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Assessment of Activity Concentration of The Naturally Occurring Radioactive Materials (Norm) in the Yankandutse Artisanal Gold Mining Belt of Kaduna, Nigeria.

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Abstract: *The activity concentrations of potassium, Radium and thorium in soil samples from a mining site in yankandutse, Kaduna north western Nigeria were measured using gamma ray spectroscopy method. Activity concentration of potassium, Radium and thorium were determined. The activity concentrations of ^{40}K, ^{226}Ra and ^{232}Th, respectively in Bq kg^{-1} in the soil samples ranged as follows: K-40 196.11±2.02 to 553.03±1.08 with average of 382.01, Ra-226 .1506±.03 to 5.67±.03 with average of 2.08 and Th-232 18.13±3.19 to 73.09±1.59 with average activity concentrations of 47.23 .The mean activity concentration of potassium and radium are below average but for thorium the activity concentration is above average.*
Keywords*: Radionuclide's; soil; mining; activity concentration; Kaduna.*

I. Introduction

OUR MATERIAL world is composed of many substances distinguished by their chemical, mechanical, and electrical properties. They are found in nature in various physical states–the familiar solid, liquid, and gas, along with the ionic "plasma." However, the apparent diversity of kinds and forms of material is reduced by the knowledge that there are only a little over 100 distinct chemical elements and that the chemical and physical features of substances depend merely on the strength of force bonds between atoms. In turn, the distinctions between the elements of nature arise from the number and arrangement of basic particles–electrons, protons, and neutrons. At both the atomic and nuclear levels, the structure of elements is determined by internal forces and energy.

Many Naturally occurring and man-made isotopes have the property of radioactivity, which is the spontaneous disintegration (decay) of the nucleus with the emission of a particle. The process takes place in minerals of the ground, in fibers of plants, in tissues of animals, and in the air and water, all of which contain traces of radioactive elements.[1]

Radioactive Decay

Before looking in more detail at different classes of instability, we will consider the general formalism describing the rate of radioactive decay. The probability per unit time that a given nucleus will decay is called its decay constant and is related to the activity A by $A = -\frac{dN}{dt} = \boldsymbol{\lambda N}$ where N (t) is the number of radioactive nuclei in the sample at time t. The activity is measured in Becquerels (Bq), which is one decay per second. The probability here refers to the total probability, because could be the sum of decay probabilities for a number of distinct final states in the same way that the total decay width of an unstable particle is the sum of its partial widths. Integrating above equation gives $A(t) = \boldsymbol{\lambda N_0 \, exp(-\lambda t)}$ where N_0 is the initial number of nuclei, i.e. the number at t = 0.[2]

Nearly 90% of the 2500 known nuclides are radioactive; they are stable but decay in to other nuclides. When unstable nuclides decay in to other nuclides, they usually emit alpha (α) or beta (β) particles .An alpha pharticle is a 4_{He} nucleus , two protons and two neutrons bound together with total spin zero. Alpha emission occurs principally with nuclei that are too large to be stable. When a nucleus emits alpha particles, its N and Z values each decrease by 4, moving it closer to stable territory on the segre chart.

There are three different simple type of beta decay; beta-minus, beta plus, and electron capture .A beta-minus particle (β-) is an electron .Its not obvious how a nucleus emit an electron if there aren't any electron in the nucleus. Emissions of b- involve transformation of neutron in to proton, an electron, and a third particle called an antineutrino. In fact, if you freed a neutron from a nucleus it would decay in a proton, an electron and antineutrino in an average time of about 15 minutes.

The energy of internal motion of nucleus is quantized. A typical nucleus has a set of allowed energy level , including a ground state(state of lower energy)and several exited states. Because of the strength of nuclear interactions, excitation energy of nuclei are typically of the order of 1Mev , compared with a few eV for atomic energy levels .In ordinary physical and chemical transformations the nucleus always remains in it

ground state . when a nucleus is placed in an excited state, either by bombardment with high energy particles or by a radioactive transformation , it can decay in to the ground state by emission of one or more photons called gamma rays or gamma- ray photons with typical energy of 10KeV to 5MeV .this process is called gamma(γ) decay.[3]

II. Materials And Methodology

2.1 Sample Collection and Preparation

Soil samples were collected from the following locations within the mines and the surrounding communities of yankandutse. The study site is located at yankandutse birnin gwari Kaduna State, northwest Nigeria. In order to ensure representative samples were taken from the area for the analysis, initial survey was carried out in the area to determine the sampling points. The selection of the sampling locations was based on the accessibility to the public and proximity to the mine. In addition, the geological map of the area was used to identify the locations where samples will be taken. Based on these criteria, 12 locations were identified for the soil samples analysis. Within the mines, soil samples were collected at ore stockpiles, tailings dams, heap leach pads, wastes dumps and open pits 1Kg of soil were collected from each location. The sampling locations were marked using a Geographical Positioning System (GPS), Geo Explorer II.

The sampling strategy that was adopted for the soil samples was random . At each identified location samples were arbitrary collected within defined boundaries of the area of concern. The soil samples were taken using a coring tool to a depth of 5-10 cm. At each sampling location, samples of soil were taken from different sections of the area into labeled plastic bags. One kilogram (1 kg) of each sample was collected for analysis. The samples were transported to the laboratory for preparation and analysis with Sodium Iodide Thallium NaI(Tl) detector[4] .

Soil Sample Preparation

The collected samples (i.e. soil or sediment) brought into the laboratory were left open (if wet) for a minimum of 24hrs to dry under ambient temperature. They were ground into a fine powder with the use of a table ceramic mortar and pistil and then a pulverizer. The process was followed by packaging into radon impermeable cylindrical plastic containers of height 7cm by 6cm in diameter. This satisfied the selected optimal sample container height (Ibeanu, 1999) i.e the detector geometry. Each container would accommodate approximately 300g of sample. A 3–stage sealing system was made for each of the packaging to prevent Ra – 222 from escape. This include, smearing of the inner rims of each container lid with Vaseline, filling the lid assembly gap with candle wax to block the gaps between lid and container and tight – sealing lid – container with a masking adhesive tape. The prepared sample were then stored for period of 30 days to allow radon and its short – lived progenies to reach secular radioactive equilibrium prior to gamma spectroscopy measurements[5].

Analysis Of Samples For Background Activity

The major nuclear technique employed in the analysis of sample for background activity is the Gamma spectrometry using NaI (Tl) detector

III. Result And Discussion

Table 3.a Result Activity concentration k-40,Ra-226 and Th-232

Site Name	K-40 (Bq/kg)	Ra226 (Bq/kg)	Th-232 (Bq/kg)
YD1	524.8834±12.44	5.6779±.03	65.4504±1.14
YD2	553.0327±1.08	3.7891±.16	63.2839±1.59
YD3	447.9005±6.84	1.3673±.04	20.0684±1.25
YD4	509.0202±1041	3.3256±.38	56.7845±.79
YD5	333.7481±9.33	2.4565±.05	52.7936±.45
YD6	196.1120±2.02	1.7497±.15	23.3751±.34
YD7	207.6205±.77	1.7265±.03	18.1300±3.19
YD8	239.0358±3.11	1.5991±.11	22.0068±.34
YD9	398.2893±10.10	.4056±.12	70.9236±.57
YD10	488.1804±8.08	.1506±.03	57.2406±1.14
YD11	419.9067±9.33	.4403±.08	73.0901±1.59
YD12	266.4075±9.33	2.3407±.03	43.6716±1.36

Table.3b Statistical Analysis for soil samples

SITE ID	N	Minimum	Maximum	Mean
K40	12	196.1120	553.0327	382.0114
Ra226	12	.1506	5.6779	2.0857
Th232	12	18.1300	73.0901	47.2348

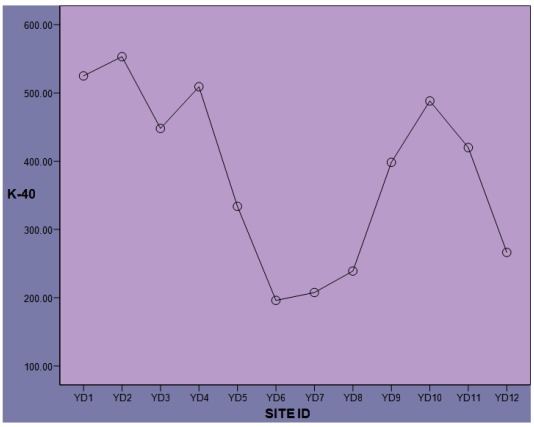

Fig. 3a. A graph of activity concentration for K40

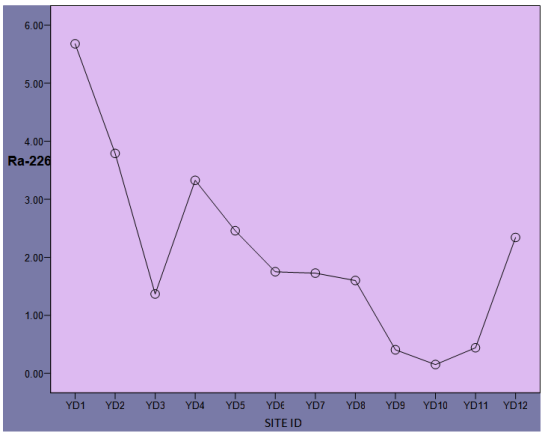

Fig. 3b. A graph of activity concentration for Ra-226

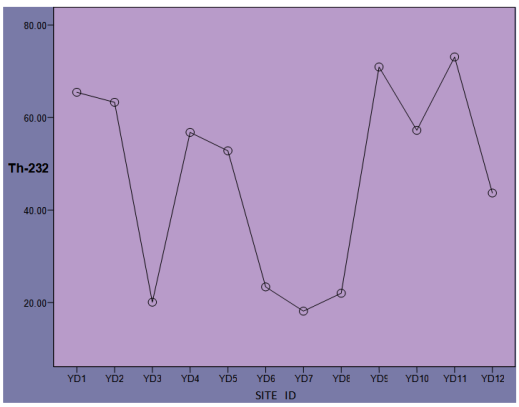

Fig. 3c. A graph of activity concentration for Th-232

IV. Result and Conclusion

From table 3a and 3b, activity concentrations of 40K ranged from 196.11±*2.02* to 553.03±*1.08* Bq/kg, with mean value of 382.01 Bq/kg. Activity concentrations of 226Ra ranged from .1506±*.03* to 5.67±*.03* Bq/kg, with mean value of 2.08Bq/kg. Activity concentrations of 232Th ranged from 18.13±*3.19* to 73.09±*1.59* Bq/kg, with mean value of 47.23Bq/kg1. The radionuclide contents show that the mean activity concentration for Ra226 2.08 is below international standard and for 40K the mean 382.01 is below average but the mean 47.23 for 232Th is above average . Figure 3a,3b and 3c are the graph of the activity concentration for K40, Ra226 and Th-232. The research show data on the activity concentrations K-40, Ra-226 and, Th-232 have been established. The activity concentrations K-40, Ra-226 and Th-232 which members of the public could be exposed to were quantified using direct gamma spectroscopic analysis

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