From Trash 2 Treasure 2.0: an experience of citizen science participatory litter mapping with college students at Kavouri Beach, Athens, Greece

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Abstract. Marine litter, especially plastic, poses a severe global environmental threat, harming marine life, ecosystems, and human health. Millions of tons of waste enter oceans yearly due to poor waste management, industrial activities, and littering. This pollution leads to habitat destruction, ingestion and entanglement of marine life, and toxic pollution in the food chain [1]. The Mediterranean Sea, with its dense coastal populations, tourism, and limited water circulation, suffers significantly from plastic accumulation, threatening biodiversity, fishing, and tourism industries [2]. Tackling this issue requires international collaboration, waste management improvements, and public awareness.Citizen science plays a key role by engaging communities in data collection, increasing data access, raising awareness, and fostering environmental responsibility [3]. This involvement also provides youth with learning opportunities about marine litter impacts and promotes open science, allowing data sharing with researchers and the public for better ecosystem monitoring [4].
San Diego State University's "From Trash2Treasure" initiative by the Metabolism of Cities Living Lab (MOC-LLAB) showcases this approach through community-driven litter collections. Following a seven-step protocol, participants engage in mapping, cleanup, and workshops to review results. The simplified, replicable methodology encourages widespread involvement across regions, empowering local communities.
We performed such protocol with a class of undergraduate students in the United States spending an abroad period at the One Year in Greece University providing a participatory litter map of the Kavouri Beach in Athens, Greece using software such as the Smash App and Google MyMaps. Finally, we discussed the results during a post-event session with participants.

1. Introduction

Plastic pollution in the Mediterranean Sea has become a significant environmental crisis, threatening marine ecosystems, human health, and local economies. The Mediterranean, which hosts some of the world's richest biodiversity, is now considered one of the most polluted bodies of water, with an estimated 570,000 tons of plastic waste entering the sea annually [1]. This pollution stems from various sources, including coastal urbanization, tourism, maritime activities, and inadequate waste management systems in several Mediterranean countries [2]. The region's enclosed nature exacerbates the problem, as plastics accumulate with limited circulation to disperse them [3].Microplastics, tiny fragments of plastic, are particularly concerning because they are ingested by marine life and eventually enter the human food chain through seafood consumption [4]. Studies have shown that over 200 different marine species are affected by plastic debris, including endangered species like sea turtles, dolphins, and seabirds [5]. Additionally, plastic pollution has a direct economic impact on fisheries, tourism, and shipping, amounting to millions of euros annually in damages [6]. Efforts to address this growing issue have been initiated, including regional agreements like the Barcelona Convention and the European Union's Plastics Strategy, aimed at reducing plastic production and improving waste management [7]. However, more comprehensive actions are needed at local, national, and international levels to effectively combat plastic. Citizen science plays a crucial role in tackling plastic pollution in the Mediterranean by engaging the public in data collection and raising awareness. Volunteers contribute to monitoring marine litter by participating in beach clean-ups, reporting plastic debris, and documenting pollution hotspots [8]. This grassroots effort provides valuable data to researchers and policymakers, helping to identify trends and sources of plastic waste [9]. Additionally, citizen science initiatives foster a sense of environmental stewardship among communities, encouraging sustainable behavior and reducing plastic use [10]. Programs like the "Clean Up the Med" campaign and the Marine Litter Watch by the European Environment Agency have shown that coordinated citizen efforts can provide reliable scientific data at a lower cost [11]. Such collaborations between scientists, citizens, and policymakers can strengthen regional actions and policies aimed at reducing plastic pollution in the Mediterranean.

2. Materials and Methods

2.1 The From Thrash2Treasure initiative

The "From Trash2Treasure" citizen science research initiative, launched by the Metabolism of Cities Living Lab (MOC-LLAB) at San Diego State University is a citizen science based data collection campaign, that developed a community-driven beach litter collection, and ensured inclusivity and promote awareness on plastic pollution.

From Trash2Treasure fosters community-lead beach litter initiatives following a 7-step protocol that included a participatory mapping activity during a beach cleanup, followed by a community workshop to discuss results and outcomes of the activity with participants[12]. Drawn from the experiences of the MOC-LLAB research team, the methodology has been designed to be simplified, accessible, and replicable across different pilot regions. This paper describes the application of the protocol with a class of undergraduate students in the United States spending an abroad period at the One Year in Greece University, The students has been involved in providing a participatory litter map of the Kavouri Beach in Athens, Greece using georeferencing apps such as the Smash App and Google MyMaps.

2.1 Target area background

Megalo Kavouri Beach, located in Vouliagmeni, Greece, is a popular seaside destination. Close to Athens, the area also features nearby tavernas, cafes, and green landscape. Megalo Kavouri Beach in Athens faces significant environmental challenges due to plastic pollution, a widespread issue affecting many coastal regions. This popular beach sees high visitor traffic, leading to an increased presence of single-use plastics, such as bottles, bags, and wrappers. These plastics often end up in the water or scattered along the shore, impacting local wildlife and marine ecosystems. Over time, plastic waste breaks down into microplastics, which are ingested by marine life, potentially entering the human food chain and posing health risks. Additionally, seasonal tourism surges amplify the amount of waste produced, overwhelming waste management systems. Despite some efforts to improve waste disposal and promote recycling, the current infrastructure struggles to cope with the volume. This ongoing pollution problem calls for stronger community involvement, improved waste facilities, and stricter regulations to protect the beach's natural beauty and ensure a healthier environment for both visitors and local biodiversity.

2.3 Data collection protocol

Data on coastal distribution of waste has been collected by four groups of students volunteers that covered each one a consequent transect of the Megalo Kavouri beach.

In total 500 m of shore has been covered by data collection.

Particularly, data collection gathered :

Data for this analysis were collected by citizen volunteers during formal cleanups.

a) *Waste distribution data:* for each litter item, volunteers recorded geo-coordinates using the Geopaparazzi© app.
b) *Post-collection*: coupled with the app and GPS data gathering, participants have been asked to compile a survey, from a given surveyor package, to count the different types of trash collected during the beach litter.

The survey was groupint trash by material standing to a ri-elaboration of the guidelines for sorting published by JRC Ispra for EU. The survey should be compiled by all volunteers of a selected reference person.

The surveyor has been crucial to assess the material flows analysis.

3. Results

Figure 1 shows the map of the collection of data performed by the citizen science initiative. Red dots are in correspondence of the waste findings , blue dots are transect delimitation. Transects are numbered considered as first (#1) the northern one and fourth the southern one (#2).

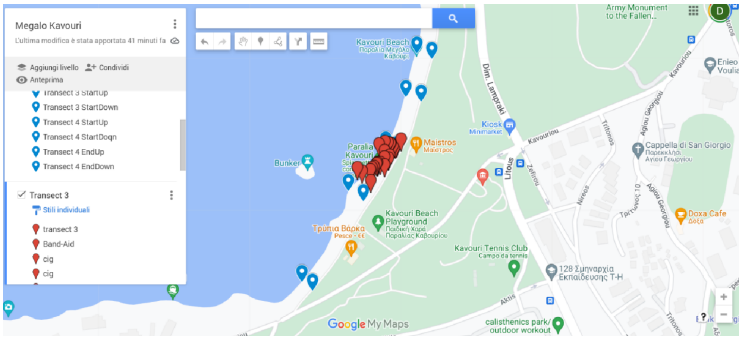


Fig. 1. From Trash2Treasure Participatory Litter Map of Megalo Kavouri Beach, in Athens, GR

Fig.1 highlights that most of the trash has been collected over Transect #2 . Figure 2 shows some shots of the typical collection by volunteers and waste types.

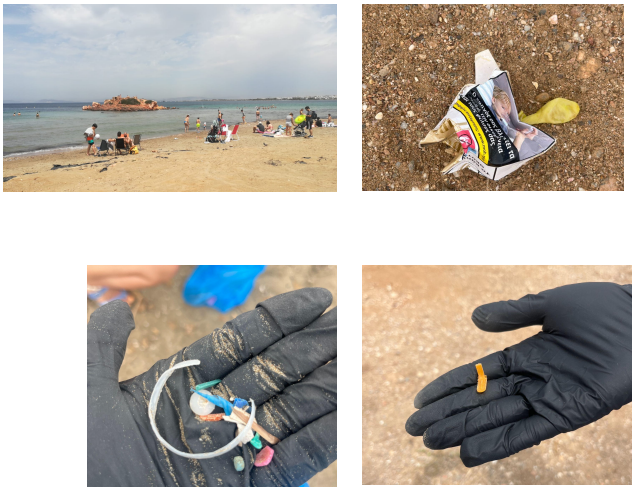


Fig. 2. Shots from the beach litter collection, Megalo Kavouri Beach and type of wastes

Figure 3 reports the results of the surveyors on the four transects.

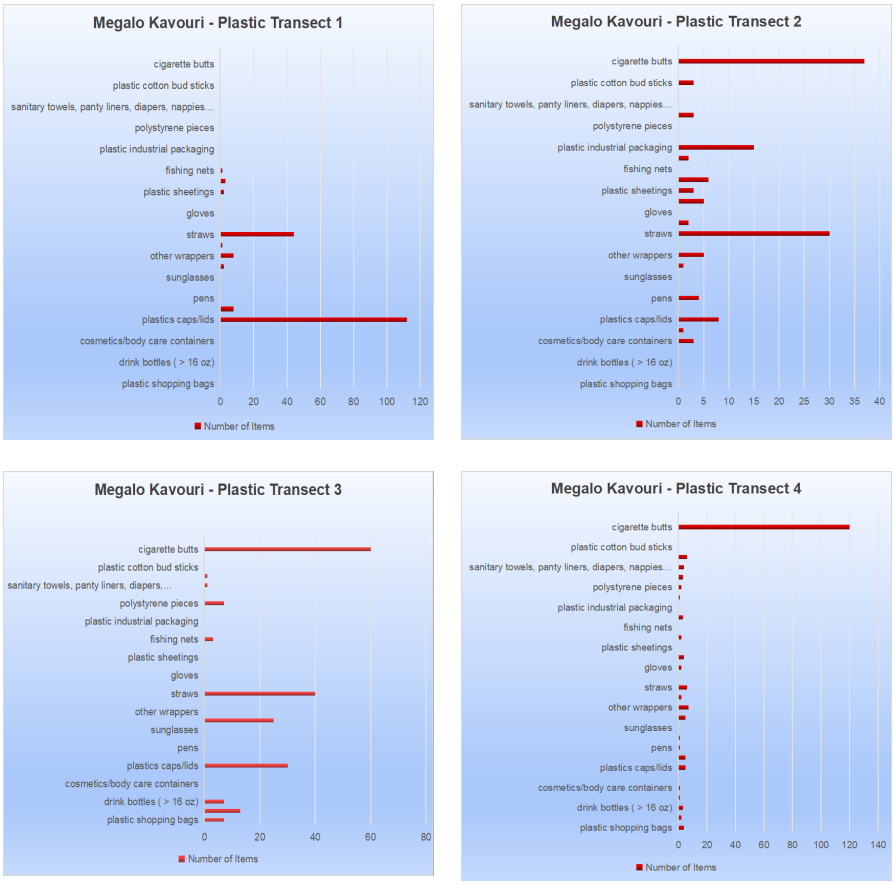


Fig. 3. Bar-chart graph distribution per object type regarding plastic wastes and cigarette butts.

The bar chart graphs of Figure 3 reports the number of wastes collected per object type regarding plastic wastes and cigarette butts. Results show that cigarette butts and straws has been found as most abundant in the coastal section. In particular the concentration is higher in Transect#2. Secondly plastic caps/lids are more abundant in Transect#1 and Transect#2. By direct observation, has been reported that more plastic fragments has been found in Transect#1.

4. Discussion

The analysis of the results of the barcharts highlights the presence of wastes typical of the persistence of the tourist sector on the coastal trait considered. Most prominent resulted in cigarette butts, straws and plastic caps.

Such considerations have been brought to the common discussion with the involved volunteers provided by the protocol of From Trash2Treasure[7]. A facilitated, group discussion has indeed involved all the students over the data collected. The discussion has been supported by the map reported in Figure 1, with all the georeferenced points where trash on the shore has been collected. The map has been also overlap with some layers of Google Maps© showing also the commercial and touristic activities nearby the areas of waste collection, Thanks to the support of the maps the common discussion brought to identify the presence of two beverage selling huts and bars on the shore, properly in Transect#2 (Figure 4). A first observation that came out from such comparison has been that the higher concentration of cigarette butts and plastic straws and caps, could be related to the presence of the two beverage selling huts.

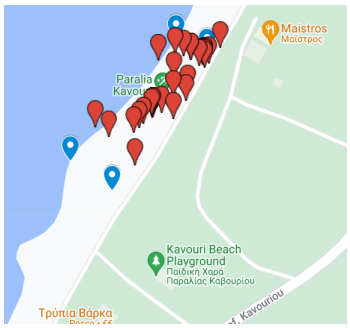


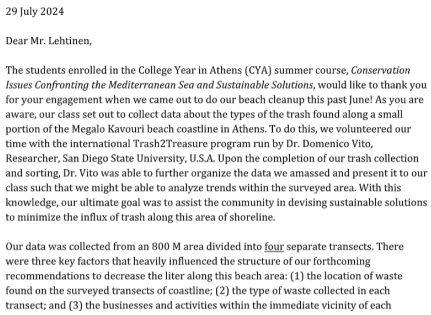
Fig. 4. Overlap of layers with commercial and touristic activities nearby the areas of waste collection

The collective deep analysis of the data collected and the maps has led also to identify the lack of sufficient number of segregated trash bins on the shore and the absence of structures to support disabled peoples to correctly dispose of wastes.

In conclusion, discussing about the geomorphological structure of the trait of the beach,it has been realized that Transect#1 was made of more rocky and stone shore that may facilitate the mechanical degradation of plastic, resulting in a higher presence of plastic fragments in that area.

5. Conclusions

The applicated “From Trash2Treasure” citizen science research initiative protocol on the Megalo Kavouri Beach, in Athens, GR with a class of undergraduate students in the United States spending an abroad period at the One Year in Greece University has generated a set of citizen science data that have been rendered in a GIS map and a series of graphs reporting the distribution of litters along the case-study beach. Fostering a citizen science approach, such outcomes have been discussed and commented on in a group discussion with the students involved
The collective reflection based on the acquired data resulted in feedback and suggestions, useful to actually recognize and tackle the environmental problem related to waste presence on the shore.
In order to be translated into effective impact the students have decided to collect their inputs and reflection in an official letter addressed to the Municipality of Athens, offering possible solutions to be implemented at the Megalo Kavouri Beach.



29 July 2024

Dear Mr. Lehtinen,

The students enrolled in the College Year in Athens (CYA) summer course, *Conservation Issues Confronting the Mediterranean Sea and Sustainable Solutions*, would like to thank you for your engagement when we came out to do our beach cleanup this past June! As you are aware, our class set out to collect data about the types of the trash found along a small portion of the Megalo Kavouri beach coastline in Athens. To do this, we volunteered our time with the international Trash2Treasure program run by Dr. Domenico Vito, Researcher, San Diego State University, U.S.A. Upon the completion of our trash collection and sorting, Dr. Vito was able to further organize the data we amassed and present it to our class such that we might be able to analyze trends within the surveyed area. With this knowledge, our ultimate goal was to assist the community in devising sustainable solutions to minimize the influx of trash along this area of shoreline.

Our data was collected from an 800 M area divided into four separate transects. There were three key factors that heavily influenced the structure of our forthcoming recommendations to decrease the liter along this beach area: (1) the location of waste found on the surveyed transects of coastline; (2) the type of waste collected in each transect; and (3) the businesses and activities within the immediate vicinity of each

Fig. 5. Front Page of the letter addressed to the Mayor of Athens after the From Trash2Treasure beach litter activity.

In conclusion the discussed case study offered a concrete application of citizen science oriented data collection protocol, showing a full stack implementation from data collection to participative discussion to the transferal into the suggestion of possible solution to the environmental problem coming from the citizen science approach.
The case study indeed also demonstrated the potential of citizen science to bridge the gaps between communities, science and policy making , rendering a more synergic interaction among the involved stakeholders that supposedly can result into a more effective and awareness-based address of the environmental problem.

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