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Note

The effects of plastic bags presence on a macrobenthic community in a polluted estuary

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ABSTRACT

The damaging effects of marine debris on wildlife are often noted through the observation of animals that ingest and/or become entangled in debris. Yet, few studies have evaluated the effects of marine litter on benthic habitats. The aim of this study was to investigate if the presence of plastic bags has any effect on benthic macrofauna in an estuary located in an urban area in North-eastern Brazil. Biogeochemical and macrofauna samples were obtained from 10 different deposition locations (location factor), under, border and distant (treatment factor) from plastic bags. The results did not show any significant alterations in the biogeochemical parameters of the sediment due to treatment effect except for summed microphytobenthic pigments. The macrobenthic community structure responded to treatment. The greatest dissimilarity (34%) was between samples that were under and distant. Effects occurred despite the high dynamics of deposition-resuspension of plastic bags and the dominance of opportunistic species. Changes in community structure are a complex result of plastic bags effects on species ecological interactions in the polluted estuarine environment, attracting deposit feeders, diminishing suspension feeders and providing mechanical protection against predation by seabirds.

1. Introduction

In accordance with the Law of Marine Residues (33 U.S. Code § 1951 et seq.), marine debris is defined as any solid and persistent material that is fabricated or processed and is directly or indirectly, in an intentional or unintentional manner, eliminated/abandoned in the marine environment. This includes synthetic products made of plastic, glass, metal or rubber, such as abandoned fishing and boating equipment, varying in size from micrometres (plastic pellets) to meters (UNEP, 2009, 2014; Lippiatt et al., 2013; Bergmann et al., 2015).

Marine debris can accumulate on beaches, oceanic gyres and in areas of ocean convergence (Goldstein et al., 2012; Leichter, 2011; Beron-Vera et al., 2016), becoming a threat to human and marine life. The adverse effects of marine debris on wildlife are often displayed through the direct observation of animals that digest and/or become entangled in debris (Laist, 1987; Derraik, 2002; Katsanevakis, 2008; Gregory, 2009; Ryan et al., 2009; Lusher et al., 2013; Gall and Thompson, 2015).

The degradation of coastal habitats due to debris deposition associated with other pollution sources, can cause long-term effects on marine biodiversity. This is due to the fact that the majority of marine species are present in areas that are of great ecological importance, for example coral reefs, mangroves, salt marshes, marine sea grass and algae meadows (NOAA, 2016), which function as growth sites or nurseries for almost all marine species. Among these significant areas, mangroves stand out as one of the ecosystems most subjected to debris deposition (Kathiresan and Bingham, 2001; Cordeiro and Costa, 2010).

The focus of most concern, regarding marine litter, is plastic debris, which accounts for approximately 80% of anthropogenic debris according to studies on marine litter (Plastic, Valuing, 2014). Plastic items represent a class of materials with highly multifunctional and desired commercial properties; including resistance, durability, low density, thermal and electric isolation and barrier capacity (Law, 2017). For this reason, they have become an icon of the disposable consummation society. According to Plastics Europe, 2016 (Association of Plastics Manufacturers), in 2015 the global production of plastic material was estimated as 269 million tonnes. In the same year, Jambeck et al., 2015 estimated that 275 million MT of plastic residues were produced in 192 coastal countries in 2010, with approximately 4.8 to 12.7 million MT of plastic residue entering the ocean.

Trawling and direct observation research has shown that plastics and other persistent products are found in all ocean seabeds across the

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world (Barnes et al., 2009). The majority of plastics are deposited in benthic environments due to the encrustation of organisms on the material, which increases the material's density causing it to sink (Ye and Andrady, 1991). The presence of debris directly affects benthic sediment, due to structural modifications that alter microhabitats which are home to diverse communities of animals, plants and algae (Gilardi et al., 2010). Consequences associated with the accumulation of plastic debris include ecological costs that result in the direct mortality of fauna and the loss of habitat, as well as economic and aesthetic costs associated with diminished tourism (Klein et al., 2004; Araújo and Costa, 2006).

However, few studies have evaluated the effects of plastic debris cover on infaunal organisms in soft bottom benthic habitats, with the exception of the manipulative study by Green et al. (2015). The authors observed that plastic bags promoted anoxic conditions in sediments, reducing primary productivity and consequently, the abundance of infaunal invertebrates. Information on benthic community composition in areas with and without plastic debris is available in Uneputty and Evans (1997), for a bay in Indonesia. In their observational study, the authors concluded that there was an increase in the abundance of meiofauna individuals and a reduction of diatoms in areas with litter when compared to litter-free sites. Meanwhile, no significant changes were observed for macrofauna density. In contrast, Moore (2008), concluded that the accumulation of plastics in benthic sediments could lead to the inhibition of gas exchange at the water-sediment interface, suffocating benthic organisms.

There is a greater abundance of information on the effects of marine litter on individuals on consolidated substrates (Chiappone et al., 2005; Richards and Beger, 2011; Aloy et al., 2011; Carson et al., 2011). Although information on the harmful effects of plastic debris at an individual level are ample, it is also necessary to collect evidence on the effects of plastic debris at higher biological organizational levels, for example, associations of species or communities, as this evidence can be used to tailor conservation measures and/or policies (Green et al., 2015). Browne et al. (2015) recently observed that the effects of marine debris on populations and at the community level are relatively unknown.

The present observational study examined the possible impacts of the deposition of commercially circulated plastic bags on macrobenthic communities in an estuarine environment with a strong history of environmental disturbance.

2. Materials and methods

2.1. Study area

This study was carried out in Pina Basin (08°4′38.7″S/34°52′29.7″W) (see Fig. 1), located in the most internal part of the Recife Port, North-eastern Brazil. The Pina Basin is formed by the confluence of the rivers Tejipió, Jiquiá, Jordão, Pina and the southern arm of the river Capibaribe and as a result is considered a complex estuary. The Pina Basin receives domestic effluents, storm water runoff and diverse types of industrial discharge (Nóbrega, 2011) and is characterized as moderately disturbed (Valença and Santos, 2012) with eutrophic conditions (Silva et al., 2017).

2.2. Sampling design

In May 2017, samples were collected to analyse the abiotic and biotic variables in the intertidal zone of the Pina river basin. Ten locations with naturally weathered and deposited plastic bags in the intertidal zone were identified during the low tide, where samples of the sediment under the bag (under), near the bag (border) and at a distance of approximately 50 cm (distant) were collected to evaluate the effect of the plastic bags on the macrobenthic community. Therefore, two factors were considered for analysis: location and treatment.

2.3. Samples and data processing

The sampling procedure and the methodology used for the analysis of the environmental parameters and microphytobenthos parameters are listed in Table 1. For the collection of the environmental and microphytobenthos parameters we used cylindrical samplers with varying surface sample areas: granulometry and organic material (area: 17.4 cm^2) where the sediment was collected up to a depth of 5 cm; microphytobenthos (area 1.13 cm^2) where samples were collected up to a depth of 2 cm from the surface. The potential of oxidation-reduction (Eh) was measured in the field at a depth of 2 cm.

Macrofauna samples were collected with cylindrical samplers (area 78.5 cm^2) up to a depth of 10 cm, packed in plastic bags and fixed in 4% formaldehyde solution. In the laboratory the samples were stained with Rose Bengal, sieved in 0.3 mm mesh and maintained in 4% formaldehyde. Samples were screened with the help of a stereomicroscope and the macrofauna individuals that were collected were identified to the lowest possible taxonomic level.

2.4. Statistical analysis

Location (deposition points 1 to 10) and treatment (under, border and distant) effects were investigated using univariate and multivariate analyses for both environmental and macrofauna data.

Univariate environmental variables (silt-clay and organic matter percentages, microphytobenthic pigments chlorophyll *a* and phaeopigments, potential of oxidation-reduction and sediment compaction) and macrofauna indices [total density, species richness, Pielou's evenness and Shannon-Wiener's diversity (log2)] were tested for factor' effects using Friedman tests.

A Euclidean distance matrix for abiotic data (normalized data) and a

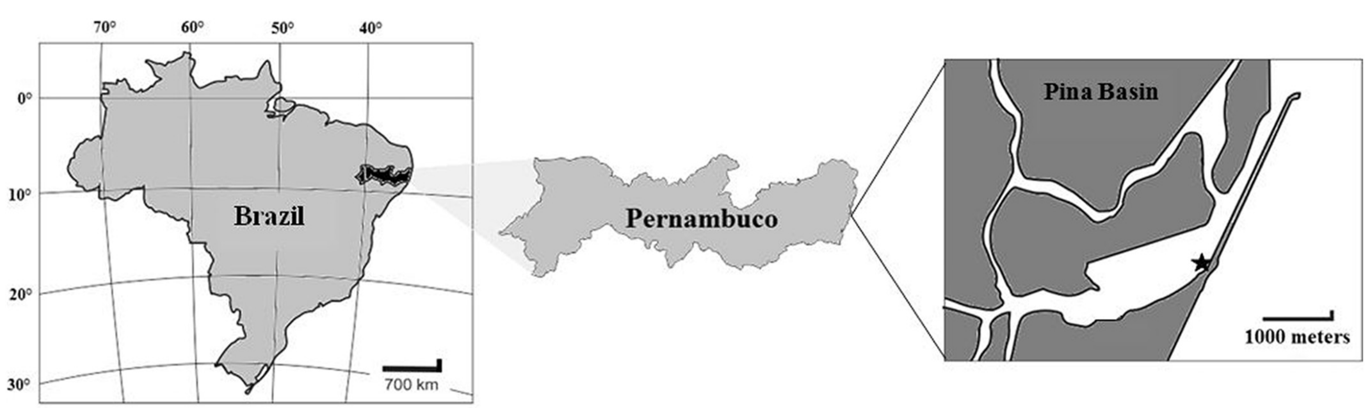

Fig. 1. Location of the study area on the coast-line of Pernambuco, North-eastern Brazil.