

An assessment of heavy metal pollution in the East London and Port Elizabeth harbours

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Abstract

The distribution of heavy metals (zinc, cadmium, copper, iron, manganese and lead) was investigated in seawater and in sediment samples from the East London and Port Elizabeth harbours. Both are ports of major importance to the area. The aim was to assess the impact of potential pollution sources, mainly from the cities' formal disposal to the sea, from industry and from dockyard and shipping activities around the harbour. At the East London harbour, metal concentrations in sea water range from 0.2 to 72.0 mg·L⁻¹ for Cd, from 0.6 to 42.6 mg·L⁻¹ for Cu, from 2.4 to 183.0 mg·L⁻¹ for Fe, from 0.6 to 16.3 mg·L⁻¹ for Pb, from 0.9 to 23.9 mg·L⁻¹ for Mn and from 0.5 to 27.6 mg·L⁻¹ for Zn. In sediments, metal concentrations using the total digestion method range from 0.12 to 1.63 mg·g⁻¹ (dry weight) for Cd, 12.7 to 183.0 mg·g⁻¹ (dry weight) for Cu, 1046.0 to 18 114.0 mg·g⁻¹ (dry weight) for Fe, 3.2 to 84.2 mg·g⁻¹ (dry weight) for Pb, 87.4 to 549.0 mg·g⁻¹ (dry weight) for Mn, 26.1 to 332.0 mg·g⁻¹ (dry weight) for Zn. In the Port Elizabeth harbour, the concentration of metals in seawaters varied between 0.3 mg·L⁻¹ and 4.0 mg·L⁻¹ for Cd, between 0.5 mg·L⁻¹ and 11.3 mg·L⁻¹ for Cu, between 3.7 mg·L⁻¹ and 21.9 mg·L⁻¹ for Fe, between 0.6 mg·L⁻¹ and 4.2 mg·L⁻¹ for Pb, between 0.7 mg·L⁻¹ and 16.8 mg·L⁻¹ for Mn and between 0.7 mg·L⁻¹ and 16.2 mg·L⁻¹ for Zn. In sediments, values of metals also using the total digestion method ranged from 0.1 to 1.4 mg·g⁻¹ (dry weight) for Cd, from 8.6 to 82.3 mg·g⁻¹ (dry weight) for Cu, from 4219.0 to 15 182.0 mg·g⁻¹ (dry weight) for Fe, from 9.0 to 61.9 mg·g⁻¹ (dry weight) for Pb, from 103.0 to 499.0 mg·g⁻¹ (dry weight) for Mn and from 18.8 to 126 mg·g⁻¹ (dry weight) for Zn. The results are indicative of the contribution of heavy metal pollution from storm water drains and streams which carry runoff from industrial, urban and residential sources. Ship repair activities are also suspected to be responsible for elevated concentrations in the upper reaches of the harbour.

Introduction

The sea, and more particularly the aquatic systems (e.g. estuaries), are the ultimate repository of man's wastes. The highly dynamic nature of the marine environment allows for very rapid assimilation of these materials by processes such as dilution, dispersal, oxidation, degradation or sequestration into sediments. However, the capacity for such assimilation is limited. Understanding this process of 'absorption' by the oceans and thereby determining their 'assimilative capacities' has been the main challenge of marine pollution research during the last few decades. There is little doubt that significant successes have been achieved in reducing the contamination of our natural waters. However, these gains have in part been offset by the increasing number and total volume of marine discharges. This situation arises from the increasing individual demands for a higher standard of living (Lord, 1989).

A previous general programme for marine pollution monitoring along the coast of South Africa has been described in detail (Cloete and Watling, 1981). The aims of this programme were to discover and monitor resources of marine pollution, to establish coastal monitoring stations and to institute a national data centre where all the information from the current studies can be stored and utilised most effectively. The identification and continued monitoring of the effects of industrial and urban coastal developments is necessary if indigenous flora and fauna are to be protected (Watling and Watling, 1983).

The influx of pollutants to the oceans in the Southern Hemisphere can be expected to be considerably lower than that in the heavily industrialised Northern Hemisphere. However, the 3 000-km long

southern coastline is becoming increasingly pressurised with new towns and industries. This increase in urbanisation and industrialisation leads to an increase of marine discharges and, therefore, the total load of pollutants being delivered to the sea (McGlashan, 1989). These discharges may contain heavy metals among other pollutants.

Through the natural process of biomagnification, minute quantities of metals become part of the various food chains and concentrations become elevated to levels which can prove to be toxic to both human and other living organisms (Ackefors, 1971; Bryan, 1971). The surface water is a medium which is commonly used for heavy metal pollution assessment. However, pollutant concentrations in sediments and water organisms provide a more stable means of obtaining an indication of the state of the associated water. Sediment profiles often uniquely preserve the historical sequence of pollution. One of the most important issues regarding the presence of contaminants in sediments in aquatic environments, according to Forstner (1978) is the potential availability of the contaminants in the sediments for aquatic life.

Heavy metals are stable and persistent environmental contaminants of coastal waters and sediments. Interest in metals like Zn, Cu, Fe and Mn, which are required for metabolic activity in organisms, lies in the narrow "window" between their essentiality and toxicity. Others heavy metals like Cd, Hg, Cr and Pb, may exhibit extreme toxicity even at low levels under certain conditions, thus necessitating regular monitoring of sensitive aquatic environments (Peerzada et al., 1990).

Several methods have been described for the determination of heavy metals in marine environments. These include graphite furnace-AAS (Burguera et al., 1995), flame-AAS (Dapaah et al., 1999; Gomez-Ariza et al., 1999), atomic fluorescence spectrometry (Cheam et al., 1992), anodic stripping voltammetry (Fischer and Van den Berg, 1999; Morales et al., 1999), ICP-AES (Hiraide et al.,

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