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Microplastics identification in an environmental reserve area of Ilha de Itamaracá – PE

Erik Castilho Bussmeyer[a], Cândida Juliana Albertin Santos[a], Laureen Michelle Houllou[a]

[a] Centro de Tecnologias Estratégicas do Nordeste-CETENE. Avenida Professor Luiz Freire, n. 01, Cidade Universitária, Recife, Pernambuco, Brasil. CEP: 50740-545. E-mail: erik.bussmeyer@cetene.gov.br, candida.santos@cetene.gov.br, laurren.houllou@cetene.gov.br.

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A B S T R A C T

Microplastics are present in numerous aquatic ecosystems worldwide. They can originate from the deterioration of larger plastics or be produced directly, such as microbeads in personal care products. Research on the presence of microplastics in aquatic environments is highly relevant due to their environmental impacts on flora, fauna, and human health. These microscopic plastic fragments, smaller than five millimeters, have been found in rivers, oceans, lakes, and even mangroves worldwide. This study aimed to evaluate the presence or absence of microplastics in environmental preservation areas, APA Santa Cruz, Ilha de Itamaracá- PE, in aquatic environments. Mangrove water samples from Ilha de Itamaracá were collected and analyzed, revealing a significant discrepancy between sample collection points that were very close. The results indicate the presence of microplastics in the area, with a notable difference between the two collection points studied. In that sense, there is a clear need for a better understanding of how microplastics interact with the aquatic environment. A more in-depth study is necessary to develop effective strategies for mitigating negative environmental impacts.

Keywords: Petrochemical pollution, ecosystems, environment, mangrove.

Introduction

Microplastic pollution has drawn attention to debates about negative environmental impacts worldwide. This is because tons of plastics are thrown into the oceans due to inadequate disposal (Neves, Pierri & Fonseca, 2022). This plastic, which ends up at sea, suffers weathering due to its exposure to various factors, such as solar radiation, temperature, salinity, and waves, and degrades into smaller pieces, known as microplastics (Brito, 2014; Silva, 2021). Microplastics can be divided into two main categories: primary microplastics, which are produced in the shape of small particles, such as microbeads present in personal hygiene products, and secondary microplastics, which are the result of the deterioration of larger plastics (Olivatto et al., 2018). These polymer particles can occur in different environments, such as oceans, rivers, soil, and air. Mangroves are characterized by trees and shrubs adapted to survive in saline and waterlogged soils, often flooded by tides (Souza et al., 2018). In the bioeconomy, we can maintain that mangroves provide highly important environmental services to society, mainly as a source of fishing resources, as mangroves are responsible for more than 95% of the food humans take from the oceans, and boost ecotourism. However, more specific functions are related to its role in physical processes on the coastline and its influence on adjacent ecosystems (Nanni, Nanni & Segnini, 2005).

Considering the different environments in which the presence of microplastics can impact, special attention has been given to mangrove areas and estuaries. Because the mangrove area is the transition between the marine and terrestrial environments, it is more impacted due to its proximity to the urban environment.

The main concern about mangrove areas is the impact of microplastics on environmental services. Mangrove areas are breeding grounds for several species of animals and, consequently, are responsible for maintaining fishing resources. Therefore, contamination of the biome by microplastic particles is considered potentially catastrophic. The threat to marine ecosystems and marine life exposed to microplastics is related to the ingestion of these particles by animals, which affects the entire food chain. Another aggravating factor is that microplastics can transport toxic chemical substances, such as pesticides and persistent organic pollutants, and, when ingested by organisms, contaminate fish, mollusks, crustaceans, and birds (Duarte, 2022).

As this contamination is anthropic, it is believed that Environmental Preservation Areas (EPAs) should have a lower contamination rate by microplastics.

However, little is still known about the extent to which these microplastics may be present in mangrove EPAs in northeastern Brazil. Therefore, the study aimed to analyze the occurrence of microplastics in mangroves in the Environmental Preservation Area (EPA).

Materials and Methods

The samples were collected at two sampling points in the mangrove at EPA Santa Cruz on the Ilha de Itamaracá in Pernambuco State (Figure 1). The collections took place in two different locations, P1 and P2. Location P1 corresponds to the coordinates 7°48'45.8"S 34°50'55.2"W, relatively far from the seafront between Forte Orange and the Trilha dos Holandeses. Location P2 corresponds to 7°48'41.0"S 34°51'26.5"W, very close to the sea on the Trilha dos Holandeses.

Figure 1. Location of the sample collection points (P1 and P2) in the Santa Cruz Environmental Protection Area (EPA), Ilha de Itamaracá, PE. Blue represents the adjacent marine area influenced by coastal and estuarine dynamics. Green indicates preserved natural vegetation, predominantly mangrove forests. Pink corresponds to the anthropogenic occupation or controlled land use. Beige patches represent clearings or sparsely vegetated zones. P1 is located closer to the marine boundary, influenced mainly by tidal waters, while P2 is positioned further inland, within the mangrove vegetation, subjected to mixed freshwater and saltwater conditions. Point P1: 7°48'45.8"S 34°50'55.2"W; Point P2: 7°48'41.0"S 34°51'26.5"W. Font: Bussmeyer & Houllou (2023).

Water samples were collected and stored in 1000-mL amber glass containers to avoid cross-contamination. At Centro de Tecnologias Estratégicas do Nordeste (CETENE)'s Laboratório de Pesquisas Aplicadas à Biomas (LAPAB), larger debris was removed through filtration through a 500-mesh metal sieve and washed with Mili-Q water five times.

Considering the optical microscopy analysis, 35% hydrogen peroxide was applied to the samples in 12 hours. This procedure allowed the organic matter present in the sample to be degraded. After that, they were rewashed in Mili-Q water and filtered again. The sample obtained at the end of this process was taken to a drying chamber at a temperature of 55°C in a 100 mL Becker Cup to reduce the solution through evaporation. After this concentration step, the concentrated solution was successively deposited in drips on a microscope slide. These glass slides, with the samples, were dried in a drying chamber for 30 minutes.

Then, the existence of fibers, fragments, spheres, and other forms of microplastic was checked using a Xiaomi optical stereomicroscope, Beaver Intelligent Microscope, model DDL-M1/Pro, with a 400-times-magnification.

Results and Discussion

All samples collected at the two collection points (P1 and P2) in the EPA of Ilha de Itamaracá contained plastic microparticles. This result indicates that, despite this area belonging to a preservation area, which, at first, should suffer less influence from anthropogenic effects (such as inadequate plastic waste disposal), it is not free from microplastics.

Figure 2 presents the results of the samples, which showed that 38,000 particles m-3 were found in location P2 and 4,000 particles m-3 in location P1.

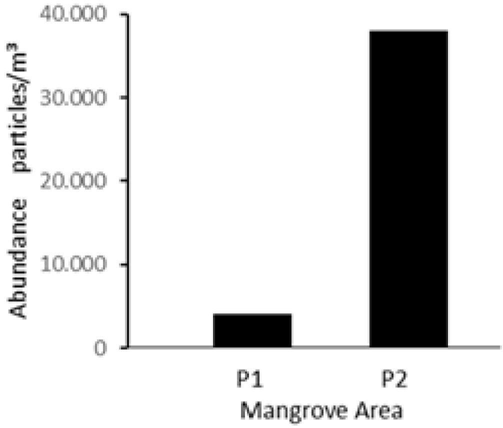

Figure 2. Comparative analysis of the microplastic particles estimated from data collected in areas P1 and P2 in the Environmental Protection Area (EPA), Santa Cruz, Ilha de Itamaracá, Recife, Pernambuco, Brazil. Font: Bussmeyer & Houllou (2023).

The numbers observed at the collection point P2 were higher than those described by Lima et al. (2014) in Goiana, PE. In this study, in Goiana, 26.04 particles 100 m^{-3} were described. Collections in the Atlantic Ocean by Silvestrova & Stepanova (2021) described detecting 1823 particles m^{-3}. According to Kye et al. (2023), microplastic particles were found in different concentrations in different marine aquatic environments. However, according to these authors, the lack of standardization in sample collection and processing could influence the differences in the quantities of particles identified in the results.

However, in the current study, the differences observed between the two collection points cannot be attributed to differences in the methodology adopted.

Ilha de Itamaracá is part of the EPA de Santa Cruz, which is a Conservation Unit (integral protection) that intends to protect natural environments by guaranteeing the existence or propagation of species or communities of local native flora and resident or migratory fauna, according to Articles 8 and 13, Federal Law nº 9,985/2000 (Brasil, 2018). However, this area has significant urban, commercial, and tourist zones. It must be considered that the presence of human activity so close to or even inserted in an EPA may be correlated to the values of plastic microparticles found in this study.

Another parameter that can influence the presence of microplastics in areas P1 and P2 is that plastic that reaches the sea degrades to become microplastic (Brito, 2014; Silva, 2021) and can be deposited in mangrove areas (Almeida, 2013) by the tides. In this way, the incidence of microplastics in mangrove preservation areas may end up significantly interfering with this biome.

It is estimated that plastic bags can take around 20 years to break down, plastic bottles up to 450 years, and nylon fishing line 600 years, but no one knows how long petrochemical plastics take to generate microplastics. Solar incidence (UV rays), common in beach, mangrove, and ocean areas, is one of the major reasons for plastic fragmentation into increasingly smaller particles. Therefore, all the incorrect disposal over the last 100 years in the EPA Santa Cruz area could be a source of microplastic contamination.

Note that P1 and P2 are close locations, 1 km apart. At this point in the collection, it was impossible to identify what could be generating a discrepancy in the abundance of plastic particles at the two nearby collection points within the same environmental protection area.

The salinity level was also highest in the area with the highest incidence of microplastic (P2) (Figure 3).

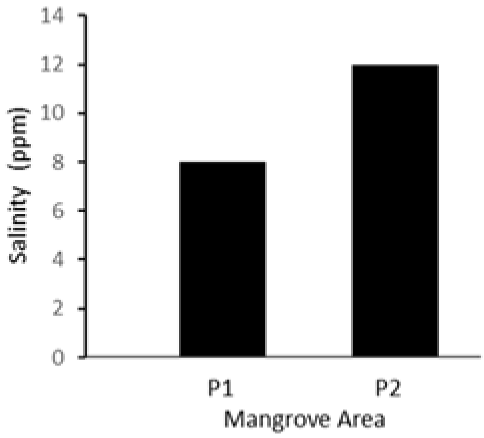

Figure 3. Comparative analysis of water salinity data collected in areas P1 and P2 of the Environmental Protection Area (EPA) Santa Cruz, Ilha de Itamaracá, Recife, Pernambuco, Brazil. Font: Bussmeyer & Houllou (2023).

The correlation between water salinity and the accumulation of microplastics has already been previously described by Zhou et al. 2021. According to these researchers, microplastic pollution in semi-enclosed seas is getting attention as it will likely accumulate in this environment. However, groundwork on the vertical distribution of microplastics and impact factors is still limited. In this study, carried out in the Baltic Sea, it was possible to distinguish the presence of salinity stratification affecting the vertical distribution of microplastics in the water column (Zhou et al., 2021). Based on Figure 3, we can see that we have 12 ppm salinity for 38,000 particles.m^{-3} at collection point P2 and 8 ppm salinity for 4,000 particles.m^{-3} at collection point P1. This result indicates that the number of plastic particles may be linked to the salinity level of the water. However, although there are indications that salinity can influence the accumulation of plastic microparticles, it is necessary to evaluate other factors (e.g., natural barriers in the relief, presence of old plastic waste in the region, the level of the marine current, the volume of water) which can also contribute to local differences in the number of plastics microparticles.

Until now, no limiting parameters of plastic particles or a reference table have been provided, classifying the amount of microplastic into tolerable levels threatening the environment. However, based on the information collected in this study, it is only possible to say whether microplastics exist. Scientific studies in the region have found microplastics on beaches and estuaries in Pernambuco (Montagner et al., 2021).

There is no standardization regarding the size and shape of the microplastic fragments found in collection areas P1 and P2 (Figure 4). Xia et al. (2021) also reported similar results regarding the variability of fragments found in water samples. This variability is believed to correlate with the different plastic sources that were fragmented and deposited in the sample collection area (Rosal, 2021).

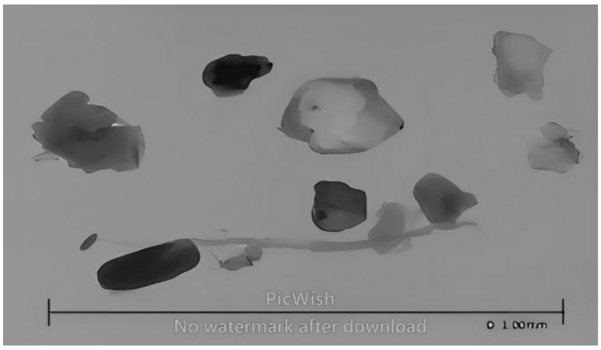

Figure 4. Examples of microplastic fragments found in collection areas P1 and P2 in the Environmental Protection Area (EPA), Santa Cruz, Ilha de Itamaracá, Recife, Pernambuco, Brazil. Bar = 1 mm. Font: Bussmeyer & Houllou (2023).

Regarding the types of fragments found in the two collection areas, the most commonly found fragments were fiber fragments, both in area P1 (Figure 5) and in area P2 (Figure 6).

Figure 5. Microplastic fibers. Example of the microplastic most commonly found in the collection area P1. Bar = 1 mm. Font: Bussmeyer & Houllou (2023).

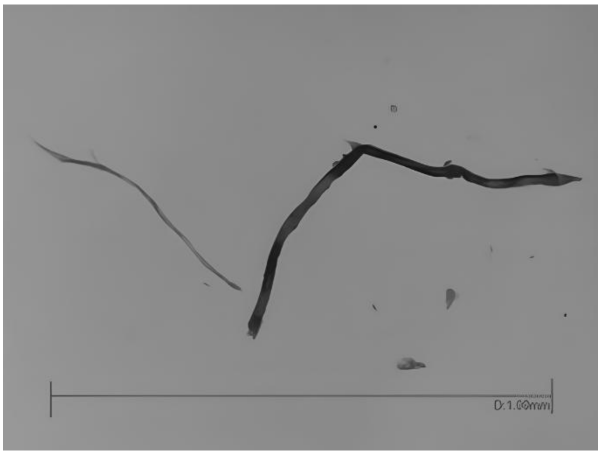

Figure 6. Microplastic fibers. Example of the microplastic most commonly found in the collection area P2. Bar = 1 mm. Font: Bussmeyer & Houllou (2023).

Generally, microplastics are found in the environment in various forms. This information is a useful tool for indicating the potential origin of particles. According to Massareli et al. (2021), it is possible to use an image analysis script to differentiate particles based on their primary morphological characteristics, such as fragments, pellets, lines, and fibers, and consequently, associate these characteristics with the primary sources of microplastic origin. On the other hand, in a recent article, Genchi et al. (2023) report that microfiber particles found in water samples, only one in four are of plastic origin. The rest are cellulose fibers. However, the sample processing used in this research (incubation in 35% hydrogen peroxide for 12 hours) would eliminate all material of organic origin. Thus, after eliminating all organic matter, it was found that the predominance of fiber-shaped microplastic particles is the most common form, regardless of the number of particles per cubic meter of water in the EPA collection areas on Ilha de Itamaracá (PE).

The presence of these particles is potentially harmful to the area's fauna as animals ingest microplastics due to their presence in different foods and forage. According to Urli et al. (2023), these small particles and additives used to improve the effectiveness and existence of these plastics can potentially cause harm to tissues and cellular systems due to their ability to "trigger off" multiple tissue function cascades, thus leading to infection, cytotoxicity, genotoxicity and immunological toxicity in cells and tissues.

Therefore, microplastics in the Environmental Preservation Area (EPA Santa Cruz) indicate the likely need for continuous monitoring to better assess the possible consequences and necessary mitigation measures for species that depend on this area for reproduction.

Conclusion

Despite restrictions on access and care in preserving EPAs, these areas are not exempt from microplastic contamination. The factors behind the differences in the number and type of microplastic particles found in the two collection areas require further study to support the understanding of the components that may be causing this discrepancy. Priority should be given to conducting further studies that identify the extent of environmental compromise, its origins, and potential mitigation methods.

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