ABSTRACT

The mining and processing of copper in Kilembe, Western Uganda, from 1956 to 1982 left over 15 Mt of cupriferous and cobaltiferous pyrite dumped within a mountain river valley, in addition to underground mine water which is pumped to the land surface. This study was conducted to assess the sources and concentrations of heavy metals and trace elements in Kilembe mine catchment. Samples of mine tailings and mine water were collected and analysed for concentration of heavy metals and trace elements. In addition, public water sources such as Catchment Rivers and streams, water wells and domestic water samples were collected. Soil samples were collected alongside the foods grown and forage while house dusts were collected from homes and public builings such as churches, schools and a hospital. Exposure of local people was assessed through collection of toe nails from volunteers. Water samples were acidified using 0.2M nitric acid while tailings, soils, sediments, house dust, foods, forage and toe nails were acid digested. Multi-element analysis of trace elements and heavy metals from point sources and sinks was conducted using ICP-MS. The study found that mean concentrations (mg kg -1) of Co (112), Cu (3320), Ni (131), As (8.6) in mine tailings were significantly higher than world average crust and were being eroded and discharged into soils and water bodies within the catchment. Underground mine water and leachate contained higher mean concentrations (mg L-1) of Cu (9470), Co (3430) and Ni (590) compared with background concentrations (mg L -1) in un contaminated water of 1.9, 0.21 and 0.67 for Cu, Co and Ni respectively. Over 25% of household water samples exceeded UK drinking water thresholds for Al of 200 µg L-1, Co exceeded Winsconsin (USA drinking) water thresholds of 40 µg L-1 in 40% of samples while Fe in 42 % of samples exceeded UK thresholds of 200 µg L-1. Besides mining activities, natural processes of geological weathering also contributed to Al, Fe, and Mn water contamination in a number of public water sources.

Pollution load indices revealed that 51% of agricultural soils sampled were contaminated with trace elements, notably Cu, Co, Ni and Zn with potential for plant uptake. The major factors influencing heavy metals and trace element distribution in the environment were distances and locations relative to point sources of contaminants. Soils sarrouinding and downhill tailing sites and along River Nyamwamba were more prone to heavy metal and trace element contamination. Zinc exceeded WHO/FAO thresholds of 99.4 mg kg-1 in 36% of Amaranthus vegetable samples, Cu exceeded EC thresholds of 20 mg kg -1 in 19% of Amaranthus while Pb exceeded WHO thresholds of 0.3 mg kg-1 in 47% of Amaranthus vegetables. In bananas, 20% of samples contained Pb concentrations that exceeded the WHO/FAO recommended threshold of 0.3 mg kg-1. Risk assessment of local foods and water, based on Hazard Quotients (HQ values) revealed no potential health effects. In forage, bio-accumulation of Zn, Cu, Ag and Cd was observed in all forage species. Pearson's correlation of Ni, Cu, Co, Zn and Pb in both soils and forage were strong and positive, suggesting that generally, forage grasses absorbed and transported the trace elements from soil solutions to plant structures proportionately. Zinc concentrations in 14% of guinea grass, 33% coach grass and 20% of elephant grasses exceeded recommended thresholds of 100-150 mg kg -1, Cu concentrations in 20% of elephant grass and 14% of coach grass samples exceeded recommended thresholds of 25 mg kg-1 and could pose potential negative

health consequences to grazers. The elevated concentrations of heavy metals and trace elements in forage may also be transferred along the food chains.

House dusts presented possible sources of exposure for local people. Based on Nova Scotia limits for trace elements in residential soils, Co exceeded the recommended limits of 22 mg kg -1 in 75% of the dust samples collected from private residences and 86 % of public buildings. Exposure of local people in Kilembe mine area was confirmed. Compared with control samples from volunteers who lived more than 400 km from the Kilembe mine, and had never lived in the study area, trace element concentrations in toenails of children were significantly different in the case of Co (p =0.009), Ni (p = 0.01), Cu (p=0.002) and As (p =0.035). By contrast, the concentrations of Cu, Co Ni and As in toenails of resident adults and control volunteers were not significantly different (p>0.05), implying that children were more exposed to trace elements and heavy metals from mine waste and water. However the high external contamination of volunteers' toenails with some elements (even after a washing process) calls into question their use as a biomarker for metal exposure in human populations where feet are frequently exposed to soil dust.

Any mitigation of Kilembe mine impacts on the biophysical environment and reduction of the exposure of local people should involve containment of tailing erosion, remediation of agricultural soils, regulation and treatment of the discharged underground contaminated water. An outreach and extension program reaching out to the local people is also necessary to raise awareness of the risks associated with the locality to enable them make informed decisions for settlements, cultivation, grazing and water collection points.