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Note

Ideal width of transects for monitoring source-related categories of plastics on beaches

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Abstract

Although there is a consensus on the necessity of monitoring solid wastes pollution on beaches, the methods applied vary widely. Therefore, creating, testing and recommending a method that not only allows comparisons of places and periods, but also the detection of source signals, will be important to reach the objectives of the source-prevention principle. This will also allow the optimisation of time, resources, and processing of samples and data. A classification of the items found into specific categories was made according to their most probable source/use (fisheries, food packaging, hazardous, sewage/personal hygiene, beach user, general home). This study tested different widths of sampling transects to be used in the detection of plastics contamination on beaches, until all the categories were significantly represented. Each transect had its total width (50 m) sub-divided into eight intervals of 0–2.5 m; 2.5–5 m; 5–10 m; 10–15 m; 15–20 m; 20–30 m; 30–40 m; and 40–50 m. The accumulated number of categories in the 50 m (up to 2.5 m; up to 5 m and so on) was used to determine the minimal width necessary to qualitatively characterize the area regarding plastics contamination. The diversity of the categories was directly related to the area of the sampling transect. These results indicate that a significant increase in the number of categories in the first intervals tend to stabilize from 15–20 m onwards.

Keywords: Solid wastes; Beach contamination; Plastics on beaches; Sampling methods; Transects; Source-related categories

Plastics, rubber, polystyrene and nylon constitute the largest fraction of marine debris (Araújo and Costa, 2006, 2005, 2004; Silva-Iñiguez and Fischer, 2003; Derraik, 2002; Debrot et al., 1999; Thornton and Jackson, 1998; Garrity and Levings, 1993; Laws, 1993; Ross et al., 1991). These are one of the five main concerns to be tackled in marine pollution at global level (Gregory, 1999). Plastics have easy dispersion (low density), slow accumulation, persistency, increasing supply with time and broad dissemination (Derraik, 2002; Gregory, 1999; Dixon and Dixon, 1981).

Lists of solid wastes on beaches have limitations, and focus on the litter only from the raw material point of view, and do not consider their most probable source (Earll et al., 1997). Although there is a consensus on the necessity of monitoring solid wastes pollution in the aquatic environments, the methods applied in qualitative and quantitative studies vary widely. Probably, this is due to beaches themselves being variable in use and nature.

Most assessment methods of beach contamination by solid wastes (Velander and Mocogni, 1999; Earll et al., 1997; Ribic and Ganio, 1996; Rees and Pond, 1995; Dixon and Dixon, 1981), do not worry about the transference of the method or standardization of measures to allow comparisons of experimental and managerial results. A method that not only allows comparisons of places and periods, but also the detection of source signals, will be important to reach the objectives of the source-prevention principle. This will also allow the optimisation of time, resources, and processing of samples and data.

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This study aimed to test different widths of the sampling transects to be used in the detection of plastics contamination on beaches, through the classification of the items found into specific categories, according to their most probable source/use.

Tamandaré beach has 9 km (Fig. 1), and is an important ecological and tourist area 100 km south from Recife, Pernambuco State Capital. The littoral is part of two marine conservation units, which include areas of the Atlantic Rain Forest, mangroves, estuaries, coastal reefs and continental shelf. The two main sources of solid wastes are beach users and the nearby rivers (Araújo and Costa, 2006, 2005, 2004). From September to March, tourists and holiday makers increase the population to 76,500 inhabitants (4.5 fold), increasing the amount of solid wastes and sewage produced. The solid wastes collected in the region are deposited in unplanned open-air landfills causing social, sanitary and environmental problems. Tamandaré receives river runoff at its north and south limits. Una River drains 32 urban centres and represents a permanent source of coastal pollution, degradation of the biological resources and threat to tourist activities (Fig. 1). Varzea do Una beach, at the mouth of Una River was also studied (Fig. 1). This second sampling area is inhabited by fishermen, and not used by tourists.

Four sampling transects (A, B, C and D) were delimited at Tamandaré beach (Fig. 1) based on the different morphodynamical characteristics of the beach, frequency and density of its use, presence of vegetation and level of urban occupation. Transects A and B are little frequented, and dunes are well preserved. Transects C and D are intensely visited during high season. Transect D has the dunes completely taken by urban occupation. At Várzea do Una beach only one transect (E) was delimited.

Each transect was 50 m wide, and run from the frontal dune to the water line at low tide. The beach is then approximately 50 m long and the total area of each transect was approximately 2500 m^2. Sampling took place in 2001 and 2002, during 10 months at Tamandaré beach and six months at Várzea do Una beach.

The marine debris in the area are predominantly plastics (>80%) (Araújo and Costa, 2006, 2005, 2004). In the present work it was decided to work with this fraction only, classified and grouped into categories according their most probable source: fisheries, food packaging and disposable utensils, hazardous, sewage and personal hygiene, beach user, general home.

Each transect had its total width (50 m) sub-divided into eight intervals (0–2.5 m; 2.5–5 m; 5–10 m; 10–15 m; 15–20 m; 20–30 m; 30–40 m; 40–50 m). The amount of categories present in each interval was recorded. The accumulated number of categories was used to determine the minimal width of a transect necessary to qualitatively characterize the area regarding plastics contamination (Earll et al., 1997).

To determine if the presence of the selected categories was dependent on transect width, and evaluate from which point onwards there was a stabilization of the number of

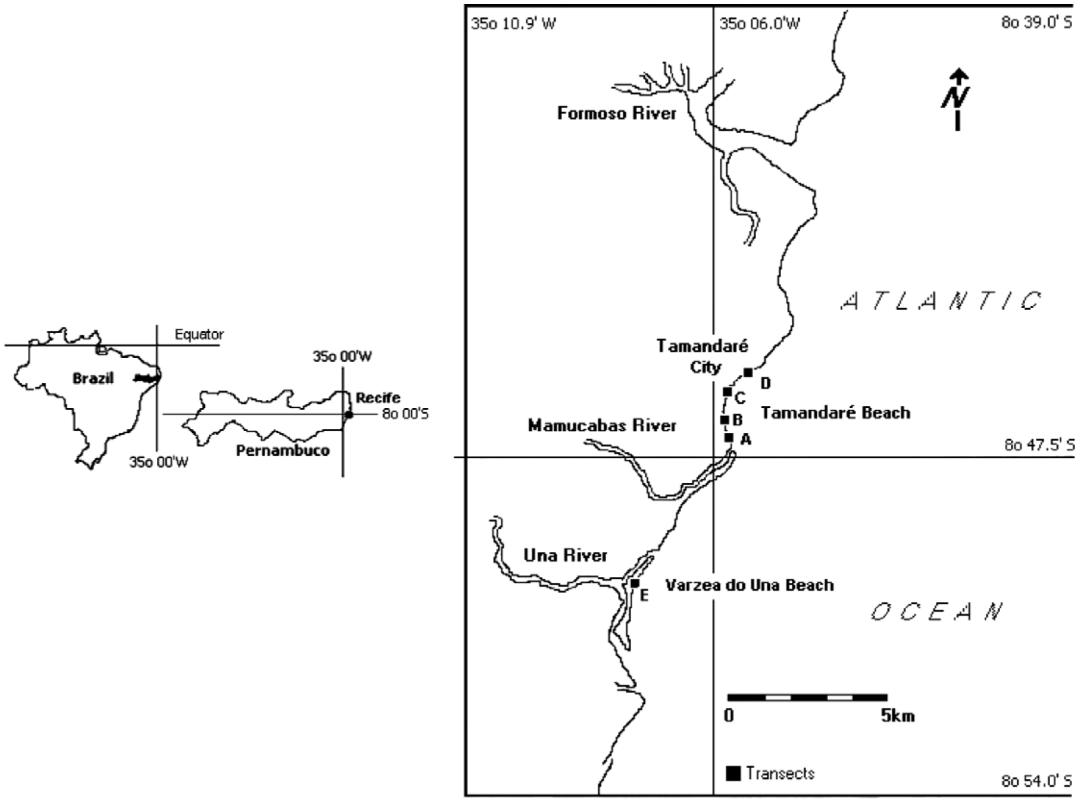

Fig. 1. Map of the area showing location of the sampling transects (A, B, C, D and E).

Table 1
Accumulated density of the 7 categories in different widths, for each transect

Transects	Intervals (m)							
	Up to 2.5 m	Up to 5 m	Up to 10 m	Up to 15 m	Up to 20 m	Up to 30 m	Up to 40 m	Up to 50 m
	125 m^2	250 m^2	500 m^2	750 m^2	1000 m^2	1500 m^2	2000 m^2	2500 m^2
A	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
B	0.2	0.3	0.3	0.4	0.4	0.4	0.4	0.4
C	0.5	0.6	0.5	0.6	0.6	0.6	0.6	0.6
D	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2
E	1.7	2.2	2.1	2.0	2.1	2.1	2.1	2.1

categories, a statistical treatment of the data was made. The analysis of the spatial variation (among transects and intervals of each transect) of the incidence of each category was made through the Friedman's test, and an *a posteriori* Tukey's test to determine homogeneous groups. The significance level used was 0.01 for both tests. The diversity index $H'_{(\log 2)}$ (Shannon) was also calculated to independently assess the qualitative and quantitative spatial distribution of the plastic items on the beach.

Transects used previously normally had 5 m width (Wetzel et al., 2004; Williams and Simmons, 1999; Thornton and Jackson, 1998; Williams and Nelson, 1997; Gabrielides et al., 1991; Pianowski, 1997). This choice was based on general ecology principles and adapted for marine debris, without discussion of how to meet the work objectives and sampling representativity (Earll et al., 1997). Most of the solid wastes work is limited to quantitative and/or qualitative aspects, looking only at composition (plastic, glass, metal, paper and wood). In this case, the sampling area probably does not influence the results.

Our results show that the ideal width of sampling transects to be used for plastics qualitative assessment on beaches was 20 m. It is important to determine the ideal width of the sampling transects before systematic monitoring starts, for the identification of the main sources of solid wastes and the adoption of adequate managerial actions.

The accumulated density (items/m^2) of plastics (Table 1), remained constant for each transect, independent of the area. If the objective of the present work was only the quantification of the debris on the beach, transects of 5 m width would produce good results. The same was not true regarding the number of categories.

Qualitative analysis showed that some categories, as food packaging and fisheries, are the most frequent in almost all intervals of most transects at Tamandaré. At Várzea do Una, the most frequent categories were food packaging, sewage and personal hygiene items and house cleaning, the two last related to river runoff. Food packaging in all intervals in both areas is due to this category, which originates from multiple sources (river runoff, beach users and ships). Dangerous rare items such as hospital wastes were detected only with the increase of the sampling area.

In all months there were solid wastes in the first 2.5 m of all transects. As predicted, an increase of transect width increased the number of categories, with a direct relation to transect width (Fig. 2A).

In our case, 5 m width was insufficient to safely identify the source of the debris. In three transects on Tamandaré (A, C and D), the percentage of the categories found in 5 m was less than 1/2 of transect E (Table 2).

Debris accumulation level was much higher on Várzea do Una beach, which is related to the distance from the main polluting source, Una River. As transect width increases, this difference starts to disappear, and the values become less dependent of the particular beach characteristics (Fig. 2A). A significant increase in the number of categories in the first intervals stabilized from 15–20 m onwards. The Friedman's test indicated significant differences among the various widths tested for all transects ($p << 0.01$) and for the number of categories.

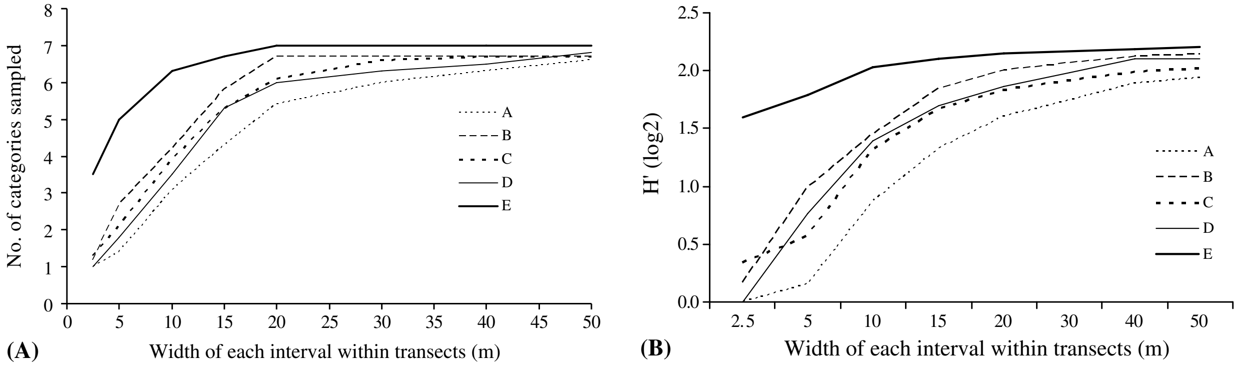

Fig. 2. (A) Mean of the accumulated number of the categories observed for each transect on Tamandaré (A, B, C and D) and Várzea do Una beaches (E). (B) Variation of the diversity index (Shannon) for each transect on Tamandaré (A, B, C and D) and Várzea do Una beaches (E).

Table 2
Mean of the accumulated percentage for the categories, presents in the intervals up to the width of 50 m in each sampling transect

Transect	Mean accumulated percentage for the categories presents in each interval							
	Up to 2.5 m	Up to 5 m	Up to 10 m	Up to 15 m	Up to 20 m	Up to 30 m	Up to 40 m	Up to 50 m
A	14.2	20.0	44.2	61.4	77.1	85.7	90.0	94.2
B	17.1	38.5	60.0	82.8	95.7	95.7	95.7	95.7
C	18.5	30.0	55.7	75.7	87.1	94.2	95.7	95.7
D	14.2	25.7	50.0	75.7	85.7	90.0	92.8	97.1
E	50.0	71.4	90.0	95.7	100.0	100.0	100.0	100.0

Table 3
(A) Homogeneous groups resulting from the Tukey's test - X. (B) Homogeneous groups resulting from diversity index analysis (Shannon) - O

	Transects																		
	A				B				C			D				E			
Up to 2.5	XO				XO				XO			XO				XO			
Up to 5	XO					XO			XO			X	XO				XO		
Up to 10		XO					XO			XO			X	XO				XO	
Up to 15		XO	XO					XO		O	XO			XO	XO			XO	O
Up to 20			XO	XO				XO			XO			O	XO			XO	O
Up to 30			O	XO				XO			XO				XO			XO	O
Up to 40				XO				XO			XO				XO			XO	O
Up to 50				XO				XO			XO				XO			X	O

The *a posteriori* Tukey's test detected differences among the intervals, allowing the identification of homogeneous groups -X- for each sampling transect (Table 3). In transect B, 15 m would bring the same information as that from larger widths, reducing the sampling effort to 70%. However, this varied slightly among the transects of the same area and a "safety margin" is needed to efficiently detect the maximum possible number of categories, regardless the density of items.

When using the diversity index analysis (Shannon), the homogeneous groups -O- remained almost the same, with very slight differences in transect E (Table 3). This analysis accounts for both quality and quantity of plastic items. For all transects on Tamandaré beach the diversity showed similar results to the qualitative analysis, levelling the diversity from 20 m. It is interesting to note that at the most contaminated site (transect E), even in the smallest space considered (2.5 m), the diversity of plastic items was already highest, confirming the qualitative results (Fig. 2B).

There does not seem to be a relationship between density of plastic items and transect width. To evaluate only density of plastics, transects with 5 m width would be adequate. This does not take into consideration the most probable source of contamination. Qualitative and quantitative, source-related, analysis will always be necessary for solving the problem of coastal contamination by plastics.

Homogeneous groups derived from the Tukey's test appear after at least 75% of the source-related categories are accumulated. For our study a minimum transect width of 20 m was necessary to qualitatively characterize the plastic items and allow suggestions for source control. It yielded over 75% of the possible source-related categories representativity. The method allows an efficient and economically viable identification of the source of the plastic items, and clearly points out the most significant sources.

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