCI0094), *Aurora Cape* (ROSCI0281), *The Marine Area from Tuzla Cape* (ROSCI00273), *Underwater Beach Eforie Nord – Eforie Sud* (ROSCI0197) and ROSPA00076 *Marea Neagra*, have been surveyed for beach litter identification and quantification.

The MarineLitterWatchAPP was used during the 2014 and 2015 years' marine litter surveys conducted within the framework of the Marine LitterWatch Campaign developed within the FP 7 PERSEUS project and during the surveys carried out in 2016 and 2017 within the national program PN 16 45 05 01. The work protocol followed the methodology described in the EU MSFD TG10 "Guidance on Monitoring of Marine Litter in European Seas (Galgani *et al.*, 2013)" for the assessment of beach litter. Thus, after visual inspection of the beaches chosen for the study (Table 2), two sectors of 100 m length each and from the strandline to the back of the beach as width were selected within each beach (only one sector on each Tuzla Cape and Eforie Sud beaches). All waste items (> 2.5 cm) provided by the mobile application categorised according to TSG – ML code given in the Annex 8.1. of the Guidance were gathered, sorted and quantified (numbered and also weighted in the surveys performed in 2016 and 2017).

In 2014 and 2015, there were conducted four beach surveys: one in June, one in October 2014, and the two others in January and June 2015, respectively. Six sectors of beach (Mangalia 1, Mangalia 2, Mangalia 3, Mangalia 5, Venus- Saturn 1 and Venus-Saturn 2) were selected, all situated within the Mangalia city territory (Fig. 2). In November 2016 and from March to June 2017, three sectors of beach were surveyed: Mangalia 4, Tuzla and Eforie Sud (Fig. 2).

The marine protected area *The Submerged sulphurous springs from* **Mangalia** stretches along 6 small "pocket" beaches, each separated by breaking waves' dykes. The hydrotechnical works and artificial nourishment of the beaches helped at reducing the accelerated sand erosion favouring the accretion processes in the area, though the catastrophic storm events may result in important loss of the sedimentary material (Project „Reducerea eroziunii costiere Faza II/ "Reduction of coastal erosion Phase II", 2016). The sectors chosen for the survey were situated within the perimeter of four of these beaches.

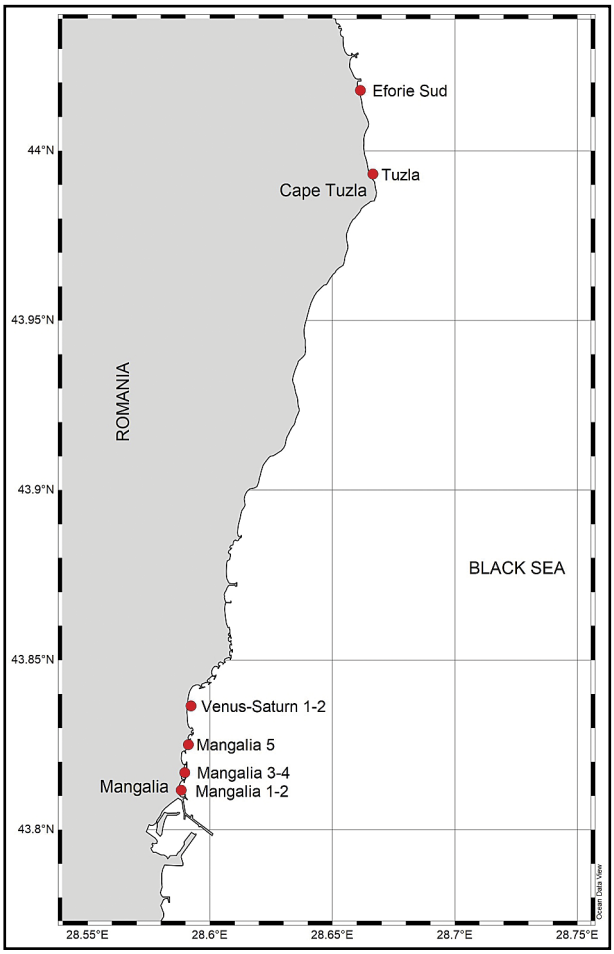

Fig. 1. The location of the beach sectors surveyed in the period 2014 – 2017

Mangalia city is the biggest touristic city of the southern littoral. Tourism brings more than 50% of the economic revenue of the city in summer (May – late September). Annually about one million tourists visit the beaches accessing the touristic facilities of the city, including the physiotherapeutic treatment base. Other socio-economic activities such as

Table 1. The geographical position of the beach sectors surveyed

Sector	Point Start/End	Latitude [degrees north]	Longitude [degrees east]
Eforie Sud	1	44°1.132′	28°39.598′
	2	44°1.078′	28°39.612′
Tuzla	1	43°59.564′	28°39.915′
	2	43°59.519′	28°39.958′
Venus-Saturn 2	1	43°50.472′	28°35.512′
	2	43°50.418′	28°35.486′
Venus-Saturn 1	1	43°50.212′	28°35.431′
	2	43°50.156′	28°35.427′
Mangalia 5 (Diana Beach)	1	43°49.437′	28°35.366′
	2	43°49.401′	28°35.333′
Mangalia 4	1	43°49.119′	28°35.339′
	2	43°49.068′	28°35.315′
Mangalia 3	1	43°48.969′	28°35.272′
	2	43°48.919′	28°35.268′
Mangalia 2	1	43°48.584′	28°35.270′
	2	43°48.570′	28°35.346′
Mangalia 1	1	43°48.686′	28°35.200′
	2	43°48.627′	28°35.211′

Table 2. The coordinates and features of the beaches surveyed

Beach	Latitude [degrees north] start/end	Longitude [degrees east] start/end	Beach length (m)	Beach Width (m) (average)	Type of substrate
Eforie Sud	44°1.132′	28°39.598′	410	14	sand
	44°0.924′	28°39.687′			
Tuzla	44°0.434′	28°39.864′	1,793	19.2	sand
	43°59.518′	28°39.958′			
Venus-Saturn	43°50.511′	28°35.780′	1,826	58	sand
	43°49.788′	28°35.552′			
Mangalia 5 (Diana Beach)	43°49.451′	28°35.374′	150	75	sand
	43°49.384′	28°35.342′			
Mangalia 3 - 4	43°49.139′	28°35.424′	532	15	sand/boulders
	43°48.913′	28°35.285′			
Mangalia 1 - 2	43°48.888′	28°35.313′	797	34	sand/boulders
	43°48.563′	28°35.364′			

amateur fishing and leisure craft navigation (Mangalia touristic Harbour), construction sector, ships building (Daewoo Mangalia Shipyard) with potential impact on beaches were also identified. The sea based sources of litter are mainly represented by professional fishing and commercial navigation.

The **beach from Tuzla Cape** has a length of about 1.8 km and an average width of 19 m, being delimited to the north by Eforie Sud city, to the south by Tuzla Cape and seaward by the ROSCI00273. The breaking waves' dyke situated at small distance in the northern part of the sector analysed enhances

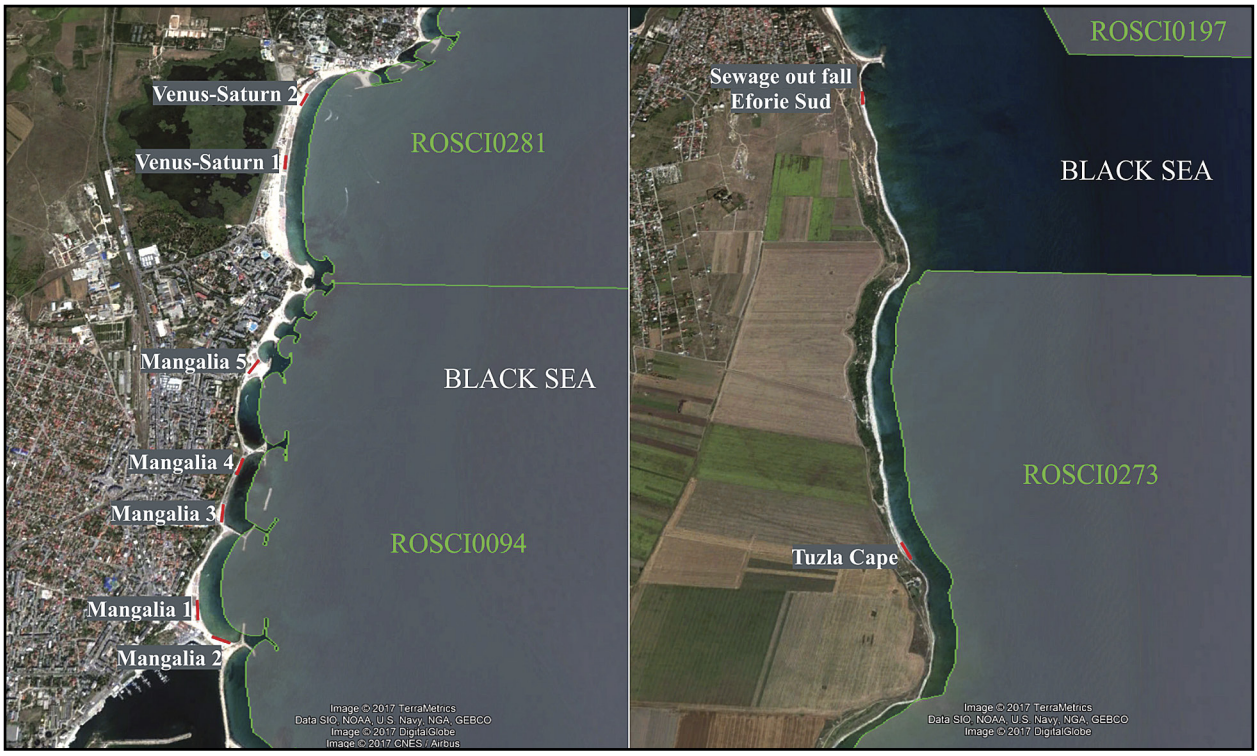

Fig. 2. Transects surveyed within each beach

the sand accretion process and at some extent the deposition of litter on the beach. The beach situated at the foot of an abrupt loess cliff, is a few hundred meters away from the Tuzla village. Unlike the other nearby resorts, Tuzla village is less developed in terms of touristic facilities. However, the summer tourism, fishing activities, development of constructions and illegal dumping of household waste have been identified as the main land based sources of waste ending up on the beach.

The **Eforie Sud beach** situated in front of two protected areas (ROSPA0076 *Marea Neagra* and ROSCI0197 *The Underwater Marine Area Eforie Nord – Eforie Sud*) has one of the most well preserved natural landscape, being at this moment less impacted by the hydrotechnical works. The dominant socio-economic activities in Eforie are related to balneal physiotherapeutic tourism based on exploitation of therapeutic mud of Techirghiol Lake situated nearby. The number of tourists that visit the beach has increased in the last years, following the growing of touristic accommodation capacity. An upsurge in construction sector has also been recorded, which led to increases of domestic and industrial waste in the zone.

3. RESULTS AND DISCUSSION

In June 2014, out of 793 items found on the sectors of beach surveyed, the *plastic/polystyrene, the plastic/polystyrene 2.5 >><50 cm* items and *cigarettes butts* made up almost 50% of all quantity. The highest amount of *plastic/polystyrene* items was observed on Mangalia 3, followed by Venus Saturn 2 and Mangalia 2 sectors (Fig. 3). Overall, the Venus – Saturn 1 and Mangalia 1 were the least impacted by the litter, although *plastic* items and *cigarettes buts* accounted for 78% and 86%, respectively.

The *cigarettes butts and filters*' total number in late autumn and winter months (October 2014 and January 2015) was 7 times higher than in June 2014. Similar, the small *plastic* items such as *caps/lids drinks* were much abundant. The highest amounts were recorded on the Mangalia 1 and Mangalia 3 sectors (Fig. 4 and 5), with more than 80% of the *cigarettes* found. Overall, a reduction in number of litter categories found in off-season months was accounted.

In June 2015, six times more *cigarettes buts and filters* than in June 2014 were recorded, 75% out of a total of 500 were found only in the Mangalia 1 sector. *Plastic* items had comparable values with those from the off- season months of 2015 and 2014 but 2 times lower than in June 2014 (Fig. 6).

Summing up, more than 5000 litter items were collected from all sector beaches surveyed in the period 2014 – 2015, out of which *cigarettes buts* and *plastic* items represented more than 75%, Mangalia 1 and Mangalia 3 sectors being the most polluted from this point of view.

In November 2016 and from March to June 2017, three new sector beaches were monitored: Eforie Sud, Tuzla and Mangalia 4.

The artificial polymer material (plastic) category was the most abundant within the Eforie Sud beach in all months monitored (Fig. 7), adding up to 67% of total amount of lit-

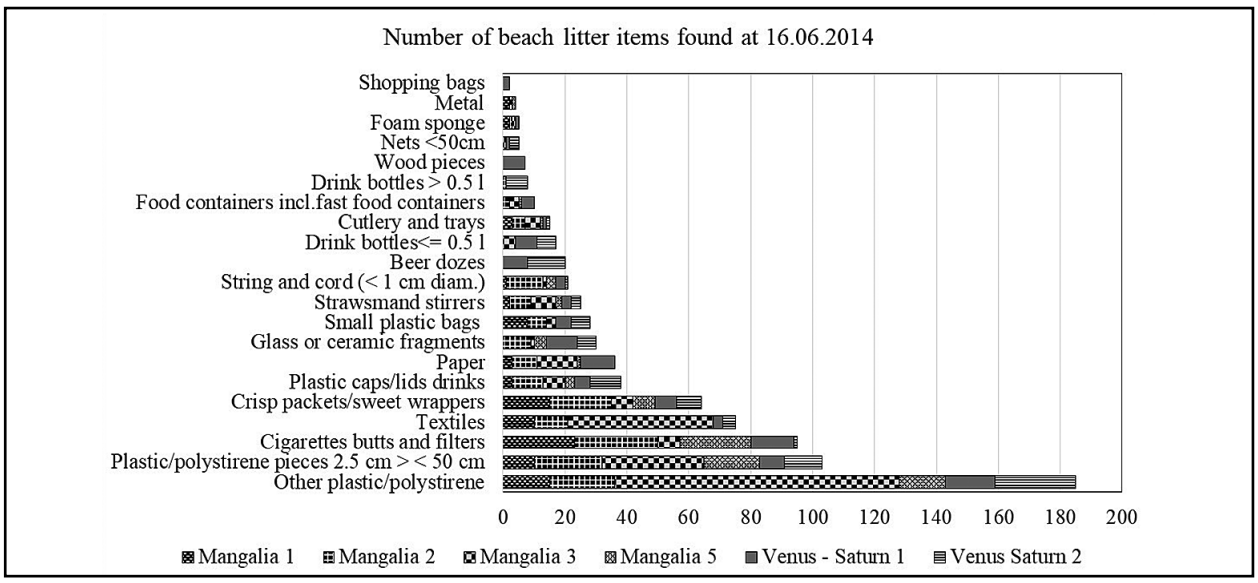

Fig. 3. Number of litter items found on the beach sectors Mangalia 1, Mangalia 2, Mangalia 3, Mangalia 5, Venus – Saturn 1 and Venus – Saturn 2 in June 2014

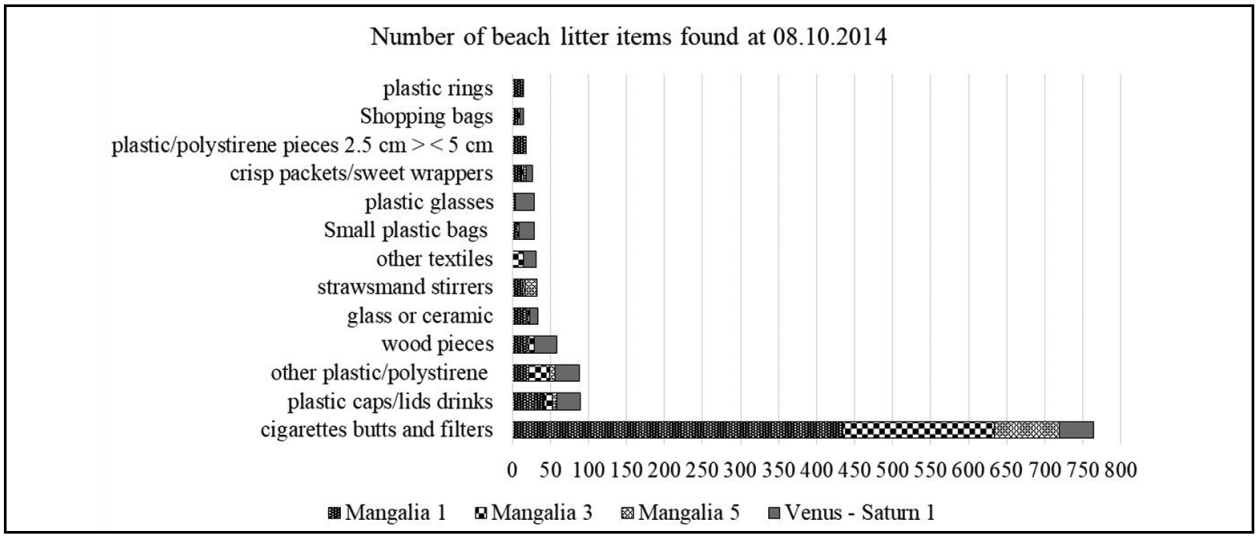

Fig. 4. Number of litter items found on the beach sectors Mangalia 1, Mangalia 3, Mangalia 5, and Venus – Saturn 1 in October 2014

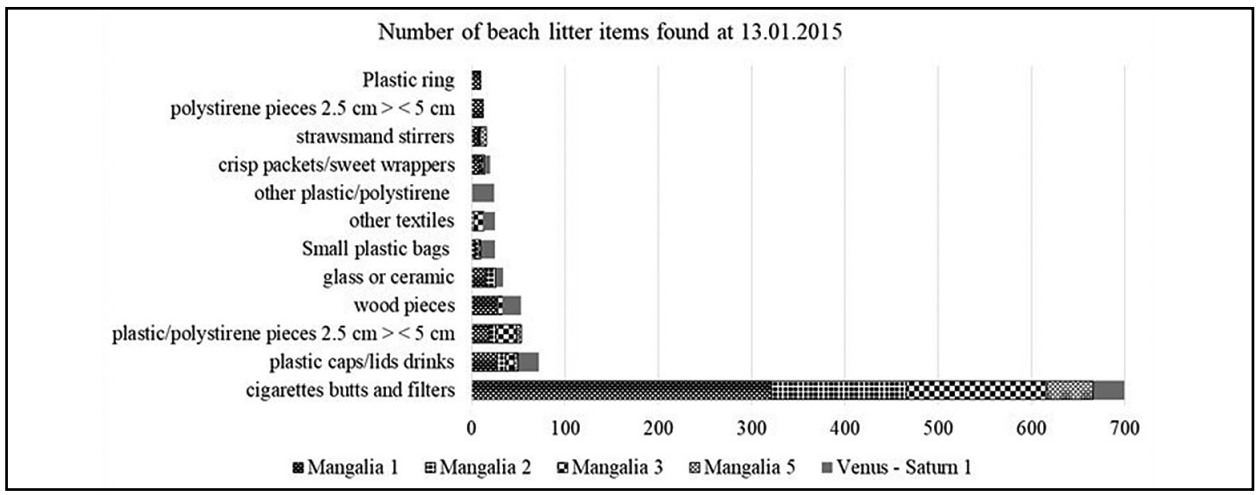

Fig. 5. Number of litter items found on the beach sectors Mangalia 1, Mangalia 2, Mangalia 3, Mangalia 5, and Venus – Saturn 1 in January 2015

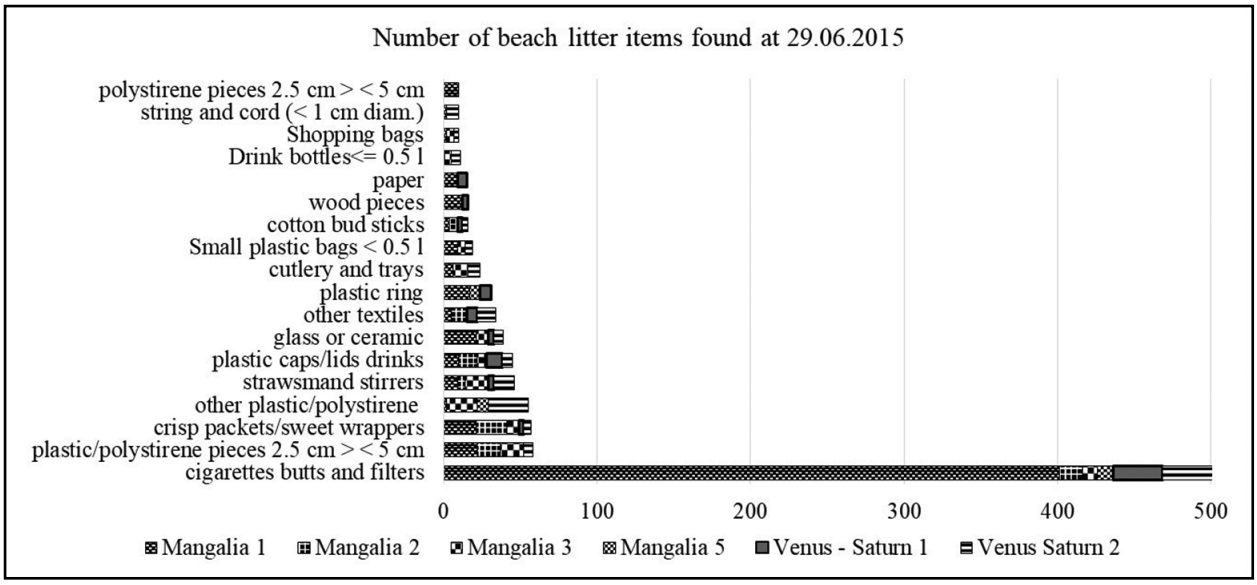

Fig. 6. Number of litter items found on the beach sectors Mangalia 1, Mangalia 2, Mangalia 3, Mangalia 5, Venus – Saturn 1 and Venus – Saturn 2 in June 2015

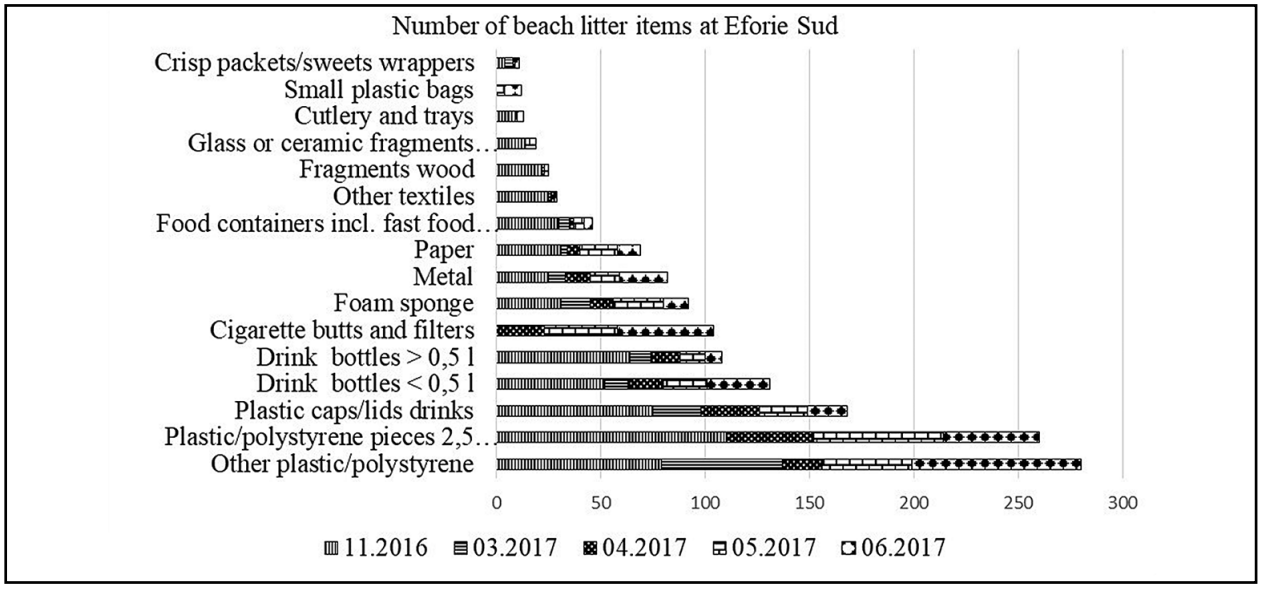

Fig. 7. Number of litter items found on the beach sector Eforie Sud during November 2016 and March – June 2017

ter collected (1484 items). The lowest quantity of litter was recorded in March and April, whereas in May and June there was a 30% increasing, especially due to *cigarettes buts and filters*, *paper, metal, foam sponge*, most probably discarded by the local community.

The major source of litter pollution on Tuzla beach during the surveys was also the *plastic/polystyrene* 2.5><50 cm (a total of 450 items); no visible improvement was noted across the period analysed. Moreover, *the other plastic/polystyrene* and *cigarettes buts* have constantly increased, reaching a maximum in June at the beginning of touristic season (Fig. 8). *Cigarettes buts* ranked second as number, with more than 300 items.

A dramatic situation was found on Mangalia 4 sector during the studied period whereas a total of 5860 items was recorded. About 45% and 31% of beach litter amount was represented by *cigarettes buts* and *other plastic/polystyrene,* respectively (Fig. 9).

It is worth mentioning that *paper tissues* in Mangalia 4 sector recorded exceptional quantities within entire studied period, being mainly found tangled in the stranded *Cystoseira* and *Ceramium* thalli. They got up to 74.48% of the total weight of items collected. One possible source of the tissues in the area it is inferred as being the nearby Mangalia hospital, which either release them through the sewage water pipe or simply throw them on the beach. However, the touristic activities could be a possible source as well.

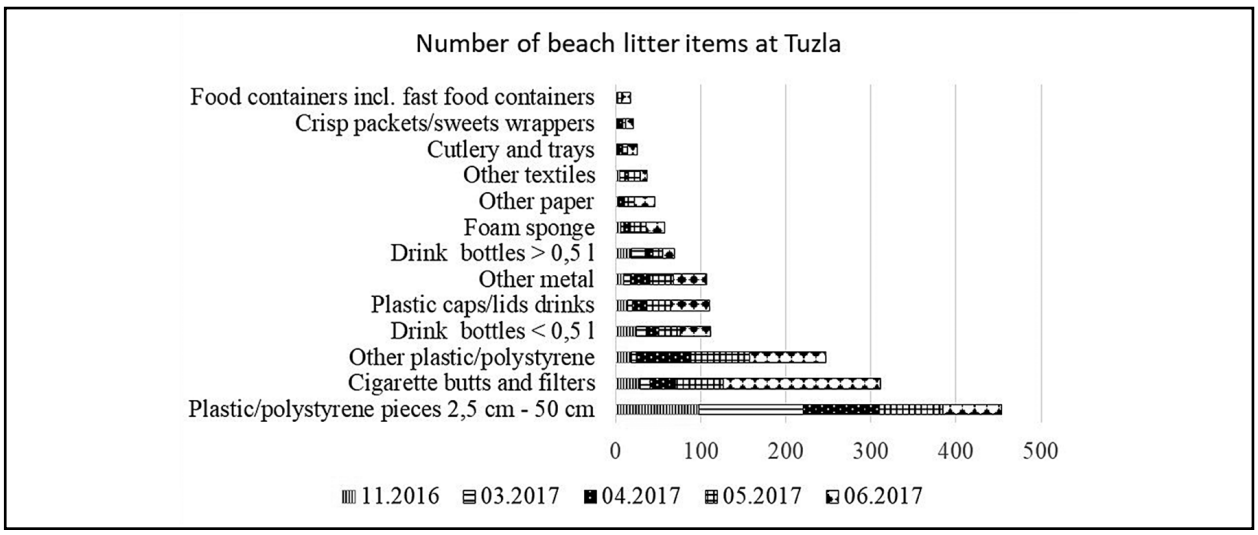

Fig. 8. Number of litter items found on the beach sector Tuzla during November 2016 and March – June 2017

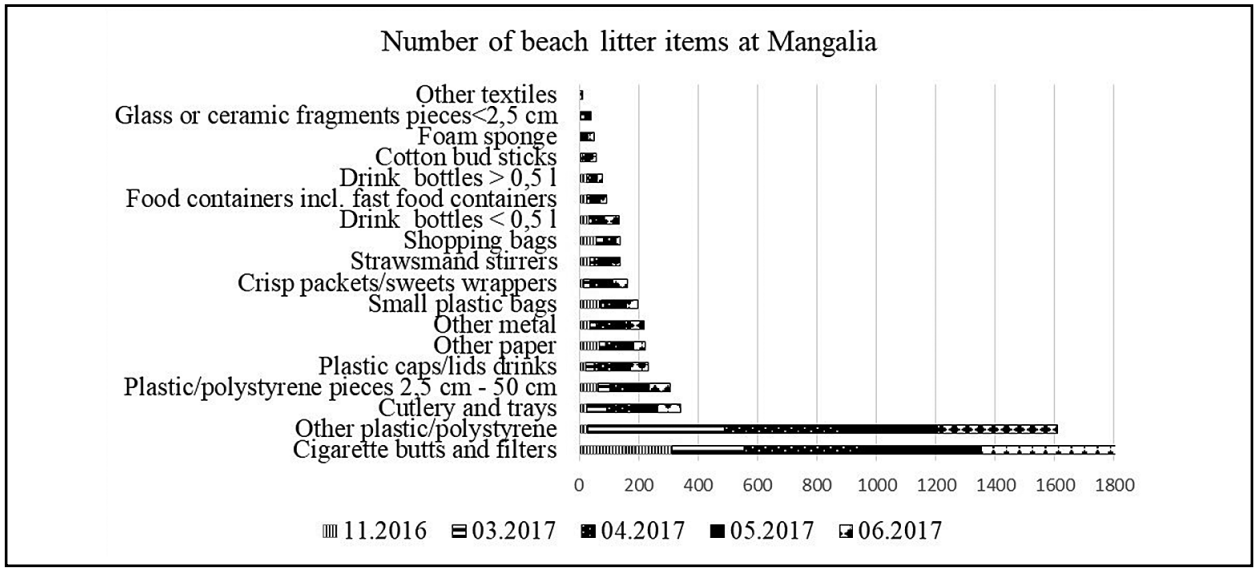

Fig. 9. Number of litter items found on the beach sector Mangalia 4 during November 2016 and March – June 2017

According to the present study, out of the twenty five litter types monitored, the artificial polymers such as *plastic/ polystyrene 2.5><50 cm, the other plastic/polystyrene and cigarettes buts and filters* made up the highest amount with more than 50% in all years. The results are compliant with the previous studies carried out at the Black Sea coast (Golumbeanu *et al.,* 2017; Tuncer *et al.,* 1998; ANPM, 2014; Balas *et al.,* 2003; ARCADIS, 2013; Kershaw *et al.,* 2013).

Considering the new evidence on the multiple risks that plastics pose to the environment, marine protection projects such as the Marine Debris Program of the US National Oceanographic and Atmospheric Administration (NOAA), included plastics litter as an emerging form of contamination (Avio *et al.*, 2016).

Besides the influence of sea based sources of pollution due to the maritime traffic, fishing activities, harbours pollution, the marine protected areas from Mangalia, Tuzla and Eforie are also subject to impact of tourism and urban development. The actions conceived by local authorities for combating waste accumulation on beaches have not been proved consistent in the long term. The plastic such as PE (polyethylene), PP (polypropylene) and PS (polystyrene, including expanded PS - PSE) once reached into water, due to their lower density comparing with seawater, would expect to float over large distances in respect with the hydrographic conditions and their buoyancy (UNEP, 2016). However, factors such as water currents and turbulence, downwelling phenomena, biofouling but also anthropic influence (e.g. hydrotechnical works), would change their buoyancy causing them to sink on the seabed, where could remain unaltered for a long

period. Other plastic types such as PVC (polyvinyl chloride) used for pipes or containers, Nylon used for fishing nets, for example, and the most common one - the PET (polyethylene terephthalate) used for bottles, some textiles, and cellulose acetate of which the cigarettes filter is made, often end up on the sea bottom, due to their negative buoyancy. Beyond their bothering visual impact on the land and seascape, the plastic presence on the beach or into the water is associated with chemical contamination and biological disrupting effects on fauna and humans because of its degradation (under UV radiation, oxygen attack, or biological) and releasing of additives (i.e. phthalates and bisphenol A) used during manufacturing. In addition, their hydrophobic surfaces (Pedà *et al.*, 2016) could further adsorb pollutants from the environment. Very few papers (Laglbauer *et al.*, 2014; Liebezeit and Dubaish, 2012; Novotny *et al.,* 2009) have brought up information on the baseline levels of contamination with plastics either of beach sand or of sediments or waters of MPAs. A recent study performed within three MPAs from the Croatian coast (Blašković *et al.*, 2017), aiming to determine the baseline values of microplastics, revealed a medium to high range of sediments contamination, the local pollution sources being the main factors incriminated. At the Romanian littoral, the level of contamination with macro- and microplastics has not been assessed yet, neither on the beaches, nor in the MPAs. This can be a task that remains to be undertaken as part of the national program of measures meant to protect and conserve in long term the MPAs' habitats and species and implicitly the human health.

CONCLUSIONS

The total litter amount on the sectors of beaches surveyed in the period 2014 – 2017 summed up to 13,150 items, of which plastic/polystyrene, plastic/polystyrene 2.5><50 cm and cigarettes buts and filters represented more than 80% of all items. The six sectors of beach surveyed in 2014 and 2015 from Mangalia revealed a generalized environmental risk posed by the litter accumulated on the beaches, both in touristic and off season. Comparing the data collected in June 2014 and 2015 respectively, at the beginning of the touristic season, with those from off season months (October 2014, January 2015), the plastics' contribution (about 70%) to the litter amount was as twice as much higher than in the cold months, the latter being dominated by the cigarettes.

In 2016 and 2017 the results of surveys performed on Mangalia, Tuzla and Eforie Sud beaches showed no significant differences of litter amount between the surveyed months. However, the results of surveys performed on the same beach from Mangalia (Mangalia 3 and Mangalia 4 sectors) evinced higher litter amount in 2016 and 2017 comparative with the previous years (2014 and 2015).

Due to all year-round presence of litter on beaches and their great amounts, the marine protected areas (ROSCI0094, ROSCI0281, ROSCI00273, ROSCI0197 and ROSPA00076) situated in the proximity, risk to not attain the GES concerning the Descriptor 10 (Marine Litter) as required by MSFD by 2020. The decision under Article 9(3) MSFD on criteria of good environmental status addresses marine litter in Descriptor 10 and aims at achieving that „Properties and quantities of marine litter do not cause harm to the coastal and marine environment".

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