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Trace metal contamination and benthic assemblages in Subaé estuarine system, Brazil

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The Subaé is one of the main tributaries of the Todos os Santos Bay (BTS), the second largest bay in Brazil, with an area of approximately 1100 km^2. Subaé has a catchment area of 390 km^2, is 50 km long, and discharges are modest (4.5 m^3/s). Nevertheless, it is the second most important source of freshwater and suspended material to the BTS (CRA, 2004). Estuarine conditions are found downstream of Santo Amaro Municipality (Fig. 1). The tides are semi-diurnal, with a mean spring tide of 2.0 m.

It has been reported that a primary lead smelter that operated between 1960 and 1993 in the Subaé catchment, in Santo Amaro, has released large amounts of metals, especially Pb and Cd. The Pb smelter produced 11–32×10^6 kg of Pb bars/year. It is estimated that, during its operation, more than 25×10^7 kg of Cd were discharged in the river, and at least another 15×10^7 kg have been released in the atmosphere. The lead burden is difficult to estimate. Until 1980 the smelter dross (1–3% lead) was freely given to the population for paving yards and was used extensively by the local council for paving streets and public places, including local schools (Silvany-Neto et al., 1989).

The smelter has given rise to many health-related complaints from local residents concerning domestic animals and crops. Over the years, it has also been found that the human population, especially children, was heavily contaminated (Carvalho et al., 1984, 1985, 1989, 2003). Reis

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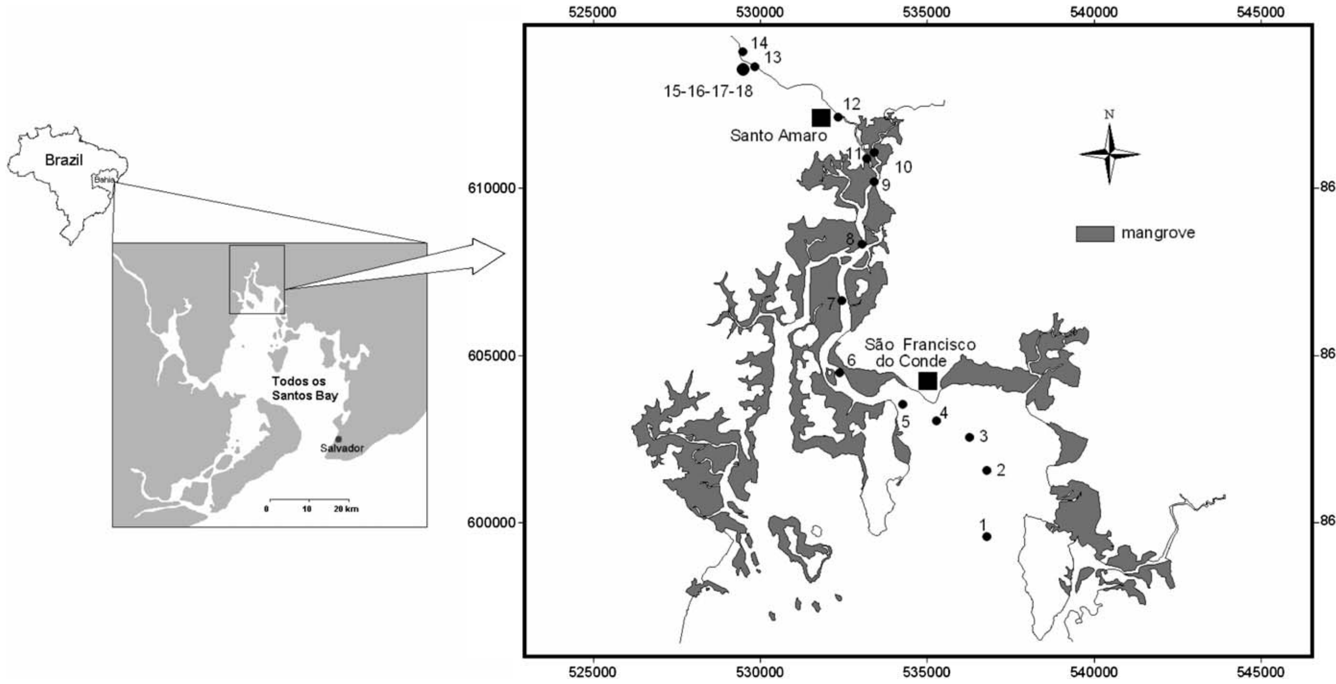

Fig. 1. Sampling location in Subaé system, Bahia, Brazil (estuarine samples: #1–11; river samples: #12–14; soil samples: #15–18).

(1975) showed that Cd and Pb concentrations in the waters of Subaé exceeded the World Health Organization tolerance limits by 8 and 16 times, respectively. High concentrations of trace metals in sediments and mollusks collected from Subaé estuary have also been reported (Tavares, 1996; CRA, 2004).

It is now more than ten years since the smelter was active. However, around 50×10^7 kg of metal enriched wastes are stored in the yards of the old smelter. This waste disposal site is open to the elements and is located no more than 500 m away from the river. The amount of contaminated material removed by surface run-off and ground water to the Subaé estuarine system and BTS has yet to be determined. In addition, there are two fishing villages and other important industrial activities in the basin, including a paper mill, sugar, and chemical industries.

Few studies have been undertaken in the area since the 1990s (Tavares, 1996; Carvalho et al., 2003; CRA, 2004). These studies had focused in the vicinity of the smelter in Santo Amaro Municipality, and no information has been published in the scientific literature assessing the contamination status of the Subaé estuarine system and/or biological responses resulting from pollutants.

It is well established that high concentrations of trace metals can have toxic effects on benthic organisms (e.g., Long et al., 1995; Gray, 1997). These effects generally involve alteration of species composition, reduction of richness and number of individuals, and may result in biodiversity losses (e.g., McGee et al., 1995). The aim of this study was to assess the current trace metal contamination of the sediments and the relationship between these contaminants, other environmental variables, and benthic macrofaunal assemblages.

Sediments and benthic samples were collected at several stations along the main channel of Subaé system in June 2004 (Fig. 1). Four soil samples were also collected in the vicinity of the lead smelter. Sediment samples (stations #1–11), for geochemical analysis, were collected by SCUBA divers using a 5 cm diameter PVC core that was dragged, horizontally, for 2 m in surface sediments (1–5 cm). Once the sample was collected, the core was capped and the tube retrieved. Soils and river samples (#12–18) were collected with plastic spoons. Samples were transferred to a precleaned LDPE container and kept frozen until analysis. All bottles and materials used for the collection and analysis were cleaned and immersed at least for 24 h in extran detergent solution and for a further 48 h in 10% HNO_3 solution, rinsed with ultra pure water, dried on a clean covered bench and stored in zip-lock bags before use.

Sediment samples were divided into two parts, the first used for the determination of particle-size distribution, and the second for chemical analyses. Before chemical analyses, sediments were wet sieved to separate the fraction smaller than 63 μm that was used for trace metal analyses. A 'pseudo-total' digestion was performed using 250 mg of sediments and 4 ml of *aqua regia* in Teflon Parr bombs, for 16 h at a temperature of 120 ± 5 °C. Additionally, an extraction using 20 ml of 1 M HCl, shaking for 12 h at room temperature was carried out. The latter extraction is reported to closely correlate with biological availability (Bryan and Langston, 1992). Sediment samples were digested/extracted in triplicates. Trace metals (Co, Cr, Cu, Pb, Mn, Ni and Zn), were determined by ICP OES (Varian, VISTA-PRO).

Blanks were included in each batch of analysis. The precision and accuracy of the analytical technique were