

Groundwater

Trace metal contamination of SA aquifers

A completed Water Research Commission (WRC) study reviewed cadmium contamination of South African aquifer groundwater systems via phosphate fertilizer.

Background to WRC study

Cadmium is a non-essential element and is toxic to plants, animals and humans. Cadmium is persistent in the environment due to it being an element, is carcinogenic by inhalation (although not by ingestion) and affects the kidneys and bones in vertebrates.

Since the late-1970s the effects of cadmium on the environment have become an issue of concern for the European Union, and since the mid-1980s countries have conducted evaluations on the exposure of their populations to cadmium in fertilizer.

Eight regional clusters (Cape Town-West Coast, Springbok, Southern Cape, De Aar, Rustenberg, Witwatersrand, Limpopo-Olifants and Phalaborwa clusters) of cadmium groundwater contamination can be observed within South Africa, present possibly as a result of natural lithological and/or anthropological contamination.

A variety of localised trace metal studies have also shown that cadmium contamination occurs within South African water systems, and the environment as a whole. The Eastern Cape mid-2000s pineapple cadmium contamination disaster provides a sobering local case study of the potential economic impact of using cadmium-contaminated phosphate fertilizer.

There are a range of options that can be implemented to reduce, remove, remediate or regulate cadmium within the environment, e.g. developing environmental quality standards; development of actions, processes and regulations that control, reduce or eliminate the release of

cadmium into the environment via raw materials, products and manufacturing/disposal processes; changing to best management farming practices that optimise crop production and minimise environmental impact; the use of phytoremediation and other trace metal treatment options for environmental remediation; and the undertaking of risk assessments.

The main conflicting pressure will be maintaining or increasing agricultural input from infertile soil, which will require the addition of fertilizer (possibly containing cadmium).

Study area

Topics reviewed during this study included fertilizer composition and types, metal speciation, metal mobility in soil and groundwater systems, metal bioavailability, health and environmental effects, and local contamination case studies.

A preliminary study site, namely the greater Hermanus region (including the Hemel and Aarde valley) was identified for trace metal and quality studies (which incorporated urban and agricultural areas in various hydrogeological settings).

Hermanus was selected due to the discovery of cadmium concentrations of 20 µg/l in a golf estate irrigation borehole during drilling and test-pumping of the borehole at the end of 2012.

Due to the absence of industrial or landfill site point sources, the only other currently known, possible local source for trace metal (and specifically cadmium) contamination of

groundwater in the estate borehole was phosphate fertilizer (applied over a minimum period of at least 70 years) and treated wastewater application (over the past 6 years) to the adjacent, century-old golf course, or within the estate itself.

The local aquifers are also not known to be naturally mineralised with respects to high concentrations of cadmium and other trace metals, other than iron and manganese.

As part of this study, groundwater samples from seven borehole sites (analysed for macrochemistry and trace metals) and eleven soil sites (analysed for trace metals) were collected in order to determine where there was a potential link between trace metals present within the upper soil surface and trace metal concentrations observed in groundwater samples through leaching.

Elevated concentrations of arsenic (up to 25 µg/l), cadmium (up to 20 µg/l), chromium (up to 60 µg/l), cobalt (up to 20 µg/l), lead (up to 20 µg/l), nickel (up to 120 µg/l) and selenium (up to 27 µg/l) were observed in the boreholes sampled.

Elevated cadmium (and other trace metal) concentrations within the Nardouw and Quaternary aquifers are possibly present as a result of phosphate fertilizer, treated wastewater or organic manure/compost application to the local golf course fairways and greens, or local/estate gardens in the Fernkloof area.

Conclusion

Cadmium is a highly mobile, bioavailable and potentially toxic trace metal, especially in environments such as acidic, sandy, non-calcareous soils (with low clay and organic matter contents) and acidic groundwater (with low salinity and hardness, and a low organic matter, suspended matter, clay and iron/manganese oxide/hydroxide content).

Although at relatively low concentrations within the product itself, continuous application of phosphate fertilizer and treated sludge/wastewater with cadmium impurities can cause long-term cadmium contamination of soil and ultimately (through leaching) groundwater systems.

The observed contamination within the unconfined Nardouw and Quaternary aquifers in the greater Hermanus region (and specifically the eastern Fernkloof residential area), could possibly be a result of the application of phosphate fertilizer and treated wastewater/sludge in local recreational residential and agricultural areas in association with acidic Table Mountain and Bredasdorp Group soil/sediment and groundwater.

Recommendations

The final report has several recommendations including that:

- Detailed geographical, hydrogeological, hydrochemical and contamination studies on each of the eight clusters of cadmium groundwater pollution within South Africa be undertaken in order to determine the source and mechanisms of cadmium contamination in these regions.
- A GIS (and possibly Web-based) cadmium groundwater contamination risk assessment model for South Africa be developed, incorporating hazard analysis (i.e. point and non-point sources of pollution, cadmium flow assessments), an environmental vulnerability assessments and coping capacity review.

Further reading:

To order the report, *Role of fertilizers in trace metal (specifically cadmium) contamination of groundwater (Report No KV 334/14)* contact Publications at Tel: (012) 330-0340, Email: orders@wrc.org.za or Visit: www.wrc.org.za to download a free copy.