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DEPTH PROFILE OF NATURAL RADIONUCLIDES IN THE SOIL AROUND THE CONSOLIDATED TIN MINE SITE BUKURU - JOS, NIGERIA.

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ABSTRACT

The depth profile of the natural radionuclides namely: ^{40}U; ^{238}U and ^{232}Th in the soil around the consolidated Tin mine site, Bukuru-Jos of Plateau State was examined in this study. Gamma scintillation spectrometry with NaI (Tl) was used for the analysis. Results revealed that the average concentration of ^{40}K is highest at a depth level of 20 -25cm and lowest at 25-30cm ^{238}U is highest at 10-15cm and lowest at 25-30cm while ^{232}Th is also highest at the level 10- 15cm and lowest at 15-20cm. The results to a large extent indicate no particular trend.

KEYWORDS: **Radioactivity, radionuclides, soil, scintillation, gamma.**

INTRODUCTION

The earth's crust and the outer space are the sources of most environmental background radiations; constituting about 85% (Eisenbud and Paschoa 1989). The bulk of these radiations come from Rn-222 and Rn 220 which are decay products of U-238. and Th-232 respectively (Adams and Lowder 1964).

The migration of radionuclides in soils has been studied by many workers. Inoue and Kaufman (1963); Tiller et al (1963) Eisenbud (1973) Thomas (1977); Selom et 011 (1977); Sposito (1981); Buchhuber et al (1982) (De laune et al 1986), Kurt Bunzl et. al 1988). It has generally been observed that subsequent to depositon of radionuclides on the forest floor, their penetration in the soil begins. To predict the period after which the radionuclides will reach plant roots or eventually the ground water table, information on their vertical rate of migration in the forest soil is needed. The objective of this investigation was therefore to determine at first the profile or vertical distribution of the natural radionuclides with the soil depth and to articulate reasons for the observed trend

The new site of Consolidated Tin mine is located on an area away from Bukuru town, Jos, Plateau State, Nigeria, (Figure 1.0) It lies between the latitude 9°46' N to 9°47' and longitude 8°49' E to 8°51' E. The area is on a cultivable lowland, indicating that farming has been discontinued some time ago (Rahaman 1985).

THE GEOLOGY OF THE AREA

The Jos area of Nigeria is located on a grantic plateau about 1400m above sea level in the North central part of the country. The main geological unit of this area (figure 2) lends itself to the mining and milling of tin. The Lithological units (Badejoko 1975) are: Basement complex, Biotite Grainte and New Basalt. Tin and columbite are associated with greisenized biotite granites (Badejoko 1975). The Jos tin industry started around 1904 and the primary purpose of the industry is to mine tin ore and mill it for Tin (SnO_2) and some by - products (especially columbite) for exportation.

METHODS

A total of 60 samples were collected from 10 locations at six different depths each: 0-5cm, 5-10cm, 15-20cm, 20-25cm and 25-30, around the Consolidated Tin Mine area. The Samples were obtained by cleaning the surface vegetable from a location and then taking a core sample from it for a specific depth of 5cm up to 20cm. That is, at each location 10 samples were collected depth wise at 5cm interval. The soil samples were taken to the counting laboratory of the Federal Radiation Protection Service of the University of Ibadan, Ibadan from the location spot wrapped in plastic bags,and then dried under laboratory temperature (Approx 27° for 72 hours) (I. A. E. A. 1981, Barry 1979, Franklin 1967). Cross contamination was avoided by maintaining utmost cleanliness while preparing each sample. About 0.1 kg of each soil sample was then transferred to the counting system which consists of a scintillation detector 7.6cm x 7.6cm NaI (Tl), a photomultiplier tube which is an integral part of the hermatic package which cannot be dissembled from the crystal and then a Canberra

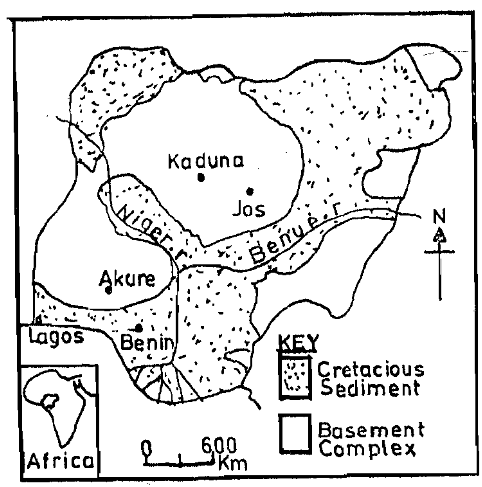

Fig.1. Location of Jos in the Geological map of Nigeria.

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TABLE 1 0

Isotope	Most prominent gamma energy (kev)	Energy used for estimation (Kev)	Proton emission probability
^{40}K	779,1120,1588 1765,2109	1461	1461
^{238}U	510,538,910,965, 2615	1765 (due to 214 Bi)	43
^{232}Th		2615 (due to 2087T1)	100

Table 2.0 results of activity concentration of 60 sample numbers average

ACTIVITY CONCETRATION AT SOIL DEPTH (0-30CM) BQ KG^{-1}

Level 0-5 cm

Sample	^{40}K	^{238}U	^{232}Th
1	751.00 ± 0.04	6.80 ±0.40	1.50 ±0.40
2	21.00 ± 0.23	8.30 ±0.30	1.70 ±0.48
3	8.0 ± 0.19	7.40 ±0.33	3.40 ±0.47
4	27.00 ± 0.20	10.10 ±0.30	2.20 ±0.60
5	17.00 ± 1.40	0.80 ±0.60	1.70 ±0.62
6	27.00 ± 1.00	24.50 ±0.10	0.0 ±0.00
7	32.00 ± 0.60	8.00 ± 0.83	0.0 ±0.00
8	0.0 ± 0.00	14.70 ±0.25	0.070 ±0.16
9	0.0 ± 0.00	16.20 ±0.19	0.40 ±0.25
10	27.10 ±0.15	11.30 ±0.15	5.80 ±0.15
Average	114.00 ± 0.48	10.80 ±0.35	2.20 ±0.39

Level 5 – 10cm

Sample no.	^{40}K	^{238}U	^{232}Th
1	31.00 ±0.40	10.60 ±0.17	5.70 ±0.16
2	25.00 ±0.54	7.40 ±0.32	6.00 ±0.13
3	23.00 ±0.74	12.90 ±0.11	5.00 ±0.22
4	0.0 ±0.00	13.30 ±0.11	1.10 ±0.62
5	154.00 ±0.11	66.20 ±0.07	4.80 ±1.00
6	161.00 ±0.10	2.70 ±0.15	9.80 ±0.39
7	51.00 ±1.00	4.10 ±0.12	25.00 ±0.60
8	707.00 ±0.05	3.60 ±0.13	0.90 ±0.49
9	0.0 ±0.00	22.30 ±0.11	0.40 ±0.18
10	10.40 ±0.36	16.70 ±0.18	0.80 ±0.09
Average	116.30 ±0.33	16.00 ±0.15	6.00 ±0.3

Level 10 - 15 cm

Sample	^{40}K	^{238}U	^{232}Th
1	130.00± 0.04	31.50±0.03	29.60±0.10
2	41.00± 0.23	12.60± 0.13	9.30± 0.06
3	44.00± 0.19	12.60± 0.12	10.10±0.05
4	15.30± 0.20	11.40±0.15	9.40±0.05
5	23.00±0.73	12.70±0.12	9.80±0.06
6	0.00±0.40	20.20±0.12	2.70±0.80
7	0.00±0.00	24.10±0.08	1.90±0.24
8	15.70±0.40	24.70±0.08	0.00±0.00
9	0.00±0.00	27.60±0.06	1.10±0.40
10	0.00±0.00	28.50±0.05	17.0 ±0.02
Average	44.80±0.30	28.50± 0.05	10.20± 0.20

Level 15-20cm

Sample	^{40}K	^{238}U	^{232}Th
1	42.20±0.32	8.60±0.25	4.60±0.24
2	36.50±0.27	14.20±0.10	2.20±1.10
3	2.70±0.39	11.20±0.10	1.60±0.04
4	13.80±0.74	5.60±0.61	1.70±0.04
5	9.20±0.11	3.50±1.60	0.00±0.00
6	6.90±0.11	4.70±0.89	0.00±0.00
7	6.90±0.11	6.60±0.41	0.00±0.00
8	32.80±0.69	34.80±0.04	0.00±0.00
9	15.00±3.40	35.50± 0.04	0.10±0.72
10	0.00±0.00	21.20±0.11	0.52±0.15
Average	130.00±0.84	14.60±0.52	1.80±0.38

Level 20 – 25cm

Sample No	^{40}K	^{238}U	^{232}Th
1	15.30±1.41	14.40±0.09	8.10±0.08
2	35.90±0.29	12.50±0.13	10.10±0.05
3	8.60±0.26	14.40±0.09	7.30±0.10
4	21.50±0.13	7.90±0.30	8.10±0.08
5	51.80±0.13	13.10±0.11	5.10±0.19
6	28.660±0.43	10.00±0.18	4.20±0.28
7	88.50±0.33	4.50±0.89	17.50±0.08
8	544.60±0.02	0.00±0.00	0.00±0.00
9	653.40±0.01	0.00±0.00	17.7±0.11
10	282.20±0.03	37.70±0.04	0.00±0.00
Average	173.03±0.07	14.30±0.23	9.80±0.12

Level 25 – 30cm

Sample no.	^{40}K	^{238}U	^{232}Th
1	42.40± 0.20	14.40±0.09	8.50±0.07
2	39.70± 0.24	13.30±0.11	9.60±0.06
3	48.20±0.15	9.00±0.23	8.60±0.06
4	14.40±0.05	10.60±0.17	9.20±0.006
5	36.30±0.32	14.70±0.10	9.30±0.07
6	21.70±0.77	12.40±0.12	5.00±0.21
7	36.10±0.32	5.90±0.53	4.50±0.24
8	36.10±0.29	9.10±0.23	3.60±0.42
9	20.00±0.08	32.70±0.05	0.00±0.00
10	1.70±0.74	14.60±0.19	15.30±0.11
Average	29.70±0.32	13.70±0.19	8.20±0.14

TABLE 3.0

AVERAGE ACTVITY CONCENTRATION (Bq Kg^{-1}), OF ^{40}K, ^{238}U, ^{232}Th WITH DEPTH (cm)

	^{40}K	^{238}U	^{232}Th
0-5	114.00±0.50	10.80±0.40	2.20±0.40
5-10	116.00±0.20	16.00±0.20	6.00±0.30
10-15	44.8±0.30	20.60±0.100	10.20±0.20
15-20	130.00±0.80	14.60±0.50	1.80±0.40
20-25	173.00±0.40	14.60±0.20	9.80±0.10
25-30	29.7±0.30	13.70±0.20	8.20±0.10

multichannel analyser (M.C.A.) for gamma-analysis. The detector was then connected to a Canberra series 10-plus portable M.C.A. which is a complete system with all the functions needed for spectroscopic analysis.

The counting time for each sample and background reading was then stripped channel by channel from each sample Hartwell (1975), Ibrahiem (1993). The most prominent gamma-energies observed in the spectrum, the corresponding emitting radionuclides and the gamma energies used for the estimation of the concentration of the natural radionuclides are as shown in table 1.0.

RESULTS AND DISCUSSION

Table 2.0 gives the results of the concentration in the 60 samples and their average activity concentrations (BqKg^{-1}) at each soil depth (cm). The radionuclide analysis of the soil sample from the Consolidated Tin Mine, Bukuru Jos site revealed that the activity concentration of ^{40}K, ^{238}U and ^{232}Th were to a large extent indicative of no particular trend in all depths. This perhaps might be due to the geological nature of the area

Table 3.0 presents the average concentration of the three selected radionuclides above, at each depth. The average concentration of ^{40}K was 114.0 + 0.5 Bqkg^{-1}, 116.0 + 0.2 Bqkg^{-1}, 44.8 ± 0.3 Bqkg^{-1}, 130.0 ± Bqkg^{-1}173.03±0.4 Bqkg^{-1} and 29.7± 0.3 Bqkg^{-1} at depths 0-5 cm, 5-10cm, 10-15cm, 15-20cm, 20-25cm, 25-30cm respectively. The distribution of the average concentration of ^{40}K with soil depth is a shown on the column chart (Fig.3a). The average concentration begins with an increase from the first depth to the third depth, then further increases to the fourth and then the fifth depth and finally drops again at the last depth. Hence no particular trend is observed, suggesting that there may be little or no migration of radionuclides within the soil.

The average concentration ^{238}U was 10.8±0.4 Bqkg^{-1}, 20.6±0.1 Bqkg^{-1}, 14.6± 0.5 Bqkg^{-1}, 14.4±0.2 Bqkg^{-1}, and 13.7± 0.2 Bqkg^{-1} at depths 0-5 cm, 5-10cm, 10-15cm, 15-20cm, 20-25cm, 25-30cm respectively. The distribution of the average concentration of ^{238}U with soil depth is as shown on the column chart Fig. 3b. The

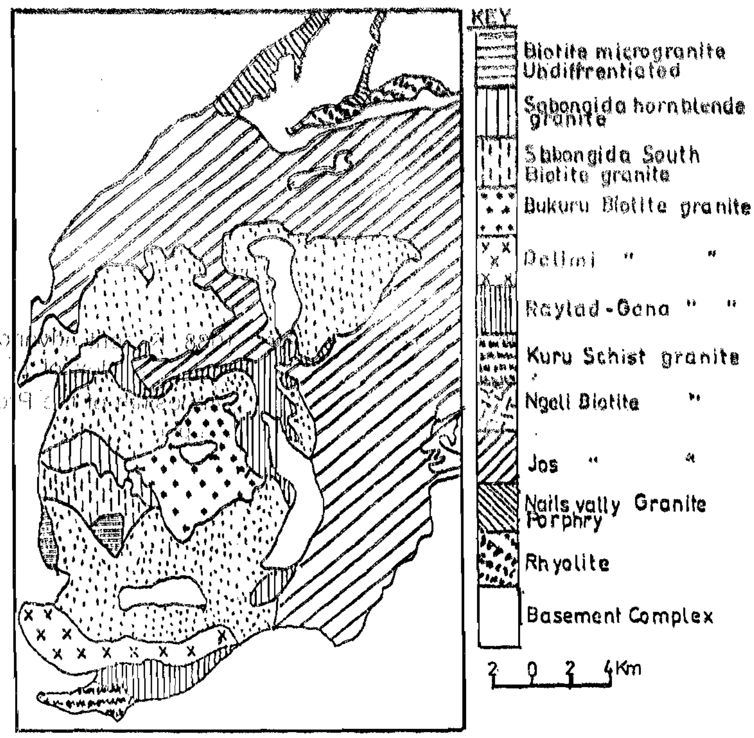

Fig .2. Geological map of Jos and environs.

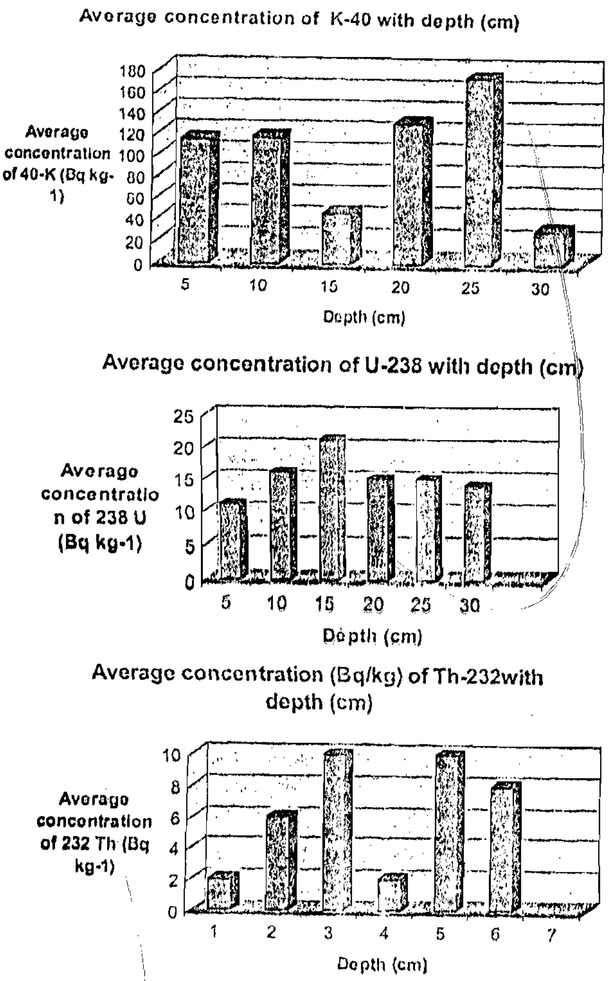

Figure 3 a,b,c; Showing the average concentration of K-40, U-238 and Th-232 with soil depth.

average concentration increased with depth up to the third depth and gradually reduced again with depth in the three depths.

The average concentration of ^{232}Th was 2.2$\pm$ 0.4Bqkg^{-1}, 6.0$\pm$0.3 Bqkg^{-1}, 10.2$\pm$0.2 Bqkg^{-1}, 1.8$\pm$0.4 Bqkg^{-1}, 9.8$\pm$0.1 Bqkg^{-1}, at depths 0-5 cm, 5-10cm, 10-15cm, 15-20cm, 20-25cm, 25-30cm respectively. The profile of the average concentration of ^{232}Th with depth is also shown on column chart Fig 3c.

The concentration increased with depth for the first three levels and drastically dropped low on the fourth level 15-20cm and then closely followed in the fifth depth by a high increase in concentration, then terminating with a small decrease on the last depth 25-30cm. Just like the profile of ^{40}K above, that of ^{232}Th has no particular trend too. This may be attributed to the geological nature of the site or it may be due to radionuclide deposition that migrated from other places by erosion since the site is a lowland in between some elevated highlands.

Finally, it is worth mentioning that the average activity concentration of ^{40}K was found to be most highly concentrated at all depths followed by that of ^{238}U. ^{232}Th was observed to be the at the lowest values in all the depths as seen on the results on table 2.0

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