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ENVIRONMENTAL IMPLICATIONS OF PHYTOEXTRACTION FOR MERCURY AND GOLD

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ABSTRACT

The overall objective of this study was to investigate how plants could be used to harvest gold (phytomining) and at the same time remove mercury (phytoremediation) from auriferous mercury-contaminated soils. This study was undertaken to find appropriate plants that could be used to harvest gold, residual in mine tailings or in uneconomic low-grade ore, and at the same time remove residual mercury, commonly used to extract the gold in artisanal mining areas. Different procedures involving analytical methodology, leaching of acid mine tailings and the growing of plants in both gold and mercury-bearing substrates were undertaken.

The analytical methods involved in the analysis of gold in the laboratory using the modern instruments were Flame Atomic Absorption Spectrometry (FAAS) and Graphite Furnace Atomic Absorption Spectrometry (GFAAS). The determination of mercury involved using Flameless Atomic Absorption Spectrometry.

To understand the induced solubility of metals in phytoextraction, Tui mine tailings were leached with several chemicals known to solubilise gold: ammonium thiocyanate, ammonium thiosulphate and urea. The pH of the tailings material was varied through amendment with lime to examine the effect of this geochemical parameter on metal solubility and thus the potential for both plant uptake and leaching. The Tui mine tailings were chosen because of their geochemistry; these are highly weathered sulphide-ore tailings that leach heavy metals into adjacent water systems.

The induced-phytoextraction potential of root crops was also examined in this thesis. Five root crops were grown in an artificial substrate consisting of 3.8 mg/kg (ppm) of elemental gold dispersed in sand. The possibility of using these root crops for phytomining was determined by separately adding chelating agents ammonium thiocyanate and ammonium thiosulphate to the substrate. In most cases there was a higher gold concentration in the roots than in the shoots. The highest mean gold

concentrations were found in carrot roots and in roots of two radish cultivars. It was concluded that there was some potential for the use of carrot to grow an economic crop of gold from mine tailings.

Results obtained from experiments where plants were grown in Tui tailings indicated that both chicory and *Brassica juncea* could be used for the phytoextraction of gold and mercury in the same crop. Under acidic conditions thiocyanate induced the uptake of gold by *Brassica juncea* and the uptake of mercury by chicory; and thiosulphate induced the uptake of mercury by chicory, but it did not induce the uptake of gold by the same plant. Under alkaline conditions, treatment with ammonium thiosulphate induced the uptake of gold and mercury by *Brassica juncea*; and treatment with thiosulphate induced the uptake of mercury by chicory but it did not induce the uptake of gold. It was therefore concluded that, *Brassica juncea* could be used for phytoextraction of gold and mercury when ammonium thiosulphate is applied to the substrate. Results from the root-crop experiment indicate that, carrots could supersede most of the plants used due to the greater apparent metal-uptake potential.

Finally, a model is proposed for field trials to examine the potential of phytoextraction for gold and mercury in Tanzania. The aim of this model is to examine how the positive results obtained from research conducted in the laboratory and greenhouse can be put into practice. The use of similar plants as well as traditional tropical species (e.g. wild cassava – a known accumulator of cyanide) is suggested along with suitable chemical amendments.

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