POLLUTION OF THE SLOVENIAN COAST WITH SOLID WASTES

ONESNAŽEVANJE SLOVENSKE OBALE S TRDIMI ODPADKI

Andreja PALATINUS

Key words: coast, solid wastes, plastic, Slovenia, pollution
Ključne besede: obala, trdi odpadki, plastika, Slovenija, onesnaževanje

ABSTRACT

Evaluation of quantity, quality and sources of solid wastes at three different localities on the Slovenian coast was carried out between May and September 2007. On 1,350 m of the coast, 16,414 pieces of litter were collected. Most common were plastic wastes and cigarette butts.

IZVLEČEK

Med majem in septembrom 2007 smo na treh lokacijah na slovenski obali ocenjevali količino, tipe in vire trdih odpadkov. Na 1350 metrih vzdolž morja smo našli 16.414 odpadkov. Najpogostejši med njimi so bili plastični izdelki in cigaretni ogorki.

1. INTRODUCTION

The term marine debris defines any manufactured or processed solid waste material that enters the marine environment from any source (Coe et Rogers 1997). This pollution is caused by humans and is scattered all over the marine environment.

For centuries, the ocean was viewed as a boundless reservoir with unlimited capacity to assimilate wastes. Now everyday wastes constitute a marine pollution problem of global proportions, clearly showing that man has the capacity to affect the ocean.

Slovenia is a European country with 46.7 kilometres long shore in the Mediterranean Sea. Port industry, intensive tourism and the biggest net migration in the country (Primorska region) present a great threat to marine life by being exposed to various marine debris.

The only scientific study of pollution of the Slovenian coast with marine debris so far was conducted in 2007. Here I describe its methods and results.

2. METHODS

According to Dixon et Dixon (1981), three different approaches are being used to investigate the composition, quantity and distribution of debris in marine environment. These include quantification of solid wastes generated aboard ships and pleasure craft, observation on or collections of surface floating litter at sea and beach survey.

Our investigation was implemented by beach survey for the following reasons:

- shoreline can be surveyed more easily and accurately than water masses,
- litter tends to accumulate on beaches, therefore statistically viable samples can be collected at any given time.

In 2005, the Ministry of the Environment in Israel launched a long-term program entitled "Clean Coast" (Alkalay et al. 2007). The cause was an unsuccessful way of cleaning Israeli beaches as practiced prior to 2005. Clean Coast Index (CCI) measures the actual cleanliness of the beach in an objective and easy way precluding bias by the assessor (Alkalay et al. 2007). Considering that plastics constitute, by far, the majority of litter on the beaches (also in Israel – 90% of all debris items), only plastic particles larger than 2 cm in size to calculate CCI were conducted in Israel.

On the Slovenian coast, the CCI method was adapted to get information regarding the level of cleanliness on some unauthorized beaches in Slovenia. One unit of our conduct had the same surface – 150 m^2, like the ones in Israel. We collected all anthropogenic debris larger than 2 cm, not just plastic, and used plastic to calculate the index.

Calculation of CCI:

$$\frac{Z}{n \times \text{segment length} \times \text{coast width}} = \text{No. of plastic debris} / m^2 \qquad (1)$$

Z – No. of plastic debris in transect in total
n – No. of segments in one transect (n=3)
segment length [m] = 50 m

Three beaches in Slovenia (Debeli rtič, Mesečev zaliv, Fiesa-Piran) were morphologically defined as three locations, each characterized by same coastal conditions (sandy/gravelled, narrow/wide, open/bordered by cliffs, etc.) (Figure 1). They were sampled on five different occasions in May, June, July, August and September 2007.

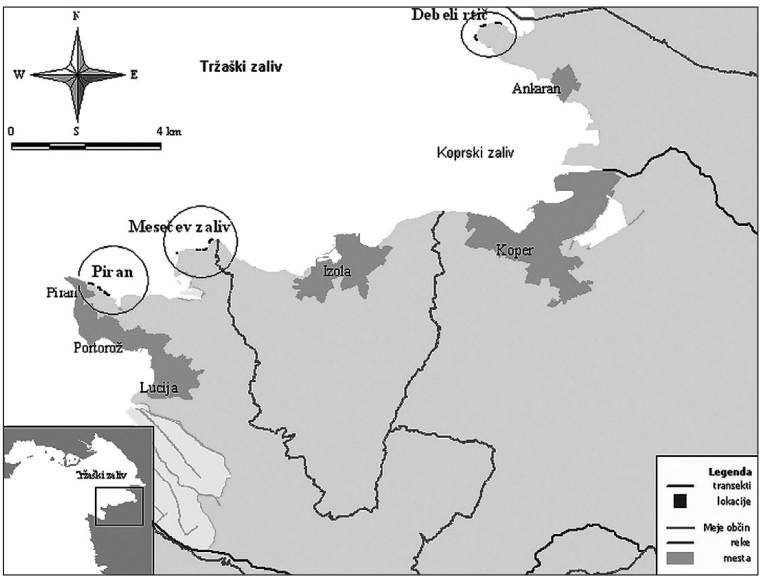

Figure 1: Map of the Slovenian coast with studied areas (circled)
Slika 1: Zemljevid slovenske obale s preučevanimi (obkroženimi) območji

Each location was divided into three transects regularly distributed on each location (from east to west) from 0.5 m below and above water's edge at the high tide line, to the border of the coast, represented by any obstacle – cliff, vegetation, path, fence. Each transect was further divided into three segments (each 50 m long) with two parallel spaces (one from the 0.5 m line above the line of the high tide to the first natural obstacle toward the land, other 0.5 m below and above the line of the high tide).

The exact measurement location point was defined with GPS system. The average area of each segment was 150 m^2 (Figure 2).

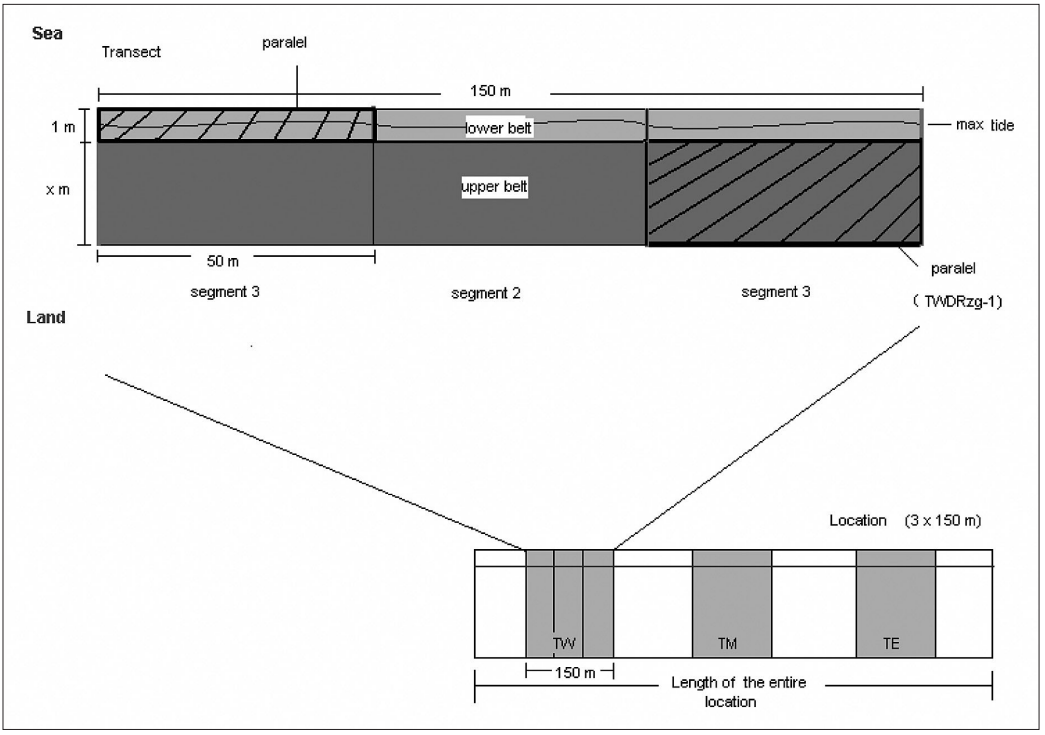

Figure 2: Presentation of transects, segments, belts and parallels
Slika 2: Predstavitev transektov, segmentov in paralel

All anthropogenic debris was collected along transects extending parallel to the water line. Each parallel was collected into its own, pre-marked bag. We collected debris forth and back (Figure 3) with the help of 4 employees of national service for protection of coastal seas (Javna vodnogospodarska služba za varstvo obalnega morja - SVOM).

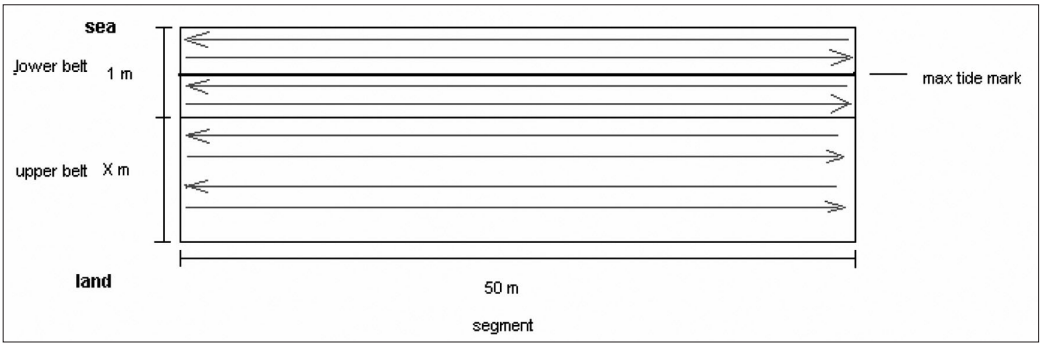

Figure 3: Collecting debris forth and back
Slika 3: Zbiranje odpadkov sem in tja

The locations of Piran and Mesečev zaliv do undergo regular cleaning by local authority, all locations are cleaned regularly (once a month) by SVOM. In April 2007, SVOM conducted initial beach cleanup at each survey site to clean the beach of all debris that had accumulated over an unknown period of time.

The collected debris was laboratory analyzed. We cleaned, dried, and divided them into categories regarding material (plastic, glass, metal, paper, Styrofoam, toxic wastes[1], fabric, composites). We counted and weighed every category separately for every parallel (Figure 2). In the end we discarded the debris.

3. RESULTS

A total of 16,414 solid waste items of different material weighing 76,079 g were recovered from the 1,350 m of sampled beaches. The most abundant were cigarette butts (2,823 pieces). In terms of numbers of items per m^2, plastic debris predominated with 64% (Table 1).

Table 1: Number and relative abundance of debris
Tabela 1: Število in relativna gostota odpadkov

Material	**Abundance**	
	No. of pieces	%
Plastic	10,552	64
Cigarette buts	2,823	17
Glass	1,513	9
Metal	524	3
Composites	435	3
Paper	336	2
Fabric	182	1
Toxic wastes	49	<1
Total	**16,414**	**100**

[1] Toxic wastes include toxic wastes according to the national legislation Pravilnik o ravnanju z odpadki, Ur.l. RS 84/98

The most polluted location was Piran (Figure 4), owing primarily to the discarded cotton buds that were very abundant on this location (altogether 1,742 pieces).

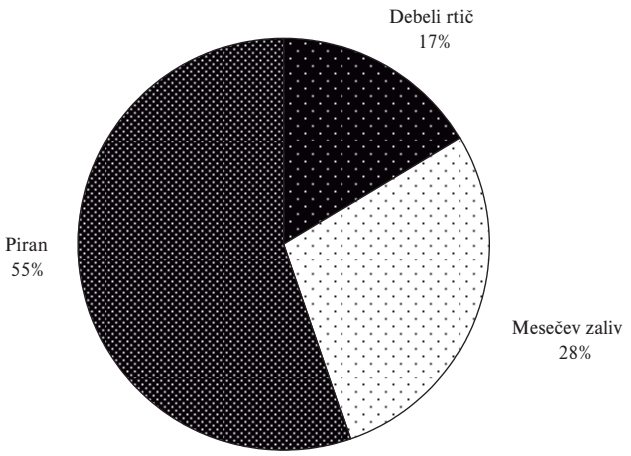

Figure 4: Abundance of marine debris on various locations
Slika 4: Gostota naplavljenih odpadkov na različnih lokacijah

The most polluted month was May (Figure 5). We concluded that this must be the consequence of inefficient initial beaches clean up carried out in April.

43% of all debris originate from land-based sources according to our research (Table 2).

Table 2: Abundance of marine debris
Tabela 2: Gostota naplavljenih odpadkov

	Number of all debris collected	**Partial Sum**	**%**	**Partial %**
Marine sources				
Styrofoam	2,225		13.5	
Shellfish farming nets	632		4	
Polyurethane foam	308		2	
Big plastic bags	237		1	
Ropes	54		<1	
Cloths	26		<1	
Plastic containers-cleaning	11		<1	
Gloves	6		<1	
Light bulbs	4		<1	
Containers for oil, gas	3		<1	
Personal hygiene	2		<1	
Fishing nets	2		<1	
Buckets	2		<1	
Carpets	1		<1	
Sum		3,513		21

	Number of all debris collected	Partial Sum	%	Partial %
Land sources				
Cigarette butts	2,823		17	
Cotton buds	1,742		11	
Glass	1,513		9	
Food and drink containers	855		5	
Cigarette boxes	73		<1	
Beach requisites	46		<1	
Balloons	35		<1	
Syringes	10		<1	
Remainder	4		<1	
Condoms	1		<1	
Sum		7,102		43
Undefined				
Bags	2,489		15	
Plastic	2,184		13	
Containers	1,005		6	
Undefined	121		<1	
Sum		5,799		35
Total sum		**16,414**		**≈100**

The index was calculated from the formula (1) for every transect (Table 3). In comparison with the Israeli results, Slovenia has much higher index values. While in Israel the values hardly exceed the figure 5, one of the indexes in Slovenia reached even the value of 143.8!

Table 3: CCI values for transects (with lowest and highest values in bold)
Tabela 3: Vrednosti CCI za posamezne transekte

Transect \month	May	June	July	August	September
TEDR	10.95	14.29	-	8.49	8.64
MDR	6.76	10.53	-	5.67	3.89
TWDR	10.35	4.71	-	2.93	1.7
TEMZ	18.13	-	4.77	-	5.76
TMMZ	38.27	8.85	29.51	-	33.92
TWMZ	20.47	6.02	3.2	-	12.3
TEPI	**143.8**	24.72	20.19	30.21	22.61
TMPI	16.58	5.19	3.67	8.56	11.51
TWPI	-	4.32	3.62	6.22	35.53

4. DISCUSSION

According to the statistical analysis, there are differences in debris abundance between locations and transects but not months. This indicates that such analysis should also be

made during winter months to assess possible differences between tourist and non-tourist seasons.

According to our positioning of locations, the most isolated among them, Debeli rtič, is least polluted. Piran and Mesečev zaliv locations are not statistically different in number of debris collected; although Piran was the most polluted site. The biggest reason for its pollution was high number of plastic buts (length 7 cm) found on beach, originating from households. Currents could bring the plastic buts to this beach, and they indeed caused high pollution rate for this beach.

High percentage of plastic debris (64%) collected on all locations is comparable with results obtained by scientists all over the world: Gabrielides (1991) (46-71%), Claereboudt (2004) (61%), Golik et Gertner (1992) (70,9%), Alkalay et al. (2007) (90%).

The most abundant items in numbers were cigarette filters (17% of all debris). Similar problem is encountered all over the world. U.S. Commission on Ocean Policy reported that litter associated with cigarette smoking was the second largest source of marine debris in the world (Reducing Marine Debris 2004).

Through Index (1) calculation, we compared the cleanliness of our beaches with the cleanliness of beaches in Israel in 2005. Our index results show that the Slovenian coast is more polluted with marine debris than the Israeli coast. According to Index, 49% of all our results fall into the categories “dirty” and “extremely dirty”. The Index values are between 0 and 20, with values above 20 indicating extreme pollution.

According to the Index values, the Slovenian coast is jammed with plastic debris at some localities and we believe that owing to some extremely high results (Piran, May: 143.8), the Index calculation should be revised and adapted even further to Slovenian conditions.

The source of coastal litter is perhaps the most important issue of the litter problem as it has a direct bearing on the strategy, which should be employed to control it (Gabrielides 1991). We have established that the majority of debris were directly related to various beach activities. Cigarette filters, plastic bags, plastic and metal food and drink containers, cigarette boxes and picnic debris represented 45% percent of all debris collected, probably most of them coming from beach activities.

Some action should be taken to inform the public about this problem and cleaning should be more thorough and backed up with supported and organized volunteer actions.

5. SUMMARY

Our findings have confirmed that the problem of marine debris in Slovenia certainly exists and that despite the effort to regularly clean the beaches the latter remain heavily polluted with marine debris. *Most* of the *debris* is comprised of *plastic* materials – the problem underlined by other researchers around the globe as well.

Some action should be taken to inform the public about this problem, and cleaning should be more thorough and backed up with supported and organized volunteer actions. Special problems are cigarette butts, cotton buds and plastic bags.

The CCI index was considered an appropriate form to compare the pollution on the Israeli and Slovenian coasts. We still believe that the Index calculation should be revised in order to establish why our results are so much higher than in Israel.

We suggest that the future monitoring is longer and conducted during the winter as well. This would support the evidence of land-based sources of debris in the summer season from tourism. Taking action should be concentrated on the main and easily reachable source.

6. POVZETEK

Naši izsledki kažejo, da problem z naplavljenimi odpadki v Sloveniji vsekakor obstaja, vendar pa kljub naporom, da se plaže redno čistijo, naše obrežje še vedno ostaja močno onesnaženo z naplavljenimi odpadki vseh vrst. *Večina naplavin sestoji iz plastičnih izdelkov – problem, s katerim se ubadajo tudi drugod po svetu.*

V tem pogledu bi bila potrebna akcija za ozaveščanje javnosti, hkrati pa bi morali poskrbeti, da je čiščenje temeljitejše in podprto s prostovoljnimi akcijami. Poseben problem so cigaretni ogorki, vatirane paličice in plastične vrečke.

Indeks CCI se je zdel pravšnji za primerjavo onesnaženosti izraelske in slovenske obale, vendar še vedno menimo, da bi bilo indeks treba revidirati, če želimo ugotoviti, zakaj so naši rezultati neprimerno višji kot v Izraelu.

Predlagamo, da je monitoring v prihodnosti daljši in da se opravlja tudi v zimskih mesecih. S tem bi dokazali, da so s kopnega izvirajoči naplavljeni odpadki v poletni sezoni posledica turizma.

7. LITERATURE

1. Alkalay, R., G. Pasternak, A. Zask (2007): Clean Coast Index - a new approach for evaluation of the actual coast cleanliness. Ocean & Coastal Management 50(5-6): 352-362
2. Coe, J.M., D.B. Rogers (1997): Marine Debris: Sources, Impacts and Solutions. New York, Springers. New York. 432 pp.
3. Claereboudt, M.R. (2004): Shore litter along sandy beaches of the Gulf of Oman. Marine Pollution Bulletin 49: 770-777
4. Dixon, T.R., T.J. Dixon (1981) : Marine Litter Surveillance. Marine Pollution Bulletin 12: 289-295
5. Gabrielides G.P., A. Golik, L. Loizides, M.G. Marino, F. Bingel, M.V. Torregrossa (1991): Man-made Garbage Pollution on the Mediterranean Coastline. Marine Pollution Bulletin 23: 437-441
6. Golik, A., Y. Gertner (1990): Solid waste on the Israeli coast: composition, sources, and management. In: Shomura R.S., Godfrey M.L. (eds.): Proceedings of the Second International Conference on Marine Debris 1989. U.S. Department of Commerce. Washington D.C.: 369-378
7. Reducing Marine Debris. 2004. In: An Ocean Blueprint for the 21st Century. Final Report. U.S. Commission on Ocean Policy. Washington D.C.: 264 – 271 http://www.oceancommission.gov/documents/full_color_rpt/18_chapter18.pdf (3. mar. 2009)

Andreja PALATINUS
Ecological Non-governmental Environmental Organisation Eco Vitae
http://www.ecovitae.org
Pot v dolino 3c
SI-1261 Ljubljana-Dobrunje, Slovenia
andreja.palatinus@gmail.com