Human health risk assessment for silver catfish *Schilbe intermedius* Rüppell, 1832, from two impoundments in the Olifants River, Limpopo, South Africa

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ABSTRACT

As rural populations grow and rural poverty increases, consumption of fish from contaminated river systems will increase to supplement dietary protein requirements. The concentrations of metals in fish muscle tissue at two impoundments of the Olifants River (Flag Boshielo Dam and the Phalaborwa Barrage) were measured, and a human health risk assessment following Heath et al. (2004) conducted to investigate whether consumption of *Schilbe intermedius* from these impoundments posed a risk to human health. The results confirmed that metals are accumulating in the muscle tissue of *S. intermedius*. No patterns were observed in the ratios of the metals bio-accumulated at each impoundment. The human health risk assessment identified that all fish analysed exceeded the recommended levels for safe consumption for lead and chromium and about 50% exceeded the recommended level for antimony at Flag Boshielo Dam. Almost all fish analysed exceeded the recommended level for lead and more than 50% exceeded the recommended level for arsenic at the Phalaborwa Barrage. We conclude that weekly consumption of *S. intermedius* from these impoundments may pose an unacceptable risk to the health of rural communities.

Keywords: risk assessment, human health, *Schilbe intermedius*, lead, chromium, antimony

INTRODUCTION

Globally, river systems have been adversely impacted by constant increases in domestic, agricultural, mining and industrial water abstraction and the release of contaminants such as metals and pesticides (Dudgeon et al., 2006; Strayer and Dudgeon, 2010; Vörösmarty et al., 2010). Although most metals and metalloids (hereafter referred to as metals) occur naturally in the biogeochemical cycle, many are released into inland waters as industrial, mining, agricultural and domestic effluents, and may be deleterious to aquatic systems (Dallas and Day, 2004). Some metals are essential micronutrients for living organisms (e.g. Co, Cu, Fe, Mn, Mo and Zn) but can exert toxic effects on aquatic biota when present at elevated levels (Heath and Claassen, 1999; Dallas and Day, 2004). Other metals occur naturally at very low concentrations in aquatic ecosystems and have no known physiological functions. These might be toxic even at low concentrations, but have become widely distributed as a result of human activities (e.g., Cd, Pb and Hg) (Davies and Day, 1998; Dallas and Day, 2004). The toxicity of metals in aquatic ecosystems is complex and dependent on their bioavailability. Water hardness, pH, dissolved oxygen, temperature, salinity, interactions with other metal salts, and the presence of mineral and organic suspended solids all influence the bioavailability of metals (Chapman and Wang, 2000).

Freshwater organisms absorb pollutants from the environment (sediment and water) and their food (Chen et al., 2000; Warren and Haack, 2001). Metals do not degrade in the environment but accumulate and are incorporated into aquatic food webs, concentrating up the aquatic food chain and posing a toxicity risk to organisms higher in the food chain: predatory fish, piscivorous birds, mammals and humans (Chapman and Wang, 2000). Human communities that regularly consume contaminated fish are at risk of genotoxic, carcinogenic and non-carcinogenic health impairment from long-term exposure to toxic contaminants (Du Preez et al., 2003). Thus, it has become increasingly important to assess the levels of metals in fish tissues as an indicator of metal pollution in aquatic systems (Rashed, 2001) and to determine whether the fish from impacted river systems are suitable for human consumption.

In South Africa, many rural communities rely on fish harvested from inland waters by subsistence fishers to supplement their dietary protein (Ellender et al., 2009; McCafferty et al., 2012). However, many inland waters have become contaminated due to year-on-year increases in mining, agricultural, industrial and domestic effluent releases (Ashton and Dabrowski, 2011). The Olifants River, a tributary of the Limpopo River in south eastern Africa, has been systemically impaired by acidification, industrial and agricultural chemicals, organic pollutants, and domestic waste, and is now one of the most polluted river systems in South Africa (Ashton and Dabrowski, 2011). Intensive and subsistence agriculture activities, in conjunction with mining and industrial activities in the Emalahleni-Middelburg and Ba-Phalaborwa areas, significantly impacting the water quality of the Olifants River (Ashton and Dabrowski, 2011), particularly in the Upper Olifants (Fig. 1). Acid mine drainage seeping from mines in the upper catchment (McCarthy, 2011) is resulting in the acidification of rivers and the mobilisation of metals from the sediment (McCarthy, 2011; Netshitungulwana and Yibas, 2012). There is, therefore, increasing concern regarding the long-term impact of water pollution on the aquatic ecosystem and the health of rural communities in the Olifants River catchment, especially those still

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Received 15 November 2013; accepted in revised form 3 September 2014.

http://dx.doi.org/10.4314/wsa.v40i4.5

Available on website http://www.wrc.org.za

ISSN 0378-4738 (Print) = Water SA Vol. 40 No. 4 October 2014

ISSN 1816-7950 (On-line) = Water SA Vol. 40 No. 4 October 2014