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Seasonal dynamics of marine litter along the Bulgarian Black Sea coast

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ABSTRACT

In this study marine litter (ML) surveys were conducted in 8 beaches along the Bulgarian Black Sea coastline within 4 seasons for 2015–2016. The monitoring applied OSPAR guideline, classifying ML in eight categories and 167 types. The results exhibited predominance of artificial polymer materials - 84.3%. ML densities ranged from 0.0587 ± 0.005 to 0.1343 ± 0.008 n/m^2, highest on the urban beaches. The seasonal dynamics of most top 10 ML showed highest quantities in summer than the other seasons, as the differences are of high statistical significance ($0.001 \le P \le 0.05$). Top 1 ML item for most of the beaches was cigarette butts and filters reaching 1008 ± 10.58 nos. in summer and from 19 ± 3.41 to 89 ± 7.81 nos. during the rest of the seasons ($P < 0.001$). For the pronounced seasonality contributed the recreational activities, increased tourist flow and the wild camping. The investigation will enrich data scarcity for Descriptor 10 "Marine litter".

1. Introduction

Marine and coastal waters are facing numerous environmental problems impacted by human activities and causing deterioration of the marine environment. The good environmental status of marine waters is of vital importance for all seas, subject of many international conventions including the OSPAR Convention for the North Eastern Atlantic, the Helsinki Convention (HELCOM) for the Baltic Sea, the Barcelona Convention and associated Protocols for the Mediterranean Sea, the Bucharest Convention for the Black Sea as well as the Global Programme of Action for the Protection of the Marine Environment from Land-based Activities (UNEP, regional seas program) (Apitz et al., 2006; Beunen et al., 2009; Atkins et al., 2011; Boyes and Elliott, 2014; Elliott, 2014).

The environmental pillar of the integrated Maritime Policy for the EU is the implementation of the Marine Strategy Framework Directive (MSFD) (2008/56/EC) (EC, 2008). The objective of the MSFD is very much in line with the objectives and approaches by OSPAR Convention and the other international conventions, seeking to achieve or maintain Good Environmental Status of all European seas by 2020 (EC, 2008; Borja et al., 2010; Hering et al., 2010; Long, 2011; Borja et al., 2013; Sardà et al., 2014; OSPAR, 2015). A cornerstone of the MSFD is the interpretation of 11 descriptors (MSFD Annex I), some of which representing the most important ecosystem features of concern - Biological diversity; Non - indigenous species; Commercial fish and shellfish; Food webs; Sea floor integrity; Hydrological conditions. Another part of the descriptors represents human drivers, pressures on the ecosystems and their resulting alterations - Fishery; Eutrophication; Contaminants; Litter; Energy and noise (EC, 2008; Borja et al., 2010; Berga et al., 2015).

One of the most important problems facing all seas is the marine litter (ML). Each year the marine and coastal waters are impacted by numerous ML, found on the beaches and in the open sea as well as on the deep sea - bed (Katsanevakis and Katsarou, 2004; BSC, 2007; Katsanevakis, 2008; Galgani et al., 2011; Galgani et al., 2013a; Evelyn et al., 2017). ML is covering any solid material which has been deliberately discarded, or unintentionally lost on beaches and on shores or at sea, including wide range of materials - plastic, metal, wood, rubber, glass, paper (UNEP, 2009; Cheshire et al., 2009; Galgani et al., 2010; OSPAR, 2014).

The ML is not only an aesthetic problem but represents a major threat to marine organisms and human health (Galgani et al., 2000; Katsanevakis et al., 2007; CBD, 2012; Galgani et al., 2013b; Galgani et al., 2014). Most of the ML, especially plastics, are extremely durable materials and persist in the marine environment for a considerable period, possibly as much as hundreds of years (Cadee, 2002; Derraik, 2002; Browne et al., 2008; Barnes et al., 2009; Corcoran et al., 2009.; Collignon et al., 2012; OSPAR, 2014; OSPAR, 2015).

The Bulgarian Black Sea environment does not constitute an exception from the global tendency of overloading with floating ML and its growing accumulation on the coasts. The Bulgarian Black Sea and its coasts are subjected to high levels of ML pollution from different sources - land-based sources, rivers and canal discharges, agriculture, shipbuilding and ship repair, navigation, fishery, tourism and recreation (Simeonova et al., 2010; Simeonova et al., 2011; Simeonova et al., 2012;

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Simeonova and Chuturkova, 2017). Another reason for the significant amount of litter which finds its way to the seashore and marine environment is the increased consumption of goods from the country population, producing more waste not being efficiently collected, disposed of or processed properly (Ilieva et al., 2010; Karapenev and Yaneva, 2014; Karapenev, 2015). ML hot spots for the Bulgarian seashore, ranked in order of their importance, are: 1. Coastal cities (including seaside resort complexes); 2. Ports; 3. Navigation routes; 4. Industrial zones along the beaches of Burgas and Varna towns; 5. Wild beaches and estuaries of the rivers (BSC, 2007).

Besides a number of international, regional and national legal instruments, the Bulgarian Black Sea has not yet received sufficient attention regarding ML pollution. The ML in the region has not yet been quantified and scientific data are still scarce (BSC, 2007). The key instrument to test the effectiveness of the existing legislation and regulations is the monitoring of ML on the Bulgarian beaches which will supports the implementation of the MSFD working for the good environmental status. Initial monitoring efforts are required, applying some of the methods which have been developed, following the MSFD recommendations for assessing litter in the marine environment (Cheshire et al., 2009; Galgani et al., 2013a; Lippiatt et al., 2013; Opfer et al., 2012). The collection of data will provide information on amounts, trends and sources of marine litter and will help to develop and suggest appropriate management strategies, policy documents and strategic plans.

The objective of this study was to collect baseline information on the full spectrum of marine litter deposited on the country beaches. The investigation was targeted to assess coastal litter pollution along the Bulgarian Black Sea and quantify the problem.

2. Materials and methods

2.1. Study area

The study was conducted along the whole Bulgarian Black Sea coast at 8 country beaches - from the farthermost northern - southern part. The beaches were selected according to the following criteria - city beaches in order to determine the influence of land-based sources of pollution; beaches near uninhabited or less populated areas subject to intense recreational activities, mainly during the summer period; beaches near rivers, flowing into the sea. The following beaches were surveyed: four Northern Black Sea beaches - *Durankulak beach; Krapets beach; Channel 2 - Varna*; *Shkorpilovtsi* and four Southern Black Sea beaches - *Obzor beach*; *Irakli beach; Black Sea saltpans - Burgas*; *Alepu beach* (Figs. 1, 2). Two of the beaches - *Channel 2 - Varna* and *Black Sea saltpans - Burgas* are within big towns - Varna and Burgas with higher population - 348,058 and 206,371 citizens respectively and major ports. The Obzor beach and Irakli are situated near rivers flowing directly into the sea. The rest of the selected beaches are situated close to or within small villages with low population from 17 to 766 citizens.

Fig. 1. Bulgaria location along the Black Sea area.

Fig. 2. Bulgarian Black Sea beaches.

Details of the eight surveyed stations are given below.

2.1.1. Northern Bulgarian Black Sea stations

- Durankulak beach (S1) is the northernmost region of the Bulgarian Black Sea coast, ID BG3322924102008002. The beach is a typical sandy with length of the coastline - 302 m and coordinates: 43° 41′ 46.89″ N and 28° 33′ 58.71″ E - 43° 41′ 38.24″ N and 28° 33′ 51.70″ E. The beach is situated 2 km east of Durankulak village, close to the protected area "Durankulak lake" and about 5 km south of the Bulgarian - Romanian border. Durankulak is a small village with low population, numbering - 371 inhabitants. The nearest port is situated on 0.460 km with 20 berths for ships. Close to the beach are located small hotels and houses visited only during the summer.
- Krapets beach (S2) is part of the bathing zone "Krapetz - north", ID BG3322939493008003, sandy beach with coordinates of the coastline: 43° 41′ 34.15″ N and 28° 33′ 50.70″ E - 43° 38′ 41.83″ N and 28° 34′ 21.37″ E. The nearest village (Krapets) is situated at 1.55 km on south. Krapets is a small village with low population, numbering - 290 inhabitants. The bathing zone includes almost 5000 m coastline within Natura 2000 and is subject to recreational activities mainly during the summer period.
- Channel 2 - Varna (S3) is situated within Varna town, connecting Varna Lake to Black Sea and is used for navigation. The coastline is not a typical sandy beach, mainly composed of gravel, with coordinates: 43° 11′ 33.12″ N and 27° 52′ 49.77″ E - 43° 11′ 8.53″ N and 27° 53′ 24.50″ E. Port of Varna East is situated along the channel. It is the largest seaport complex in Bulgaria, offering full services with approximately 40 berths. Varna town (the sea capital of Bulgaria) is the third biggest town of Bulgaria with higher population - 348,058 citizens, subject to intense recreational activities, mainly during the summer period when the population increases considerably. The coastline of the channel is used all year long especially for recreational fishing.
- Shkorpilovtsi beach (S4) is part of the Shorpilovtsi bathing zone, ID BG3311383404003019, typical sandy beach with coordinates: 42°

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