# Heavy metals (Cd, Pb, Cu, Zn) in mudfish and sediments from three hard-water dams of the Mooi River catchment, South Africa

**WJ van Aardt* and R Erdmann**

*School of Environmental Sciences and Development, Potchefstroom University, Private Bag 6001, Potchefstroom 2520, South Africa*

## Abstract

Fish tissue from *Labeo capensis* and sediment core samples from three dams in the Mooi River catchment area were collected and analysed for Cd and Pb by electro-thermal AAS, and for Cu and Zn by flame AAS. The highest Cd concentrations were found in the clay fractions in all three dams, with a range between 66.0 $\mu g \cdot g^{-1}$ and 107 $\mu g \cdot g^{-1}$. Lead concentrations below 34 $\mu g \cdot g^{-1}$ were found in all six sediment types from Klerkskraal Dam, while Potchefstroom Dam had the highest lead levels (range: 34 - 62 $\mu g \cdot g^{-1}$) for the six sediment fractions and also for all the fish tissue types (range: 38 - 79 $\mu g \cdot g^{-1}$). Lead alkyls from motorboat exhausts were probably responsible for the high lead concentrations in the sediment of Potchefstroom Dam and in the mudfish tissues. The mean zinc concentrations from five of the six fractions in Boskop Dam were significantly higher compared to the other dams, with a range between 25 $\mu g \cdot g^{-1}$ to 59 $\mu g \cdot g^{-1}$. The combined six fractions were between five and 100 times lower in concentration when compared to the pelitic sediment samples from sediments at the Lebanon and West Driefontein mines in the Mooi River catchment. Copper concentrations in dam sediment from the six fractions for the three dams, ranging between 11$\mu g \cdot g^{-1}$ to 36 $\mu g \cdot g^{-1}$, were higher when compared with copper levels worldwide. The kidneys, gills and liver had the highest levels of Cd, Pb and Cu respectively compared to other tissues from *L. capensis*, while the gills had the highest concentration of Zn. In conclusion, higher than normal metal concentrations were found in Boskop Dam sediments, which could be linked to gold mine operations inside the Mooi River catchment area. Lead, Cd, Cu and Zn concentrations in *L. capensis* tissues were much lower compared to reported data on South African fish, but on par with world levels. The percentage of uranium present in sediment samples (analysed by energy dispersive X-ray spectrometry) from the three dams was 9.0 % (SD 2.1%). In sediment it was found that cation exchange capacity measurements and the dolomitic hard water and high pH of the Mooi River water effectively 'detoxified' Cd and Pb, forming insoluble complexation products buried in the sediment.

**Keywords**: Cd, Pb, Cu, Zn, dam sediment, fish tissues, CEC, sediment profiles

## Introduction

There is an increasing awareness of the potential hazards that exist due to the contamination of freshwater impoundments by toxic metals associated with the mining industry (Kelly, 1988; Du Preez et al., 2003; Quek et al., 1998; Feather and Koen, 1975). The reason is the world demand for minerals, which has intensified the exploitation of natural resources. The water and tailings waste from mining and milling operations are discharged into settlement and treatment dams or tailings ponds. Eroded or disused tailings dams may contain considerable concentrations of toxic metals, usually dissolved in water at pH values as low as 1.7 (Wittmann and Förstner, 1977a) that may be released into the environment. The close proximity of the Mooi River catchment to the West Wits goldfields area near Carletonville, South Africa, and the established release of mine water into a tributary of the Mooi River (Fig. 1) may contribute to enhanced toxic metal levels in the water and sediment (Wittmann and Förstner 1977a; Kelly 1988). In a report (Wade et al., 2000) to the South African Water Research Commission it was found that not only were heavy metals enriched in Mooi River sediments, but radionuclide concentrations in the sediment at a locality in a Mooi River tributary near West Wits gold mines were higher than stipulated by the Nuclear Energy Act of 1993.

Many of the dissolved metals that enter rivers are adsorbed onto colloid particulates. Also at high alkalinity and pH, the metals, particularly lead and cadmium, precipitate by forming complexation products, resulting in an array of chemical speciation of metals that dramatically influence metal toxicity (Van Aardt and Booysen, 2004; Van Aardt and Venter, 2004) Therefore, precipitation and sedimentation of cadmium and lead and, to a lesser extent, copper and zinc in alkaline water bodies could be greater at the dam inlet where sedimentation processes act as a sink for metals (Harding and Whitton, 1978). Heavy metals such as lead, copper, nickel and zinc are usually deposited in sediments not deeper than 15 cm (Ochsenbein et al., 1983; Santos Bermejo et al., 2003).

The mine drainage from gold and uranium recovery operations at the West Wits goldfields has an enrichment factor of 500, 600, 1800 and 2600 respectively for Cd, Pb, Cu and Zn (Wittmann and Förstner, 1977 a or b). The Mooi River catchment and its fish were not included in the report of a national survey on metal accumulation in fish (Heath and Claassen, 1999) on six major river catchments of South Africa.

In this study, we report on the accumulation of four heavy metals in different sediment particle sizes, sediment profiles and different fish tissues in the Potchefstroom Dam and the Boskop Dam, from where the city of Potchefstroom obtains its irrigation and potable water supply. Metal concentration data are compared with sediments and fish tissues in the Klerkskraal Dam (as control dam), situated in the upper reaches of the Mooi River catchment, not affected by mining activities.

* To whom all correspondence should be addressed.
☎+2718 299-2376; fax:+2718 299-2370; e-mail: drkwjva@puknet.puk.ac.za
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