

Composition and abundance of beach litter in Montenegro (South Adriatic Sea)

Ines PERAŠ¹, Milica DIVANOVIĆ², Ana PEŠIĆ¹, Aleksandar JOKSIMOVIĆ¹, Olivera MARKOVIĆ¹, Mirko ĐUROVIĆ¹ and Milica MANDIĆ^{1*}

¹Institute of Marine Biology, Dobrota bb, 85330 Kotor, Montenegro, e-mail: mamilica@ac.me

²Ministry of agriculture and rural development, Rimski trg 46, 21000, Podgorica, Montenegro

ABSTRACT

This paper presents results of the first investigation of beach litter in Montenegro. Sampling was performed during four seasons, autumn (October) 2014, winter (January), spring (April) and summer (July) 2015, on two beaches. One of them, Igalo beach is situated in the area of Boka Kotorska Bay, while second one - Kamenovo beach is situated at the open part of Montenegrin coast. Methodology that was used during sampling was developed during IPA Adriatic DeFishGear project. Total of 2 992 pieces of litter items, with total weight of 51.47 kg was collected during all seasons. Summarizing the monitored results of surveyed beaches from all four seasons, results showed that the plastic was dominant type of litter with 75.3% on Kamenovo beach and 77% on Igalo beach, followed by cloth, metal and wood items. Results showed relatively big amount of marine litter and further investigation should be concentrated on wider area.

Keywords: marine litter, plastic, pollution, tourism, Adriatic Sea

INTRODUCTION

Marine litter on beaches is becoming more abundant in Montenegrin coast every year. It's defined as any persistent, manufactured or processed solid material discarded, disposed of or abandoned in the marine and coastal environment (UNEP, 2009). It consists of items that have been made or used by people and deliberately discarded or unintentionally lost into the sea or coastline including such materials transported into the marine environment (UNEP, 2009). Litter can have different origin and characteristics, but according to its weight and shape, marine litter is divided into two categories: floating litter and sinking litter (Kusui & Noda, 2003). Origin of litter can be from land- or sea-based sources (UNEP, 2005). Land-based sources includes tourism and recreational uses of the coast, domestic, agricultural and industrial activities, harbors, untreated municipal sewage and improper waste management. Furthermore sea-based sources of marine litter include merchant shipping, ferries and cruise liners, commercial and recreational fishing vessels, military fleets and research vessels, pleasure craft, offshore installations such as oil and gas platforms, drilling rigs and aquaculture sites (Galgani *et al.*, 2013).

In neighbouring countries, there are several studies related to beach litter, although the data are scarce (Kwokal & Štefanović, 2010; Laglbauer *et al.*, 2014; Munari *et al.*, 2016). Studies conducted in northern part of Adriatic Sea, north-western, as well as in south-eastern Adriatic showed that that amount of litter is not affected by tourism as much as it was predicted (Laglbauer *et al.*, 2014). Bigger influence on litter have wind direction, sea currents, fishing activities, aquaculture and river inflow (Laglbauer *et al.*,

2014; Munari *et al.*, 2016). Study conducted in the area of Mljet island showed that accumulation of beach litter depends to the important extent from the open sea conditions and direction of sea currents (Kwokal & Štefanović, 2010). Litter from neighboring countries can easily be transported with sea currents and could make more damage than home waste (Kwokal & Štefanović, 2010). Influence of marine litter, beside being affecting nature and ecosystems, marine and coastal organisms, can cause economic decline, especially in tourism (Laglbauer *et al.*, 2014; Munari *et al.*, 2016).

The purpose of this study is to find answers for these questions: what is the quantity, composition and distribution of beach litter in Montenegro, are there any differences in the types of litter at different locations and which are the main sources of litter.

MATERIAL AND METHODS

Two beaches were chosen as appropriate for monitoring activities. First one, Igalo beach, is situated in the area of Boka Kotorska Bay, while second one, Kamenovo beach is situated at the open part of Montenegrin coast (Figure 1). The reason for choosing those two beaches is fact that beaches are exposed to different environmental conditions, especially sea currents and winds.

Igalo beach is situated in the Municipality of Herceg Novi (30864 residents) (MONSTAT, 2011). It is sandy beach with low slope of 10%, with length of almost 500 m. Near the beach there are some restaurants, mini markets and food stands. On the west end

of the beach is small river Sutorina. Table 1 shows GPS coordinates of sampling area on Igalo beach.



Figure 1. Two monitored beaches: Igalo and Kamenovo

Table 1. GPS coordinates of all four corners of the sampling unit of monitored area on Igalo beach

GPS	Latitude	Longitude
1	42° 27' 31.8"	18° 30' 57.2"
2	42° 27' 31.6"	18° 30' 57.3"
3	42° 27' 32.0"	18° 31' 00.7"
4	42° 27' 31.8"	18° 31' 00.5"

Kamenovo beach is situated in the village that belongs to the municipality of Budva. The beach is about 330 m long with a view towards the south-east. This is pebble beach, with a very small percentage of large stones (10%), slopes gently toward the sea, with a 15% slope. In the hinterland of the beach there is a walking path made of stone and concrete, as well as the objects of temporary character that sells food and drinks. The nearest town, Budva, is located 7 km towards the west. Budva has a population of 23000 residents (MONSTAT, 2011). Only during the tourist season this number varies significantly, due to the large number of tourists. Nearest port is a

port of Bar (to the southeast), whose main activity is transshipment and storage of goods. The mouth of closest river to the beach is mouth of the river Bojana (60 km away towards the south-east). GPS coordinates of sampled area on Kamenovo beach are presented in Table 2.

Table 2. GPS coordinates of four corners of monitored area on Kamenovo beach (*In the first 100 m of the sampling area there were discrepancies compared to first season, due to the presence of large area covered with seaweed, and two coordinates were changed)

GP	Latitude	Longitude
1	42° 16' 27.5"	18° 53' 17.8"
2	42° 16' 27.2"	18° 53' 17.2"
3	42° 16' 29.8"	18° 53' 14.5"
4	42° 16' 29.6"	18° 53' 14.4"
5*	42° 16' 30.3"	18° 53' 15.1"
6*	42° 16' 26.8"	18° 53' 17.9"

Both beaches are used mainly during the summer season, which includes the period from May to October. The beaches are cleaned every day during the tourist season, and the rest of the year only after a storm accompanied by large waves. They are cleaned by hands, and it is obligation of the beach tenants (Sl. list br. 21, 2009).

Depending on weather conditions, the most common winds in both monitored areas are "jugo" (warm and moist wind which blows from the directions east-southeast to south-south-west) and "bura" (dry and cold wind blowing in gusts from the north-northeast and east-northeast), while during the summer "maestral" (a daily, thermic wind blowing from the direction of the north-west) is characteristic type of wind (ZHMS CG, 2016).

Methodology (protocol) for monitoring macro-debris (> 2.5cm) on beaches used for this surveys was developed in the frame of the IPA Strategic project DeFishGear. In order to follow all requirements prescribed by the protocol monitoring activities need to fulfil the following conditions:

- Beaches should be located near the harbour, marinas, estuaries, urban parts, tourist destinations and relatively remote areas.
- Beaches should have a length of at least 100m, slope 15-30°, clean access to the sea, to be available for monitoring throughout the year, not to be previously cleaned and that monitoring does not disturb flora and fauna.
- The sampling area should be accurately recorded by the coordinates of the four monitoring angles. During beach monitoring, two transects should be marked, which must have a length field of 100 and a height of 10 m.

Sampling was performed during four seasons, autumn (October) 2014, winter (January), spring (April) and summer (July) 2015, on two beaches. All litter items are removed from the beach during the survey and disposed properly. Larger items that cannot be removed (safely) by the surveyors were marked, so that they will not be counted again at the next survey.

All material that was collected was directly identified, weight was measured and data recorded in the appropriate sheet. Further analyses of collected data were performed in Microsoft Office Excel 2007.

RESULTS

During the monitoring activities for all four seasons huge amount of different type of litter was collected: different types of plastic, paper, metal, glass and ceramics, textile and wood. It was collected in total 2 992 items of litter which weight was 51.47 kg. Kamenovo beach showed bigger amount of items - 2 097 (35.57 kg), compared to Igalo beach where 895 (15.9 kg) items were found in total.

The abundance of different litter items collected during different seasons is presented in Figure 2 and 3. For Kamenovo beach the results showed highest values in summer with 952 pieces of litter. In autumn the quantity of litter pieces was also very high - 601 pieces, despite that was not time of touristic season. In winter there were 314 pieces of litter and 228 pieces in spring (Figure 2). On Igalo beach in summer results showed that total amount of litter items was 439 pieces. Lower amounts were present in autumn with 131, in winter the amount of litter was 222 pieces, while in spring it was 112 items (Figure 3).

Results showed that on Igalo beach it was found 94 pieces of plastic items with total minimum weight of 0.4 kg during the autumn 2014, while maximum weight of plastic items was measured next year in spring 2.28 kg (for 60 pieces). The maximum number of plastic items (370) was found in summer but their weight was relatively small (0.74kg) (Table 3).

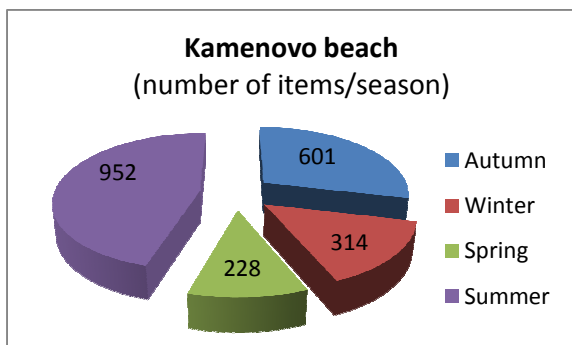


Figure 2. Amount of litter items/season for Kamenovo beach

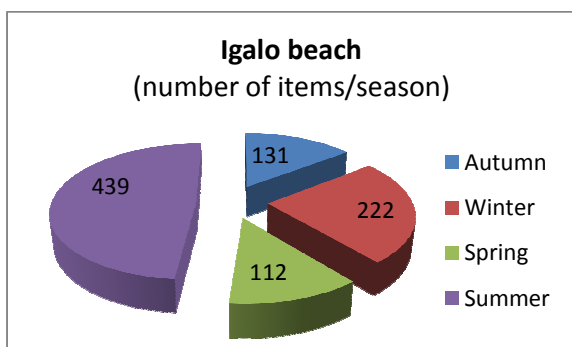


Figure 3. Amount of litter items/season for Igalo beach

Percentage share and weight of different type of litter found at Igalo beach during four seasons are presented in Tables 3 and 4. Total weight of litter at Igalo beach was 7,5 kg in autumn 2014. While in winter 2015, total weight from one transect was 5.3 kg. In spring it was 2.86 kg and in summer 2.04 kg (Table 3).

Second surveyed area, Kamenovo beach, showed also dominance of plastic in all four investigated seasons, where the maximum count was in summer (840) (that could be issue of touristic season), and minimum in spring (168). Other types of litter did not reach the same maximum and minimum values in months as plastics. Results from all four seasons at Kamenovo beach showed that most dominant (in number of items) type of litter was plastic (Table 5). Maximum weight of litter (16.16 kg) was recorded in winter 2015, while minimum was recorded in summer of the same year (3.61 kg).

Statistical analyses of different type of marine litter and count of collected items showed no significant difference between investigated beaches and seasons (Table 7).

Table 3. Presence of different types of litter on Igalo beach

Seasons	AMP(plastic)		Rubber		Cloth textile		Paper cardboard	
	weight (kg)	count	weight (kg)	count	weight (kg)	count	weight (kg)	count
Autumn	0.4	94	0.02	5	3	10	0.025	7
Winter	1.78	168	0.025	3	1.88	15	0.01	8
Spring	2.28	60			0.04	4	0.025	15
Summer	0.74	370			0.035	2	0.13	21
Seasons	Wood		Metal		Glass, ceramics		Other litter	
	weight (kg)	count	weight (kg)	count	weight (kg)	count	weight (kg)	count
Autumn	1.97	4	0.21	9	0.01	1	1.86	1
Winter	0.83	3	0.5	12	0.3	13	0.015	1
Spring	0.17	3	0.11	10	0.23	10		
Summer	0.048	19	0.215	23	0.87	4		

Table 4. Percentage share of litter collected in Igalo beach

Material	Weight %
APM (plastic) weight	29.33
Rubber weight	0.28
Wood weight	17.03
Glass ceramics weight	7.95
Metal weight	5.87
Paper cardboard weight	1.07
Cloth textile weight	27.98
Other litter weight	10.6

Table 6. Percentage share of litter collected on Kamenovo beach

Material	Weight %
APM (plastic) weight	23.99
Rubber weight	2.22
Wood weight	24.86
Glass ceramics weight	24.92
Metal weight	15.03
Paper cardboard weight	1.38
Cloth textile weight	7.47
Other litter weight	0.14

Table 5. Presence of different types of litter on Kamenovo beach

Seasons	AMP(plastic)		Rubber		Cloth textile		Paper cardboard	
	weight (kg)	count	weight (kg)	count	weight (kg)	count	weight (kg)	count
Autumn	1.38	424	0.23	7	0.51	31	0.18	50
Winter	2.81	168	0.51	11	1.23	25	0.005	3
Spring	2.71	147	0.04	6	0.92	14	0.035	8
Summer	1.64	840	0.01	2			0.27	46
Seasons	Wood		Metal		Glass. ceramics		Other litter	
	weight (kg)	count	weight (kg)	count	weight (kg)	count	weight (kg)	count
Autumn	1.52	16	2.67	42	1.02	27	0.04	4
Winter	6.7	17	1.64	54	6.07	36		
Spring	0.57	6	0.69	32	0.5	15	0.01	2
Summer	0.06	22	0.35	35	1.28	7		

DISCUSSION

Results of this study showed prevalence of plastics items as the major components of the litter recorded, with high percentage (>75%) compared to total litter found. The results are highly in accordance with previous investigations which showed that on European beaches plastics represent around 75 % of all debris followed by metal and glass (STAP-GEF, 2012). The relatively high proportion of

plastic in comparison to other materials is consistent at other locations (Gregory & Ryan, 1997; Derraik, 2002; Morishige *et al.*, 2007; UNEP, 2009). This trend holds true for seabeds where items of plastic debris recovered by fishermen have been found to be more abundant (> 58 %) than those of metal (21 %) (KIMO, 2008). The main reason for this is fact that the plastic is used in almost all human activities (professional and recreational), together with its long persistence in the marine environment, its contributes litter's durability and easy distribution through the marine environment (Derraik, 2002).

Table 7. Value of t calculated for each season and type of material

Material	t -value	
	Weight	Count
AMP (plastic)	0.004493*	0.066506*
Rubber	0.092847*	0.028834*
Cloth textile	0.239617*	0.064763*
Paper		
cardboard	0.086362*	0.165921*
Wood	0.198722*	0.03555*
Metal	0.060962*	0.012497*
Glass ceramics	0.125081*	0.04839*
Other litter	0.194758*	0.176694*

* not statistically significant for $p = 0.05$

According to the results for all four investigated seasons we can conclude that the plastic was most abundant in summer (July). During survey the most abundant pieces were plastic bags, plastic bottles, cups, food packing, etc. The amount of the plastic items found during the monitoring activities showing that beach users had biggest part in the pollution of the beaches. Looking at the percentage share of plastic litter in peak of touristic season - in July, it was 84% for Igalo beach and 88% for Kamenovo beach what leads to the conclusion that the behaviour of local people and tourists are one of the main sources of beach pollution.

In some locations, the impact of marine debris on the tourism industry is largely esthetic, relating to the attractiveness of the coastline and beaches with clean ups needed in order to continue to attract tourists to the area (STAP-GEF, 2012). There are few studies of monitoring beach litter on Adriatic beaches so we can compare results with them (Kwokal & Štefanović, 2010; Laglbauer *et al.*, 2014; Munari *et al.*, 2016). On Slovenian coast it was noticed huge amount of plastic litter on beaches with participation of 64 % (Laglbauer

et al., 2014). It was also pointed out that litter in Slovenian beaches is closely linked to the tourism sector and play a major role in choosing the beach by tourists. According to them the touristic season increases the amount of litter on beaches, so in the peak of the touristic season the most commonly litter were cigarette butts (Laglbauer *et al.*, 2014). In other study, researches gave results that participation of plastic litter was 81.1% so it confirms that the plastic waste is the most represented type of litter (Munari *et al.*, 2016). Also the cigarettes butts were most abundant type of litter (Munari *et al.*, 2016).

Larger amount of waste that was recorded on investigated beaches in July could be linked to tourism as a consequence of the increased number of beach users. According to the analysis of data collected between 2002 and 2006 52% of marine litter in the Mediterranean originates from shoreline and recreational activities, 40% from smoking related activities, 5% from boat activities, 2% from dumping activities, and 1% from medical and personal hygiene (PNUE/PAM/MEDPOL, 2009). If the beaches are near the mouths of rivers, harbors, and sometimes depending of direction of sea currents also can lead to accumulation of garbage on the coast (Kwokal & Štefanović, 2010). Igalo beach, because of its inner position, can have some of these problems because the water in Boka Kotorska bay circulate slowly so accumulation of litter is higher. According to this, larger amount of litter can appear in the months when the summer touristic season ends. Thus, our results showed that in January higher amount of litter appears as consequence of its position near the promenade or litter can be deposited by currents.

Statistical data analysis (Table 7) has shown that there is no significant difference in the weight and number of different types of

marine litter items at two sites that were examined. Even though they are in positions that are under different influence of the open sea and sea currents, winds and other factors that affecting distribution of marine litter. It is therefore necessary to repeat the research and strengthen its dynamics in order to obtain more detailed data and to provide a more statistically relevant datasets.

On the shores of south-east Adriatic, one study was conducted in which authors outlined similar factors that affect the purity of the coastline and beaches (Kwokal & Štefanović, 2010). Actually it is about Mljet island bays that due to the currents that are dominant in this region affect the accumulation of litter in most coves of the area (Kwokal & Štefanović, 2010). Same authors points out to accumulation of garbage by ocean currents, which in most cases are coming from neighboring countries and only a small percentage from the domestic waste. Results of this study are also in good accordance with the results of Laglbauer *et al.*, (2014), that showed an increased amount of litter, in this case plastic, on the beaches that are located close to the rivers and harbors.

CONCLUSION

This study is the first one on the Montenegrin coast which provides information about the type and quantity of litter on two beaches, one in the open part of the coast and the other in the area of Boka Kotorska Bay. Results indicate that the largest amount of litter belongs to the plastic, with > 75 % of share, regardless of the position of the beach. Higher amount of litter that was recorded during summer is most probably associated with tourism, while phenomenon of increasing of the litter amount in October and January at the Kamenovo beach and in January at Igalo

beach is probably the consequence of influence of surrounding rivers or harbors, as well as the position of the beach, the direction of the winds, sea currents or a storm, as well as the result of a rare cleaning and maintenance of beaches off the summer tourist season.

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Sastav i količina otpada na plažama u Crnoj Gori (južni Jadran)

Ines PERAŠ¹, Milica DIVANOVIĆ², Ana PEŠIĆ¹, Aleksandar JOKSIMOVIĆ¹, Olivera MARKOVIĆ¹, Mirko ĐUROVIĆ¹ and Milica MANDIĆ^{1*}

SAŽETAK

Ovaj rad predstavlja rezultate prvog istraživanja otpada na plažama u Crnoj Gori. Sakupljanje je obavljeno na dvije plaže tokom četiri sezone: jesen (oktobar) 2014, zima (januar), proljeće (april) i ljeto (jul) 2015.g. Jedna od njih, plaža Igalo se nalazi u oblasti Bokokotorskog zaliva dok se druga, plaža Kamenovo nalazi na otvorenom dijelu obale Crne Gore. Metodologija koja se koristila tokom sakupljanja podataka je bila razvijena tokom IPA projekta za Jadran DeFishGear. Ukupno je tokom svih sezona sakupljeno 2 992 komada otpada, ukupne težine 51.47 kg. Sumirajući rezultate na dvije plaže. tokom četiri sezone zaključujemo da je plastika bila dominantni tip otpada na plaži Kamenovo 75.3% i na plaži Igalo 77%, a nakon toga dolaze odjeća, metalni i drveni predmeti. Podaci ukazuju na relativno veliku količinu otpada i dalja istraživanja treba usmjeriti na širu oblast.

Ključne riječi: otpad u moru, plastika, zagađenje, turizam, Jadransko more