Integrating geotechnology and marine litter on beaches – a citizen science approach.

Integrando geotecnologías en desechos marinos en playas una aproximación desde la ciencia ciudadana.

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ABSTRACT

The objective of this work was to engage students from public schools of São Paulo coast (Brazil) in the study and control of litter on beaches. Two public schools from coastal cities of São Paulo State (Peruíbe and Ubatuba) had students trained to sample and quantify marine litter on beaches. After this training, using Google Earth images, two beaches of each city were chosen to the study. On each beach, samples were taken in the 100 meters of the selected stretch. The residues were classified by type of material and type of item (seeking to associate to sources). After the sampling surveys, the students were oriented to the data analysis. The students prepared a presentation with sampling results, hypotheses to explain the possible origin of the marine litter and measures that could be taken to reduce the problem on the studied beach. For both schools, this workshop revealed great students' involvement during all process, from the fieldwork and data analysis, to the development of hypothesis and solution propositions. The beaches located in Peruíbe were more isolated and in one of them most of the waste was coming from the sea, which carried litter from boats and nearby villages. Meanwhile, the beaches in Ubatuba had greater urbanization and had high occurrence of construction materials, indicating a miss-managed discard of litter by local residents. The main outputs of these workshops were: (1) giving the students an experience of how a scientific project is developed, (2) generating reliable data on marine litter in the school

areas, (3) stimulating discussion about sources and proposing solutions and (4) establishing a cooperation network between the school and the university.

Keywords: marine litter, monitoring, beaches, citizen science.

RESUMEN

El objetivo de este trabajo fue involucrar a estudiantes de escuelas públicas de la costa de São Paulo (Brasil) en el estudio y control de la basura en las playas. Dos escuelas públicas de las ciudades costeras del estado de São Paulo (Peruíbe y Ubatuba) capacitaron a estudiantes para que muestrearan y cuantificaran la basura marina en las playas. Después de este entrenamiento, utilizando imágenes de Google Earth, se eligieron dos playas de cada ciudad para estudiarlas. En cada playa, se tomaron muestras en los 100 metros del tramo seleccionado. Los residuos se clasificaron por tipo de material y tipo de elemento (buscando asociar a las fuentes). Después de las encuestas de muestreo, los estudiantes se orientaron al análisis de datos. Los estudiantes prepararon una presentación con resultados de muestreo, hipótesis para explicar el posible origen de la basura marina y las medidas que podrían tomarse para reducir el problema en la playa estudiada. Para ambas escuelas, este taller reveló una gran participación de los estudiantes durante todo el proceso, desde el trabajo de campo y el análisis de datos hasta el desarrollo de hipótesis y propuestas de soluciones. Las playas de Peruíbe estaban más aisladas y en una de ellas la mayor parte de los desechos provenían del mar, que transportaba basura desde botes y pueblos cercanos. Mientras tanto, las playas de Ubatuba eran urbaner y tenían una gran presencia de materiales de construcción, lo que indicaba que los residentes locales descartaban los desperdicios de la basura. Los principales resultados de estos talleres fueron: (1) dar a los estudiantes una experiencia de cómo se desarrolla un proyecto científico, (2) generar datos confiables sobre la basura marina en las áreas escolares, (3) estimular la discusión sobre fuentes y proponer soluciones y (4) establecer una red de cooperación entre la escuela y la universidad.

Palabras clave: basura marina, monitoreo, playas, ciencia ciudadana

INTRODUCTION

Marine litter is defined as persistent anthropogenic solid waste in marine environment (Coe & Rogers, 1997). Although cases of marine animals entangled by marine litter have been observed since 1930s, the amount of reports increased dramatically in the 80s (Fowler, 1987). Since then, marine litter, the scientific community

has defined especially plastic materials, as a dangerous material to the marine environment, with more impacts been reported to different marine organisms and ecosystems each year. So far, cases of entanglement (Gilardi et al., 2010; Hanni & Pyle, 2000; Page et al., 2004; Phillips et al., 2010; Raum-Suryan, Jemison, & Pitcher, 2009; Stewart, 1987), ingestion (Barreiros & Barcelos, 2001; Colabuono et al., 2009; Davison et al., 2011; Jacobsen et al., 2010; Lazar & Gračan, 2011; Tomas et al,, 2002), and transport of invasion species (Barnes, 2002; Barnes & Fraser, 2003) are well known as potential impacts caused by marine litter. However, other impacts have been investigated, such as the potential vectors of chemicals from the ingested plastic to the marine animals (Thompson et al., 2009).

The increasing concern regarding the marine litter issue, volunteer clean up campaigns occur worldwide once a year to remind people to avoid producing marine litter, i.e. Clean Up Day and International Coastal Clean Up. Although these actions have an important role in increasing the awareness of citizens, they lack in standardized methodology, what makes it difficult to compare the amounts of marine litter in different parts of the world. However, the marine litter surveys are time consuming and expensive to cover large areas, therefore, the surveys conducted exclusively by scientific teams are usually focus in a specific aspect of marine litter, for instance microplastic, and extending less than one year (Hidalgo-Ruz & Thiel, 2015), while the studies involving citizen science approach usually focus in more general aspects of marine litter in intertidal zones and generally extended from less than one year to two years (Hidalgo-Ruz & Thiel, 2015).

Citizen science based studies involve the participation of untrained volunteers to collect data following specific proceeds (Bonney et al., 2014). Regarding the barriers and challenges in the marine litter monitoring in all over the world, the citizen science approach has been indicated as the best option to this type of monitoring (Hidalgo-Ruz & Thiel, 2015; Ribic et al., 2010; Ribic et al., 2012).

In 2009, a guideline to marine litter survey and monitoring was published by UNEP intending to standardize the methodologies all around the world (Cheshire et al., 2009). In Brazil, as well as in all Southern countries, there is a lack of data regarding marine litter. The objective of this study was to implement workshops about marine litter, monitoring importance and possible solutions; by which scholar students were trained to sample and analyze marine litter trough UNEP survey guidelines. Two public schools in coastal cities of São Paulo State (Brazil) were chosen for the activities and students surveyed marine litter in beaches near these schools. This training would have four outputs: (1) to give the students an experience of how a scientific project is developed, (2) to generate reliable data on marine litter in the school areas, (3) to

stimulate discussion about sources and proposing solutions and (4) to establish a cooperation network between the school and the university.

MATERIAL AND METHODS

A four-days' workshop was developed to introduce the students to the concepts and issues of marine litter, the basis of a scientific survey, and train them on the methodological procedures to marine litter survey and monitoring. The workshop included a day of theory, half-day of field trip, the data analyses and a presentation of the results by the students, followed by a discussion on possible solutions based on what was found on the beaches.

Two public schools were partners in this project, one located in Peruíbe, in southern coast of São Paulo (Figure 1A), and the other in Ubatuba, northern coast of São Paulo (Figure 1B). The workshops were conducted in October 2015 and August 2016, respectively. Forty students from each school attended the workshop; their ages ranged from 11 to 16 years old. Both schools had a historic of developing scientific and/or environmental projects with the students.

In both workshops, students were also presented to important aspects that can influence the amount and composition of marine litter on beaches, as the presence of a river mouth, the distance of residences, the presence of a vegetation on the back of the beach and the access by the road or by trails to the beach. The beaches chosen to be surveyed were presented using Google Earth images, and the students had to identify the aspects cited above using the digital platform of satellite images.

In Peruíbe, the beaches selected were Caramborê and Guarauzinho (Figure 1A), one located on a pristine area and the other close to an urban region. The surveys were conducted on October 6th and 7th 2015, respectively. In Ubatuba, the beaches selected to the survey were both located in urban areas, very close to the school (Figure 1B). They were Perequê-Mirim and Enseada and the surveys were conducted on the morning and afternoon of August 9th 2016, respectively.

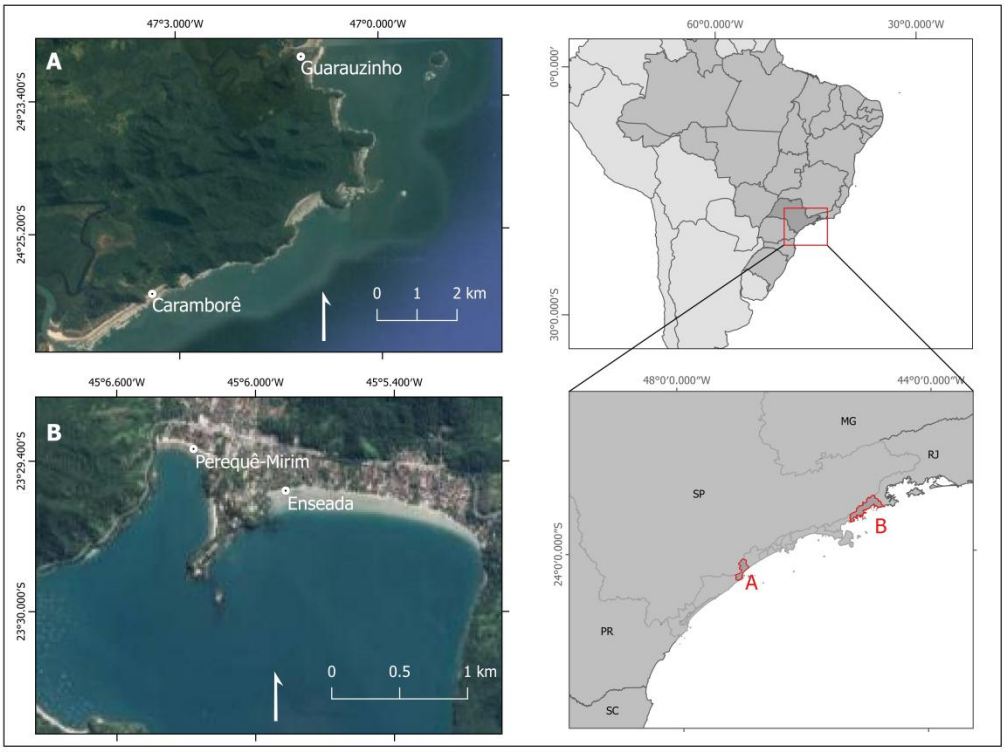

Figure 1. Study area, A and B represent respectively Peruíbe and Ubatuba.

On each beach, a stretch of 500m was defined. Samples were taken in the 100 central meters of the selected stretch (100m along-shore X across-shore length of the intertidal, and vegetated back of the beach zone) and an area of 200m to the right and left of the central area was cleaned and set as a buffer zone. The residues sampled at the central 100m stretches were classified by type of material and type of item, seeking to associate them to the sources; methodology adapted from the UNEP guidelines (Figure 2). The different beach compartments (intertidal zone, backshore zone and vegetated back of the beach zone) were considered separately.

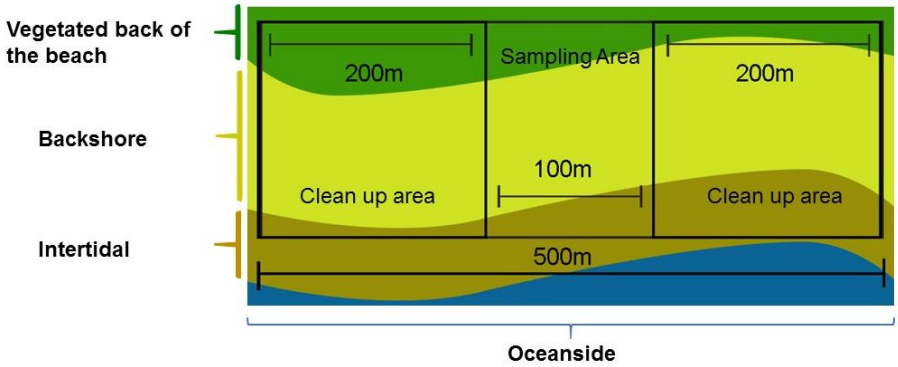

Figure 2.Sampling area and compartments.

Students also measured the beach profiles to verify their slopes, which can influence the deposition of the debris. The beach profiles were measured with two aligned

graduated rods. The intersection of the rods with the horizon allows the determination of differences in level along the profile (Emery, 1961). The central coordinates of each sampling area were acquired using GPS Garmin eTrex Legend in the WGS 84 system.

After the field survey, students were oriented through data analysis. This included the insertion of the GPS coordinates acquired on field on Google Earth platform to indicate the location where students have worked. At the end, each group of students prepared a presentation with the results, hypotheses to explain the origin of the marine litter found and measures that could be taken to reduce the problem on the studied beach.

RESULTS

On the field trips of both workshops the students were divided within subgroups with different functions (collecting, registering, taking GPS location, and making the profile of the beach). Like that, all students were involved in the activities. In the data analysis phase, the students were also divided in subgroups based on different functions (transcribing the register to the computer and producing the graphics to the presentation and discussion). For the presentation, the students (already divided into groups based on the beach they sampled) had the chance to volunteer themselves to present the results. The main results from the marine litter surveys in Ubatuba and Peruibe beaches are described bellow.

In Peruíbe, Guarauzinho beach is in a pristine area, in the mouth of Guaraú river, close to a village. The beach has around 800m of extension and 44m of width. The profile showed a slight slope, with a height of 1.25m in comparison to the sea level. Guarauzinho has a vegetated back. However, due to the low slope and the high tides, on the day of the fieldwork, the beach had not a defined backshore. Total items collected in both compartments (vegetated and intertidal zone) was 959, with the major amounts corresponding to plastic items, (916 in total, Figure 3A). Total weight in both compartments was 8.30 kg. From this total, 5.44kg was found in the vegetated area and 2.86kg in the intertidal zone.

Caramborê beach is also a pristine area, with a small river mouth in the middle of the beach, around 600m of extension and 55m of width. The profile showed a slight slope, with a height of 1.50 m compared to the sea level. The beach has a vegetated back and the backshore was easily identified. Total items collected in all the compartments (vegetated, backshore and intertidal zone) was 841, with the major amounts corresponding to plastic items (808 in total, Figure 3A). Total weight in all compartments was 11.15 kg. From that, 9.56kg were collected in the vegetated area, 1.0kg in the backshore and 0.59kg in the intertidal zone.

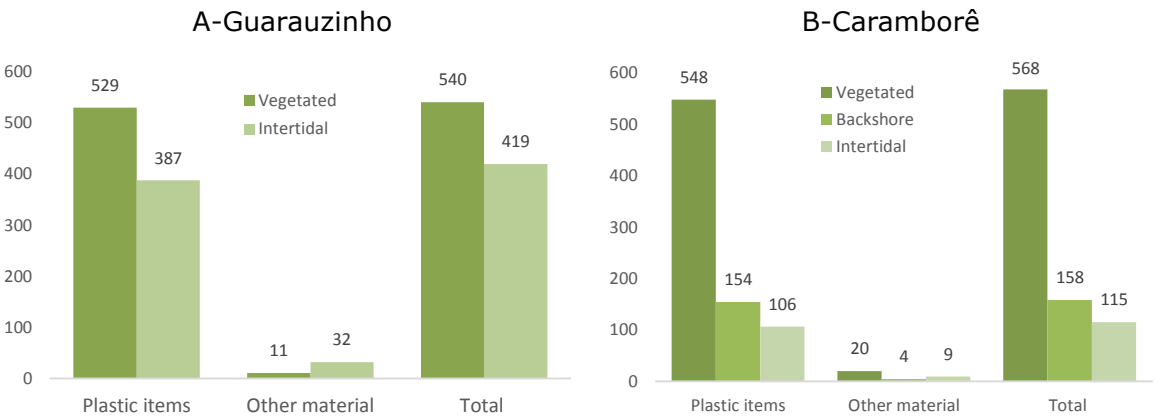

Figure 3. Type of material in Peruíbe beaches, in backshore and intertidal zone.

The most frequent items in Guarauzinho beach were monofilament lines in the vegetated back of the beach followed by unidentified plastic fragments. In the intertidal zone the most common item were unidentified plastic fragments followed by monofilament lines (Figure 4).

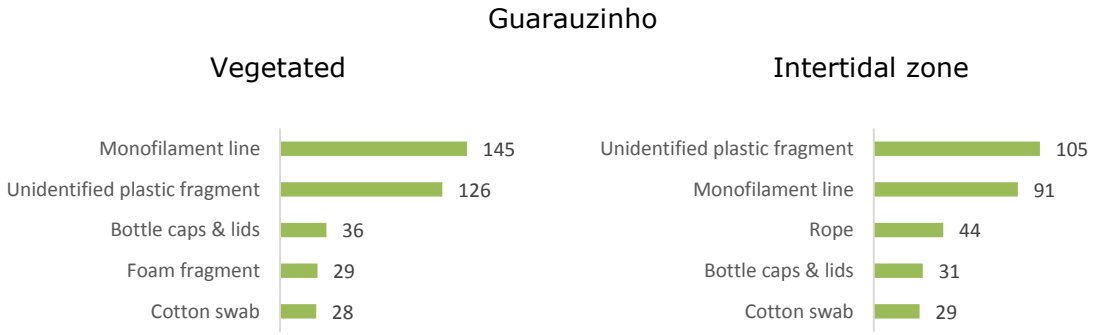

Figure 4. Five most frequently collected items Guarauzinho beach in each compartment.

In Caramborê beach, the most frequent items were unidentified plastic fragments followed by bottle caps and lids in the vegetated back of the beach as well as in the intertidal zone. In the backshore they were unidentified plastic fragments followed by plastic food containers fragments (Figure 5).

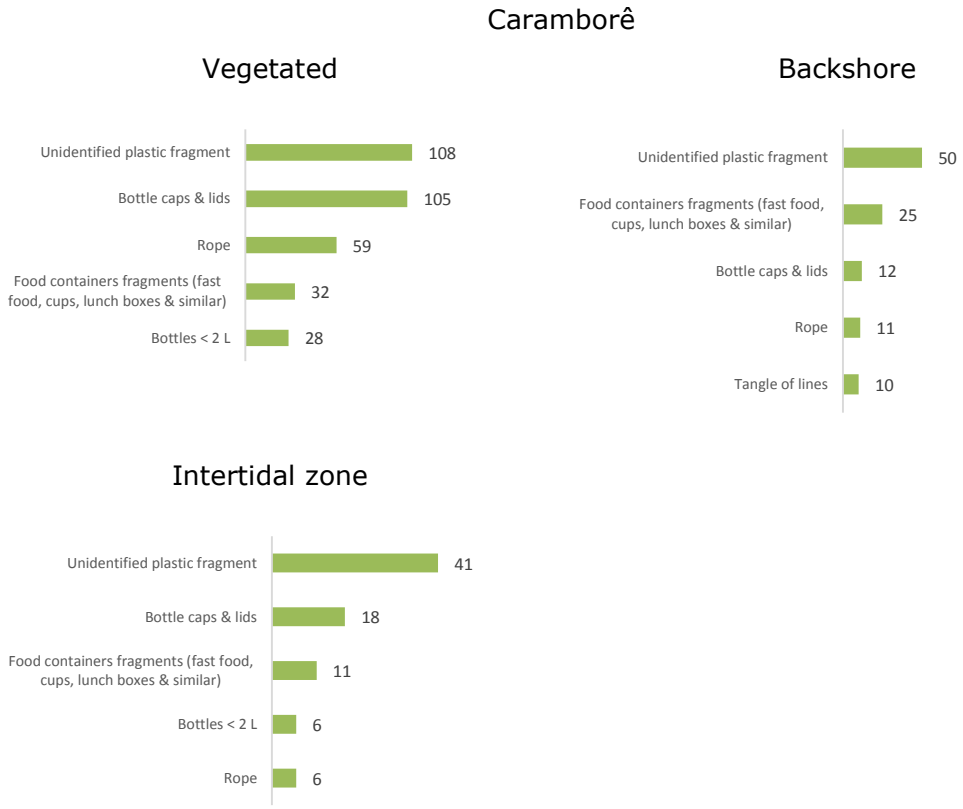

Figure 5. Five most frequently collected items Caramborê beach in each compartment.

In Ubatuba, the Perequê-mirim is an urban beach, with around 500m of extension and 32m of width. This beach did not have a vegetated back. Instead there were constructed areas, which excluded the vegetated back area from the sampling sites. The beach profile showed a steep slope, with a height of 2.80m compared to the sea level, relevant for the results of the survey. Total items collected in both compartments (backshore and intertidal zone) was 1,237, with the major amounts corresponding to other materials (637 items, Figure 6A). Total weight in both compartments was 9.29 kg, 5.22kg in backshore and 4.07kg in intertidal zone.

Enseada beach is also located in an urban area and has around 1600m of extension and 26m of width. The profile showed a slight slope, with a height of 1.40m from the sea level. As for Perequê-Mirim, Enseada beach had no vegetated back but only constructed areas. Total items collected in both compartments (backshore and intertidal zone) was 1,347, with the major amounts corresponding to plastic items (718 in total, Figure 6B). Total weight in both compartments was 9.12kg, 4.84kg in backshore and 4.28kg in intertidal zone.

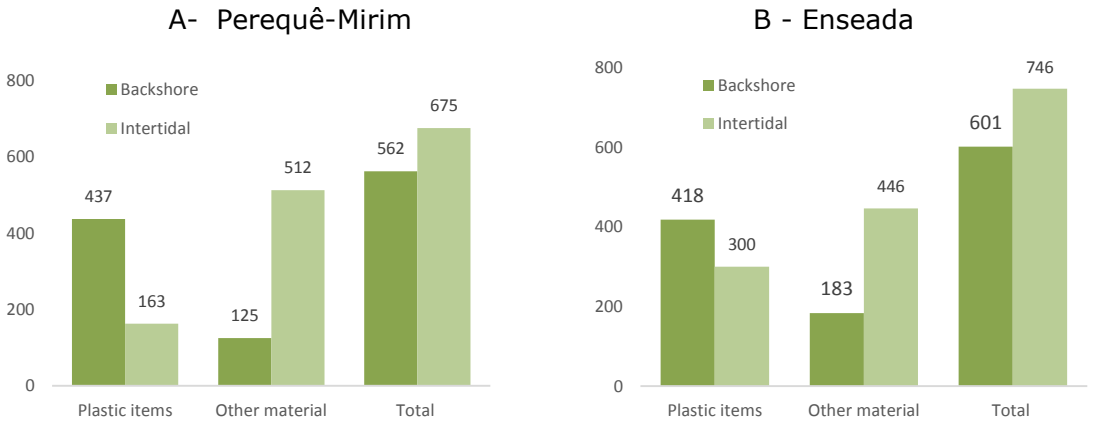

Figure 6. Type of material in Ubatuba beaches, in backshore and intertidal zone.

For both beaches, the most frequent items were cigarettes, butts and filters in the backshore of both beaches; and construction material (brick, cement, pipes) followed by glass or ceramic fragments in the intertidal zone (Figure 7).

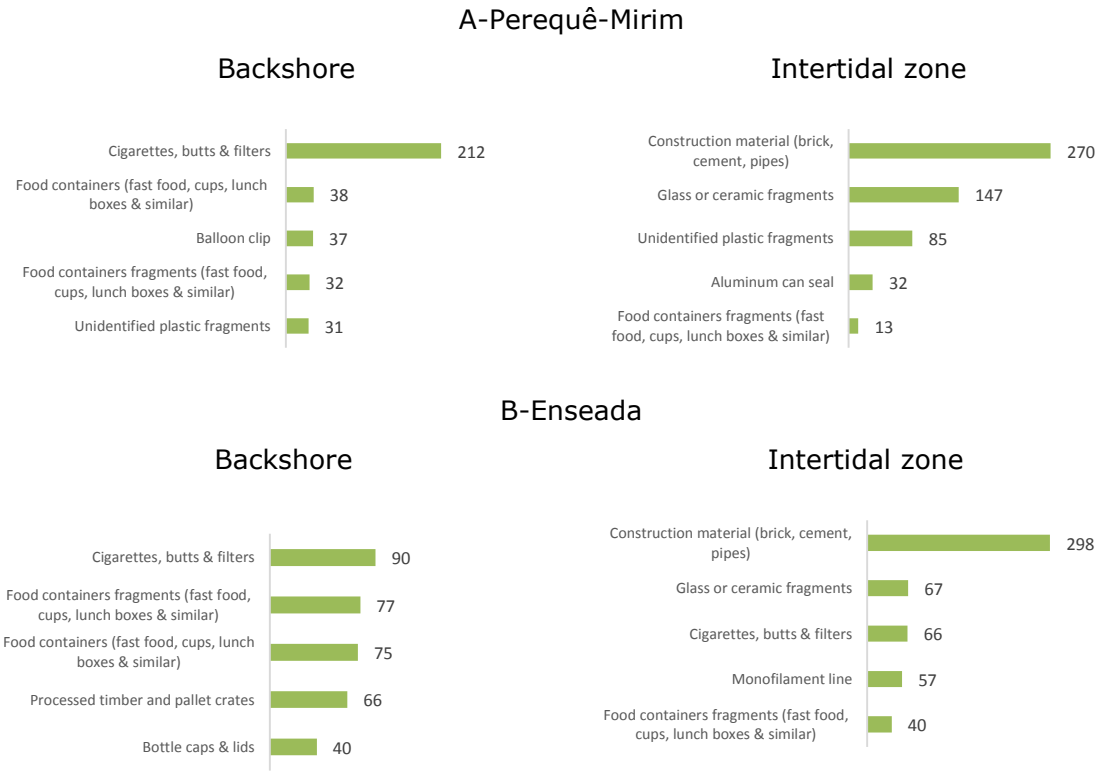

Figure 7. Five most frequently collected items Ubatuba beaches and compartments.

DISCUSSION

In both workshops the students had to raise propositions that could explain the results they found. The discussion of such hypothesis was done in the last day of the workshop, after the presentations.

In Peruíbe, the main sources were related to monofilament lines, unidentified plastic fragments, and ropes. As those beaches were in pristine areas, students suggested that most of the marine litter were brought to those beaches by winds and currents. The students also proposed that the litter was coming from the villages located near the main rivers and from fishing boats. As measures to avoid this type of litter they suggested to inform fishermen on the impacts of marine litter and to pressure the local government to act against litter entering the local rivers.

In Ubatuba, the main source of marine litter was related to construction material, probably coming from local sources, once ceramic fragments and bricks would not be transported easily by wind or by currents. Thus, the students proposed that this type of litter has a local source, as well as the cigarettes related debris. As measures to avoid this type of litter, the students suggested actions to inform the local citizens about the problems related to marine litter, and the installation of trash bins in those areas.

The use of satellite images in Google Earth platform before and after the surveys assisted the students to identify probable sources of the marine litter to those beaches. The differences among the beaches sampled in Peruíbe and in Ubatuba were clear on the satellite images. The beaches had different back of the beach coverage (vegetated and constructed), access facilities, and ocean dynamics (one was in a protected bay and the other in open area). The results from the surveys confirmed the different type of marine litter expected from the location of the beaches.

As conclusion, satellite images are used in diverse areas, and has been used as an educational tool. This study, intended to give the students a wide view of their surroundings focused in the marine litter in beach and asked the students to propose the main sources and measures to avoid the entrance of marine litter. Most part of the students had a mobile and probably had previous contact with Google Maps and Google Earth, but they have never interacted in an objective and methodologic way with those apps. Differently from a mobile, few students had previous contact with a GPS, so its use raised their attention, giving wider possibilities on how they could use those resources.

The contact established in this workshop was enriching, making possible the approximation between the school and the university that, in addition to increasing the information level of the population, opened the possibility for the establishment of participatory monitoring (citizen science approach), which in the future may be adopted in other schools.

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