Marine Pollution Bulletin 126 (2018) 275–280

Contents lists available at ScienceDirect

Marine Pollution Bulletin

journal homepage: www.elsevier.com/locate/marpolbul

Baseline

Carbon accumulation and storage capacity in mangrove sediments three decades after deforestation within a eutrophic bay

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ARTICLE INFO

Keywords:
Mangrove sediments
Carbon accumulation
Organic matter source
Deforestation
Eutrophication

ABSTRACT

A dated sediment core from an eutrophic mangrove area presented non-significant differences in carbon accumulation rates before ($55.7 \pm 10.2\ g\ m^{-2}\ yr^{-1}$) and after three decades of deforestation ($59.7 \pm 7.2\ g\ m^{-2}\ yr^{-1}$). Although eutrophication effects appear to compensate the loss of mangrove organic matter input, the results in this work show a threefold lower carbon accumulation than the global averages estimated for mangrove sediments. The effects of increasing eutrophication and enhanced sediment dry bulk density observed after deforestation (~30% higher) did not result in higher carbon stocks. Moreover, the lower TOC:OP (< 400) and C:N (~20) molar ratios, as well as increased nutrient accumulation, reflect the dominance of phytoplankton-derived organic matter after deforestation, resulting in less-efficient sedimentary carbon sinks. These results indicate that the organic material deposited from eutrophication may not compensate mangrove deforestation losses on carbon accumulation in mangrove ecosystems.

The role of mangrove forests in accumulating high quantities of carbon has become increasingly evident (Kristensen et al., 2008; Breithaupt et al., 2012; Alongi, 2014). Although mangrove forests occupy ~1% of the global coastal area, these ecosystems are estimated to accumulate up to 20% of the sedimentary coastal carbon (Donato et al., 2011; Chmura et al., 2003; Ferreira and Lacerda, 2016). Mangrove trees and shrubs are also known to be important in filtering and burial nutrients (Sanders et al., 2016), providing stability to waterlogged sediments and protecting coastal areas against tidal forces, heavy rains and other hydrological pressures (Kathiresan and Bingham, 2001; Beard, 2006; Alongi, 2014).

However, current studies indicate that anthropogenic impacts on mangrove forests, such as deforestation and eutrophication, may significantly modify the carbon and nutrient accumulation rates and stocks within these ecosystems (Sanders et al., 2014; Lee, 2017; Pérez et al., 2017). These frequent anthropogenic impacts have had negative effects on the role of mangroves as a carbon sink. Many studies have determined the net loss of sedimentary carbon, and an increase in the release of carbon to the atmosphere and oceans due to deforestation (Lovelock et al., 2011; Breithaupt et al., 2012; Alongi, 2014; Bulmer et al., 2015; Grellier et al., 2017; Pérez et al., 2017). Moreover, anthropogenic eutrophication influences the ability of mangrove ecosystems to sequester carbon by enhancing carbon accumulation (Alongi et al., 2005; Lee, 2017). This sequestration is related to increasing the primary production and nutrient consumption (Kristensen et al., 2008; Duarte et al., 2013), changing the sedimentary organic matter sources (Sanders et al., 2014; Machado et al., 2016), increasing mangrove shoot production and decreasing root production by altering the physiological requirements (Lovelock et al., 2006, 2009).

Since the early 1950's, the mangrove-bound Guanabara Bay (Southeastern Brazil) has been exposed to a high influx of urban sewage and industrial effluents, which has accelerated the eutrophication processes (Monteiro et al., 2012; Brandini et al., 2016; Cotovicz et al., 2015). Furthermore, as a result of the urban development in the catchment during the previous decades, several mangrove areas within Guanabara Bay have been deforested (Kjerfve et al., 1997; Borges et al., 2009). The aim of this research is to assess the effects of mangrove deforestation on the carbon accumulation rates and stocks under the influence of anthropogenic eutrophication. Although it is assumed that deforestation may decrease the storage capacity of mangrove sediments, whereas eutrophic conditions may increase the carbon accumulation rates, there are currently no studies that combined both deforestation and eutrophication effects on sedimentary carbon accumulation.

This research was conducted in Guanabara Bay, located within the metropolitan region of Rio de Janeiro (SE Brazil) (Fig. 1). The Bay

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https://doi.org/10.1016/j.marpolbul.2017.11.018
Received 11 July 2017; Received in revised form 8 November 2017; Accepted 13 November 2017

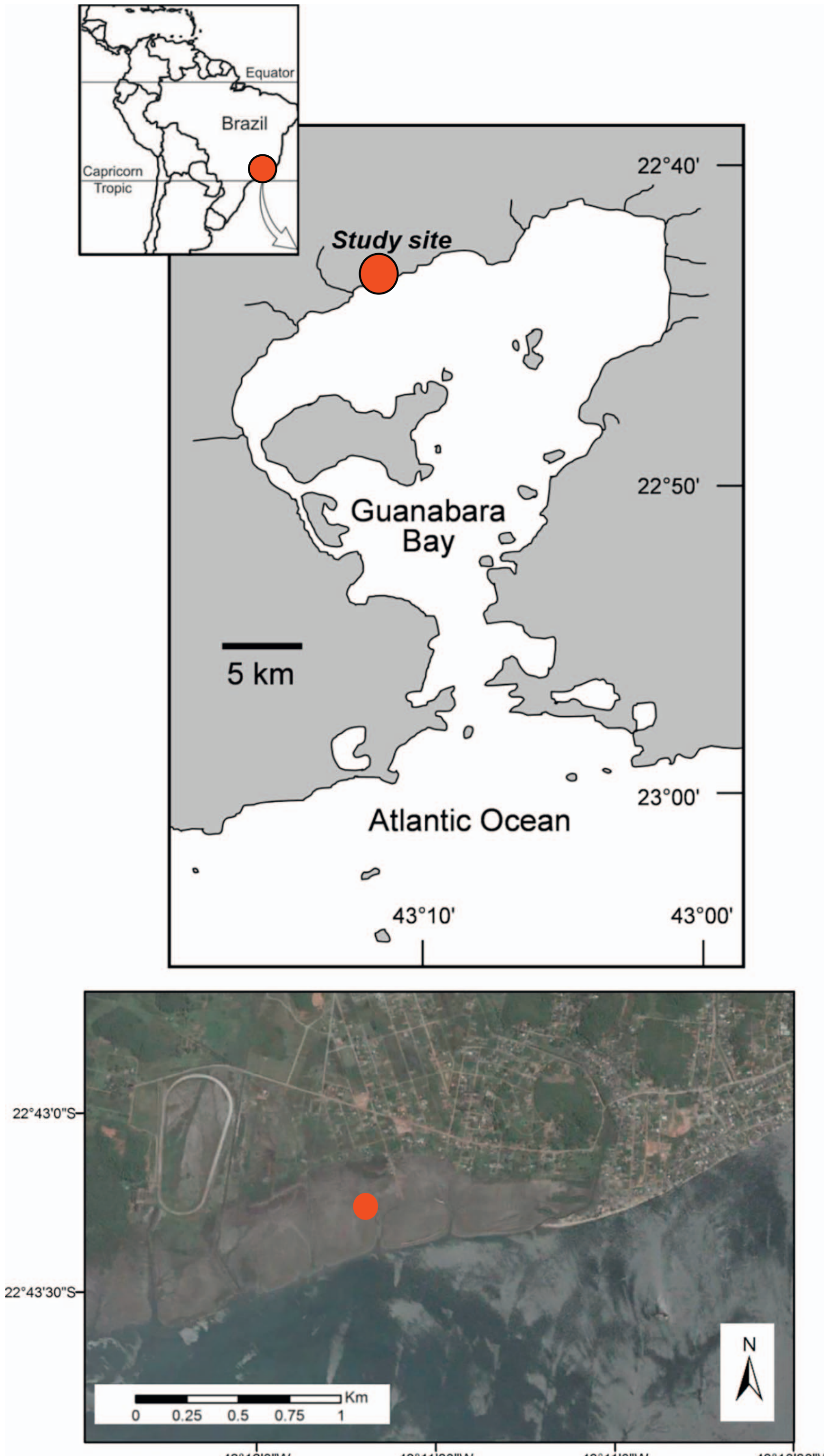

Fig. 1. Location of the sampling station within the Guanabara Bay (red circle). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

covers 384 km^2 of coastal area, a mean depth of about 5.7 m and, a semi-diurnal microtidal regime with an annual mean of 0.7 m (Kjerfve et al., 1997; Meniconi, 2012). The residence time of water for 50% of the water volume renewal is approximately eleven days, with a complex water circulation modulated by tides and geomorphology, with water velocities of 0.3 ms^{-1} in the inner regions with a predominant salt water circulation (Kjerfve et al., 1997). Furthermore, the Bay receives high quantities of untreated urban sewage, equivalent to ~ 350 $T\,d^{-1}$ of organic matter discharges (Bidone and Lacerda, 2004), resulting in predominantly anoxic and suboxic conditions in sediments and bottom waters, respectively (Ribeiro and Kjerfve, 2001; Matos et al., 2016). Furthermore, due to the urban development during the several previous decades, mangrove deforestation has increased, mostly *Rhizophora mangle* on the Northwestern area of the Bay, suffering a net mangrove forest loss of ~170 km^2. Also, the mangrove area extent is ~90 km^2 within the Bay, of which ~43 km^2 are located within