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Marine litter monitoring: the case study of Paros island

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Abstract Marine litter have been characterized as one of the main threats for societies, while among them, plastics have been found in various marine ecosystems. A monitoring project on marine litter, based on beach visual-surveys started in 2019, on Paros Island in the Aegean Sea, under the Clean Blue Paros initiative. Four main sandy beaches with different characteristics were primarily selected for seasonal sampling. Among the findings, Plastics were the most abundant litter category, covering 80.45% of the total items, followed by Food Waste and Textiles (7.3% and 5.2%, respectively). Among the beaches, only 3 items covered more than half of the total, namely cigarette butts and filters, ropes and small plastic bags. In a primary analysis, significant differences were found in the mean values of collected items between the two sampling years (2019 and 2020) in Martselo beach ($p < 0.05$, ANOVA test). In an effort to locally connect marine litter with their sources, a scoring matrix technique was applied for each beach, highlighting beach visitors as the primary input source, followed by fishing-related activities. On-going monitoring and additional awareness actions have been implemented to further support the overall effort of plastic pollution mitigation in the island.

Keywords: marine litter, Paros island, plastics

1. Introduction

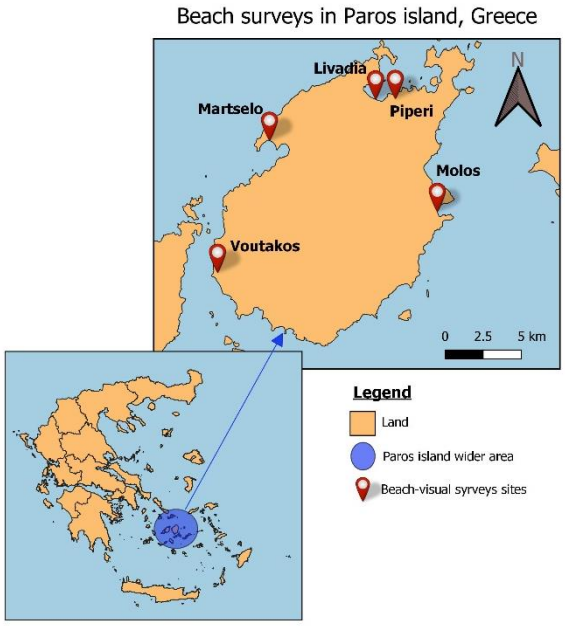
Marine litter is descripted as "persistent, manufactured or processed solid materials" (MSFD, 2008/56/EC) and have been widespread in various marine habitats, through direct, indirect, intentional, or unintentional abandonment (UNEP, 2016). Commonly, plastics are recorded in high quantities and abundances in various forms and shapes (Bergmann et al., 2015).

In an effort to assess the range and impact of plastic pollution, previous studies have estimated that approximately 690 marine species affected by plastic pollution, through entanglement and ingestion (Cannon et al., 2016). Furthermore, at least 17% of those species are included in the Red List of IUCN and characterized as near threatened or above (Gall & Thompson, 2015).

Throughout the previous decade, European legislation and international agreements described the issue of plastic pollution and proposed measures to identify its range and impact. Several methodological approaches and tools have been designed and implemented, aiming to meet the regulatory goals, such as biota content analysis and visual surveys (TSG-ML, 2013). The last includes beach-visual surveys focusing on macro-litter assessment (debris that could be identified with naked eye). For the purpose of the present study, beach-visual surveys were considered the most appropriate methodology. Visual surveys have previously been applied in citizen science projects (Haar et al., 2020; Hidalgo-Ruz & Thiel, 2015) as they are easily combined with coastal clean-ups (recording and collecting the marine litter for further disposal) and have a low implementation cost.

2. Materials and methods

A desktop review was initially carried out to collect all the necessary information on the physical environment and the dominant anthropogenic activities on the island. Thence, field work and in-situ evaluation took place to accordingly address any local characteristics. The main findings were subsequently revised as it was necessary to optimize their utility. A minimum of 4 beaches were selected for seasonal sampling that met the main criteria (such as sandy beaches, at least 100-meter length, a minimum of 10-meter width, low to moderate beach slope) (Figure 1).



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beach, since the unexpected presence of a seasonal stream posed extra difficulty on the implementation of the surveys.

Through the visual surveys, two marine litter record forms have been used in line with MSFD related guidelines (TSG-ML, 2013). Macrolitter items with a diameter greater than 2.5 cm were recorded and were further organized into 8 combined categories, named:

1) *Artificial Polymer Materials,*
2) *Paper & Cardboard,*
3) *Cloth & Textiles,*
4) *Glass & Ceramics,*
5) *Metals,*
6) *Processed & worked wood,*
7) *Rubber, and*
8) *Unidentified, chemicals & food waste.*

The categories described above responded to 94 individual items. In addition, the second record form was used to collect beach profiling information, including the survey's coordinates, beach slope, weather conditions, activities taking place in the vicinity of each beach, categorization of the impact of anthropogenic activities and finally a section for additional comments regarding the borders of the selected area and adjacent locations.

As the research strategy of marine macro-litter monitoring has been part of the overall effort of Clean Blue Paros initiative, the intention has been the involvement of volunteers, aiming to transfer the knowhow of the data collection. Training sessions took place prior and throughout the field work, while guidelines were available during every survey. Supplementarily, a photo guide was also produced to ensure accurate identification of marine litter.

Data have been organized into worksheets for further analysis, aiming to highlight a) marine litter abundances, b) the most frequent items, c) significant differences throughout and within years and d) primarily possible connection between frequently found items and the anthropogenic activities that have been take place in the area.

3. Results

Since the beginning of the study in 2019, more than 6200 items have been collected in total. Plastic items have commonly been the most abundant throughout each survey, covering a range of 32-96% of the total items. Indicatively, throughout the last data collection period (Autumn 2020), 80.45% of items were Plastics, followed by Food Waste (7.3%) and Textiles (5.2%) (Figure 2).

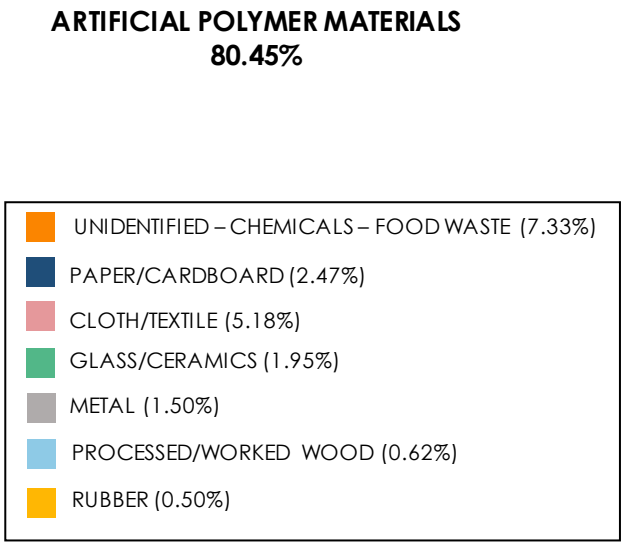


Figure 2. Example of categories distribution of found items for Autumn 2020.

Concerning the most frequently found items, a diagram with the top 10 most frequently collected items was produced for each year. Only three and four individual items for 2019 and 2020 respectively, covered more than 50% of the total, while the most frequent one had been cigarette filters for both years. In addition, common items presented within the two years in lower occurrences, such as ropes, food waste, textiles, plastic bags and plastic caps (Figure 3). Further analysis on the sites among sampling years, revealed that only one site (Martselo beach) reported significant differences on marine litter quantities ($p < 0.05$, ANOVA test), while in

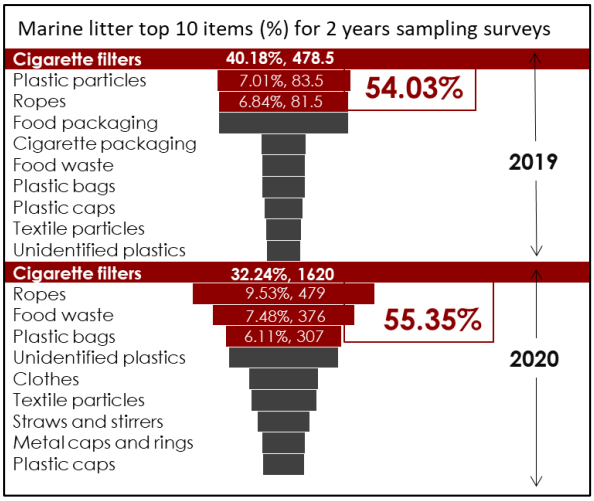
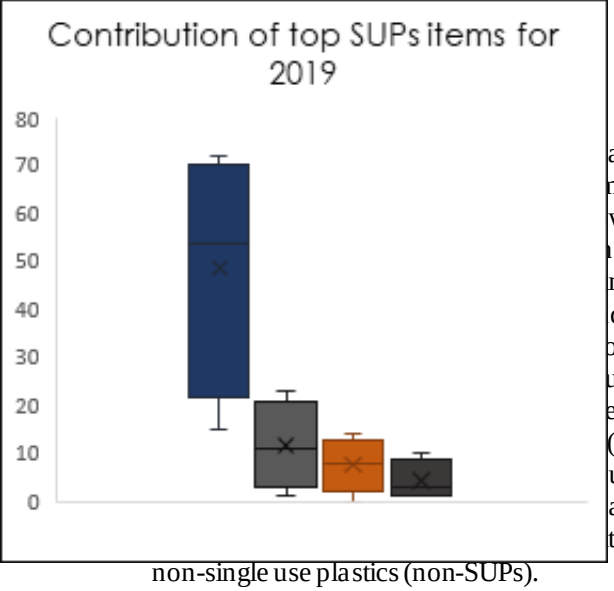


Figure 3. Marine litter top 10 items (%) found in 2019 and 2020 from beach-surveys in Paros island.

general slightly higher quantities were recorded during the second year of the survey (2020).

In an effort to primarily connect marine litter with their sources, different approaches were applied during the 2019 survey. Firstly, the group of smoking-related marine litter that consisted of four items: Tobacco pouches/plastic cigarette box packaging, cigarette



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Compared to other beach litter data collected at an EU level, the current approach was harmonized with the list of common single-use plastic items found in European beaches as presented in Addamo et al. (2017), where some categories are aggregated and others are handled as individual categories (e.g. caps, bags and bottles), in order to highlight the importance of subcategories for which data are available.

'Cigarette butts' is the dominant group of the SUPs items covering range between 22% and 72% of the total, followed by shopping bags, Other items such as bottles and straws (Figure 4), while at an aggregated level,

Figure 4. Boxplot graph: SUPs items found in 2019 surveys presented in presentnce of the total.

accounted for half (51%) of the litter items recorded at the 4 beaches in 2019.

In addition, a Matrix Scoring Technique was applied, assessing the likelihood of origin of the individual items with the potential sources, (Veiga et al. 2016; Tudor & Williams, 2004). The likelihood between the marine litter items and the potential sources presented with a scale of probability, as followed: "Very unlikely (UU); Unlikely (U); Possible (P); Likely (L) and Very likely (LL)". Touristic and fishing related activities presented as a very likely potential source for the majority of the found items in every beach.

Further, the beach cleanliness was also assessed using the Clean Coast Index (CCI, Alkalay et al., 2007). CCI gives the number of plastic litter items (n) counted per square meter of transect area, with transect area defined as the product of the transect length (l) and width (w):

$$CCI = \left[{}^{n}/_{(w \times l)} \right] \times K$$

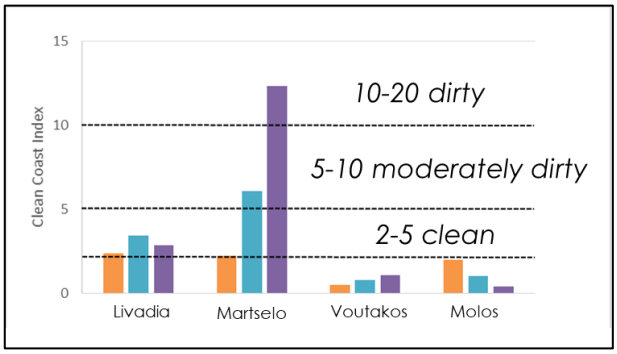

Figure 5. Clean Coast Index presented for four beaches and 3 different seasons .

K: a constant that equals to 20.

The Martselo beach site was highlighted as the one with the greatest range of CCI values estimated from "Clean" to "Dirty", while the rest of the sites exhibited a smaller range, characterised as "Very Clean" or "Clean" through the seasons (Figure 5).

Discussion

To summarise the findings, plastic items had been the most abundant throughout the sampling years, within the seasons and among the different sites. Since the majority of items was dominated by only a few items, specific actions targeting those items could contribute to their mitigation. In details, smoking-related items contributed significantly to the total found items in most surveyed sites. The large number of smoking-related items collected is indicative of the related activity which is primarily touristic and recreational. It is likely that during the crowded touristic season, beach cleaning activities (picking up trash and emptying bins) from the municipality and any businesses operating on the specific sites, take place regularly and systematically. It should also be noted that in Autumn and Winter, the prevailing weather conditions could also contribute to scattering of significant quantities of litter. At the same time due to the warm and calm weather conditions of summer, several beach goers still use the beaches and often leave trash behind. The majority of those items also categorised as SUPs, could explain their high quantities. Further, taking into consideration the results of the matrix scoring technique and the previous findings, tourists (such as sea goers) could be confirmed as a group of interest, while

fishing related activities had also highlighted as another group of interest.

As this study is a part of Clean Blue Paros initiative, the specific goals of the project, such as the volunteers' participation and local stakeholders' involvement, have been a great part on the selected research strategy. Along these lines, the aim of the study, not only focused on marine litter monitoring, but also on producing tools that are applicable by the community, remain accurate and could be used independently in the future. It is worth mentioning that, in the context of Clean Blue Paros objectives, field trainings, public hearings, focused-groups and public engagement actions have been on-going activities. For instance, the groups of participants that undertook specific beaches' surveys throughout the year, aiming their engagement, but also ensure continuous data that could further contribute on marine litter pollution monitoring in the area.

Concluding, following results analysis is considered important to further highlight marine litter sources and monitor the evolvement of plastic pollution issue in Paros.

Acknowledgement

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