Occurrence of trace elements in soils, plants, water and stream sediments of the tin-tantalum mining area of Gatumba, Rwanda

Tobias K. D. Weber*, Inga Paulmannb, Andrew Muwangac, Michael Oworc, François-X Naramabuyed, Francis Gakwerere*, Michael Biryabaremaf, François Gakwerere*, Harald Bisetera, Walter Pohlg, and Rolf Nieder*

*Technische Universität Braunschweig | Institut für Geoökologie
b Golder Associates GmbH, Vorbruch 3, 29227 Celle
Department of Geology, Makerere University, PO Box 7062, Kampala, Uganda
Faculty of Agronomy, National University of Rwanda, PO Box 117, Butare

Aims

• Analyze soils, vegetation, spring water, stream water and stream sediments for a number of environmentally relevant elements
• Test the influence of seasonality on the trace element status of soils, plants, water and stream sediments
• Clarify toxicity issues
• Provide a baseline for environmental impact studies in other coltan mining areas in Central Africa

Introduction

Mining has become one of the most important sources of toxic elements in the environment. Contamination of soils and surface water or groundwater with toxic elements represents a great threat to human health due to its high potential to enter into the food chain. During a dry season (August 2010) a rainy season (March 2011), we studied the environmental impact of artisanal coltan mining in the Gisuma-Kibilira catchment, a sub-area of the Gatumba Mining District (GMD) of western Rwanda. It is located in the Muhororo Sector of the Ngororero District, ca. 50 km west of Kigali. The minerals of economic value are found in dikes of weathered Lithium-Cesium-Tantalum pegmatite bodies which are mined by ground sluicing.

Materials and Methods

Soils are directly (Technosols on pegmatite), indirectly (Fluviosols, Nitosols, Lithosols, Umbrisols) affected by mining. Samples were taken by horizon from 16 profiles during the dry and rainy seasons.

Plants were sampled from the plots adjacent to the sampled profiles.

Spring water was sampled from the flowing source.

Surface water samples were taken from the middle of the stream at medium depth.

Stream sediments were sampled in proximity to the stream water sample sites.

Total contents of As, Bi, Cd, Cr, Cs, Cu, Li, Ni, Pb, Rb, Sb, Zn, and U in soils, sediments, plants and waters were analyzed by ICP-MS, except for Li, Cr, Cu, As, and Pb in the sediments by ICP-OES.

Results: Water and Sediments

Slight increase in trace element concentrations below the Ruhanga mine and dilution after the Gisuma reaches the Kibilira. A similar trend can be observed for the stream sediments (Fig. 4b). This can be attributed to the weathered pegmatites. All values are lower than internationally accepted guideline values.

Results: Plants and Soils

Upper soil horizons, independent of the influence of mining, show slightly elevated Cr, Cu, Li, Rb and Zn concentrations (Fig. 2). The medians of trace element contents hardly show any difference between the dry and rainy seasons. In all of the soils, trace element concentrations are low compared to internationally accepted guideline values (cited in Nieder et al., 2014).

Independent of the plant species and their use (vegetables, animal feed, fruit plants, wild plants, medical plants), trace element contents are low except for Li, Rb and Zn. Guideline values are not exceeded, except for Zn on some sampling sites. Differences between dry and rainy seasons are not significant.

Conclusion

Our chemical data on soils, plants, water bodies and stream sediments in the GMD reveal no dangerous toxic element levels. Except for Pb and Zn in some plant species; concentrations in soils, plants, sediments, and waters are below internationally accepted guideline values or in the natural. An exposure of the local population to toxic elements is most probably not the case. However, the status quo of trace elements may be different in other mining areas.

Besides the question of toxicity and seasonality, the sediment load in the water courses derived from active and inactive mining sites within the GMD is high. The rate of erosion of fertile topsoil material from the steep and scarcely vegetated hills is currently unknown.

Fig. 1: Sampling points in the study area. Arrow marks the longitudinal river transect shown in Fig 2a,b.

Fig. 2: Trace element contents in the upper horizons of nine soil profiles in the dry and rainy seasons

Fig. 3: Trace element contents in plants of nine sites in the dry and rainy seasons

Fig. 4: Longitudinal transect of Li, Rb, and Cs concentrations in a) stream water an b) sediments.

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