

Trace metal pollution in Umtata River

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Abstract

Dissolved trace metals, i.e. Fe, Mn, Al, Cu, Zn, Pb and Cd were determined in the Umtata River. High levels of Al, Cd, Pb, Zn and Cu were observed, which may affect the "health" of the aquatic ecosystem. The high levels of Al, Cd and Pb may also affect the health of the rural community that uses the river water directly for domestic use without treatment. Generally the sources of the metals in the river appear to be diffuse, which include rural, urban and agricultural runoff sources in the catchment, although there may be contributions from natural and point sources.

Introduction

The accumulation of metals in an aquatic environment has direct consequences to man and to the ecosystem. Interest in metals like Zn and Cu which are required for metabolic activity in organisms, lies in the narrow "window" between their essentiality and toxicity (Skidmore, 1964; Spear, 1981). Others like Al, Cd and Pb exhibit extreme toxicity even at trace levels (Merian, 1991; DWAF, 1996a-c).

The presence of Al in a natural water system is of major concern because of the potential threat to the health of a number of species including humans (Lewis, 1989; Radunovic and Bradbury, 1993). Al is known to be toxic to the central nervous system and plays a role in causing dialysis encephalopathy and dialysis osteodystrophy (Alfery et al., 1976; Savory and Wills, 1991). Some lakes, rivers, groundwater and domestic tap waters contain Al in high concentrations either naturally (Al could be mobilised from soils and sediments by both natural weathering and accelerated acidification processes, resulting in detectable concentrations in surface waters) or because Al has been added as a flocculant in the purification process (DWAF, 1996b). The implication of this may be serious since Al ions have been demonstrated to be toxic especially to individuals with impaired renal function (Savory and Wills, 1991).

Zn, Cu, Pb and Cd are common pollutants, which are widely distributed, in the aquatic environment. Their sources are mainly from weathering of minerals and soils (Merian, 1991); atmospheric deposition (Merian, 1991); industrial effluents (Asami, 1974; Prater, 1975) domestic effluents (Dean et al., 1972; Preuss and Kollman, 1974), urban storm water runoff (Sartor et al., 1974; Field and Lager, 1975) and spoil heaps (Heitfield and Schottler, 1973).

Extensive literature on the aquatic toxicity of Zn and especially its toxicity to fishes has been reviewed by Alabaster and Lloyd (1980) and by Spear (1981). Zinc is unusual in that it has low toxicity to man, but relatively high toxicity to fish (Alabaster and Lloyd, 1980).

Copper is one of several heavy metals that is essential to life despite being as inherently toxic as non-essential heavy metals exemplified by Pb and Hg (Scheinberg, 1991). Plants and animals rapidly accumulate it. It is toxic at very low concentration in water and is known to cause brain damage in mammals. (DWAF, 1996b).

Cadmium has been found to be toxic to fish and other aquatic organisms (Rao and Saxena, 1981; Woodworth and Pascoe, 1982). The effect of Cd toxicity in man includes kidney damage (Friberg, et al., 1986a; Herber et al., 1988) and pains in bones (Itai-itai disease) (Tsuchiya, 1978; Kjellstroem, 1986). Cd also has mutagenic, carcinogenic and teratogenic effects (Fischer, 1987; Friberg et al., 1986b, Kazantzis, 1987, Heinrich, 1988).

Lead is defined by the United States Environmental Protection Agency (USEPA) as potentially hazardous to most forms of life, and is considered toxic and relatively accessible to aquatic organisms (USEPA, 1986). Low Pb concentrations affect fish by causing the formation of coagulated mucous over the gills and subsequently over the entire body and thus cause the death of fish due to suffocation (DWAF, 1996b). Lead is bio-accumulated by benthic bacteria, freshwater plants, invertebrates and fish (DWAF, 1996b). The chronic effect of Pb on man includes neurological disorders, especially in the foetus and in children. This can lead to behavioral changes and impaired performance in IQ tests (Lansdown, 1986; Needleman, 1987). The major effect of the presence of Fe and Mn in domestic water is aesthetic because of the colour.

The pH of a water body determines the chemical species of many metals and thereby alters the availability and toxicity in the aquatic environment (DWAF, 1996b). Metals such as Al, Cd, Pb, Cu, Mn, and Zn are most likely to have increased detrimental environmental effects as a result of a lowered pH (DWAF, 1996b).

Lead absorption by aquatic organisms is dependent on the action of Ca; therefore hardness is an important factor in determining the toxicity of Pb in the aquatic systems (DWAF, 1996b). Lethal concentrations of Cd also vary with water hardness and type of test animal. (DWAF, 1996b).

This study reports the levels of dissolved Al, Cd, Zn, Cu, Pb, Fe and Mn in the Umtata River and the associated pH and total hardness values of the water body. This catchment supports a rapidly growing population and there are concerns regarding the water quality of the river. The main uses of water in the catchment are domestic, agricultural (i.e. livestock watering), aquatic ecosystem use and recreational (e.g. swimming). Water from the Umtata River is rarely used for irrigation.

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