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Geochemical mapping of soil and water around abandoned mines in Kadoma, Zimbabwe

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In Zimbabwe, toxic element releases from mining into agro-ecosystems pose a serious threat to the health of communities that continue to reside in surrounding environments, well after the cessation of mining activities. Issues of contamination, including the concentration levels of toxic elements (in relation to background values), their extent, migration pathways and routes of exposure are poorly understood, because few environmental geochemical studies and mapping programmes have been undertaken to date. Once these data are accrued, research studies into improved remediation techniques and use of novel methods such as phytoremediation, can then be designed to address these contamination issues.

The aim of the present study was to produce geochemical maps for highly mineralised, historically heavily mined areas in Kadoma, Zimbabwe, and thus begin the characterisation of the environmental geochemistry of these areas to ascertain levels of soil and water contamination. Georeferenced soil, stream sediment and water samples were collected and analysed for the concentrations of 53 elements that included arsenic, cadmium, chromium, copper, lead, mercury, nickel and zinc. Areas of known abandoned and active mine facilities were identified and digitised from satellite imagery and field mapping.

Maps produced through contouring and surface modelling techniques using geographical information system (GIS) applications revealed areas of significant soil and water contamination in the vicinity of the major abandoned mining areas with locations having levels of toxic elements well above the recommended Food and Agriculture Organization/ World Health Organization (FAO/WHO) maximum levels. Most soils around the mines have arsenic values with two digits (96.7, 81.3, 31.1, 91.6, 21.9, 30, 31.6 ppm). Total chromium values in the soils were also high (up to 406 ppm) with further analysis required to determine the chromium form in question as this has an impact on toxicity (hexavalent chromium is considered highly toxic). Though most water samples (surface and borehole water) contain key chemical elements responsible for large-scale health effects through drinking water exposure in concentration below the recommended WHO guidelines for safe drinking water, some streams have high arsenic values (166, 142 and 5847 ppb) compared to the recommended 10 ppb. The study also noted that one stream running across a number of abandoned mines has most key chemical elements responsible for large-scale health effects through drinking water exposure much higher than the recommended guidelines for safe drinking water.

The extent to which elevated toxic element levels affect the cultivable potential and acceptable land use designation of the soil is assessed. We demonstrate the effectiveness of the accrued dataset for monitoring soil and water pollution in the area and for strengthening other aspects of future ecological risk assessment campaigns.

Keywords: Mining, toxic elements, soil, water, contamination, GIS, ecosystem health, Kadoma