Ecotoxicology and Environmental Safety 104 (2014) 373–378

Contents lists available at ScienceDirect

Ecotoxicology and Environmental Safety

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

Toxicity of sediments from a mangrove forest patch in an urban area in Pernambuco (Brazil)

D.D. Oliveira [a,*], L.P. Souza-Santos [a], H.K.P. Silva [b], S.J. Macedo [a]

[a] Universidade Federal de Pernambuco – UFPE, Departamento de Oceanografia, Av. Profº Moraes Rêgo, S/N. Cidade Universitária – Recife/PE. CEP. 50670-901, Brazil

[b] Associação Instituto de Tecnologia de Pernambuco – ITEP/OS - Laboratório de Química de Água – LQA; Av. Profº Luiz Freire Nº 700. Cidade Universitária – Recife/PE. CEP. 50740-540, Brazil

ARTICLE INFO

Article history:
Received 6 July 2013
Received in revised form
4 February 2014
Accepted 5 February 2014
Available online 17 April 2014

Keywords:
Brazil
Pollution
Tisbe biminiensis
Sediment
Trace metals

ABSTRACT

Industrial and urban residues are discharged every day to the rivers and may arrive at the mangrove forest and prejudice the quality of the environment and the organisms present there. The mangrove forest patch studied is encircled by an urban area of the city of Recife (Brazil) that has approximate 1.5 million inhabitants and is one of the most industrialized centers in Northeast Brazil. The aim of this study was to assess the quality of the sediments of this mangrove patch in terms of metal contamination and ecotoxicology. Samples of surface sediment were collected in six stations for toxicological tests and trace metal determination (Cr, Zn, Mn, Fe, Cu, Pb, Co and Ni), in July and August, 2006 (rainy season); and in January and February 2007 (dry season). Toxicity tests with solid-phase sediments were carried out with the copepod *Tisbe biminiensis* in order to observe lethal and sub-lethal endpoints and correlate them with chemical data. In June, there were no observed lethal effect, but two stations presented sub-lethal effects. In January, lethal effect occurred in three stations and sub-lethal in one station. The levels for Zn and Cr were at higher levels than international proposed guidelines (NOAA). There was a negative significant correlation between the copepods' fecundity, and Zn and Cr concentrations. Therefore, the studied sediments can be considered to have potential toxic to benthos due to the high content of Zn and Cr.

1. Introduction

Mangrove sediments have the capacity to accumulate material released in coastal and marine environments due to their particular physicochemical properties (Harbinson, 1986; MacFarlane and Burchett, 2000). For this reason, high concentrations of trace metals were recorded in sediments of mangroves around the world, and often, it reflects long-term pollution caused by human activities (Perdomo et al., 1998; Harris and Santos, 2000; Tam and Wong, 2000).

Contaminated sediments have been recognized as a significant environmental risk, since they usually have strong associations with high concentrations of different classes of anthropogenic pollutants. This contamination may be a source of stress for benthic communities (Zabetoglou et al., 2002). In order to measure such stress, ecotoxicological methods have been developed to assess the effects of polluted sediments at different levels of biological organization (Luoma and Ho, 1992).

Recife is a city with an approximate 1.5 million inhabitants and it is the most industrialized center in the northeastern region of Brazil. Capibaribe and Beberibe rivers flow through this city to the Atlantic Ocean. During the years of the city's growth, large mangrove areas were suppressed and nowadays there is only one large remaining mangrove area that is called “Mangrove Park.” It is one of the largest mangroves of Brazil, situated on the city of Recife. The area is encircled by an extremely dense population. The rivers Jordão and Pina that flow into this mangrove received domestic and industrial effluents.

This study evaluated the toxicity of the sediments of the aforementioned mangrove forest patch through bioassays, by using the benthic harpacticoid copepod *Tisbe biminiensis* and by observing lethal and sub-lethal endpoints, as well as the concentration of trace metals in sediments. Marine copepods have been widely used in ecotoxicology to test water and sediment samples (Williams, 1992; Chandler and Scott, 1991; Chandler and Green, 2001; Chandler et al., 2004). Several species of copepods are currently being used in sediment bioassays around the world:

* Corresponding author.
E-mail address: dedel.duda@gmail.com (D.D. Oliveira).

http://dx.doi.org/10.1016/j.ecoenv.2014.02.004
0147-6513

Tigriopus japonicus, *Tigriopus brevicornis*, *Tigriopus fulvus* (Seo et al., 2006; Kwok et al., 2008; Todaro et al., 2001), *Amphiascus tenuiremis* (Kovatch et al., 1999; Hagopian-Schlekat et al., 2001; Bejarano et al., 2005, 2006), *Tisbe holothuriae* (ISO 14669, 1999; Miliou et al., 2000; Pounds et al. 2002; Thomas et al., 2007), *Tisbe battagliai* (Miliou et al., 2000; Taylor et al., 2007), *Microarthridion littorale* (Kovatch et al., 1999), *Nitocra spinipes, Nitocra sp.* (Bengtsson, 1978; Lotufo and Abessa, 2002), *Schizopera knabeni* (Lotufo, 1997), *Attheyella crassa* (Turesson et al., 2007), and *Robertsonia propinqua* (Hack et al., 2008; Stringer et al., 2012).

The genus *Tisbe* has been demonstrated to be appropriate for environmental risk assessment since it has a wide geographic distribution and a short life cycle (approximately 12 days to nauplii stage to adult), plus, animals in all stages of development can be cultivated at any time of the year (Williams, 1992; Williams and Jones, 1994; Kusk and Wollenberger, 2007; Araújo-Castro et al., 2009). *Tisbe biminiensis* is a native species that has been cultivated in the laboratory for years (Pinto et al., 2001) and it has been tested as a toxicity model for sediment samples (Araújo-Castro et al., 2009).

2. Material and methods

2.1. Collecting site

The study area is a mangrove forest patch of 225.82 ha wide, encircled by an urban area of Recife, capital of Pernambuco State in Northeast Brazil. This area is bathed by Jordão and Pina rivers and also receives the affluents of Capibaribe river, Jaboatão, Jiquiá and Setúbal Channels (Fig. 1). Surface sediment samples were collected for metal analyses and toxicological tests in June and August 2006 (representing the rainy season) and January and February 2007 (representing the dry season) in six stations. These stations were georeferenciated by a GPS Garmin model Etrex Summit and defined according to geomorphology. Two of them were located on the Jordão river estuary (E and F), three stations on the Pina river (B, C and D) and one was in the point of confluence of both systems (A) (Fig. 1).

The superficial sediments were collected to 10 cm depth on the low-tide exposed banks of the river with a stainless steel spatula. The samples were composed of type, as the grain size of these sediments showed a 67 percent silt/clay and 33 percent fine sand. They were stored in decontaminated plastic containers inside refrigerated boxes until arrival at the laboratory where they were sieved through 64 μm and maintained at 4 °C until bioassays. For the toxicity tests, three sediment samples (replicates) in each station were collected. For metal analysis, only one sample per station was taken.

2.2. Ecotoxicological bioassay

The bioassays were performed after the sampling and followed the method described by Araújo-Castro et al. (2009), modified from Lotufo and Abessa (2002). The sieved sediment (fine fraction) was distributed in three sub-samples that consisted of approximately 2 g of sediment, which was sufficient to form a 0.5 cm layer in each test recipient (glass recipient with 4.5 cm diameter and 6 cm high with a plastic cap and 40-mL capacity). Each recipient received 20 mL of a diatom suspension of *Thalassiosira fluviatilis* or *Chaetoceros gracilis* at 0.2 μg Chl-a mL^{-1} and was incubated at 25 °C under 12-h light/dark photoperiod. Three sub-replicates were created for each of the three sediment samples collected from each sampling site, totaling nine sub-replicates per sampling site. The control consisted of five sub-replicates samples of sediment sampled in Maracaípe mangrove considered to be having no significant pollution (Araújo-Castro et al., 2009). After 24 h of sedimentation, 10 ovigerous females of 12 days old were placed in each test recipient. The experiment lasted seven days, with the addition of 1 mL of concentrated diatom every other day. Dissolved oxygen concentration (D.O.), pH and salinity were determined at the beginning and end of the experiment with an oximeter, a pH meter and a refractometer, respectively. At the end of the bioassay, the entire content of each test recipient was stained with Rose Bengal and fixed with formaldehyde (4 percent) for subsequent counts and determination of the lethal parameter (non-stained adult females were considered dead) and sub-lethal parameter of fecundity, which is the sum of nauplii and copepodites produced during the bioassay.

2.3. Metals analyses

The extractions of metals (Cr, Ni, Cu, Pb, Zn, Mn, Co, Cd and Fe) from sediment samples were made from drying, 64 μm sieving and a digestion in a microwave (DGT 100 Plus Cost) for 10 min with Nitric Acid (HNO_3), Perchloric Acid ($HClO_4$) and Hydrofluoric Acid (HF) adapted (USEPA, 2001). The metals determinations were made using an Inductively Coupled Plasma–Optic Emission Spectrometer (ICP–OES, SPECTRO) (USEPA, 2001). To validate the method we used the standard certificate of Communitary Bureau of Reference (CBR # 625 labeled CRM 277 – Estuarine Sediment). All reagents used were of high analytical grade; working solutions were prepared with corresponding pattern of SPECSOL. The detectation limits were $< 10\ \mu g\ g^{-1}$ to Cr and Mn and $< 20\ \mu g\ g^{-1}$ to Fe and Zn.

The sediment used to determine the natural levels or background of metals was collected near Navy radio area (08°05′58.4″ Se, 34°53′35.01″ W) in November 2006. This area was chosen because no contamination was observed in the sediment in preliminary studies.

One of the Sediment Quality Guidelines (SQG) used to evaluate the biological effects of trace metals in sediments was set by NOAA (1999), and it has two limits: TEL (Threshold Effect Level), the level below which no adverse effect to the biological community was usually observed; and PEL (Probable Effect Level), the level above which adverse effects were likely to be detected. Another criterion was established by Long et al. (1995), whom after conducting field studies with marine and estuarine sediments determined two limits to assess the quality of sediments: the ERL (Effect Range – Low), is threshold concentration below which the

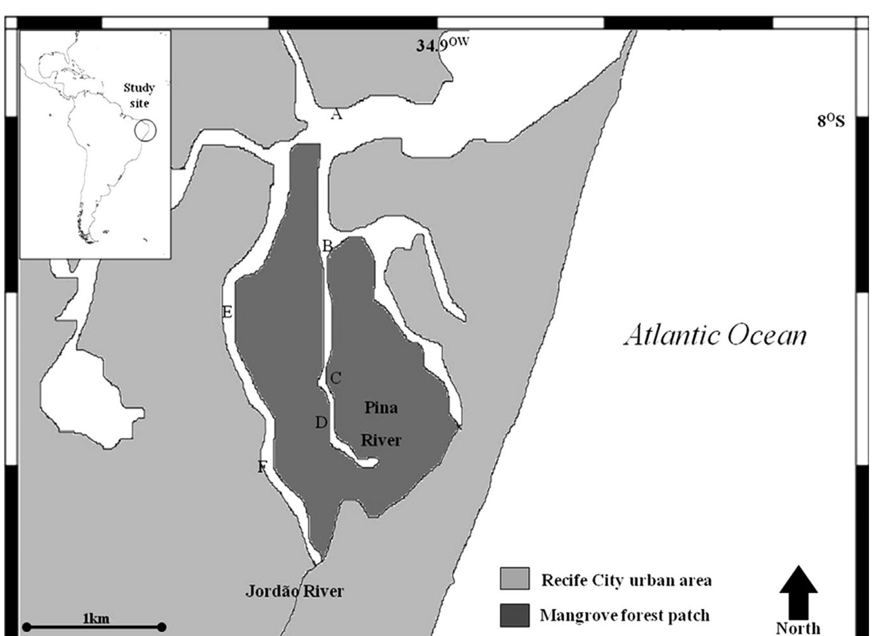

Fig. 1. Map for localization of the mangrove patch and sediment sampling sites.