Microplastic Particles in Sandy Beaches of Thessaloniki Gulf, Greece

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Abstract: - Microplastic pollution is a major issue for aquatic ecosystems. In this study, an assessment of microplastic pollution in beach sediments of Thessaloniki Gulf is presented. Sand sampling was performed in October 2021, in three different coastal areas along the seashore of Thessaloniki Gulf, in NW Aegean Sea. In total, nine sand samples were collected and examined. The morphology of the detected microplastics was recorded: they were fragments and microfibers. Their abundance ranged from 0-32 items/m^3. Higher concentrations of microplastics were observed in Karabournaki Beach, located in the city of Thessaloniki. It is the second largest city in Greece, inhabited by about 1,5 million people. Regarding the color, black, red, blue, green, and transparent microplastic fragments were found. Black and blue particles were the most common. Chemical detection and identification were performed with FT-IR spectroscopy. Four polymers were detected: polyethylene (PE), terephthalate (PET), high-density polyethylene (HDPE), polypropylene (PP), and polytetrafluoroethylene (PTFE). Polyethylene terephthalate was the dominant identified polymer (50%). The need for plastic pollution management in coastal areas, as well as the need to communicate the issue of plastic marine pollution and enhance public awareness, are discussed.

Key-Words: -marine pollution; microplastics; sediments; FT-IR; coastal management, Thessaloniki Gulf.

Received: March 17, 2023. Revised: October 9, 2023. Accepted: December 12, 2023. Published: December 31, 2023.

1 Introduction

Microplastic pollution is a major environmental problem as a result of the multiple uses of plastic in modern societies. Microplastics (MPs) are a threat to both marine organisms and human health since their presence has become evident in most ecosystems, [1]. The cumulative global production of plastics in the 50's was 1.5 million tons, while in 2020 reached 367 million tons, [2]. Marine plastic pollution affects ocean health, ecosystems, biodiversity, wild animal conservation, and welfare, [3]. The first records of plastic ingestion by Canadian seabirds are from the early 1960s, [4], [5].

Microplastics are plastic pieces smaller than 5 mm [6]. Two types of microplastics are contaminating the world's ocean: primary and secondary microplastics. Primary MPs are those that enter the environment when their dimension is <5 mm, [7]. They are produced through industrial production and are mainly used in personal care products, creams, cosmetics, and other plastic nanoparticles. Secondary microplastics result from the fragmentation and weathering of larger plastic items, [8].

Identification and quantification of microplastics in the marine environment is a major concern during the last decade, [9], [10], [11]. In the present work, microplastic particle concentrations were determined on three sandy beaches of Thessaloniki Gulf. The study aimed to provide data on microplastics' degradation in the beaches around the metropolitan area of the city of Thessaloniki, assess the abundance of microplastics in Thessaloniki Gulf and identify the chemical composition of the collected microplastic fragments.

2 Materials and Methods

2.1 Description of the Study Area

Three beaches located along the coastline (Figure 1) of the Gulf of Thessaloniki (inner Thermaikos Gulf), were selected for sampling, based on their geographic location (Table 1). Thermaikos Gulf is a semi-enclosed coastal basin, located in the northern part of the Aegean Sea. Along the northern coast of the gulf is located the city of Thessaloniki, the second largest city in Greece inhabited by about 1.5 million people. Four rivers, Axios, Aliakmonas, Loudias, and Gallikos, discharge in the gulf forming an ecologically important deltaic environment, [12], [13]. Various sources of pollution affect water and sediment quality in the coastal zone: effluents from the industrial zone of Thessaloniki, the wastewater treatment plant of the city, agricultural runoff from Thessaloniki's rural areas as well as the activities in the harbor of the city and plastics used in intensive mussel farming, [14].

The coastal area of Aggelochori (Figure 2, right) is located in the southeast part of the gulf. Kalochori (Figure 2, in the middle) is located to the west of Thessaloniki Gulf. The lagoon in this area is part of the European Ecological Network of NATURA 2000 Areas, a network of nature protection zones in the territory of the European Union. Karabournaki- Deauville beach (Figure 2, left) is one of the beaches of the city in the suburb Kalamaria. The beach is still used by some swimmers.

Fig. 1: Sampling sites

Fig. 2: Photos of the sampling sites

2.2 Wind-driven Circulation of Waters

Coastal hydrodynamics in the area are affected mostly by the wind. The circulation of waters is characterized by the entrance of northeastern less saline waters from the North Aegean and the Black Sea, moving along the east shores to the west and northwest of the gulf, [14].

2.3 Sampling

At each sampling area the "Guidance on Monitoring of Marine Litter in European Seas" protocol was used to collect and analyze sediment samples, [15]. A random grab sampling of beach sand for microplastic separation was carried out on the 21st of October 2021. On each beach, three random sampling sites of 1 m^2 each were chosen. A jar of 250 mL of sand was collected from every point, using a stainless steel spatula. The filled jars were placed in a dark and cool place, as soon as possible, to prevent deterioration of the samples.

Separation of the lighter plastic particles from the heavier sediment grains, was obtained by mixing a portion of the sample (100 g) with a saturated solution (concentrated saline NaCl solution 1.2 g cm^{-3}) and stirring for a certain period, [16], [17]. This method was chosen, among others, because it is simple and environmentally friendly. The sample was filtered through a 20 μm filter. The filter was rinsed with deionized water to remove any salt. During the analysis in the laboratory, researchers wore lab coats and there was a filter wetted with deionized water on the bench top, to study any contamination of the laboratory environment.

Table 1. Geographical coordinations of the sampling sites

Site	Longitude	Latitude
Kalohori (Axios River Delta)		
1	22.670807	40.526942
2	22.671766	40.527112
3	22.674461	40.527854
Aggelohori (beach to the eastern Gulf)		
1	22.817236	40.498427
2	22.816932	40.498025
3	22,816502	40.497475
Thessaloniki-Karabournaki (Deauville Beach)		
1	40.588831	22.942297
2	40.588974	22.942789
3	40.589357	22.943632

2.4 Sample Characterization

After the separation, the samples were examined under a stereomicroscope (SLX-3, OPTIKA, magnification 10x), to identify the type of microplastic items and record their color. The samples were analyzed by FT-IR spectroscopy method with a Jasco FT-IR 6700 spectrometer. In each sample, spectrum was recorded three times in the area of 4000-400 cm^{-1}, after 64 scans and baseline correction. This method provides a unique spectrum for each type of polymer, it requires a small sample quantity and provides great reliability, [18]. Interpretation of the spectra was performed with the aid of OpenSpecy software, [19].

Fig. 3: Microplastic fragments of sediment samples from the beach in Kalamaria

3 Results

3.1 Microplastic Observation and Enumeration

A total of thirty-one microplastic particles, were collected from the three beaches shown in Table 1. Most of the items found in these samples were fragments (55%) and microfibers (45%).

From Kalohori, close to the Axios river Delta, two fragments and one microfiber were collected. The size of the items was too small to conduct FT-IR analysis. From the beach in Aggelochori, to the east of Thessaloniki, two fragments were collected and one of these was PET. From Karabournaki-Deauville Beach in the suburb Kalamaria, twenty-three items, thirteen fragments, and eleven microfibers, were collected (Figure 3). The highest percentage 70%, of microplastics were found in Karabournaki, and the lowest, 9.6%, in the Axios river Delta (Figure 4).

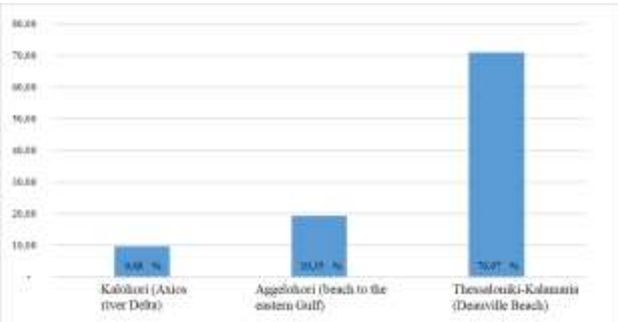

Fig. 4: Microplastics % in each sampling site

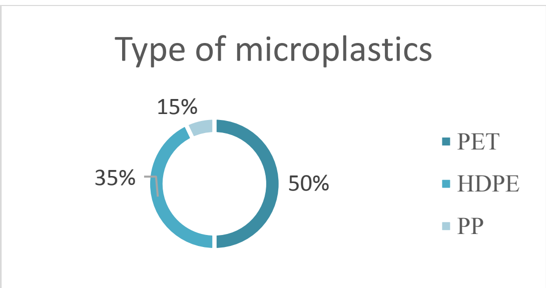

Fig. 5: Type of microplastics

Microplastic fragments and fibers were 54.8% and 45.1% of the items, respectively. Most of the fragments were blue (59%) followed by red color (29%). Among the fibers black was the dominant color (71%), followed by red (14%). Terephthalate (PET) was the origin of 50% of the microplastics (Figure 5). The second most abundant polymer was high-density polyethylene and a smaller percentage was polypropylene.

3.2 FT-IR Analysis

The fragments from all samples were analyzed by FT-IR spectroscopy method. Figure 6 and Figure 7 show the beached IR spectra of HDPE and PET, respectively. Characteristic PET peaks were at 2833 and 2851 cm^{-1} [16]. HDPE spectrum of the samples peaks were at 2872 and 2950 cm^{-1}, [20].

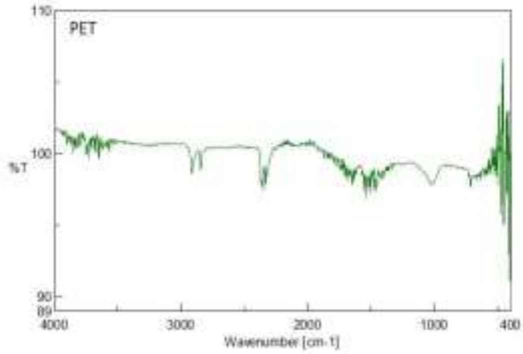

Fig. 6: Beached sample IR spectrum of PET

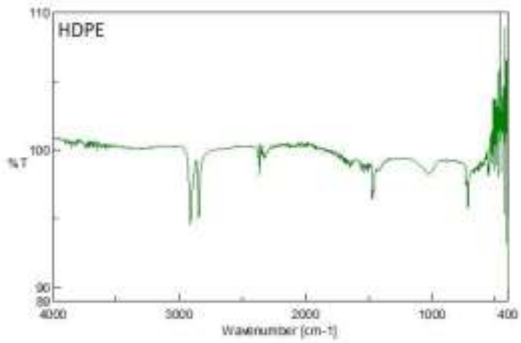

Fig. 7: Beached sample IR spectrum of HDPE

4 Discussion

Plastic fragments and microfibers were found on the three beaches in Thessaloniki Gulf, made of PET and HDPE. PET was identified as the prevailing polymer in all three sampling locations, while on Karabournaki Beach, most of the fragments originated from HDPE. Plastic polymers can be found in our daily life such as polyethylene terephthalate in plastic bottles, polyethylene in plastic bags, or polypropylene in food packaging and ropes. Polyethylene is an indispensable commodity polymer widely used in the production of synthetic packaging materials, [21]. This polymer can be further classified as high-density and low-density polyethylene (HDPE and LDPE). Samples from Karabournaki Beach presented a greater occurrence of microplastics, possibly due to Thessaloniki's high population and the proximity to major urban sources. Since many of the micro and nano plastics are dangerous for the environment and human health, [22], more studies are necessary to evaluate microplastic pollution in Thermaikos and Thessaloniki Gulfs. Regulation of the urban development in coastal environments is necessary since the level of pollutants in coastal aquatic habitats is of increased concern, [23], [24]. The management of marine plastic pollution has many aspects: starting from people's perception of the environmental risks of plastic use, to legislation and decisions from the stakeholders and decision-makers. Public awareness of the environmental threat of microplastics is needed as well as appropriate legislative and management actions for plastic use and disposal in the oceans.

5 Conclusion

Polyethylene terephthalate (PET) was the dominant identified polymer on Thessaloniki Gulf beaches, as a result of plastic bottles carelessly disposed of in the coastal zone and marine environment. Management measures are required for marine litter disposal.

Acknowledgement:
The authors want to express their appreciation to Dr. Anastasia Kyriakoudi, post-graduate researcher in the Laboratory of Food Chemistry and Biochemistry, School of Agriculture, AUTh, for her valuable contribution to FT-IR analysis.

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Contribution of Individual Authors to the Creation of a Scientific Article (Ghostwriting Policy)

- Ioanna Tzioga carried out the field and laboratory work. She also prepared the initial draft.
- Amalia Moriki was responsible for organizing research and contributed to editing and the final manuscript.

Sources of Funding for Research Presented in a Scientific Article or Scientific Article Itself

No funding was received for conducting this study.

Conflict of Interest

The authors have no conflicts of interest to declare.