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Preliminary studies of the distribution of some trace metals in the top soils of farmlands in the Jos tin mining areas

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ABSTRACT

Trace metal concentration in arable soils from intensive tin mining areas of the Jos Plateaus was determined using an Energy Dispersive X-ray fluorescence (EDXRF) method, operated using a 22.1 KeV 25m C_i ^{109}Cd as the exciting source. The elements analysed in the soils are; Ti, V, Cr, Mn, Fe, Co, Sn, Ni, Pb, and Mo with concentrations of Fe, Ti, Sn and V being generally high while those of Ni, Pb and Mo were very low. This implies that the crop production in these areas could bring about the enrichment of the crops in certain elements.

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INTRODUCTION

Many trace metals occur naturally in soils with variation in their concentrations. According to Underwood [1] top soils from which plants are nourished also vary in their trace element composition. The variation is governed by such factors as, the chemical nature of the rocks from which the soils were formed, the types of industrial activity going on in an area, types of fertilizers and agrochemicals used for agricultural purposes, the types of waste disposals practices and typesa of energy sources, types of sewage sludge and other materials that could be dumped on the soil [2]. Trace metals, classified according to their effect in the body include:

i. The macro-nutrients: calcium, sodium, potassium and magnesium.
ii. The micro-nutrients: iron, selenium, zinc, manganese, copper, molybdenum, cobalt, chromium, silicon, nickel and tin.
iii. Metals for which essentiality has not yet been established, although there is evidence of their involvement in some cell reactions: barium, arsenic, strontium, cadmium and vanadium.
iv. Metals found in the body for which no metabolic function is known: lead, gold, mercury, silver, bismuth, antimony, boron, beryllium, lithium, gallium and titanium [3].

Reilly [3] also reported that some of these classified essential metals had turned out to be toxic to the plant or animal when their forms changed or when they are accumulated beyond a tolerance level. He also observed that many plants if placed in a nutritionally balanced soil, would take up nutrients to the extent needed for growth only. The others are known to posses special abilities, which enable them to take-up certain elements with the attendant accumulating of same to dangerous levels, thus making the plant toxic Toxic- chemical Release Inventory [4,5].

In his work on ecological plant materials, Allen [6] recognized that many ecological plant materials do differ significantly in chemical composition when the environmental conditions have been altered. In the course of tin exploitation on the Jos Plateau, the chemical compositions of the top soils have continuously been altered also [7]. There is a possibility that the trace metal composition of farmlands in the area has been altered too.

In this work, an EDXRF system based on ^{109}Cd isotope excitation is used to determine the concentrations of some metals in the top soils of the farmlands in the mining areas. In similar works, Kump [8] Angeyo *et al* [9] and Funtua [10] used modified versions of the Emission Transmission (E-T) method that involves the use of pure target materials (Mo) to measure the absorption factors in the samples. The Mo target served as a source of monochromatic X-rays, which are guided through the samples as primary radiation and then penetrate the sample on the way to the detector. The absorption factor is experimentally determined in this way and programmed for use in the quantification of the trace metals in the soils.

EXPERIMENTAL

Sample collection

Table 1: Trace metal concentrations (ppm) in the soils

Sample	Ti	V	Cr	Mn	Fe	Co	Sn	Ni	Pb	Mo
BLD - S_1	8230	519	395	564	42,500	195	644	97	39	6
BLD - S_2	5550	436	255	265	52,400	234	635	66	47	6
BLD - S_3	2990	577	293	440	35,500	134	654	65	45	5
$\bar{X}$	5590	510	314	423	43,466	188	644	76	44	5.8
S.D	2620	71	72	150	8,491	50	8	4	4	0.4
BSA - S_1	1750	502	358	196	9,170	127	676	62	35	5
BSA - S_2	2110	563	389	198	11,300	106	678	57	33	5
BSA - S_3	2410	571	263	238	14,900	103	675	96	28	5
$\bar{X}$	787	545	337	211	11,790	112	676	72	32	5
S.D	1093	38	66	24	2896	13	1.5	21	4	0
BKK - S_1	5300	656	354	545	26,300	130	622	82	39	6
BKK - S_2	2890	506	511	347	16,000	156	674	101	41	5
BKK - S_3	2220	878	484	312	17,500	209	1,590	42	51	10
$\bar{X}$	2315	680	450	404	19,933	165	962	75	44	7
S.D	2077	187	84	123	5564	40	544	30	6	3
JJN - S_1	11,800	836	350	947	60,200	147	577	84	40	5
JJN - S_2	12,200	518	427	910	67,800	164	623	93	44	7
JJN - S_3	2,740	483	363	236	8,400	111	677	53	36	5
$\bar{X}$	8913	612	380	539	45,467	141	626	77	40	5.7
S.D	5350	195	41	308	32,325	27	50	21	4	1.2
JJS - S_1	2740	498	316	193	9720	143	678	68	39	5
JJS - S_2	1560	481	334	176	9940	103	680	76	161	5
JJS - S_3	4350	478	301	258	20,600	144	668	62	50	5
$\bar{X}$	2883	486	317	209	13420	130	675	69	83	5
S.D	1401	11	17	43	6219	23	6	7	68	-
$\bar{X}$	4590	567	360	388	26,815	147	719	74	49	6
s	3373	129	74	251	20,041	40	243	18	32	1.4

Sample collection was done from the 11th to the 15th of January 2004 at approximately the same time of the day. The period coincided with the dry season, when mobility of metallic ions in the soils was minimal because of dryness. 3 top soil samples were taken from each of three different spots in 5 Local Government Areas of extensive tin mining activities on the plateau. Each of the fifteen samples was taken after clearing off the weeds on the soil surface and the soil was dug to a depth of 10cm. The soils lumps were thoroughly fragmented at the spot and thoroughly mixed before taking out 1g of fragments into labelled polythene bags. The samples collected were coded as:

L.G.A.	Sample		
B/ladi	BLD-S_1,	BLD-S_2,	BLD-S_3.
Bassa	BSA-S_1,	BSA-S_2,	BSA-S_3.
Bokkos	BKK-S_1,	BKK-S_2,	BKK-S_3.
Jos North	JJN-S_1,	JJN-S_2,	JJN-S_3.
Jos South	JJS-S_1,	JJS-S_2,	JJS-S_3

Elemental analysis

An Energy Dispersive X-Ray Fluorescence (EDXRF) method was used. The 15 collected soil samples were ground manually < 125 μm to with an agate mortar and pestle. Pellets of 19mm diameter of

the soil were then prepared from 0.300g of the powder mixed with 3 drops of an organic liquid binder (Polyvinyl chloride dissolved in Toluene) and this was pressed afterwards at 10 tons with a hydraulic press. Measurements were then performed using annular 25mCi ^{109}Cd as the exciting source that emits Ag-K x-rays (22.1 KeV) in which case all elements with lower excitation were accessible for detection in the prepared soil sample pellets. The quantitative analysis of the samples pellets was carried out using the Emission-Transmission (E-T) method for which a number of quantitation methods have been developed and applied [8,11,12,13]. These quantitation methods provided different approaches to correct matrix absorption as well as some enhanced effects. Results obtained are presented in the accompanying table.

RESULTS AND DISCUSSION

Trace metals of interest, Ti, V, Cr, Mn, Fe, Co, Sn, Ni, Pb and Mo, were found in all the 15 soil samples as tabulated. Included in the table also are the means, and standard deviations. Also found in all the soils were other metals such as K, Ca, Sc, Cu, Zn, Ta, W, Ga, As, Rb, Th, Y, U, Zr, and Nb with varying concentrations.

The order of relative abundance of the trace metals in the soils is; Fe >Ti > Sn >V>Mn > Cr > Co> Ni > Pb > Mo. While Bokkos soils were found to be relatively richer in V, Cr, Mn, Co, Sn, Ni and Mo, B/Ladi soils were found to be richer in Ti, Mn, Fe, Co and Ni; soils from Jos North were also found to be relatively richer in Ti, Cr, Mn, Fe and Ni, while those from Jos South were richer in Pb. Bassa soils do not show relative richness in any particular trace metal more than any of the L.G.A.s.

CONCLUSIONS

The top soil samples collected from five local government areas of intensive mining activities were found to contain Ti, V, Cr, Mn, Fe, Co, Sn, Ni, Pb and Mo. The levels of Fe, Ti, Sn and V were generally high (567 to 26, 815 ppm) while that of Ni, Pb and Mo were generally very low (6 to 74 ppm). This implies that crop production in the area could bring about enrichment of the crops in certain elements as well as deficiency in others.

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