A note on the concentrations and bioavailability of selected metals in sediments of Richards Bay Harbour, South Africa

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Abstract

Sediments are considered to be the ultimate sink for most contaminants and therefore pose the highest risk to these aquatic environments. This paper presents the levels of metals in sediments from Richards Bay Harbour, 20 years after the construction of the harbour and studied spatial and temporal, as well as the proportion of the bioavailable metal fraction. Sediment samples were collected from nine sites in Richards Bay Harbour. Sequential extractions of metals were carried out and samples were analysed for aluminium, chromium, copper, iron, manganese and zinc. Metal concentrations in sediment samples varied only slightly between seasons but showed significant spatial variation, which was significantly correlated to sediment particle size composition. Highest metal concentrations were found in sites with substrata dominated by fine mud. Manganese and Zn had more than 50% of this concentrated in the easily reducible fractions. Zinc concentrations were not elevated when compared to historic data. More than 70% of Cr was concentrated in the inert fractions nevertheless concentrations recorded at some sites were still above action levels when considering only the bioavailable fractions.

Keywords*:* sediments, metals, bioavailability, sediment composition, Richards Bay Harbour

Introduction

In recent years there has been growing concern over increased contamination of estuaries and harbours from a variety of anthropogenic sources (Gümgüm et al., 1994). Reduced circulation and dispersion of sediment-bound contaminants following dredging activities in harbours make them especially susceptible to contamination (Henry et al., 1989). Heavy metals and hydrocarbons are of particular concern, due to the nature of the activities taking place in these systems. A survey of five major harbours in South Africa., showed that in four of them (Richards Bay Harbour being one), one or more of the trace metals occurred at levels greater than normal background levels (Henry et al., 1989). This is cause for concern, especially in light of the fact that Richards Bay Harbour serves as an important sheltered refuge, nursery, and feeding ground for numerous marine organisms (Forbes et al., 1996). Indeed previous studies on bioaccumulation of metals in tissue of mullet from Richards Bay Harbour and the adjacent Mhlahtuze Estuary indicated that there were elevated metal levels in the environment (Vermeulen and Wepener, 1999; Mzimela et al., 2003). However, very few data are available on metal concentrations in Richards Bay Harbour sediments and the changes in these concentrations over the years since the harbour was constructed in 1976.

Sediments are considered to be the ultimate sink for many contaminants and therefore pose the highest risk to the aquatic environment as a source of pollution (Bervoets et al., 1994; Williamson et al., 1996). However, chemical processes at the sediment-water interface are complex and consideration must be given to the physico-chemical characteristics of the sediment, such as grain size and percentage organic content, which strongly influence the availability of contaminants (Forbes and Forbes, 1994). In addition, sediments may serve as a secondary source of pollution should variables such as pH, salinity, temperature, redox potential or ionic strength change, resulting in the release of bound contaminants back into solution (Coetzee, 1993; Dickinson et al., 1996; Baeyens et al., 2003). This is especially important in the zone of mixing where metals may be depleted from sediments due to processes of desorption as a result of increased turbidity, pH and complex recirculation patterns characteristic of estuarine and near-shore marine environments.

The mobility and bioavailability of metals in sediments strongly depend on the mineralogical and chemical forms in which they occur (Baeyens et al., 2003). It is therefore necessary to study these different forms rather than the total metal concentrations to obtain an indication of the bioavailability of metals. Since the early 1980s and 1990s sequential extraction methodologies have been developed to determine speciation of metals in sediments (Tessier et al., 1979; Coetzee, 1993). The speciation approach looks at the distribution of metals over the various sedimentary substrates, e.g. carbonates, iron and manganese oxihydroxides, organic matter, silicate, sulphides, etc. (Baeyens et al. 2003).

The aims of this study were threefold. Firstly, to determine the levels of selected metals in sediment samples 20 years after the construction of Richards Bay Harbour. Secondly to determine whether these concentrations vary seasonally and /or spatially and thirdly, what proportion of the metals measured are in the bioavailable fractions following the application of the five-phase extraction procedure described by Tessier et al. (1979).

Materials and methods

Sampling procedures

Sampling sites were selected to cover the different habitat types occurring in Richards Bay Harbour. Samples of surface

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