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ENVIRONMENTAL IMPLICATIONS OF PHYTOEXTRACTION FOR MERCURY AND GOLD

A thesis presented in partial fulfilment of the requirements for the degree of Master of Science in Earth Science at

Massey University

Fletcher Abduel Msami Msuya

2000

Massey University
Palmerston North
New Zealand

ACKNOWLEDGEMENT

My sincere thanks are due to my chief supervisor Professor Robert Brooks for his encouragement, guidance and advice during this study. I personally thank him and his family for being very supportive and concerned about my peaceful stay in New Zealand.

I feel greatly indebted to Dr. Chris Anderson and Dr. Brett Robinson for their tireless assistance, guidance and cooperation during the whole period of this study.

I thank all members of staff of Soil and Earth Sciences, in particular Assoc.Prof. Mike Hedley, Dr. Robert Stewart, Assoc. Prof. Paul Gregg, Assoc. Prof. Nanthi Bolan, Dr. P. Loganathan and Assoc. Prof. Vince Neall for their support; the Secretary Hera Kennedy for her patience and support, the technical staff namely, Mike Bretherton, Ian Furkert, Bob Toes, Anne West, Glenys Wallace and Ross Wallace, who were always ready and willing to offer assistance and memorable amusement.

I would like to extend my appreciation to my colleagues namely, James Hanly, Asoka Senerath, Steven Trolove, Bhupinderpal Singh, Afriqur Khan, Tin Maung Aye, Jamie Blennerhassett, Hewana Sumanasena, Saman Bowatte, Arivin Rivaie, Liu Qinhe, Hutham Sabti and Liao Mingtan, for their assistance especially with computer work.

I wish to acknowledge the support of the New Zealand Overseas Development Agency for a grant to enable me to study at Massey University. I also feel greatly indebted to my Company Pugu Kaolin Mines Ltd., The State Mining Corporation and the government of Tanzania, for allowing me to pursue further studies in New Zealand.

I would like to thank my friends and their families both in Australia, New Zealand, and Tanzania namely Glenda Mill, Alphonce Ndibalema, Fred Mpelasoka, Alieu Sartie, Prof. Cliff Studman and his wife Irene, Tara Nath Pandey and his wife Narayani Tiwari Pandey, Gary George, Peter and Christine Akester, my uncle Abduel Kenge, Peter Gembe, Hayaz Mruma, Dickson Mchomvu and Dr.G.A.Mchomvu. I wish to thank sincerely my brothers Haldgod, Zacharia, Elihuruma and Kajiru, my sisters Emma, Veronica, Beatrice, Mary and Happiness and their families, for their support during my study.

Most importantly, I would like to express my deepest thanks to my family namely, my wife Grace and children Emma, Naetwe, Masecha and Joseph for their inspiration, understanding, faith and support during the course of my study.

I dedicate this research to my late parents:

Abduel Msami Msuya and Tamari Abduel Msami Msuya.

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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