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Challenges to the Development of the Marine Litter Monitoring System in Bulgaria

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Abstract. **This report presents the results of a study of the development of the marine litter monitoring system in Bulgaria in the period 2016-2022. The system has been structured and operates as part of the implementation of the requirements of the Marine Strategy Framework Directive 2008/56/EC and in particular Descriptor 10 "Marine litter". Until 2022, the monitoring surveys of the distribution, abundance and accumulation of marine litter were carried out in accordance with specific criteria for macro- and micro-litter. In parallel, the potential sources of marine litter and the pressure of its introduction into the marine environment, beaches, water column and seabed have been analyzed. A comprehensive comparative analysis has been conducted in regards to the applied monitoring procedures, as well as the results of numerous monitoring surveys conducted in the frames of Bulgarian national marine litter monitoring system, during the studied period. As a result the main challenges for the development and the upcoming increase in the scope of the system were identified end presented in this paper. Opportunities to improve the functioning of the system, directed to eliminating weaknesses in relation to used observation protocols, monitoring sites, frequency of monitoring, ensuring representativeness and comparability of monitoring data and information are listed.**

Keywords Marine litter, monitoring system, Marine Strategy.

I. INTRODUCTION

At global and regional scale marine litter is environmental, economic, health, aesthetic and cultural problem [1]. The overloading of the marine environment with marine litter – floating debris as well as contained in the water column and accumulated on the sea bottom, and its increasing accumulation on the coasts has been recognized as one of the main environmental problems worldwide. [2],[3]. The huge variety of anthropogenic waste enters the marine environment from human activities on land and at sea. According to United Nations Environment Programme (UNEP), marine litter is any persistent, manufactured or processed solid material discarded, disposed of/ or abandoned in the marine and coastal environment [4]. This definition once more gives a glance at the interconnection and interdependence between socio-economic development and the disturbance of ecological balance on a global scale. Marine litter affects negatively coastal and marine ecosystems, wellbeing of societies, especially the coastal population, e.g. fisheries, tourism and recreation, sea-oriented economy, industry, shipping, etc. Impacts to marine life vary from physical or chemical harm to marine biota, to wider effects on biodiversity and ecosystem functioning [5].

Among the diversity of material, plastics are the largest, most harmful and persistent part of marine litter. (ML) Their product characteristics - light, durable, economical for mass production and single use, due to improper disposal have turned them into a pervasive environmental pollutant in the long term [6]. In addition, majority of plastics are insoluble and non-degradable in the marine environment. Low relative weight of products made from synthetic polymers contributes to their spread over extremely long distances, through aeolian and hydrological transport. According to the UNEP, approximately 7 billion of the 9.2 billion tonnes of plastic produced between 1950 - 2017 became waste in landfills or dumped [7]. Particularly, the amount of plastic litter in the world's oceans has been constantly rapidly growing (Borrelle et al., 2020; Jambeck et al., 2015; Ryberg et al., 2019), accounting for at least 85 % of total marine litter [7]. Pieces of plastic have been found in the digestive system of many aquatic organisms, including marine turtle species, seabirds and marine mammals. [7]. Particles smaller than 5 mm (microlitter) are included in food chains [8]. Ingested by marine organisms, they have a direct negative impact on ecosystems and indirectly on the humans consuming sea food.

Marine litter is a complex and transboundary problem although it is included in international, regional and national plans, the problem requires implementation of

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active measures to reduce quantities and limit the distribution in the marine environment. Despite of institutional efforts and involvement of citizen science there still is a lack of public understanding and behavior on negative effects of marine litter.

Monitoring and assessment of marine litter in the coastal and marine environment, requires a high-resolution classification system for litter items, which enables them to be recorded in a clear, and harmonized way [9], [10], [11].

In this context the national ML monitoring system has been established in Bulgaria in 2015. Now still further development and coordination at regional level in order to ensure collection of the required ML data in proper manner is needed.

Current research aims to identify the gaps and organization, structure and functioning of the system for ML in Bulgarian part of the Black Sea.

II. MATERIALS AND METHODS

The subject of the present study is the ML monitoring system in Bulgaria with its structure, provision and functioning. A comprehensive detailed analysis has been performed to evaluate the level of conformity of Bulgarian ML monitoring system's state of art to the required EU level regarding scope, organization, and performance of the system.

Marine Strategy Framework Directive (MSFD) [9] is one of the pillars of the integrated EU Maritime Policy and tackles the achievement of good environmental status (GES) of marine environment via 11 quality desctriptors. EU member states are obligated to monitor and access the achievement of GES under all descriptors including Descriptor 10 (D10) "Marine litter".

Monitoring protocols have been developed in order to obtain comparable data regarding composition, abundance and accumulation of marine litter. Implementing the MSFD as a part of European Union Bulgaria has developed national monitoring program on D10.

The research has been specifically focused on the subsystem marine macro litter monitoring. Official data, including statistical data and information, e.g. annual reports, survey protocols and other relevant documentation, had been used for the purposes of this investigation [12].

III. RESULTS AND DISCUSSION

In order to provide consistency, compatibility and comparability of monitoring data a classification system has been developed by OSPAR Commission [13]. It has been adopted by Bulgarian Ministry of Environment and Waters prior first ML monitoring survey in Bulgaria, 2015, because of its applicability to ML in coastline, surface layer of the water column, seabed and biota.

That detailed identification, recording and reporting is organized in specific categories. In this way it is provided a link between monitoring data and the ML potential sources. By MSFD technical groups were developed protocols for monitoring of marine litter with photo catalogue and list of categories to increase the comparability of data and assessments between Member States. In order to understand better the impact of marine litter to the marine environment were given methodological recommendations and advice on how to sample, analyze, and record marine litter to support designing and implementing monitoring programmes [14], [15], [16]. Monitoring programmes under MSFD D10C1, indicator 1 had been established and implemented by the Ministry of Environment and Water [17]. Thus, the national monitoring system partially meets the requirement regarding commonly structured monitoring structured systems in EU.

To specify the monitoring sites or monitoring polygons a set of unified criteria has been applied in the frames of the subsystem Beach marine litter monitoring. Aassessed beach systems included in the programme have minimal anthropogenic activities - no concession or municipal regular cleaning and maintenance, because of the impact on the accumulation and distribution of macrolitter on the coast. Monitoring campaigns had been conducted along the Bulgarian Black Sea coast in regard to above mentioned criteria – in order to escape of maintenance influence.

Surveys include following beaches: Durankulak North - 1, Krapets – North, Channel 2 - Varna (coastline along a canal connecting the Black sea with Varna lake), Shkorpilovtsi- North, Byala – Kara dere, Children camp Obzor, Irakli, Black Sea saltpans – Burgas, Alepu, beach at the mouth of the Veleka river and Lozenets - Coral (Table I).

Two of the monitoring sites - Channel 2 - Varna and Black Sea saltpans JRC- Burgas, are within the scope of the two largest cities on the Bulgarian Black Sea coast with ports of public importance and the rest are close to small villages, far away from industrial areas but overpopulated by tourists during the summer season.

Bulgarian monitoring system on Descriptor 10 (D10), criteria D10C1 has to provide information on the quality (individual categories and subcategories) and quantity of macrolitter along the Bulgarian coast (number and weight of individual categories, total weight and number of all collected debris from a specific section). Assessment is based on the main eight categories in accordance to main recommendations of the European Guidelines for Monitoring Marine Litter under MSFD [14].

The monitoring methodology in use for monitoring according to criterion D10C1 along the Bulgarian coast follows the recommendations indicated in the Monitoring Guidance under Descriptor 10. The same recommends that survey and data collecting is from at least two 100 m sections (100 m length and 100 m width) of the selected at least 1000 m beach or coastline for lightly or moderately polluted beaches. [14], [18].

Method applied for conducted monitoring on marine debris is in situ manual collecting in a site with length of 100 m along the coast line and the back of the beach (dunes, cliff, vegetation line, artefacts). Samples collected are classified according to the Guidance of MSFD Technical Subgroup on Marine Litter [14] and with Revised Decision 2017/848/EU repealed 2010/477/EU established specific criteria (including criteria elements), methodological standards, specifications and standardized methods for monitoring and evaluation, and determination of threshold values. [10].

TABLE I SAMPLING UNITS ON MARINE MACROLITTER PROGRAMME, 2016 – 2022

	Sampling units on marine macrolitter programme, 2016 – 2022		
	Sampling unit	***Category***	***Pressure***
1	Durankulak North - 1	Unguarded beach	Transboundary transfer of waste
2	Krapets - North	Coastline	Transboundary transfer of waste
3	Canal 1 - Varna	Unguarded beach	Pressure from large populated area, with >100000 p.e (Varna town)
4	Shkorpilovtsi North	Nature-friendly tourism beach; Unguarded	Pressure from less populated area, with < 2000 p.e (Shorpilovtsi village); seasonal recreational sites; recreational activities during summer; influence of the river "Fundukliyska" and transfer of waste from currents
5	Byala - Karadere beach	Unguarded beach	Reference site; inflow of small rivers - the river "Cherna" and the river "Byala"; transfer of waste from currents
6	Children camp Obzor	Nature-friendly tourism beach; Unguarded	Pressure from large settlements > 10000 p.e. (town of Obzor); influence of the river "Dvoinitsa"; seasonal resort sites; agricultural lands and forests
7	Irakli	Unguarded beach	Offshore reference place; mainly forests and arable land; transfer of waste from currents
8	Black sea Salt Pans JSC	Unguarded beach	Pressure from settlement with > 100000 p.e. (Burgas town) and Sarafovo neighborhood; in close proximity to "Black Sea Solnitsi" AD Salt plant; balneotherapy spot
9	Alepu	Unguarded beach	Pressure from large settlements > 10000 p.e. (town of Sozopol); seasonal resort sites ("Dyuni" resort and other smaller ones); close to "Alepu" swamp and transfer of waste from currents
10	Veleka river	Unguarded beach	Pressure from small settlements < 2000 p.e. (village of Sinemorets); seasonal resort sites; influence of the "Veleka" river and transfer of waste from currents
11	Lozenets - Coral	Unguarded beach	Pressure from small settlements < 2000 p.e. (village of Lozenets); seasonal resort sites and camping; transfer of waste from currents

The results for the period 2016-2022 were summarized in tabular format, on marine macrolitter on beaches (D10C1) as well as comparability by researches per year and seasons, category, total amount in kg and number of items collected. [12].

In order to understand the effectiveness of the conducted monitoring during the observed period 2016 - 2022 it has been done a comprehensive and comparative analysis on applied monitoring procedures and results of the surveys along the Bulgarian black sea coast. During the studied period number of beaches observed has fluctuated from 8 to 10, Veleka river was changed with Lozenets – Coral beach in 2021.

National monitoring system on beach macrolliter, although it was developed according to the requirements of the MSFD, does not address the specifics of the selected areas - their lithodynamic and hydrodynamic characteristics, which are decisive for the distribution and retention of macrolitter in the coastal unit. Information on any entangled fauna encountered during the survey (details of the organism, nature of entanglement, live or dead).

Regarding survey frequency and timing, it should be carried out 4 surveys per year for each survey unit. The proposed periods are winter in January, spring in April, summer in July and autumn in October [16]. These periods are more or less evenly distributed throughout the year. However, regional or even local conditions might prevent the performance of surveys in the periods proposed. Weather conditions (e.g. snow) in particular could prevent surveys in winter or spring. In addition, a high volume of tourists and extremely hot weather might hinder surveys in July. Surveys should not be undertaken during periods when there is a risk of affecting endangered or protected species, such as sea turtles and birds (i.e. nesting period). While using harmonized monitoring periods among the countries is highly recommended, it is up to the national coordinators of beach litter surveys to choose the survey periods best suited for their regions.

Sampling frequency was not achieved in any of the years. Winter period (January) has been observed/ monitored once in winter period (2016), only 8 sampling units. As pilot monitoring on D10C1, indicator 1 surveys are conducted mostly in spring, summer and autumn (Table III).

The comparative analysis shows direct proportionality when comparing the number of units and the total weight of the marine debris. 2017 is an exception due to a high number of marine litter G79 in the area at the mouth of the Veleka River. In this case, 33 car tires were found. (fig.1, Table II)

The result of data analysis from the implementation of the monitoring system during the observed period identifies that the coordinates of the 1000 m and 100 m sections coincide in the period 2016-2022, except for the replacement of one beach system with another (Veleka river with Lozents - Coral) but the scope of the territories of the selected beaches for the presence of macro litter was not measured or reported.

The width of the sampling unit (perpendicular to the shoreline) is defined as the distance between water's edge and beach back (dune base, rock, vegetation line or human artifacts) and measured at half the length. The width of the beach should be measured at the mean water level in regions with small tidal amplitudes as Black Sea.

Meta data from sampling units do not include the width of the selected transects. For a correct analysis and comparability of the results, it is necessary to take into account the changes in the beach systems as a result of the different hydro-meteorological conditions according to the seasonal dynamics of the coastline (water's edge) affecting the width of the beach, respectively of evaluated area size [16]. With an inscribed width of each section of 100 m, there will be consistency and coparabiliy in the assessment.

In regard to other 2 indicators Floating marine litter (D10C1 indicator 2) and Seafloor macro litter (D10C1 indicator 3) the data on the conducted monitoring are extremely limited. The studies were carried out in the

period 2016-2017: on D10C1, indicator 2, a pilot monitoring campaign was carried out within 8 days. Classification on amount, type, size and spatial distribution of litter floating on the sea surface >2.5 cm has been done in the coastal and shelf areas of the Bulgarian waters of the Black Sea.

Marine macrolitter on the sea bottom - the research was carried out in the shelf area in 2017. The results for the distribution and quantity were calculated as items/km^2.

The national macro waste monitoring system is characterized by incompleteness of research and data sets on floating and seabed sediments. No program, research or results available for Mesolitter and Pellets [16].

Data and information from the conducted studies is fragmented and not available in a single open portal, platform or data center for future and analysis. On messoplastics and pellets (also called plastic nurdles) programme has not been developed.

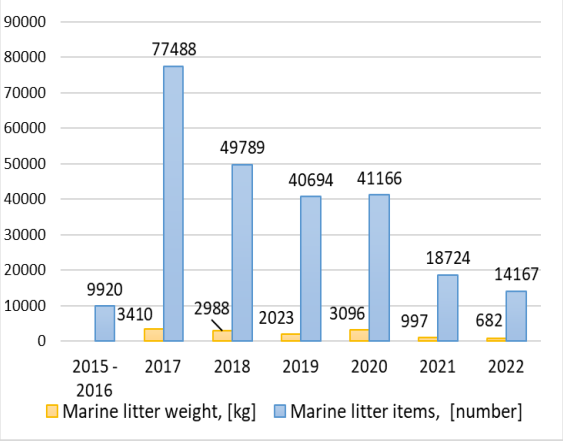

Fig. 1 Total number of items and total wight, [kg/year], 2015-2022

TABLE II MARINE MACROLITTER MONITORING SURVEYS

Year	Marine macrolitter monitoring surveys, 2015-2022			
	Number of surveys	*Number of beaches*	*Total weight, kg*	*Number of items*
2015 - 2016	4	8		9920
2017	3	10	3410.204	77488
2018	4	10	2987.644	49789
2019	4	10	2023.293	40694
2020	4	9	3095.88	41166
2021	4	10	996.539	18724
2022	4	10	682.479	14167

TABLE III MONITORING SURVEYS D10C1, MACROLITTER ON BEACHES, 2016-2022

Season	Winter	Spring	Summer	Autumn
Reference JRC 2023	***January***	***April***	***July***	***October***
2015				September October December
2016		March		
2017			August September	October November
2018		May	July	September October
2019		June	July August	September October
2020		May	July	September October
2021		April June		September November
2022		May, June		September, November

IV. CONCLUSIONS

Monitoring results and data collected from surveys conducted during the period 2016-2022 has been analysed, in particular for criteria D10C1 – beach macrolitter. Comprehensive comparative analysis has been done in regards to the applied monitoring procedures. As a result, it has been identified gaps and weaknesses in the monitoring system, applied protocols, monitoring sites, frequency of observations, representativeness and comparability of monitoring data used for the assessment of the environmental status in accordance to MSFD [12].

Despite conducting regular long-term monitoring in the period 2016-2022, there has no regularity by seasons, during the winter season monitoring has not been provided. That is very important factor because of hydrometeorological conditions typical for the coastal area - strong winds and swell, which are affecting the transport of macrolitter from the sea to the land.

Analysis of collected information in the period 2016-2022 raised the question how is guaranteed the validity, representativeness and the comparability of the results and the quality of the data collected by national marine litter monitoring system. Due to the lack of information on the size of coastline areas observed, also because chosen subcontractors and participants were mostly volunteers, data obtained need to be confirmed - has the monitoring meets the minimum requirements for methodology and representativeness of the results. It is an option to verify the reliability of the results with other methods (e.g. ROV, UAV).

Forms/protocols for fieldwork should be revised so it is provided the actual field area and obtained reliable and comparable data on the composition, abundance and accumulation of ML.

An additional challenge for the marine litter monitoring system is the lack of an adequate legal definition, which leads to a gap in the state's responsibility as an institution

in law enforcement and commitment in providing financial resources.

The opportunity for future development and improvement the system consists in an update of the program in accordance with the recommended guiding documents at the European and international level, as well as meeting the minimum scientific requirements for presentation and comparability of the results. In that way the suspicion of working with unreliable data would be avoided and convergence ensured, as well as the subsequent correct interpretation of the data and assessment of the GES of the marine environment under descriptor D10.

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