Research Paper

High fluoride drinking water in Gokwe, northwest Zimbabwe

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ABSTRACT

More than 200 million people worldwide are exposed to excessive fluoride in drinking water. According to the World Health Organization, the optimal concentration range of fluoride in drinking water is 0.5 to 1.5 mg/L. Above this range, populations may contract dental fluorosis or, in severe cases, crippling skeletal fluorosis. In the Gokwe area in NW Zimbabwe, where drinking water contains up to 11 mg/L fluoride, fluorosis prevalence has previously been estimated at 62%. This paper investigates the water quality of 126 water sources in Gokwe (58 pumped boreholes, 15 flowing artesian boreholes, 46 wells and 7 streams). The water chemistry, determined from high performance ion chromatography and field measurements, showed that the water source types exhibit significantly different ($P < 0.05$) concentrations of F^-, Cl^-, Na^+, K^+, Ca^{2+}, Mg^{2+}, temperatures, pH and conductivity values. Thirty-five (28%) of the 126 water sources (18 pumped boreholes, 15 artesian boreholes, one well and one stream) contained $F^- > 1.5$ mg/L, indicating that fluoride contamination in the area is a characteristic of deeper groundwater, possibly due to its interactions with the potentially fluoridic coaly and carbonaceous materials of the Lower Karoo Aquifer at depth. The plausibility of providing alternative low fluoride water, and defluoridation, should be investigated.

Key words | artesian, defluoridation, fluorosis, Lower Karoo Aquifer, water quality

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INTRODUCTION

Water is the principal source of fluoride for humans (World Health Organization 2011). In small doses (0.5–1.5 mg/L), fluoride helps prevent dental caries but it can be toxic at concentrations above 1.5 mg/L (US National Research Council 1993; Fawell *et al.* 2006; World Health Organization 2011). Human signs of chronic fluoride toxicity vary from dental fluorosis (staining, pitting and brittleness of teeth), through skeletal fluorosis (adverse changes in bone structure) to crippling skeletal fluorosis (crippling bone and joint deformities) as the level and period of exposure increase (US National Research Council 1993; Fawell *et al.* 2006). It is estimated that several tens of millions of people worldwide suffer from fluorosis, making fluorosis one of the biggest endemic health problems associated with natural geochemistry (Fawell *et al.* 2006; Fewtrell *et al.* 2006). In total, it is estimated that about 200 million people are exposed to excessive fluoride in drinking water worldwide (Edmunds & Smedley 2013).

Apart from water, other contributors to fluoride exposure in humans include food, beverages, dental products, fluoride supplements and infant formulas (World Health Organization 2011). In addition, atmospheric exposure to fluoride may occur due to indoor burning of high-fluoride coal and consumption of brick tea as in parts of rural China (World Health Organization 2011). Most fluoride in the environment can ultimately be attributed to the rocks of the Earth's crust and, in particular, to fluoride-bearing minerals such as apatite, fluorite, micas, amphiboles and topaz (Goldschmidt 1962; Koritnig 1978; Owen & Jones 1995; Edmunds &

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