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Seasonal Composition and Density of Marine Litter on Asparuhovo Beach, Varna, Bulgaria

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Abstract. Marine litter is a growing environmental problem affecting oceans and seas worldwide. Waste created by humans on land or at sea has been discharged into coastal or marine environments. Marine Strategy Framework Directive establishes the basis of integrated marine assessment taking into account the human pressures and their environmental impacts, including marine litter under Descriptor 10. In this study the composition and density of coastline debris were analysed as indicators of marine litter. Two monitoring campaigns for collection and identification of marine litter took place at Asparuhovo Beach (Varna) in 2019, covering the surveyed area of 8814 m^2. In the spring campaign, 3608 items of artificial polymer materials, rubber, textile, paper, processed wood, metal and glass with a total weight of 19.591 kg were collected. Litter density was estimated at 0.41 items.m^{-2} in abundance and at 0.002 kg.m^{-2} in mass. In the autumn survey, the number of collected items decreased to 1461 items and the weight – to 4.189 kg. Compared to spring, the results for beach litter density manifested 2.4 fold decrease in abundance (0.17 items.m^{-2}) and 4 fold decrease in mass (0.0005 kg.m^{-2}). In both surveys, the artificial polymer materials prevailed in abundance – 87% and 86% respectively. Cigarette buts, plastic/polystyrene pieces, industrial packaging, plastic cups and rings were predominant in marine litter composition. The Clean Coast Index classified the Asparuhovo Beach as "Moderate" beach in spring and as "Clean" in the autumn season.

Key words: marine litter, beach monitoring, Bulgarian Black Sea, MSFD, Descriptor 10.

Introduction

Marine litter is a waste created by humans that have been discharged into coastal or marine environments, resulting from human activities on land or at sea. Marine Strategy Framework Directive – MSFD (EC, 2008) establishes the basis of integrated marine assessment and it is aimed at achieving Good Environmental Status (GES) in the European seas by 2020. The marine environment is assessed based on 11 qualitative descriptors (characteristics) taking into account the state of the marine environment, types of pressures and impacts on it. Marine litter (D10) is one of the Descriptors related to the types of pressures on the marine environment. The MSFD requires the EU Member States to be certain that by 2020, the marine litter available in the coastal and marine environments will do no

harm marine life (Directive 2008/56/EC; Commission Decision (EU) 2017/848). The marine debris has been assessed on beaches, sea surface and seabed. Monitoring activities related to coastline litter should evaluate and describe litter pollution and provide data to national assessments of marine debris and support to assess the level of threat to biota and ecosystems.

Numerous studies on monitoring methods for assessing litter in the marine environment have been published over the last decades, but the most comprehensive are those, published by Cheshire et al. (2009) and Galgani et al. (2013a). Studies examine the existing methods for marine litter surveys, monitoring methods and protocols used during the beach surveys. Marine litter can be categorized as plastic, metal, wood, rubber, glass or paper. Of all categories of litter, artificial polymer (plastic) waste is the most damaging. The threat from plastic litter is one of the most dangerous ones since it is insoluble and non-degradable in the marine environment (Zarfl & Matthies, 2010; Cole et al., 2011; Engler, 2012; Galgani et al., 2013b). The impact of plastics on the environment is significant. Some of the marine species swallow small pieces of plastics, which leads to internal damage and even death. Some of the marine species are entangled in ALDFG (Abandoned, Lost or Discarded Fishing Gear). Entanglement kills and injures animals, while ghost nets continue trapping sea life (Brown& Macfadyen, 2007; Kühn et al., 2015; Matsuoka et al., 2005; NOAA Marine Debris Program, 2015; IUCN, 2016). Other environmental impacts are habitat destruction (Chiappone et al., 2005; Yoshikawa & Asoh, 2004), consequences of chemical transport and introduction (Lithner et al., 2011; Mato et al., 2001; Ogata et al., 2009) and spread of invasive species (Kiessling et al., 2015). Persistent plastics, with an estimated lifetime for degradation of hundreds of years in marine conditions, can break up into a micro- and nanoplastics over shorter timescales, thus facilitating their uptake by marine biota throughout the food chain (Urban-Malinga, 2018). There are also economic impacts, social impacts and human health and safety (Lang et al., 2008; Campanale et al., 2020).

Marine litter related information in the Black Sea and along Bulgarian coast remains limited, inconsistent and fragmented (Topcu et al., 2013; Ioakeimidis et al., 2014; Moncheva et al.,2015; Simeonova et al., 2017). Within this context the need for accurate scientific data on marine litter in the Black Sea is evident in order to address marine litter problems effectively, ensuring the sustainable management and use of the marine and coastal environment.

The current study is aimed to conduct two seasonal surveys on Asparuhovo Beach (Varna, Bulgaria) in 2019 to collect and assess the composition and density of coastline marine litter pollution.

Material and Methods

Two monitoring campaigns for collection and identification of marine litter were conducted at Asparuhovo Beach (Varna) in spring (on 17th April 2019) and in autumn (25th October 2019) seasons. The selected Asparuhovo Beach is situated in the suburbs of Varna. The city of Varna is the third biggest town of Bulgaria, numbering 471 252 citizens in 2019 and important touristic city. The local city beach is vast, tranquil and not attended by many tourists – Fig. 1. Human activities on the beach include restaurants, fishing village and port of Varna close to the beach.

For all surveys, the methodology recommended by Galgani et al. (2013a) in Marine Strategy Framework Directive Guidance was applied. The sampling unit represents 100m fixed section, randomly selected on the Asparuhovo Beach, covering the entire area from the water's edge and the area where the sand ends and the asphalted part begins. The total surveyed area was 8814 m^2. The same sampling area was used during the spring and autumn surveys. The monitored section of 100 m length was marked by permanently marked GPS points and by rope for efficient waste monitoring. All artificial objects with size more than 2.5 cm, stranded on the monitoring unit were collected and counted. Collected marine

litter was separated and classified according to the main types of materials (plastic, metal, paper/cardboard, glass, rubber, wood, textile, other), placed in the separate disposal bags and weighted by type. The amount per each category was recorded. The collected debris was analyzed and separated to subcategories under laboratory conditions, according to the Master List of Categories of Litter Items, following the Guidance of MSFD Technical Subgroup on Marine Litter. During the laboratory processing, some items with size less than 2.5 cm (>2 cm) were registered and also included here as a result. Observed litter densities were estimated as the number of items per square meter, and in terms of mass - as kilograms per square meter. All data were uploaded and available at Marine Litter Watch Portal.

Beach cleanliness was assessed through the Clean Coast Index (CCI) according to Alkalay et al. (2007). CCI was estimated by formula:

CCI = (Total litter on transect/Total area of transect) x K

where: K (constant) = 20.

Beach condition by seasons was classified from "Clean" to "Extremely dirty" according to Alkalay et al. (2007) scale – Table 1.

Table 1. Clean Coast Index classification (after Alkalay et al., 2007).

CCI	Very clean	Clean	Moderate	Dirty	Extremely dirty
Value	0 - 2	2 - 5	5 - 10	10 - 20	20+
Definition	No litter is seen.	No litter is seen over a large area.	A few pieces of litter can be detected.	A lot of debris on the shore.	Most of the beach is covered with plastic debris.

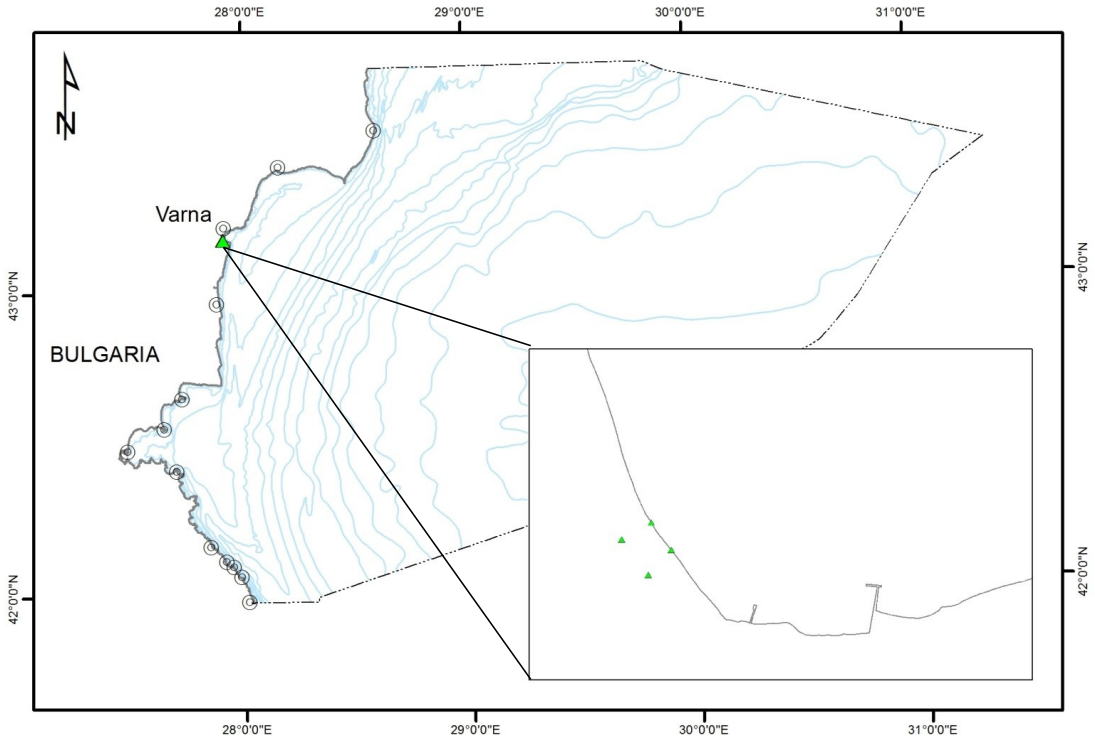

Fig. 1. Sampling area (Asparuhovo Beach) during spring and autumn monitoring campaigns for the collection of marine litter in 2019.

Results and Discussion

The results of the conducted two marine litter monitoring surveys in 2019 on Asparuhovo Beach showed a total number of 5069 items and 23.78 kg collected beach litter. The number of items was highest in spring (3608 items, 0.41 items.m^{-2}) and lower in autumn (1461 items, 0.17 items.m^{-2}). A similar tendency was observed in terms of weight – highest in spring (19.591 kg, 0.002 kg.m^{-2}) and lower in autumn (4.189 kg, 0.0005 kg.m^{-2}).

Collected marine litter was classified into 7 categories and 102 subcategories. The most abundant type of debris during both seasons was category "Artificial polymer materials" with shares of 87% (spring) and 86% (autumn) of the total number (Fig. 2), followed by paper/cardboard (5%, 3%), glass/ceramics (3%, 4%) and processed/worked wood (2%, 3%). In terms of weight, plastics prevail in spring survey (47%), but in autumn season – the "Glass/ceramics" category overcome in the total weight, representing 39% of total weight, followed by wood (29%), artificial polymer materials (28%) and metal (2%) - Fig.2. The shares of the rest of the categories were around 1% or less.

Artificial polymer materials prevailed with 58 subcategories in spring and 29 subcategories in autumn. In April, most of the inventories were plastic pieces, packets and cigarette buts – Fig. 3. In October, the most abundant were cigarette buts, plastic/polystyrene pieces 2.5 cm, industrial packaging and plastic cups and rings (Fig. 3).

„Paper/Cardboard" was the second abundant category, presented by 5 subcategories, constant in April and October. Inventories include cardboard, newspapers, tetra pack, cigarette packets, paper fragments and other paper items – Fig. 4. „Glass/ceramics" was the third category concerning the accumulation of marine litter, presented by 3 subcategories in April and by 4 – in October. Inventories include tableware, light tubes, glass items, bottles, pieces etc – Fig. 4.

„Processed/worked wood" category was presented by 4 subcategories in April and 2 – in October. Inventories include processed timber, ice-cream sticks and other wood – Fig. 5. „Metal category" was presented by 8 subcategories in April and 5 – in October. Inventories include wire, aerosol/spray cans, cans, fishing items, cables, bottles, caps etc. – Fig. 5.

„Cloth/textile" category was presented by 6 subcategories in spring and 4 – in autumn. Inventories include clothing, shoes, bags, carpet & furnishing, rope, string, nets and other textiles – Fig. 6. „Rubber" category was presented by 4 subcategories in spring and 2 – in autumn. Inventories include balloons, tires, rubber bands and other rubber pieces – Fig. 6.

A Clean Coast Index (CCI) was developed and applied as a tool for evaluation of the beach cleanness (Alkalay et al., 2007). It measures marine debris as a beach cleanliness indicator. The CCI was used to increase public awareness regarding coast cleanliness and motivate the authorities to clean their beaches (Alkalay et al., 2007). The Clean Coast Index classified the Asparuhovo Beach as a ''Moderate" beach (CCI = 8.19) in spring and as "Clean" (CCI = 3.32) beach in autumn. Visual descriptions of beach cleanliness provided by Alkalay et al. (2007) were consistent with the CCI values obtained.

Artificial polymer material was the dominant debris during the study as had already been reported from Black Sea (Topçu et al., 2013; Simeonova et al., 2017), Adriatic (Munari et al., 2016), Mediterranean (Asensio-Montesinos et al., 2019), USA waters (Hardesty et al., 2017) and in many other studies worldwide (Derraik, 2002; Ryan et al., 2009). We estimated the top 10 most common items, observed during both studies in 2019 (Fig. 7). Plastic pieces, cigarette butts, food packets and wrappers, plastic caps, and lids are all common items in both datasets due to touristic activities and different beach uses. The main reason for this is that plastic is used in almost all human activities, together with its long persistence in the marine environment.

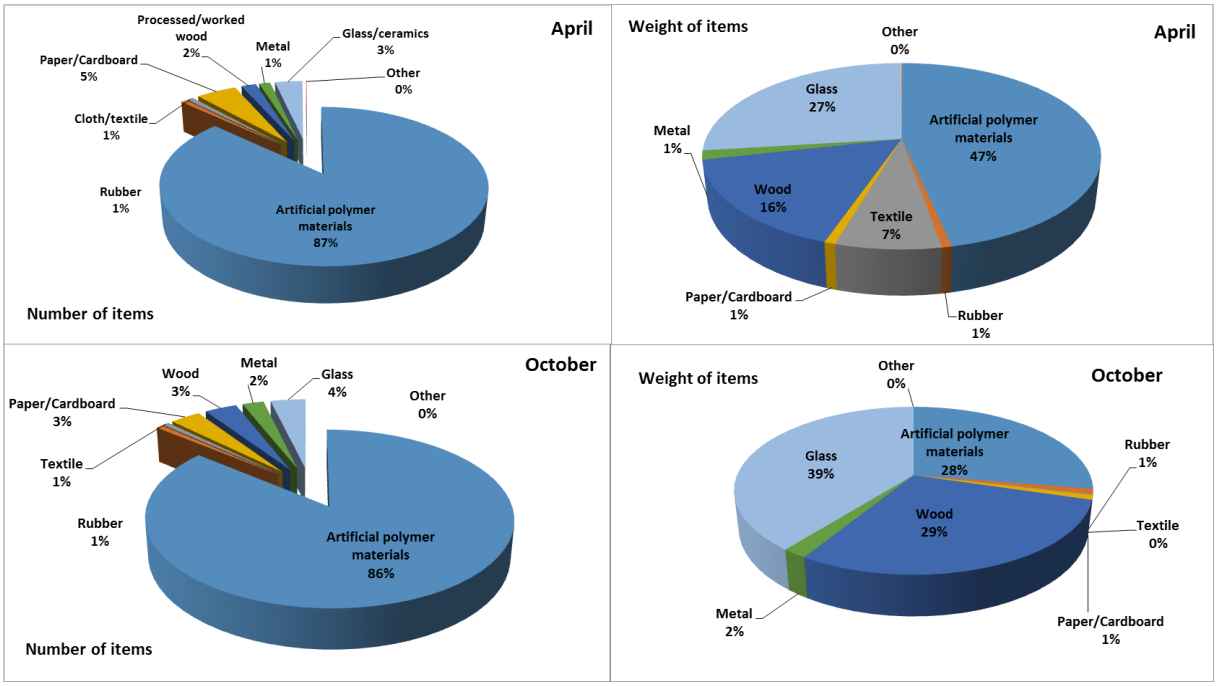

Fig. 2. Shares (in numbers and weight, kg) of collected items per categories depending on the material.

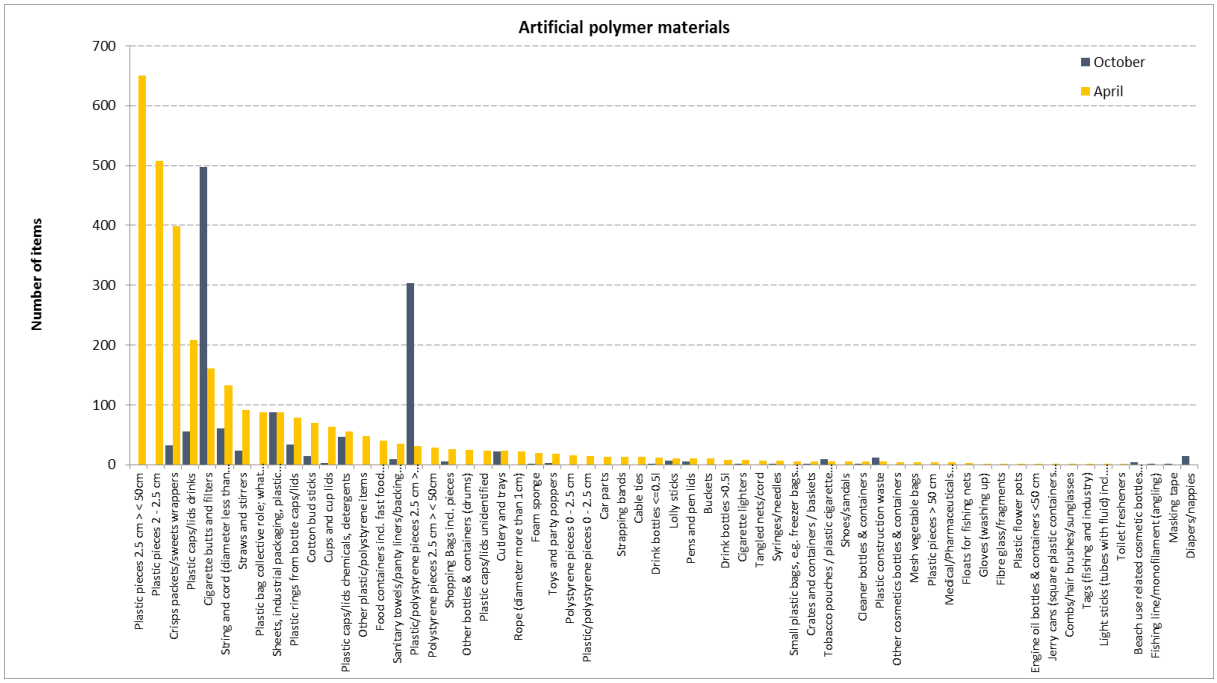

Fig. 3. Subcategories of Artificial polymer material, present in the surveyed area in 2019.

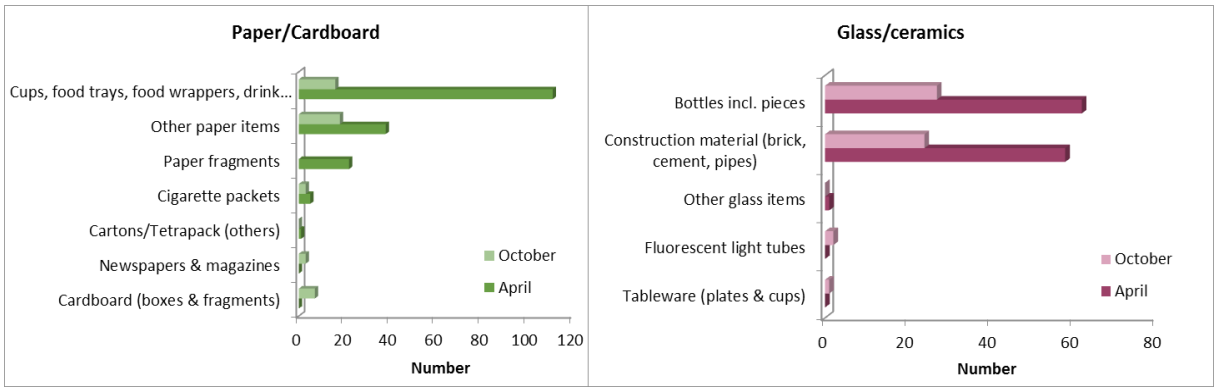

Fig. 4. Subcategories of „Paper/Cardboard" and „Glass/ceramics", present in the surveyed area in 2019.

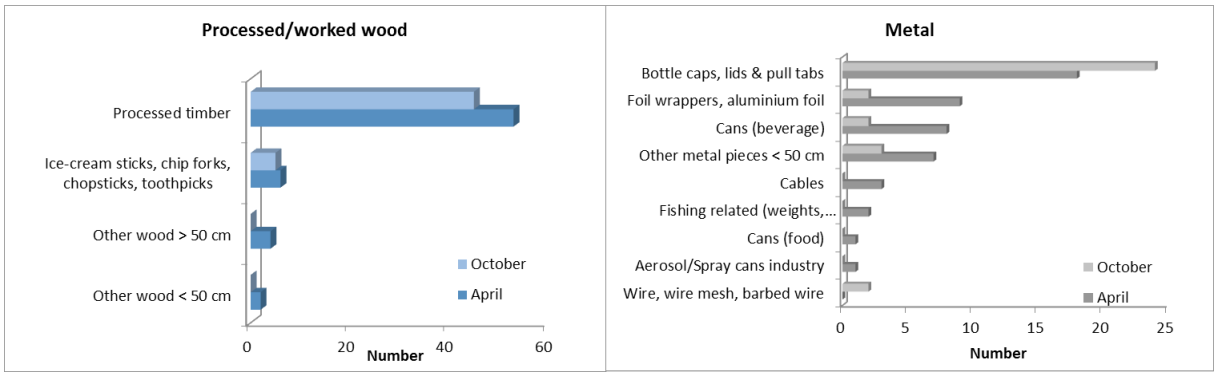

Fig. 5. Subcategories of „Processed/worked wood" and „Metal", present in the surveyed area in 2019.

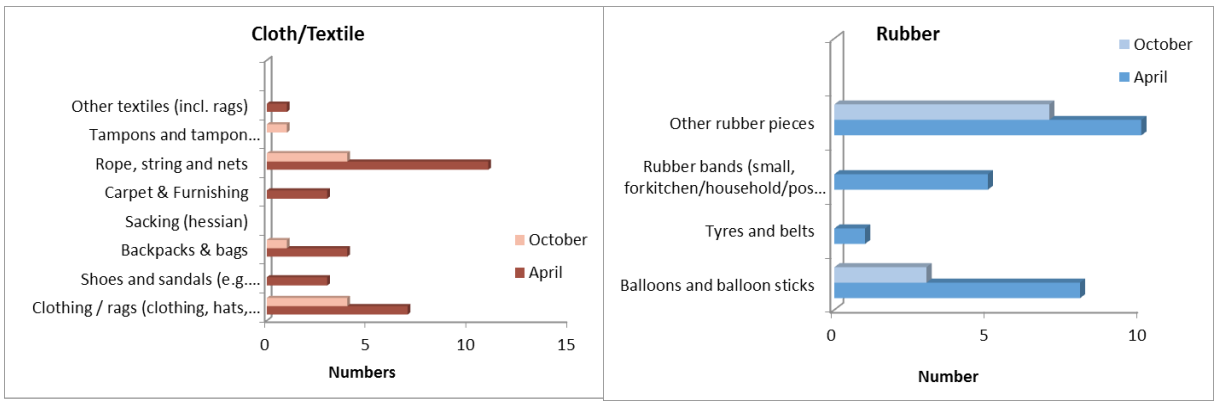

Fig. 6. Subcategories of „Cloth/Textile" and „Rubber", present in the surveyed area in 2019.

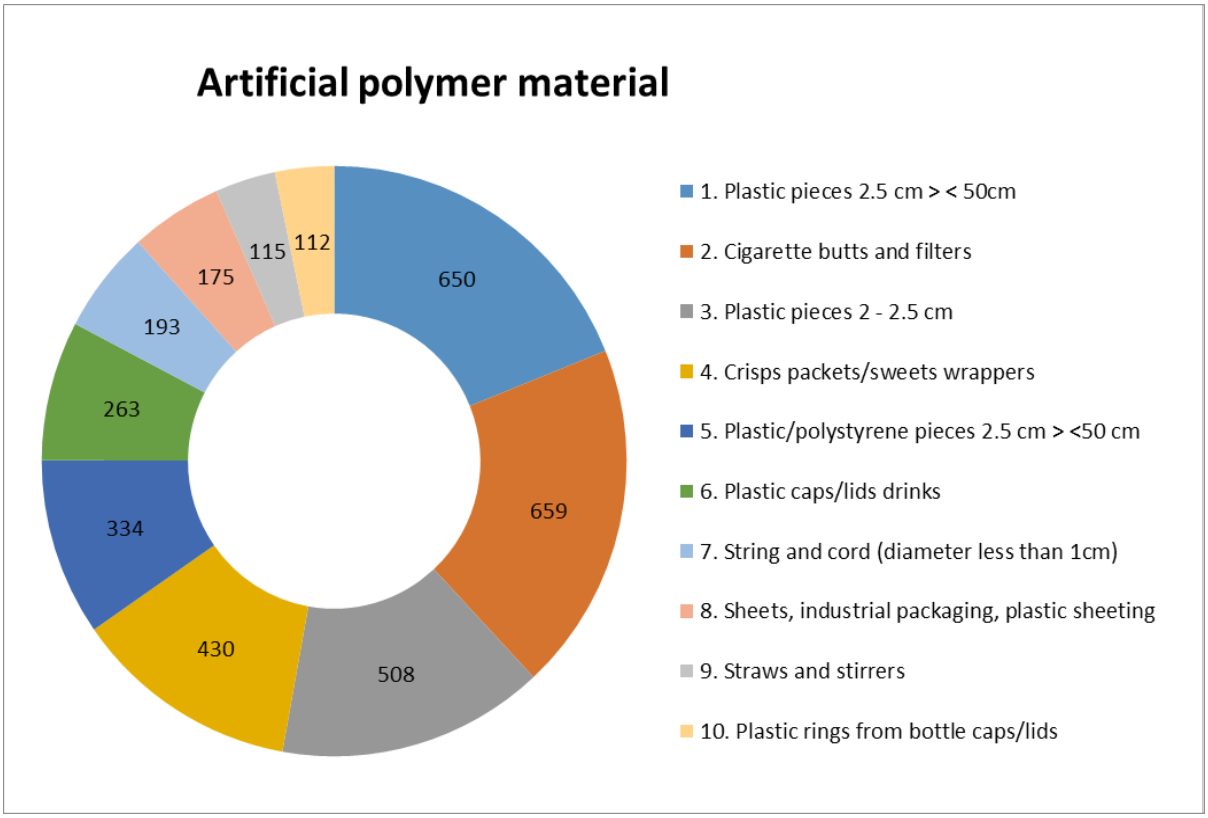

Fig. 7. The top 10 most commonly found plastic items from coastal surveys on Asparuhovo Beach in 2019. The total number of collected items in 2019 is given on the figure.

For the Bulgarian coast, our results confirm that the plastics, followed by paper/cardboard are the most abundant categories (Simeonova et al., 2017) in beach litter composition. For the Asparuhovo Beach area, Simeonova et al. (2017) reported lower densities of marine litter (0.1343 items.m^{-2}), compared to our results in 2019 and increasing trend in coastal beach pollution was observed during the years. The data collected during the monitoring campaigns allow tracing the seasonal dynamics in marine debris abundance. Comparison between results from spring and autumn monitoring campaigns showed that the number of items per square meter reduced 2.4 times fold from spring to autumn and in terms of mass – 4 times fold. The main reason probably is that after the touristic season in September, large quantities of marine litter are acumulated on the beach by winds and currents during the winter season. On the opposite side, during the summer, due to an increasing number of beach visitors and intensive recreational activities, the owners of beach restourants and tenants put efforts for beach cleanup and in early and mid-autumn (October) the beach is still clean (CCI=3.32). The main sources for the observed composition of marine litter on the Aspruhovo Beach are shoreline and recreational activities, smoking-related activities, fishing activities and medical/personal hygiene. The presence of marine litter on the beach, exept the loss in aesthetic value, could cause an economic harm, such as loss from tourism and additional cleaning costs. Ecological harm resulting from the ingestion of litter, including the uptake of microparticles (mainly microplastics), could seriously affect marine fauna.

Monitoring of marine litter and prevention of pollution of marine environment by adequate legislation and measures is the main challenge in Bulgaria. Current monitoring activities are irregular and there is an insufficiency of data for assessment of the current state and development of thresholds by different criteria and indicators of D10. Collection of new data is required for formulation of the basic state of macro- and microlitter, elaboration of respective thresholds and assessment of progress in achieving GES by criteria D10C1 and D10C2 (quantity of marine litter on the coast/beaches; litter on the sea surface and on the seabed). It can be assumed that GES is achieved when the litter and its degradation products present in and entering in marine waters do not cause harm to marine life and habitats, do not pose direct or indirect risks to human health and not lead to negative socio-economic impacts.

The increase of public awareness and involvement of stakeholders and citizens in common activities related to marine litter is important for the successful implementation of measures reducing coastal pollution.

Conclusions

The results of the conducted monitoring surveys for marine litter on Asparuhovo Beach in April and October 2019 revealed moderate beach pollution. The most significant level of pollution was due to the category of Artificial polymer materials – 86 - 87%. With the highest frequency in this category, including 58 subcategories, were cigarette buts, plastic/polystyrene pieces, industrial packaging and plastic cups and rings. The obtained results showed a reduction in the number of marine litter items in the autumn season compared to the spring season in 2019. The Clean Coast Index classified the Asparuhovo Beach as ''Moderate" beach in spring and as "Clean" in autumn. The conducted monitoring on the Bulgarian Black Sea coast could contribute to collecting new data about the composition and abundance of marine litter, distributed on the beaches and development of thresholds regarding indicator 1 (D10C1) of MSFD and achieving good environmental status of the marine environment.

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