Title

On single use plastic straws: pre-ban findings on touristic beaches in Crete.

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Abstract

This baseline intends to report on littering related to single-use plastic straws, contextualized on two touristic beaches on the Northern shores of Crete (Greece). While beached straws were found to be mainly depending on local drivers, the study further highlighted an additional source of pollution related to plastic straws: the clear wrap in which single-use items can be offered to users. Over the summer months, a number of discarded straw wraps was in fact found, significantly related to both beach width and the presence of colorful straws. Wraps are different in shape, material, as well as likelihood of being dispersed and broken down in the environment,

and easily escape estimates from non-targeted sampling. The ban on single use items seems then to be the most effective approach to avoid straws and, indirectly, straw wraps litter or spills.

Keywords

Plastic Straws; Beach Litter; Tourism; Single Use Plastic; EU Directive 2019/904

Introduction

The ban on single use plastic straws is reaching a worldwide dimension, with an increasing number of Countries and/or States implementing such legislation. In the EU, the ban will be implemented in 2021. Namely, the EU Directive 2019/904 on the reduction of the impact of certain plastic products on the environment -commonly called the Single-Use-Plastic Directive- was voted by the European Parliament in June 2019, and enters into force in July 2021 with the ban of specific products following targets to be reach throughout the UN decade for sustainability. Beyond the ban, general goals of international actions relate to: plastic products consumption reduction; extended producer responsibility scheme; requirement for increase recycles plastic in products composition; separate collection of plastic for recycling. Items to be banned were defined by their constant presence among beach litter (straws but also cutlery, beverage stirrers, plates, food and beverage containers made of expanded polystyrene, as well as cotton buds ticks and stick supporting balloons). Beached straws were included among items threatening birds by ingestion (Battisti et al., 2019), but also, given their size and the hollow shape, could act as traps for beach resident macroinvertebrates (Romiti et al., 2021, but for fauna reported from touristic beaches in Crete see Fanini et al., 2014)

In view of the ban implementation, we decided to carry out an estimate of beached straws findings, related to beach bars activities in a highly touristic context. Our goal was to highlight the amount of straws potentially spilled over a beach arc with active beach bars, and the characteristics of pollution related to single-use plastic straws in this context.

The specific case of islands merits a specific focus, due to the fact that islands are often considered as model systems due to the clear identification of boundaries and the lower complexity of certain dynamics. In the case of plastic-related issues, islands have seen a raising attention and often became living laboratories for small-scale initiatives, see e.g. the Plastic Waste Free islands project by IUCN (https://www.iucn.org/theme/marine-and-polar/our-work/close-plastic-tap-programme/plastic-waste-free-islands), or the project MEDfreeSUP, looking at reducing Single-

Use-Plastic uses within the food and beverage sector in the Greek islands (http://www.unsdsn.gr/medfreesupeit-climate-kic). The island of Crete is highly depending on tourism (the Institute of the Association of Greek Tourist Enterprises (INSETE) estimated that the tourism sectors contribute up to 30% of the national GDP at Country level, while for the Region of Crete this value is expected to be higher, https://insete.gr/wp-content/uploads/2020/09/20_09_Tourism_and_Greek_Economy_2018-2019.pdf for 2019 data)_, with a large part of the international arrivals directed to seaside holiday making and most infrastructure available on the northern shores of the island. In this setting, the small commercial activities such as beach bars are widespread and relevant to the local social-economic landscape. But also, they have to carry the pressure of both a huge demand of services restricted to the summer season, and the lack of separate collection or recycling infrastructure (Swarbrooke and Horner, 2007).Data related to plastic straws as target items could hence support not only further research on the effects of the ban, but also serve as governance support for specific situations under high pressure driven by the touristic market.

Materials and methods

Sites. We selected two beach arcs (toponyms Gournes and Kokkini Chani; N35°19'59.02" E25°16'14.42" and N35°19'54.12" E25°15'35.59" respectively, in the center of the arc) on the northern shores of the island of Crete. Each arc extended for 400 m (measured with Google Earth pro tools), delimited on the long-shore dimension by groynes, and with the beach width defined by the seaside road presence. There were beach bars active in the late spring-summer season at both sites (N = 6 in Gournes and N = 4 in Kokkini Chani), offering service both as take away to the free beach sector, and to the umbrellas on the beach, also under the direct management of the bar. Beach cleaning was performed by hand by the beach bar personnel during their opening period.

Sampling times. Sampling was performed on Monday mornings, considering Sunday afternoon as peak for presence of people on the beach (personal observations; including families and young people alike). The choice of Monday mornings for sampling was also found a common strategic approach to leisure-related beach litter, see e.g. www.operationstraw.org (Manly Cove, NSW, Australia). The weather conditions over the weekends were also noted down. Sampling started on the 15th of April 2019, i.e. after Easter holidays, but when bars were still closed, beaches not equipped with umbrellas, and littoral not cleaned. Given the interaction between climatic and

social drivers in tourism (Swarbrooke and Horner, 2007) this was a condition exclusive of the Easter time, not continuous such as summer holiday time, thus has no replicates. Weekly sampling proceeded until the 16th of September 2019. Other two sampling events were carried out in low season, again with beach bars closed, in November and December 2019.

Beach variables. In order to integrate litter studies with relevant social-ecological features, the variable "beach width", as distance in meters from the water mark to the end of the supralittoral (in this case terminated by the presence of the seaside road, but see Fanini et al., 2020 for definition of beach units as social ecological systems) was selected as most relevant. In fact, beach width is known to be a variable shaping faunal patterns (McLachlan and Defeo, 2017) on both ecological meso- and macro scales. At the same time, beach width is used to assess the available supralittoral surface –the unit valuated in the tourism market (see e.g. Houston, 2008). Consequently, in correspondence of each sampling event, beach width was measured at each site in the central part of the fixed beach arc, i.e. where the littoral is most extended.

Sample analysis. In the first step of the analysis, straws were classified in types based on their colour and shape, and a dataset (supplementary material 1) was built, following the structure for dataset used for biodiversity studies (see Battisti et al., 2017), where instead of species were straws types. The item "clear wraps" was added to the items list: many straws were in fact found accompanied by their wraps, either still partly attached, or dumped in their proximity. Routines of the software Primer 6 were applied to identify those items contributing to similarities and dissimilarities among the two sites. The resulting most informative items were retained for further analyses as follows: a distribution fitting (goodness of fit test) was performed on the item categories as part of data exploration, and a Spearman rank correlation was applied to test whether a) beach width and straw categories were related and b) straws categories and clear straw wraps were related. Analyses were carried out with the software XLStat 2017 (Addinsoft).

Results:

Even if both beach arcs are facing North and subjected to the same wind exposure, the two sites were undergoing different erosion conditions: Gouves beach width ranged 7 – 24 m, while Kokkini Chani beach width ranged 0 – 6m. Due to the harsher erosion, on the 15th of April; 6th of May; 1st

of July; 12th and 16th of August; 16th of September the whole supralittoral of Kokkini Chani was completely swashed. Beach width was consequently noted as a zero, and the samplings were discarded from the analyses.

Weekend weather was rainy and then windy from April through most of May; windy from mid-July to mid-August; good for the rest of the dates (see environment data in supplementary material).

Only in Kokkini on the 19thof August no straws were found. All other sampling events returned a variable amount of items, totaling 250 straws in Gouves and 41 in Kokkini Chani (full dataset –set up for biodiversity analyses- in supplementary material). Throughout the study 84 clear wraps were found in Gouves and 8 in Kokkini Chani, though wraps findings were limited to the time span of late May (in co-occurrence with the first weekend of good weather) – late August (Figure 1).

The SIMPER analysis highlighted that black thin straws (from "freddo" coffee), and clear wraps (i.e. the wrap in which single-use food related items are often packed) accounted for top rates of both of similarity and dissimilarity between sites (Table 1). Other items were consequently pooled, creating three categories: "black thin straws"; "colorful straws"; "clear wraps". Such pooling gathered the extreme variety of colorful straw findings over time and by beach unit.

Table 1. SIMPER analysis results on the straws collected throughout the study.

	Black thin straws (% contribution)	Clear straw wraps (% contribution)	Colorful straws (% contribution after pooling)
Gouves similarity (average 33.23)	28.39	27.31	34.41
Kokkini chani similarity (average 12.94)	39.35	24.28	27.68
Gouves-Kokkini chani dissimilarity (average 83.83)	15.86	21.66	54.01

The distribution fitting performed on the three categories indicated distinct data distributions for each one of them: a negative binomial distribution for black thin straws (p-value goodness of fit

test = 0.953; AIC Log-Likelihood = 80.970 on 38 df); an exponential distribution for colorful straws (p-value goodness of fit test = 0.763; AIC Log-Likelihood = 188.801 on 38 df); a logistic distribution for straw wraps (p-value goodness of fit test = 0.023; AIC Log-Likelihood = 180.455 on 38 df). Spearman rank correlations pointed to significant positive correlation of all three categories of straws with the variable "beach width" (i.e. higher numbers of straw-related litter was expected on wider beaches): in the Spearman matrix, black thin straws correlated to beach width with a value of 0.426 (p-value = 0.016); colorful straws correlated to beach width with a value of 0.578 (p-value = 0.001); clear straw wraps correlated to beach width with a value of 0.626 (p-value < 0.001). The presence of clear wraps was found significantly related to colorful straws only (correlation value in the Spearman matrix = 0.457; p-value = 0.009).

Top density values for straws were recorded on the 15th of April, i.e. after Easter holidays but before the opening of the beach bars: 3.0 colorful straws per width meter and 0.30 black thin straws per width meter, both in Gouves. No clear wraps were found at that date. Clear wraps top density value (0.92 per width meter) was instead recorded on the 15th of July, also in Gouves (Figure 1. Overall, throughout the surveys, only three weathered straws were found.

[insert Figure 1 around here]

Figure 1. Occurrence of straws and straw wraps per beach width at the two sites. X axis = time of sampling. Y axis = items per beach width. Romboids = "freddo" straws; Squares = other straws; Triangles = clear straw wraps. Missing values in Kokkini Chani correspond to days in which the beach was completely swashed, hence beach width was equal to zero. The frame, from sampling 6 (17th of June) to sampling 16 (26th of August) refers to the school closing and opening time of the beach bars.

Discussion:

Most straws collected were related to direct littering, with only a minimal amount of weathered straws found throughout the study. The autumn-winter collections, even if taking place after storms and windy days, also returned a lower amount of straws than in summer days. Rather than beach bars activities, which also provide a service of beach cleaning which reduces the accumulation of litter, the driver for the presence of littered straws seems then to be related to the use of the available beach width by beachgoers. This is supported by the correlation found

between beach width (on which also the number of beachgoers depends) and straw categories' presence. A hypothetical longshore transportation of straws from nearby areas would have led to higher concentrations in conditions of narrower beaches, i.e. after a period of increasing swash, with accumulation on the wave mark. But this was not the case. The highest amounts of straws found after Easter holidays and before beach bar openings suggest that the litter source were drinks brought as take away. While the amount of straws used by beachgoers was surely higher during the touristic peaks, their collection was at least attempted by the bar management. The relationship between beach bars, beachgoers and plastic litter is similar to studies conducted in other part of the Mediterranean Sea (see Laglbauer et al., 2014 in Slovenia; Munari et al., 2016 in Italy; Portman et Brennan, 2017, in Israel) and the world (see Widmer and Hennemann, 2010 in Brasil; Evans et al., 1995 in Indonesia). This highlights a clear range of actions in terms of spatial scale, and stakeholders, for targeted strategies.

Straws and straw wraps. Straws are small, light items; they are likely to leak in the environment at all stages of their use and disposal, and even in the case of a correct disposal in -garbage bins the likeliness of spillover is still high. Garbage bins during the summer fill in more rapidly than the garbage collection by municipal services, and this is particularly true in touristic islands, where the waste management system is under pressure having to deal with the waste production of three to five times its yearly population. The dispersion of straws in the environment can also easily occur during their collection, transportation and disposal of garbage bins content to landfills. There is no waste management plan specifically dedicated to straws items which would tackle the specific challenge such items causes. Thus the complete ban of plastic straws in the market will prevent direct littering, as well as all potential spills if it is properly enforced and not replaced by items which may cause similar damages (e.g. biodegradable straws). An important finding was the one related to clear wraps. Associated to single-use items such as straws, discarded clear wraps were found a relevant (typifying and discriminating item) component of the samples, and brought to light a so far hidden extra source of pollution. The issue was identified thanks to the targeted single-item approach. Wraps were in fact clearly associated to straws: matching size and shape, buried nearby the correspondent straw, or even still partly hanging from the straws. Given their lightness, they have a higher likelihood of being blown away by wind, buried in sand, and escape collections. In general, they escape analyses in which the association with straws is not considered. Within the OSPAR methodology (accessed from repository.oceanbestpractices.com on the 10th of January 2021), straws have the ID 22 while straw wraps do not have a categorization,

hence could be assigned to ID 117 or ID46 “plastic/polystyrene pieces” of different length classes. All the three cases belong to the category “Artificial polymer”. Indeed their material is different: straws are mainly polypropylene (PP) and colorants, while food wraps are usually Polyethylene (PE). The potential of impacting ecosystem is here also inferred as different; the shine of the wraps could differentially attract beach organisms, due to their mechanisms of search attraction (e.g. shorebirds, see Rossi et al. 2019). The ban would therefore indirectly act on two different pollutants sources, one of them (the wraps) broadly overlooked.

Acknowledging the need of identifying common denominators in inter-disciplinary studies (Oeberg et al, 2011), the use of the variable beach width was here used as a parameter relevant to assess the abundance of beached items, and depict their temporal dynamics, but also likely to relate to 1) beach ecology variables 2) socio-economic variables such as estimated revenues per surface of littoral available (Houston, 2008) and estimated damage to beach attractiveness due to litter presence (Anfuso et al., 2017).

Local context and attitudes. Ecology and attitudes are not two separate containers. Specifically, as in the case of top-down initiatives such as bans, “bypassing the attitude-change process does not mean you can ignore attitudes” (Heberlein, 2012).Taking into consideration the intrinsic link between plastic straw consumption and social habits in Greece, plastic straw uses are very much based on the daily consumption of “freddo” coffees (iced coffee served nationwide in Greece on site, take away or delivered anywhere from houses to public places and beach). The straws used for the iced coffee are generally thin, of black color and often shorter than normal colorful straw thus, thus easily recognizable. On the other hand currently, as for the use of straws, in Greece beachgoers don’t have much other choice than the use of plastic when consuming beverage, the consumption is fueled by beach bars, cafes and restaurants which provide freely and rigorously straws with any drink purchases. In our case, the presence of clear wraps was found related to colorful straws rather than “freddo” ones, though these dynamics are particularly narrow in time and space, depending on the lot of straws purchased by the single bars for example.

Even though littered plastic straws are not identified as offensive as other items (Nelson et al., 1999), the ban has a huge social resonance, and a suite of alternative products is being

commercialized. The present baseline could hence support studies and projects targeting small-scale environmental actions with high potential to connect social and ecological templates (see e.g. Battisti et al., 2020), but also coastal tourism-related impacts and the up-take of top-down bans. It further confirms the need to target food and beverage operators as prime providers of single-use plastic items found in beach likely to leak in the marine environment. It will also serve as a reference to assess the impact of the plastic straw ban set to enter into effect on the 1st of July 2021 in Greece, right at the beginning of the tourism season. However the real effect should not be expected before 2022 as the law prohibit the straw availability on the market not explicitly its use, therefore it is likely that many businesses would have anticipate the ban by stockpiling and go through the season with a mix of plastic straws and alternatives solutions (e.g. paper, bamboo straw, or biodegradable plastic straw).

Finally, these data refer to 2019, though it is worth noting that a consequence of the Covid-19 pandemic was the increase in usage of plastic straw wrap as even drinks on site (in cafes, beach bars) are being served with plastic straw in wraps for hygiene reasons.

Acknowledgements

We are grateful to the referees and to the handling editor for their work on this manuscript

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