Assessment of the Marine Litter on the Romanian Black Sea Beaches *(Elena Stoica, Magda Nenciu, Silvia Mădălina Creangă, Mihaela Cosmina Tănase, Dragoș Marin, Andreea Mădalina Ciucă, Vasile Pătrașcu)*	**"Cercetări Marine" Issue no. 51** **Pages 49 - 63**	**2021**
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ASSESSMENT OF THE MARINE LITTER ON THE ROMANIAN BLACK SEA BEACHES

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ABSTRACT

The paper presents the results of seasonal marine litter surveys carried out during the period 2018 – 2019 along the Romanian littoral of the Black Sea on 3 sandy beaches differing in their touristic exploitation and urbanisation. The assessment of abundance and composition of macrolitter (> 2.5 cm) and microplastics (1-5 mm) followed the monitoring methodology described in the EU MSFD TG10 guidance (Galgani *et al.*, 2013). Out of the fifty-five litter types mostly monitored, cigarettes buts and plastic/polystyrene pieces (2.5 cm - 50 cm) made up the highest contribution with more than 50% in all years. The mean abundance of total microplastics ranged from 4 and 272 particles/m^2 among sites; the microplastics were mostly expanded polystyrene (EPS), fragments and films. The microplastic abundance in touristic beaches of Mamaia resort (Marina Regia and Malibu) was between 2 and 30 times higher than in protected wild areas (Vadu). Overall, the different types and quantities of marine litter found during our study were related to differences in human activities set up in all three locations in touristic and post-touristic season 2018 and 2019. The highest macrolitter and microplastic concentrations were recorded in the southern area of Mamaia summer resort (Malibu beach) indicating that beside the level of coastal infrastructure development, the seasonal tourists and local population density are important factors affecting marine litter pollution level on the Romanian beaches.

Key-Words: marine litter, macrolitter, microplastics, beach sediment, Black Sea

AIMS AND BACKGROUND

Marine litter (ML) is widely considered a critical ocean pollution concern of our time, being present in all marine habitats. Beaches are particularly vulnerable to the litter pollution due to their location in the transition zone between the marine and terrestrial environment.

Additionally, the extensive recreational and touristic exploitation of the marine beaches at the global scale contributes to continuously their exposure to littering pressure [UNEP, 2005; Hidalgo-Ruz, 2012; Hompson *et al*., 2009; Galgani *et al*., 2015; Ryan, 2015; UNEP 2015].

Beach litter can be defined as any item which is directly or indirectly discarded and dumped on beaches, as a result of human activity. The presence of macrolitter (discarded man-made objects > 2.5 centimeters in length) together with microplastics (1 – 5 mm in size) are ubiquitously on the world's beaches, resulting in beach pollution, negatively impacts on the economy, human wellbeing and environment health (Cheshire et al., 2009; Cole et al., 2011; UNEP, 2012; Addamo *et al*., 2017; Abascal *et al*., 2021; Terzi *et al.,* 2020). Due to the easily access and less costs to get samples on the beach, as well as the general tendency to accumulate a large quantity of marine litter generated by its close to land-based sources of it, beach is the most popular and surveyed compartment of the marine environments where marine litter occurs. So far, numerous studies from almost all world regions report on litter occurrence on surface and in sediments of marine beaches (Poeta *et al*., 2014; Araújo *et al*., 2018; Simeonova *et al*., 2018; Merlino *et al*., 2020; Topcu *et al*., 2013; Rey *et al*., 2021).

The occurrence of anthropogenic litter on the Black Sea beaches has been reported in the recent years by various researchers, and is highlighted as a growing threat (BSC, 2007; BSC, 2019; Aytan *et al*., 2020; Moncheva *et al*., 2016; Öztekin *et al*., 2020, Simeonova *et al*., 2020). To date, the macrolitter on beaches have been actively studied in Romania (Golumbeanu *et al*., 2017; Muresan *et al.*, 2017; Paiu *et al*., 2017). Although several studies investigated their categories, types, densities, seasonal dynamics and factors influencing macrolitter distribution and accumulation along the Romanian Black Sea coast, at this time there are no reported assessments for monitoring purposes on microlitter (microplastics) occurrence in the sand of the Romanian Black Sea beaches. The present study is the pioneer to determine detailed assessment of abundance and composition of both macro– and microlitter along three Black Sea beaches, in Romania. The obtained data will fulfill the requirements of the Romanian ML monitoring program and may be helpful to improve ML management in the Romanian marine environment.

EXPERIMENTAL

Survey area and sampling sites

In 2018 and 2019, three different sandy beaches of the Romanian Black Sea littoral have been surveyed for both beach macro- and microlitter identification and quantification: one in May, one in late-August 2018, and the two others in April and October 2019, respectively (Table 1 and Fig. 1).

The surveyed beaches have similar morphological characteristics but different degrees of urbanization:

- *Vadu beach* is an undeveloped, wild beach, located in the administration area of the Danube Delta Biosphere Reserve, not being introduced in the tourist circuit, even if there is a summer tourism represented by a small number of tourists. The monitored surface has a length of 100 m, the width of 18.5 m being naturally delimited by the presence of vegetation.

- *Marina Regia Beach* is located in the north of Mamaia resort and is used for tourism purposes. It is one of the three Romanian beaches certified as Blue Flag beaches, namely beaches that meet the criteria of water quality, ease of access, safety and cleanliness. Monitoring is done on an area with a length of 100 m and a width of 75 m.

- *Malibu beach* is situated in the extreme south of Mamaia resort and generally used for tourism purposes (e.g., bathing, recreation and walks), mainly in the warm season. It is also one of the popular beaches used by local population for spring, autumn and winter outdoor walks. The sampling unit has an area with a length of 100m and a width of 60m. The nearest port is Tomis Tourist Port, located at a distance of approximately 4.9 km, in the southwest. In the north, at 14.4 km is located the Petromidia industrial area.

Fig. 1. Map of the study area showing the sampling sites

Beach macrolitter monitoring

The macrolitter deposited on the selected beaches was collected following the work protocol described in the EU MSFD TG10 "*Guidance on Monitoring of Marine Litter in European Seas-2013-JRC Scientific and Policy Reports*" (Galgani *et al*., 2013). The methodology implies the visual identification of 100 m long fixed section of beach covering the whole area between the water edges (where possible and safe) or from the strandline to the back of the beach. All litter items greater than 2.5 cm were collected, counted, and categorized according to TSG – ML code given in the Annex 8.1 of the Guidance.

Table 1. Geographical location of the surveyed Romanian beaches

Beach	Point Start/End	Latitude [degrees north]	Longitude [degrees east]
Vadu	1	44.4305220	28.76960600
	2	44.43177994	28.77093758
Marina Regia	1	44.28622174	28.62365462
	2	44.28702655	28.62374252
Malibu	1	44.21927122	28.63917068
	2	44.21982087	28.63651870

Beach microlitter assessment

The protocol used for assessment of abundance and the main categories of large microplastics (particles in the size range 1-5 mm) on selected sandy beaches (Vadu, Marina Regia and Malibu) was based on the criteria described by the MSFD Technical Subgroup on Marine Litter and A Rocha International with minor modifications (Galgani *et al.*, 2013; Calcutt *et al*., 2018). The protocol involves the following steps: (i) *Collection of the sand samples from the survey site*: For each study site, we collected sand from five replicate 50x50cm quadrats (sampling squares) that was positioned randomly along two transects of 100m length. Each replicate was separated by 5m. The sediment was sampled by collecting with a metal spoon the top 5cm of sand from the area contained within sampling squares (quadrat) and stored in a non-plastic container (e.g. metal container or paper/textile bag) until the next step; (ii) *Sieving the sand:* The sand collected was sieved to collect all items in the sand that were between 1 and 5mm in size. This was done in laboratory of NIMRD Constanta and involved sieving the dry beach sand samples by placing a sieve with a 5mm mesh on top of a sieve with a 1mm mesh; (iii) *Collecting the items between 1 and 5mm in size*: By means of a metal spoon we transferred the items from each sieve (1mm and 5mm mesh) into a paper bag or a glass jar for storage until the next step of procedure. The bag or jar were labelled with the study site, date, transect number, quadrat number and type of the sieve used ; (iv) *Density separation of microplastics from the other 1 to 5mm items : t*o extract the microplastics from the sieved samples, we carefully transferred the contents into a glass serving dish containing filtered NaCl solution (approximately 35g/L), as the most microplastics items are a lighter density than the salt water ; (v) *Classifying and recording the microplastics :* the microplastics were recorded one by one as we taken them out of our sample of 1 to 5mm items and transferred into a petri or other small glass labelled dish to view their size, shape and color under the stereomicroscope at 4.5x – 10x magnification or the digital microscope (Optika Microscope B-150DB bino-digital, 40x-1000x). All microplastics were photographed. The open software ToupView (www.touptek.com) was

used to analyze each collected picture. Representative microplastic particles were removed from samples using tweezers and stored on microscope slides until the final quantification and identification by type, size (length of fibres and cross-section of other particles) and colour. Microplastic abundance was expressed in particles per square meters (Mazariegos-Ortiz *et al*., 2020).

RESULTS AND DISCUSSION

Beach litter abundance

Macrolitter (> 2.5 cm) abundance: In the current surveys, a total of 4527 items were found on the selected beaches within the three regions of the Romanian Black Sea littoral, differing in their touristic exploitation and urbanization. The total number of macrolitter items observed per site ranged from 63 items at Vadu (pre-season 2019) to a maximum of 1401 at Malibu (post-season 2019) (Table 2). The macrolitter abundances on surveyed beaches varied between sampling sites and seasons, which can be attributed to the direct anthropogenic influence (e.g., tourism and recreational activities or illegal dumping) on sampling sites. In terms of macrolitter abundance, the Malibu beach recorded the highest abundance during 2018-2019 (Table 2).

Table 2. Number of total macrolitter items (per 100 m of beach) generated in each surveyed Romanian beach during pre- and post-season 2018 and 2019

Beach	**Time**	**Seasons**		**Total items**
		Pre-Season	**Post-Season**	
Vadu	2018	140	236	376
	2019	63	102	165
Marina Regia	2018	138	328	456
	2019	196	383	579
Malibu	2018	204	832	1036
	2019	514	1401	1915

Microplastic (1-5 mm) abundance: The data obtained allowed us to get local and seasonal (pre- and post- summer season) density values for microplastics. The obtained results indicated that all surveyed beaches contained microparticles with an average size between 1 mm and 5 mm. A total of 2612 microplastic particles were extracted and identified from the collected sand samples. We found differences between the three surveyed beaches with diverse anthropic-influenced characteristics. Generally, the highest abundance of microplastics was in Malibu (urban touristic beach, with a maximum of 272 particles per square meter), followed by Marina Regia beach (Blue Flag beach, maximum 30 particles per square meter) while the lowest abundance was registered in the study site Vadu located in marine protected areas MPAs (maximum 7 particles per square meters) (Fig. 2, Table 3). As described above, we also found that plastics were the most

dominant type of macrolitter on the same surveyed beaches. Considering the plastic on beaches is commonly exposed to chemical and mechanical fragmentation to huge numbers of smaller particles (microplastics), the microplastic levels found in this study would represent high levels of pollution of microplastics.

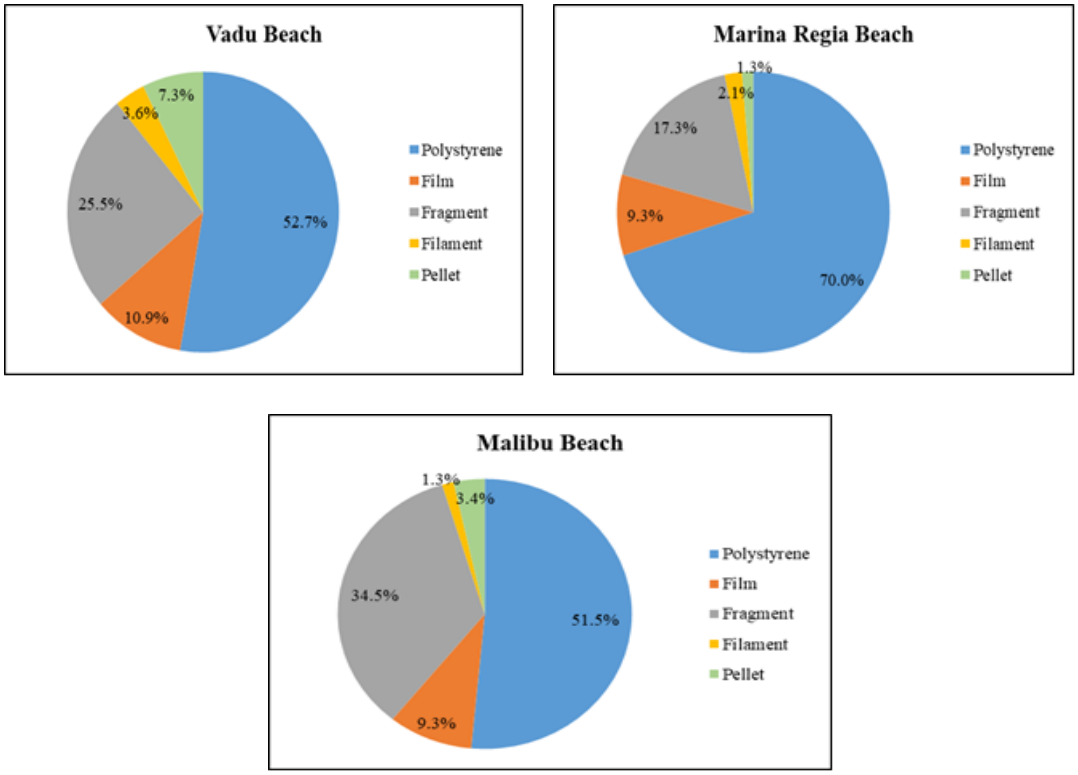


Fig. 2. Microplastics abundance and contribution of their different types in beach sediments at all study sites at Romanian coast during 2018-2019

Table 3. The number of particles found per each morphological type of microplastic at Vadu, Marina Regia and Malibu beach, during 2018-2019

Beach	Polystyrene (Foam)	Fragment	Film	Pellet	Filament (Fiber)	Total
Vadu	29	14	6	4	2	55
Marina Regia	580	143	77	11	17	828
Malibu	890	597	161	59	22	1729
Total	1499	754	244	74	41	2612

Beach litter composition

Macrolitter (> 2.5 cm) composition: The composition of the macrolitter (the number of categories) did not differ meaningly between the studied coastal beaches in 2018 and 2019. at all three Romanian beaches are shown in Fig.3.

The artificial polymer materials (plastics) were the most dominant category of litter collected from all three sites: Vadu (78.4%), Marina Regia (82.7%) and Malibu (85.5%) beaches. This category was followed at a great distance by paper/cardboard (~6.5%), as well as cloth/textile (~5.9%), metal (~4.4%) and glass/ceramics (~3.3%). The fewest (< 1%) belonged to rubber and processed/ worked wood.

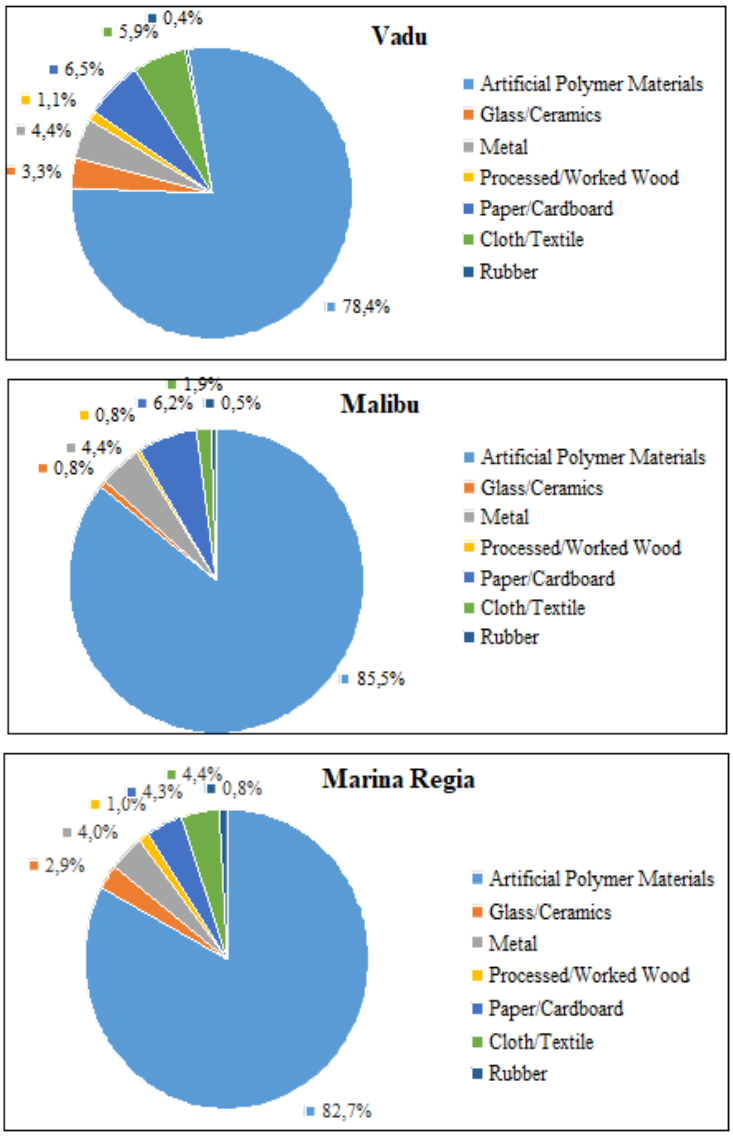


Fig. 3. Proportion of the major categories of macrolitter found on each evaluated Black Sea beach from Romanian sector during 2018-2019

Plastics were the most-represented items of anthropogenic litter in all the evaluated Romanian marine beaches, both in pre- and post-season. Fig. 3

shows the distribution of marine litter per each survey area and categories where it can be seen the very large difference between artificial polymer material and other categories. Plastics occupied the largest number of the 10 most common items of beach macrolitter. Eight items included in the top 10 marine litter were composed of plastics (Fig. 4 and Fig. 5).

Out of the fifty-five litter types mostly monitored, cigarettes buts and plastic/polystyrene pieces (2.5 cm - 50 cm) made up the highest contribution with more than 50% in both years Cigarette butts were found as a serious contributor to litter pollution not only in the Romanian touristic beaches Marina Regia and Malibu.

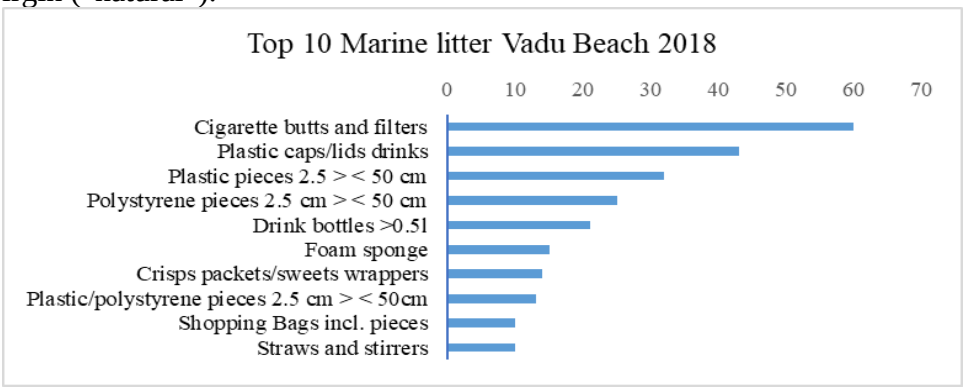
In 2018, cigarette butts and filters (G27) constituted the highest number of artificial polymeric material (n=60) for the wild beach Vadu (Fig. 4). The most frequently ranked plastic items on TOP 10 in the investigated Romanian beaches for 2018-2019 ranged from 7 to 8 among sites (Fig. 3 and Fig. 4). In addition to cigarette butts, in the category artificial polymeric materials were also found other plastic items such as shopping bags incl. pieces, plastic caps/lids drink, drink bottles <=0.5l, tobacco pouches/plastic cigarette box packaging, crisps packets/sweets wrappers, rope, string and nets, plastic / polystyrene pieces 0-2.5 cm, food containers including fast food containers (Fig. 4 and Fig. 5).

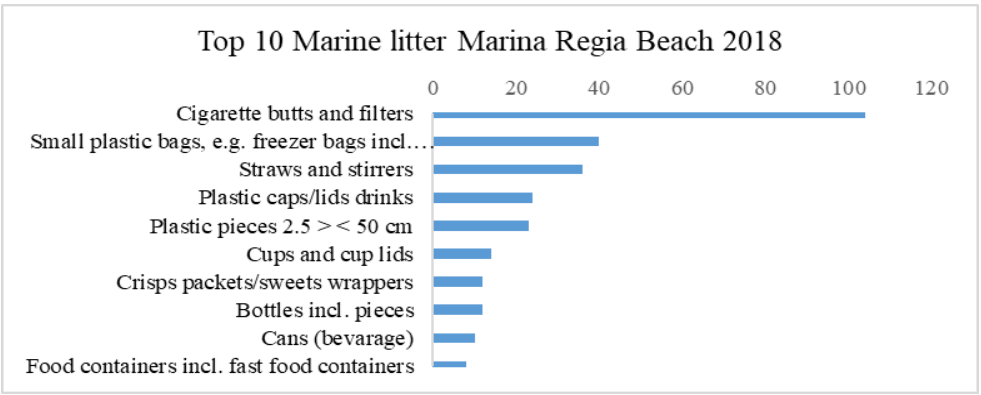
Microplastic (1-5 mm) composition: The diversity of microplastics (the number of microparticle types) were not significantly different between the three Romanian beaches surveyed in 2018 and 2019. The following five morphologic (microscopic) types of microplastic were distinguished in the composition of microplastics of the analyzed beach sediments: polystyrene (foam), film, fragment, filament and pellet (Table 3). We found that polystyrene (foam), plastic fragments and films were the most dominant microplastic types. Thus 57.40% of total microplastics were identified as polystyrene (foam), 28.9% as fragments and 9.3% as films, indicated that secondary microplastics dominated the Romanian Black Sea beaches. By contrast, filaments and pellets were the numerically smaller microplastics types (< 4.5%) found at beach sites (Table 3). The main proportions of microlitter types found at all three Romanian beaches are shown in Fig. 2.

Regarding the microplastics color, there were many different colors from white, blue, red, green, yellow, black, transparent and other colors. No multicolor microplastics were identified. The majority (83.87%) of the identified microplastics were white, followed by blue (2.75%), black (2.64%), green (2.10%), red (1.83%), and other colors (6.8%) (Fig. 6).

Microplastic color can provide information to predict their source. In this study, the majority of the microplastics were white in color, and 66.47% of the white colored particles were foams (polystyrene). Thus, the high abundance of foams has a considerable influence over the overall color proportion. Generally, microplastics are classified according to their color in

two distinct types: precolored (additives) and white and/or semitransparent virgin ("natural").





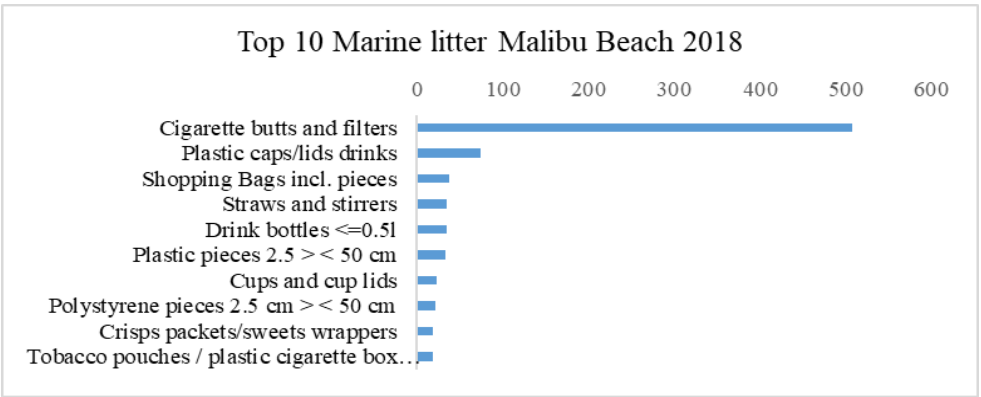


Fig. 4. The most frequently ranked macrolitter items on TOP10 in three beaches located within the Romanian coastal area of the Black Sea, in 2018

The permanence of the virgin plastics in the marine environment influences their degradation and leads to changes in aspect and color (Merlino *et al*., 2020). Also accounting for color differences in the sampled microplastics can give information about the percentage of their period of

degradation (relatively new and aged) and fragmentation (Karapanagioti *et al*., 2010; Merlino *et al*., 2020). The results of our study are comparable to the other marine regions.

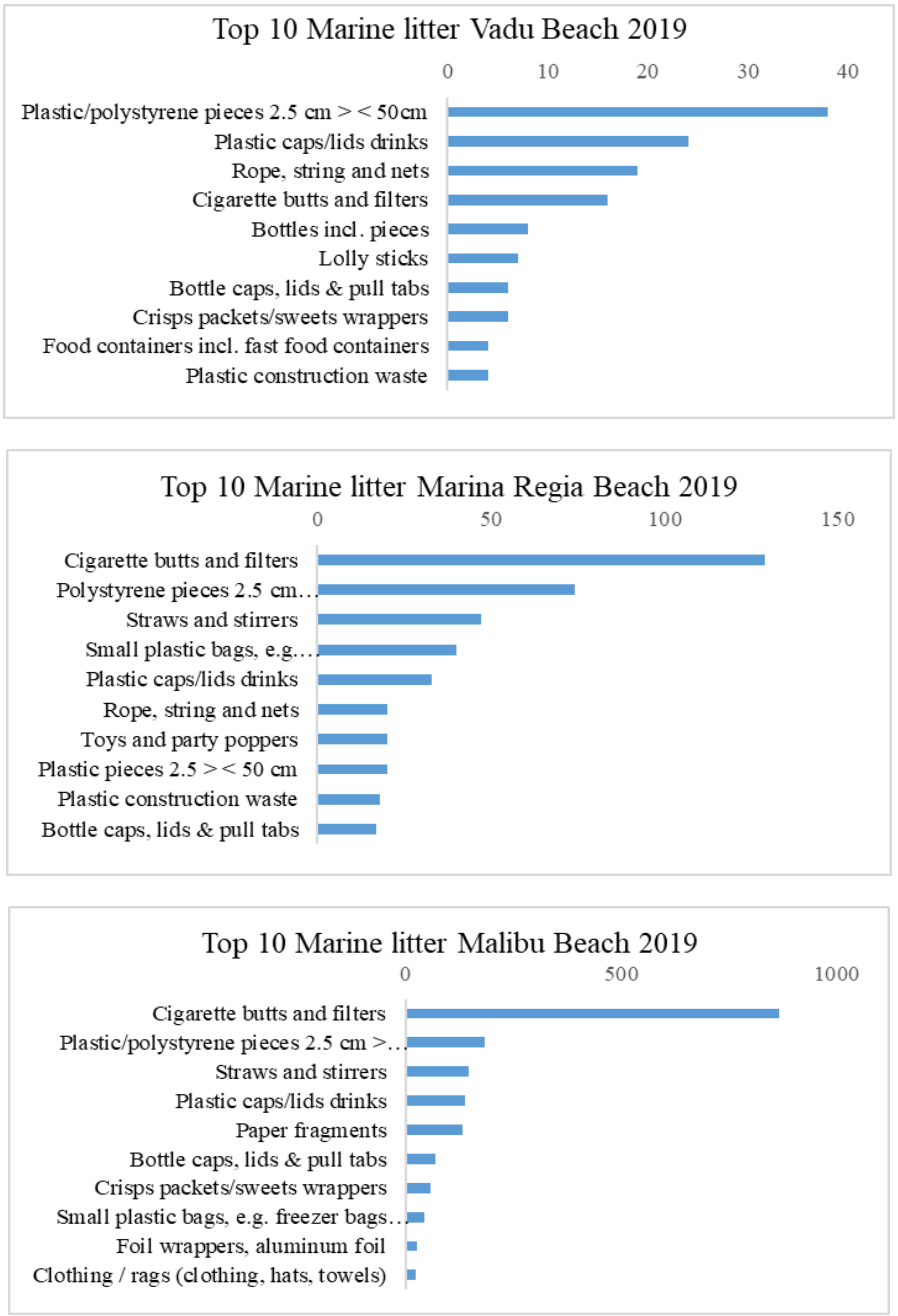


Fig. 5. The most frequently ranked macrolitter items on TOP10 in three beaches located within the Romanian coastal area of the Black Sea, in 2019

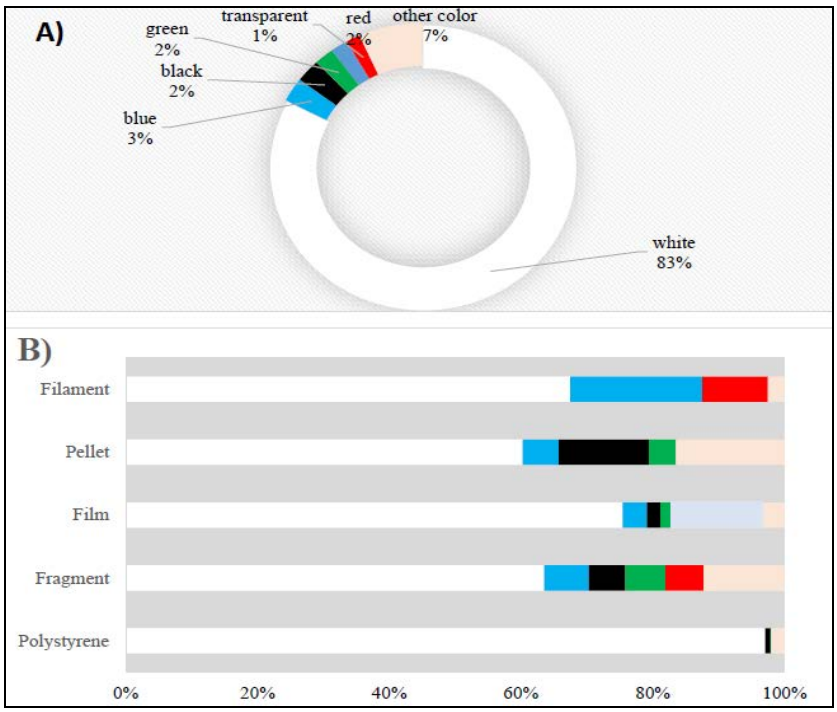


Fig. 6. Percentage of the different colors of microplastics identified (A) throughout the study and (B) by each microplastic type (polystyrene, film, fragment, filament and pellet). "Other color" represents the sum between the following colors: beige, brown, orange, pink, purple, yellow, and grey.

A high abundance of the polystyrene (foam) was also previously reported form sandy beaches from Peru (De-La-Torre *et al*., 2020), South Korea (Eo *et al*., 2018), and Russia (Esiukova, 2017). However, most of the studies from around the world reported mainly fragments and fibers (Hidalgo-Ruz and Thiel, 2013; Lots *et al*., 2017). Some examples of the different types of microplastics found in the sand samples collected from all surveyed Black Sea beaches are shown in Fig. 7.

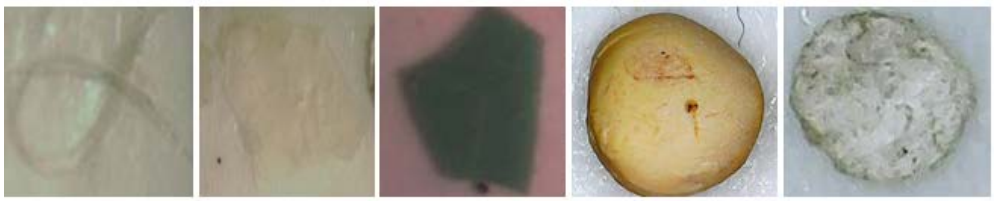


Fig. 7. The five types of microplastics found in the beach sediments at Vadu, Marina Regia and Malibu during 2018 and 2019. From left to right: filament, film, fragment, pellet, and expanded polystyrene - EPS

CONCLUSIONS

The results of the present study showed litter accumulation on the Romanian Black Sea beaches at three important sites (Vadu, Marina Regia and Malibu) with the highest macrolitter and microplastic concentrations recorded in the southern area of Mamaia summer resort (Malibu urban beach). The composition of the macrolitter recorded on each surveyed beach indicating that beside the level of coastal infrastructure development, the seasonal tourists and local population density are important factors affecting marine litter pollution level on the Romanian beaches. The monitoring data on the Black Sea beach macrolitter showed a clear predominance of plastic (> 85 % of the total items), thus confirming the general picture already described regarding the plastic items dominance of ocean litter (Kideys and Aydin, 2020; Serra Gonçalves *et al*., 2019).

Our study also showed for the first time the presence of diverse microplastics types in the top 5 cm of the marine sandy beaches of Romania, with high densities values of polystyrene (EPS). The analysis of the morphological properties of the sampled microplastics allows us to identify some differences in beach use and management. Therefore, further detailed studies would be worthwhile in better understanding the mechanisms leading to the litter, in particular microplastic, accumulation and dispersion on the Black Sea coastal beaches and fate of it to combat litter pollution and its related problems.

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