Marine litter categorization on two Montenegro beaches

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Abstract. For the purposes of this marine litter research, two beaches on the Montenegrin coast were selected - Jaz beach and Blatna beach. The total number of items in each sampling unit was registered and calculated using the litter density as a number of items per square meter (items/m^2) and per 100 m stretch of the shoreline. Costal clean index (CCI) is also defined for both beaches. During all research seasons dominant litter type was plastic items. The total amount of litter per 100 m of beach stretch obtained by this research shows that on both selected beaches the amount of beach litter is 10 to 16 times higher than the defined TV at the EU level (i.e. 4 to 5.5 times higher for the Mediterranean level).

Keywords: marine litter, beach, plastic items

1 INTRODUCTION

The pollution of the sea and the ocean, as a consequence of human activity, is to a large extent created by various activities. The main threats to marine ecosystem health are referable to human activities, leading to coastal water eutrophication, resource overexploitation, global climate change, the spread of invasive alien species, oil spills and industrial sewage discharge, as well as habitat modification and coastal erosion.

Lately, an increasing impact on the health of marine ecosystems is due to marine litter, which exerts additional pressure on already endangered organisms, habitats and the overall ecosystem health. Changes in marine ecosystems usually have multiple causes, whose interaction, together with degrading pressures on marine biota, play a critical role in maintaining diversity of species, ecosystem health and achieving the Good Environmental Status – GES (defined as the "ecological status of marine waters that are ecologically diverse and dynamic and seas that are clean, healthy and productive, while the use of the marine environment is at a sustainable level, thus protecting the potential and activities of present and future generations"; EC, 2008).

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2 PROBLEM BACKGROUND

The marine environment is sensitive to various pollutants that can be found in the sea in different forms and come from different sources, which is mainly the result of human activities on land. The amount of waste on the beaches is constantly increasing, along with the increase in the amount of seabed and floating waste. Waste in the sea and coastal area is carried by rivers, it can be the result of direct dumping due to various activities on land, it also originates from ships, while a part of the waste is the result of illegal and/or bad management of city (municipal) waste.

Marine litter (any manufactured or processed material in a solid state, which is discarded into the sea or coastal area) represents a major threat to marine ecosystems in the Mediterranean Sea, due to ecological, economic, security, health and cultural impacts.

Litter in the sea is one of the biggest problems on a global scale. Beaches, coastal areas and river basins, which are the basis of tourism in Montenegro, are under the negative influence of waste, and it is very important to reduce the amount and negative impact of waste in the sea through cooperation, state and inter-institutional approach that relies on strengths and resources local communities, organizations and state institutions.

The baseline values for beach litter are defined as 149 litter items in 100 m of beach length, while TV for beach litter are defined as 20 litter items/100 m of beach length, corresponding to 15th percentile value of the EU baseline dataset [1].

2 MATERIALS AND METHODS

2.1 Methodology of sampling and selected transects

2.1.1 Study area

For the purposes of this research, two beaches on the Montenegrin coast were selected - Jaz beach and Blatna beach. The aim of monitoring is the distribution, weight and categorization of marine litter. Jaz beach belongs to Municipality of Budva and it is situated in the vicinity of the Jaška River. Blatna beach belongs to Municipality of Herceg Novi and it is situated in the vicinity of Sutorina River. Starting and ending coordinates, as well as estimated area of transects are given in the Table 1. On Figures 1-2 investigated transects are presented.

Table 1. Coordinates and estimated area of transects on selected beaches

Transect	Starting coordinates	Ending coordinates	Estimated area
Jaz beach	42°16'46.35"N	42°10'49.48"N	4000 m^2
	18°47'58.89"E	18°48'00.37"E	
Blatna beach	42°27'10.68"N	42°27'08.08"N	1500 m^2
	18°30'22.28"E	18°30'19.72"E	

Figure 1. Transect on Jaz beach

Figure 2. Transect on Blatna beach

2.1.2 Survey method

Two transects (sampling units) per beach were monitored, by at least 50 m of distance, wherever possible. A fixed 100 m transect of sandy beach was defined, as recommended in most beach litter monitoring methodologies ([2], [3] and [4]) covering the whole area from the strandline to the back of the beach (usually coinciding with the beginning of sand vegetation). The boundaries of each sampling units were georeferenced using a GPS in order to ensure that the same sampling units were monitored for all repeated surveys. During the surveys, macro-litter (>2.5 cm) was collected manually and classified into nine different categories (artificial polymer materials – APM, rubber, cloth/ textile, paper/cardboard, processed/worked wood, metal, glass/ceramics, unidentified and/or chemicals). Detailed sub-categorization within main litter groups was done in the laboratory. Each litter item was counted and weighed.

2.1.3 Data analyses

The total number of items in each sampling unit was registered and calculated using the litter density as a number of items per square meter (items/m^2) and per 100 m stretch of the shoreline.

Beach cleanliness was assessed through the Clean Coast Index – CCI [5]:

$$CCI = CM \times K$$

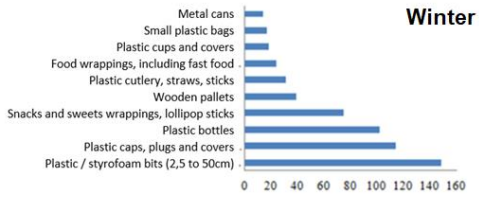
where CM is the density of litter items per m^2 and K is a constant that equals to 20. According to the CCI scale values from 0 to 2 indicate very clean beaches, 2–5 clean, 5–10 moderately clean, 10–20 dirty and >20 extremely dirty beaches.

3 RESULTS

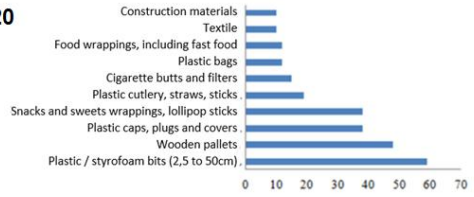
The data obtained during the monitoring of the amount and type of waste on the beaches showed a significant amount of waste on both beaches, with a pronounced dominance of plastic waste. During the autumn of 2020, a total of 3494 pieces of waste with a total weight of 4.78 kg were collected on Jaz beach, while a total of 1186 pieces of waste with a total weight of 13.66 kg were collected on the transect at Blatna beach.

The waste distribution shows an abundance of 0.87 pieces of waste per m^2 on Jaz beach, while on Blatna beach the abundance is 0.79 pieces of waste per m^2. The most common types of waste collected during the autumn of 2020 are shown in graphs 1 and 2.

During the winter season of 2020, the situation worsened, where a total of 382 pieces of waste with a total weight of 23.66 kg were collected on Jaz beach, while a total of 778 pieces of waste with a total weight of 35.1 kg were collected on the transect at Blatna beach. The distribution of waste shows that on the Jaz beach the abundance of waste is 0.09 pieces per m^2, while on Blatna beach there is 0.51 pieces of waste per m^2. The most common types of waste collected during the winter of 2020 are shown in graphs 3 and 4.

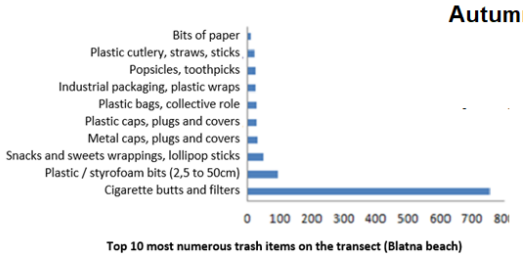


Graph 3

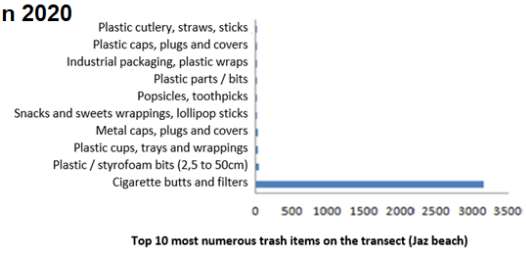


Graph 4

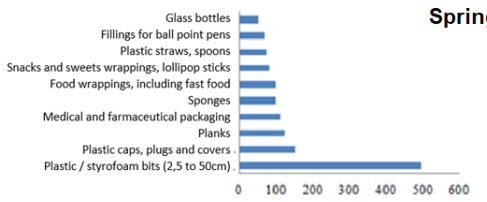
During the spring season of 2021, a total of 409 pieces of waste with a total weight of 19.97 kg were collected on Jaz beach, while a total of 1895 pieces of waste with a total weight of 38.47 kg were collected on the transect at Blatna beach. The most common types of waste collected during the spring of 2021 are shown in graphs 5 and 6. On Jaz beach, the results show a distribution of 0.10 pieces of waste per m^2, while on Blatna beach the distribution of waste is 0.85 pieces per m^2. According to the coast cleanliness index calculated according to Alkalay [5], Jaška plaža belongs to the group of clean beaches (CCI = 2.05), while Blatna plaža belongs to the group of extremely dirty beaches (CCI = 25.26).



Graph 1



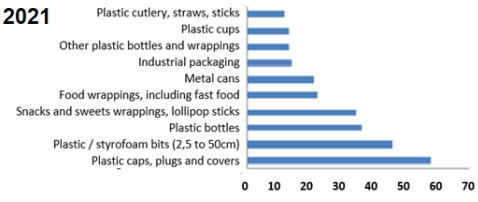
Graph 2



Top 10 most numerous trash items on the transect (Blatna beach)

Graph 5

Spring 2021



Top 10 most numerous trash items on the transect (Jaz beach)

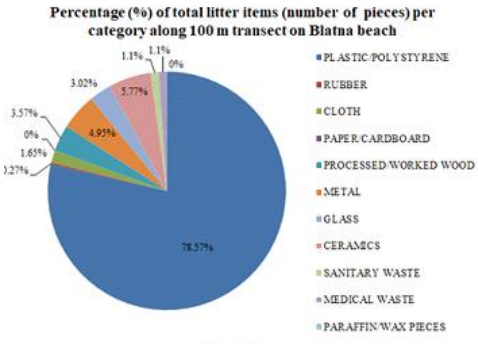
Graph 6

On Jaz beach, during winter season 2021, 607 items/100m of marine litter was collected, with total weight of 75.27 kg, while on Blatna beach 364 items/100m were collected, with total weight of 40.21 kg. Abundance of marine litter on Jaz beach transect was 0.15 items/m^2, while on Blatna beach transect 0.24 items/m^2. Based on the CCI (Clean Coastal Index) [6] both beaches belong to clean beaches with CCI ranged from 2 to 5 (Jaz beach CCI= 3; Blatna beach CCI= 4.8).

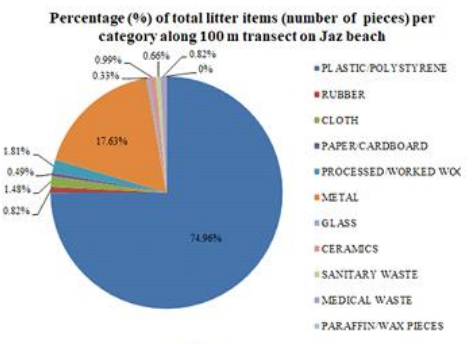
On Jaz beach during all four seasons it was found in total 4834 items/100 m with total weight of 123.67 kg, while on Blatna beach it was found in total 4195 items/100 m with total weight of 125.21 kg. Average abundance of marine litter during all three seasons was estimated to be 0.35 items/m^2 (350 items/100 m stretch) and 0.85 items/m^2 (850 items/100 m stretch) on Jaz and Blatna beach, respectively. According to CCI Jaz beach belong to moderately "clean" beaches (CCI = 7), while Blatna beach belong to "dirty" beaches (CCI = 17.14).

The largest percentage share of marine litter belongs to APM on both beaches with cumulative percentage of 90.6% and 79.11% of total litter on Jaz and Blatna beach, respectively.

Based on the number of collected items the largest percentage share of litter belonged to plastic on both transects. On Jaz beach plastic presented 74.96% of total litter, while on Blatna beach plastic presented 78.57% of total litter. After plastic, dominant group on Jaz beach was metal (17.63%), while on Blatna beach ceramics (5.77%) was the second dominant group (graphs 7 and 8).

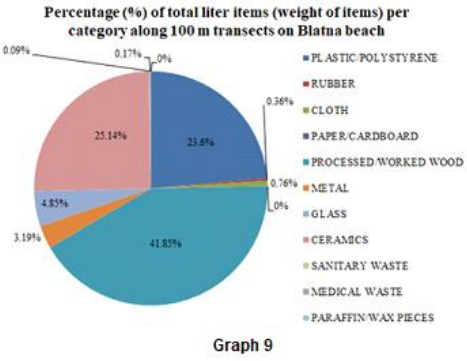


Graph 7

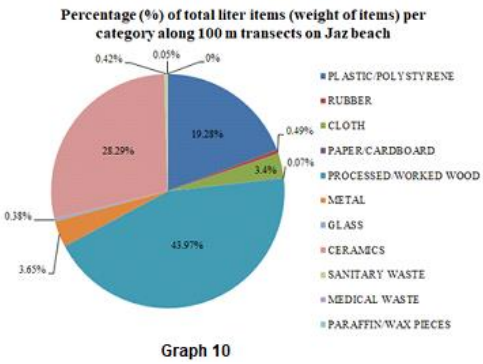


Graph 8

Based on the total weight of collected items the largest percentage share of litter belonged to processed wood. On Jaz beach processed wood presented 43.97% of total litter, while on Blatna beach processed wood presented 41.85% of total litter. After processed wood, dominant groups on Jaz beach were ceramics (28.29%), and plastic (19.28%). On Blatna beach dominant groups were ceramics (25.14%) and plastic (23.6%) (graphs 9-10).

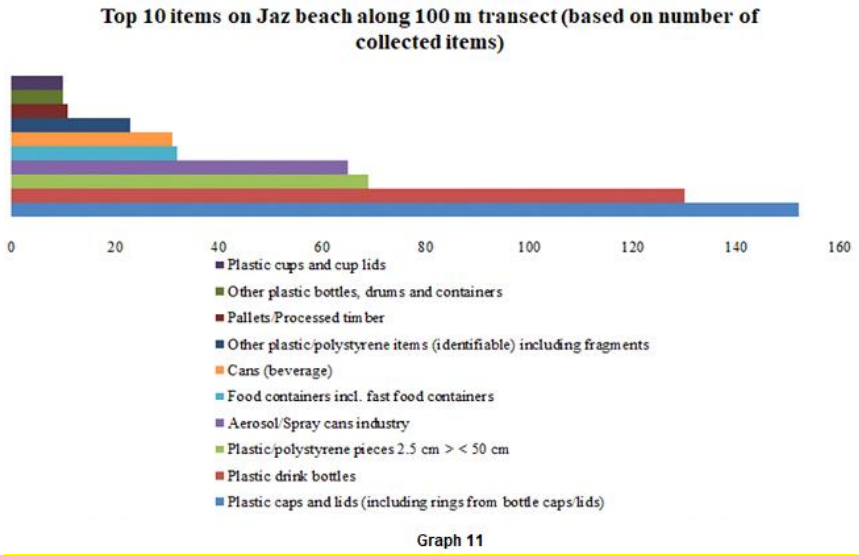


Graph 9



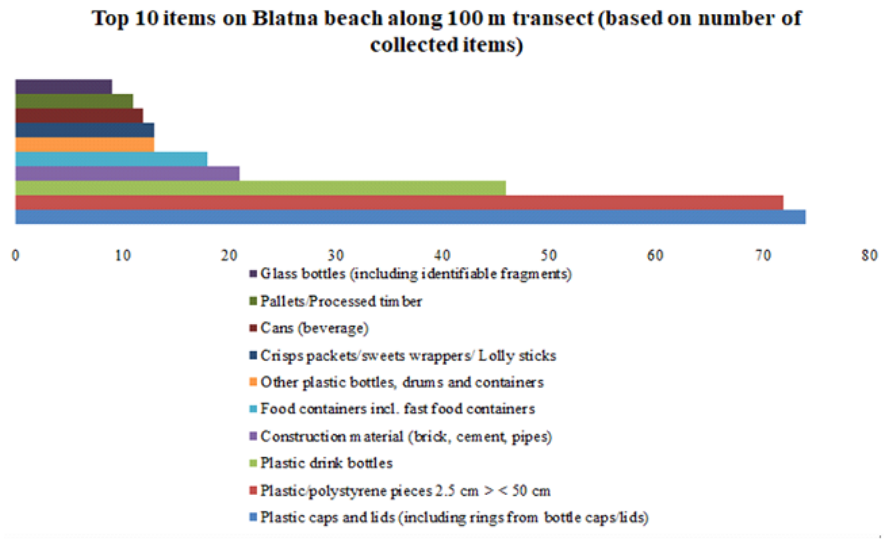
Graph 10

Dominant litter type (based on the number of collected items) on Jaz beach were plastic caps and lids. Dominant litter items by size belonged to plastic drink bottles and plastic/polystyrene pieces 2.5 cm - 50 cm. In total, it was collected 152 plastic caps and lids, 130 plastic drink bottles and 69 plastic/polystyrene pieces 2.5 cm - 50 cm (graph 11).



Graph 11

Dominant litter type (based on the number of collected items) on Blatna beach were plastic caps and lids. Dominant litter items by size belonged to plastic/polystyrene pieces 2.5 cm - 50 cm and plastic drink bottles. In total, it was collected 74 plastic caps and lids, 72 plastic/polystyrene pieces 2.5 cm - 50 cm and 46 plastic drink bottles (graph 12).



Graph 12

4 FUTHER WORK

This research is just one of few in our country. Namely, in Montenegro doesn't exist continuously monitoring of marine litter on the beaches. Beginning of the new field work is planned in next few weeks. Except marine litter on the beaches, plan is to collect and categorize floating marine litter as well as macro plastic in selected fish species. After analysis the obtained results recommendations for better waste management in Montenegro will be provided.

5 CONCLUSIONS

Results of this research showed that majority of marine litter items belongs to plastics, as one of the most common beach litter material worldwide ([6], [7], [8], [9], [10] and [11]). The total annual input of plastic in the Adriatic Sea in 2010 was estimated to be 10.000–250.000 tons [11]. Among plastics, the most frequent category of litter items was related to food and beverage packaging ("plastic caps/lids from drinks", "crisps packets/sweets wrappers", "drink bottles > 0.5l", "drink bottles <= 0.5l", "cups and cup lids" and "food containers incl. fast food containers") which contribute with 48.93% in the top 10 plastic items.

Average litter abundance per surveyed seasons is beloved 1 items/m^2. Those values are comparable to the values reported by other surveys carried out in the Adriatic Basin ([12], [7], [9] and [14]). Our result shown that our beaches had less beach litter then beaches in

Albania and Italy. Similar results was presented in paper which is compered data in three countries [15].

The most dominant litter categories belonged to single-use plastic items ("plastic caps/lids from drinks", "crisps packets/sweets wrappers", "drink bottles > 0.5l", "drink bottles <= 0.5l", "cups and cup lids" and "food containers incl. fast food containers") very similar to results of other studies related Adriatic beaches ([9], [14] and [16]).

The baseline values for beach litter are defined as 149 litter items in 100 m of beach length, while TV for beach litter are defined as 20 litter value of the EU baseline dataset [1].

Integrated Monitoring and Assessment Program of the Mediterranean Sea and Coast and Related Assessment Criteria – IMAP (UNEP/ MED WG.482/23) prescribes the obligation to achieve GES in such a way that litter on the coast and in the sea does not adversely affect the coastal and marine ecosystem. The IMAP Common indicator 22 defines that number/amount of marine litter items on the coastline do not have negative impact on human health, marine life and ecosystem services. Regarding IMAP (UNEP/MED WG.482/23) the baseline values for beach litter are defined as 329 litter items in 100 m of beach length, while TV are defined as 59 litter items/100 m of beach length.

The total amount of litter per 100 m of beach stretch obtained by this research shows that on both selected beaches the amount of beach litter is 10 to 16 times higher than the defined TV at the EU level (i.e. 4 to 5.5 times higher for the Mediterranean level).

According to the CCI scale values from 0 to 2 indicate very clean beaches, 2–5 clean, 5–10 moderately clean, 10–20 dirty and >20 extremely dirty beaches. During analyzed period CCI for our beaches was depends on season. Blatna beach was extremely dirty during spring field analysis, while Jaška beach was clean during all research period.

Based on the obtained results, it can be judged that the source of the waste is on the beaches. Namely, waste is left on beaches, in most cases, by beach users. Accordingly, it is necessary to change the habits of beach visitors themselves. It is necessary to introduce recommendations to tenants of beach bars to reduce the use of plastic packaging, glasses, and straws.

As the selected beaches are located at the mouths of rivers and the sea, we can say that part of the waste was brought from the hinterland.

Analyzes were done through 3 seasons, autumn, winter (2x) and spring. The summer was deliberately skipped because the tenants of the beaches, during the summer season, are obliged to clean them, so the collected amount of waste would not be relevant for the research.

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Skills

- Fluent in Montenegrin (native language) and English, and passive knowledge Ru
- Proficient in Microsoft Office;
- Flexible team player and open-minded.
- Able to work in culturally diverse environment.
- Proven relationship-builder with great interpersonal skills.
- Dependable and responsible with a commitment to success.

Education

- **MA Biology**

-Faculty of Natural Science-Mathematics, University of Montenegro

- **BA Biology**

-Faculty of Natural Science-Mathematics, University of Montenegro **October, 200**

Activities

- Member of the Technical-operating body responsible to provide assessment for Montenegro
- Conference on Climate Change and Sustainable Development - Mediterranean re
- Presentation on a transmission of the good sustainable development practices

-Presented by the members of the Government of the Republic of Slovenia

- Workshop on integrated management of water ecosystems, Drač, Albania
- Workshop for project writing

-Project was financed from IPA funds.

- Study Tour of Italian national parks

- Tour organized by Food and Agriculture Organization (FAO)

- Workshop on strengthening of capacities of the Western Balkan, Bečići, Montenegro
- Workshop on Cartagena Protocol and GMO
- Workshop on assessment procedures for CDM projects in Montenegro

Work Experience

- **Environmental Protection Agency of Montenegro**, Podgorica

Adviser at the Department for monitoring, analyses and reporting **August, 2008 –**

- Worked on a development of the monitoring program;
- Prepared information on the state of the environment;
-Prepared proposals of the measures and specific activities necessary to implement to reduce environmental
-Participated in a preparation of responses for the EU Commission Questionnaire;
-Prepared data reports on biodiversity for SOER 2010;

- **The Monitoring Center CEMI**, Podgorica, Montenegro

Strategic marketing assistant

-The Monitoring Center CEMI is a non-governmental, non-profit organization with the main goal of prov
continuous monitoring of the overall process of transition in Montenegro.