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Continental Shelf Research

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Research papers

Spatial variation, speciation and sedimentary records of mercury in the Guanabara Bay (Rio de Janeiro, Brazil)

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ARTICLE INFO

Article history:

Received 23 June 2011

Received in revised form

18 November 2011

Accepted 6 December 2011

Keywords:

Mercury

Contaminated sediments

Enrichment factor

Inventory

Selective sequential extraction

Guanabara Bay

ABSTRACT

As part of the "TAGUBAR" (TANGential GUanabara Bay Aeration Recovery) project, surface and long core sediments of the Guanabara Bay (Rio de Janeiro, Brazil) were investigated for mercury (Hg). The main, but not the only, input of Hg into the Bay's waters is known to be a Chlor-Alkali Plant (CAP) located in the Acari-São João de Meriti River system, on the northwestern side of the Bay. Mercury distribution in surface sediments (< 0.1 – 3.22 mg kg⁻¹, average 0.87 ± 0.80 , $n=40$) seems to be controlled by the organic component, along with sulfur rather than grain-size, where Hg concentrations are less than 1 mg kg⁻¹. Conversely, where the metal contents are higher than 1 mg kg⁻¹, accumulation in surface sediments is mostly related to the presence of nearby contamination sources, such as industrial and urban settlements in the western sector of the Bay. Although total Hg contents in surface sediments exceed the values suggested by the effects-based standard quality guidelines as potentially toxic for the benthic community, results from a sequential extraction procedure showed that the contribution of the more soluble, easily exchangeable and eventually bioavailable Hg phases was found almost negligible ($< 0.1\%$). Most of the metal is strongly bound to the mineral lattice of the sedimentary matrix and should therefore be considered almost immobilized.

The reduction in Hg accumulation in bottom sediments, expected as a consequence of the adoption of contamination control policies (i.e. Hg-free technologies in the CAP and sewage treating facilities), has not been clearly observed in the core profiles. Current estimates of Hg accumulation rates at the core top range from approximately 1 to 18 mg m⁻² yr⁻¹. Pre-industrial bottom core samples indicate that the central and northeastern sectors of the Bay are strongly affected by Hg enrichment: concentrations exceed the estimated baseline concentration by up to 20 factors. A cumulative Hg inventory suggests that the metal content has increased with the same order of magnitude in the vicinity of potential contamination sources on the western side of the Bay, but at a different rate; this is apparently determined by local conditions. A natural attenuation of Hg concentrations to background levels is not predictable in the near future.

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1. Introduction

Coastal lagoons and estuaries are often surrounded by urban and industrial areas and are frequently loaded to a significant level with a variety of pollutants. The shallowness and limited water exchange of such coastal systems mean that the residence time of water and suspended sediments is generally much longer than in open coastal areas. This makes these environments vulnerable to even small levels of loading.

Mercury (Hg) is considered to be one of the most harmful pollutants for the marine environment, and is recognized to be extremely toxic even at low concentrations. The negative effects of Hg on ecosystems and human health are mostly related to its transformation into the more toxic and mobile organic form, methyl-Hg (Ullrich et al., 2001), which can be biomagnified along the trophic chain up to human beings (Porcella, 1994). The presence of Hg in aquatic systems can be attributed to several sources, for example atmospheric deposition (Schlüter, 2000), and/or past mining and modern industrial discharge (e.g. Baldi and Bargagli, 1984; Covelli et al., 2001; Trombini et al., 2003). Mercury accumulated in sediments may be subjected to burial and/or to biogeochemical processes, which affect its speciation

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