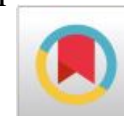# DETERMINATION OF THE URANIUM CONTENT IN SOME SOIL SAMPLES FROM AJAOKUTA, KOGI STATE: NIGERIA

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Abstract

This work present the Uranium (238U) content in soil samples collected in Ajaokuta from some villages was been determined. The measurement of the soil Uranium activity concentration were made using a multi–channel pulse height analyzer (Camberra series 10 plus) coupled to a 76.2mm x 76.2mm NaI (TI) scintillation detector. 2.93)□The mean Uranium content in the analyzed samples was found to be (44.26 Bq/kg which is higher than the world mean value of 35Bq/kg. The results were in good agreement with others for soils from region which is considered as normal or slightly high in radioactivity level.

Keywords: Uranium; Soil Samples; Ajaokuta; Gamma Ray Spectrometry.

1. Introduction

Natural radioactivity occurs when a nucleus decays spontaneously without external interference. The greatest contribution to the average public radiation exposure comes from radioactive elements in the earth crust and from cosmic radiation originating in deep space. Natural sources contribute on the average more than 98% of the human radiation dose excluding medical exposure [1]. The most common of these primordial radionuclides are ^{40}K, ^{238}U and ^{232}Th and progenies. Uranium (^{238}U) which is the heaviest chemical element of natural occurrence and can be found in food, soils, waters sediments and living organism in trace quantities. Hence different techniques are usually employed to determine small amount of Uranium among which are: mass spectrometry, neutron activation analysis, nuclear fission track registration technique and gamma spectroscopy [2].

Studies on radiation levels and radionuclide distribution in the environment provide vital radiological baseline information. Such information is essential in understanding human exposure from natural and man-made sources of radiation and necessary in establishing rules and regulations

relating to radiation protection [18]. Uranium and radium belong to the group of primordial radionuclides, as they have always been present in the earth. The radionuclides ^{238}U, ^{235}U and ^{232}Th, which decay through three distinct series of radionuclides, are of great importance in the nuclear fuel cycle. Not only are they present in the human body and foodstuffs but some Uranium has been detected in a variety of foodstuffs. The highest concentrations are found in shellfish, and lower levels have been measured in fresh vegetables, cereals and fish. The average per capita intake of uranium in food has been reported to be 1.3 µg/day [18] and 2 - 3 µg/day [20] in the USA and 1.5 µg/day in Japan [19] In a review of naturally occurring sources of radioactive contamination in food, dietary intakes of ^{238}U were found to range from 12 to 45 mBq/day in several European countries, from 11 to 60 mBq/day in Japan (the higher values were found in uranium mining areas) and from 15 to 17 mBq/day in the USA. The average daily dietary intake was in the order of 20 mBq, or about 4 µg. It was often difficult to determine whether these dietary intakes included intake from drinking-water, and it was emphasized that intake from drinking-water has sometimes been found to be equal to intake from the diet [20] Following ingestion, uranium rapidly appears in the bloodstream [20] where it is associated primarily with the red cells [22]; a non-diffusible uranyl-albumin complex also forms in equilibrium with a diffusible ionic uranyl hydrogen carbonate complex (2 3 UO HCO+) in the plasma [22] Because of their high affinity for phosphate, carboxyl and hydroxyl groups, uranyl compounds readily combine with proteins and nucleotides to form stable complexes [22]. Clearance from the bloodstream is also rapid, and the uranium subsequently accumulates in the kidneys and the skeleton, whereas little is found in the liver [23]. The skeleton is the major site of uranium accumulation [23]. Based on the results of studies in experimental animals, it appears that the amount of soluble uranium accumulated internally is proportional to the intake from ingestion or inhalation. It has been estimated that the total body burden of uranium in humans is 40 µg, with approximately 40% of this being present in the muscles, 20% in the skeleton and 10%, 4%, 1% and 0.3% in the blood, lungs, liver and kidneys, respectively [22]. Uranium is the proximate source of radium and radon in the soil and rocks. Uranium prospection through the analysis of soil, rocks, plants and water has been reported by many workers [19] [20]. Uranium, present in the earth, is transferred to water, plants, food supplements and then to human beings. Uranium accumulated in humans may have a dual effect due to its chemical and radioactive properties. High intake of uranium and its decay products may lead to harmful effects in human beings. According to an estimate [21], food contributes about 15% of ingested uranium, while drinking water contributes about 85%. An exposure of about 0.1 mg·kg−1 of body weight of soluble natural uranium results in transient chemical damage to the kidneys [23].

Human beings have always been exposed to natural radiation, which is mainly due to the activity concentration of primordial radionuclide's ^{238}U(^{226}Ra) series, ^{232}Th series and ^{40}K that present in the earth's crust, in building materials and in air, water and foods and in the human body itself [1]. As these radionuclides are not uniformly distributed, the knowledge of their distribution in soil, sand and rock play an important role in radiation protection and measurement. Radionuclide's are classified into four groups according to their origins: cosmic-ray produced nuclides (such as ^{7}Be an d ^{14}C), artificially-produced nuclides (such as ^{137}Cs and ^{90}Sr), primordial isotopes (such as ^{238}U and ^{40}K); and natural decay products (such as INAC 2009, Rio de Janeiro, RJ, Brazil. ^{226}Ra and ^{222}Rn). The three naturally occurring radioactive decay chains include the ^{238}U, ^{235}U, and ^{232}Th, which decay through a series of radioactive elements up to stable Pb isotopes [16].

In Brazil there are about 15,000 miners employed in thorium mining. Their work consists of two activities: - the monazite mining and its processing in order to obtain rare earths chloride and thorium as a by-product, - and the mining and processing of other minerals with Th and U associated to the crystal structure. This processing transforms these radionuclide's and daughters into products, by-products or waste [17].

Uranium results from radionuclide sources found in the earth's crust occurring in different types of rocks and soil and the concentration and activity of uranium in any given environment depend on factors such as the geological features of the area, weather conditions, human, economic and industrial activities [12] . Several of the elements in the decay of Uranium (^{238}U) emit beta and gamma rays, the radiation of which also form a significant portion of the external radiation field on the earth's surface [3]. Hence the presence of ^{238}U in large scale in the study area can induce its accumulation in living beings and consequently will represent a potential radiological risk to the population of this area of concern. In this way the knowledge of the ^{238}U concentrations in soils is important not only to assess the contamination level but also to understand the transference processes which have occurrence at different levels of the feed chain. People can be exposed to uranium from the environment by inhaling air and dust and ingesting water, soil and vegetation. Naturally occurring uranium poses very little radiological danger because it is present in small amounts in the environment. Uranium is not considered a human carcinogen, and genetic effects of radiation from uranium have not been observed at any level of exposure. The chemical toxicity of uranium is considered a greater health concern and has a greater potential to cause observable effects than its radioactive properties. Its toxicity depends on the route of exposure (inhaled or ingested) and the solubility of its chemical form (compounds). The primary potential health effect of high levels of uranium most soluble, and therefore readily absorbed, uranium compounds are kidney toxicants if exposure is kidney disease. Uranium exposure limits and guidelines developed by various government agencies to protect human health are based on the chemical toxicity properties of uranium, rather than its radiological properties. This is because the concentrations of uranium that would pose a chemical risk are lower and more restrictive than the concentrations that would pose a radiological risk. Exposure to uranium concentrations at or below the guidelines would result in a radiation dose below the CNSC dose limit in the *Radiation Protection Regulations* (1 mSv per year for members of the public).

The study area is Ajaokuta LGA located at latitude 7^0 33' – 7^0 55' and longitude 6^0 39' – 6^0 65' on a granite of about 1740m above sea level in Kogi State in the North Central part of Nigeria. The Aim of this study is to determine the Uranium content in some soil samples collected from Ajaokuta LGA, North Central – Nigeria. The area lends itself to the rolling and milling of Iron, the Ajaokuta steel complex. The lithological formations in the area are composed of basement complex biotite granite, sedimentary rocks and new basalt.

2. Materials and Method

A total of 20 surface soil samples of natural origin were collected from the 20 different locations at the same depth level of 0 to 7cm around Ajaokuta LGA. The samples were collected from 10 villages with two sample collected from a village at 2kilometer square apart and these points of collection were marked out using (GPS). Samples are obtained by clearing the surface vegetation and removing dead organic matter from the surface of the location and then taking a core sample

from it from a depth of 7cm, sample mass varied from 1.2 to 1.6kg.At the collection point the soil sample was wrapped in black plastic bag and again double bagged to avoid cross contamination of the samples then taken to the laboratory. All soil samples were individually allowed to dry for 72hours under laboratory temperature of about 27°C and relative humidity of about 70 % [4]. Each dried soil sample was grinded and sieved using a 2mm mesh screen. The large particles were disposed off and the meshed soil samples were stored in plastic containers of specific dimensions for four weeks to allow time for secular equilibrium for ^{238}U and its corresponding progenies. The plastic container of fixed geometry used was ensured air-tight by using an epoxy glue to seal samples.

About 100g each of meshed soil sample was then transferred to a 100cm^3 capacity aluminum container and analyzed for gamma activity immediately.

The gamma-ray analysis was done on a very sensitive gamma spectroscopic system which consists of a 76.2cm x76.2cm NaI (TI) scintillation detector coupled to a Camberra series 10 plus multichannel analyzer (MCA). The detector has a resolution of about 7.4% at the 662keV line for 137Cs which is good enough for distinguishing gamma-ray energies of the radionuclide being measure [5]. The detector was placed in a 5cmthick lead shield to reduce the effects of natural background radiation [6] ,[7]).The gamma ray spectrometry located at Centre for Energy Research and Training University of Nigeria Nsukka, Nigeria was employed in the determination of activity concentration of the uranium (^{238}U). The soil samples were mounted on the surface of the scintillation detector and each counted for 21600 seconds in reproducible sample detector geometry. A computer based multichannel analyzer system with an ACCUSPEC program (model 2007p) was used for the data acquisition analysis of gamma spectra. The gamma transition of energy of 1765kev (due to 214Bi) was used to determine the concentration of ^{238}U in the soil sample

3. Results and Discussion

Table 1: Activity concentration of uranium (^{238}U) Bq/Kg

Sample Location	Longitude (°) E	Latitude (°) N	(^{238}U)concentration(Bq/Kg)
Agarugu 1	6 42'	7 28'	33.07±3.59
Agarugu 2	6 40'	7 30'	72.36±3.84
Ajagu 1	6 41'	7 32'	11.54±2.62
Ajagu 2	6 41'	7 36'	48.08±2.59
Ebiya 1	6 66'	7 40'	20.04±4.63
Ebiya 2	6 65'	7 42'	95.69±2.66
Adogo 1	6 64'	7 39'	15.78±0.38
Adogo 2	6 63'	7 37'	18.96±1.63
Ajaokuta 1	6 58'	7 43'	45.25±3.48
Ajaokuta 2	6 65'	7 45'	40.34±1.04
Osara 1	6 39'	7 50'	26.07±1.85
Osara 2	6 43'	7 52'	49..70±3.24
Geregu 1	6 64'	7 54'	103.83±3.47
Geregu 2	6 63'	7 54'	99.63±3.13
Gaduma 1	6 65'	7 37'	44.26±3.47

Gaduma 2	6 63'	7 38'	30.25±3.13
Ogodo 1	6 38'	7 39'	28.15±4.59
Ogodo 2	6 37'	7 40'	23.86±3.71
Ohunene 1	6 62'	7 49'	46.18±0.12
Ohunene 2	6 64'	7 55'	32.07±4.64
Average			44.26±2.89

Table 2: Comparison of ^{238}U activity concentration levels for soil samples from Ajaokuta LGA with values obtained in some areas.

Country / Region	Sample Location	Activity concentration(Bq/Kg)	Reference
Saudi Arabia	Riyadh	10.8 – 29.7	[8]
Brazil/Santos	Mangle-Area sediment and soil	38.5 – 226	[9]
Turkey/Istanbul	Near City Area soil	2.63 – 58.95	[10]
India/Kangra	Country area soil	9.26 – 25.4	[11]
China/Xiazhuang	Near Uranium Ore Field Soil	40.2 – 442	[12]
Nigeria/Ibadan	Near Road Area Soil	10.2 – 40.7	[13]
Nigeria/Zaria	Around Center for Energy Research and Training	4.8 – 11.9	[14]
Nigeria/Jos	Bukuru – Jos	80.0 – 1240	[6]
Nigeria/Port Harcourt	Around Cement Companies	17.34 – 49.90	[15]
Nigeria/Ajaokuta	Ajaokuta LGA	11.54 – 103.83	present work

The uranium contents obtained in this work for all the soil samples and their mean value from Ajaokuta LGA Kogi State, Nigeria are as presented in Table 1.

Table 1, show that activity concentrations of Uranium in the soils of Agarugu 2, Ajagu 2, Ebiya 2, Ajaokuta 1, Ajaokuta 2, Osara 2, Geregu 1, Geregu 2, Gaduma 1 and Ohunene 1 all have high concentrations above the allowed limit. The highest activity concentration was recorded at Geregu 1 with a value of 103.83±3.47Bq/Kg, this is closely followed by that recorded at Ebiya 2 with 95.69±2.66Bq/Kg.

The average value found in this work for Uranium content in some soil samples is 44.26Bq/kg higher than the world mean value of 35Bq/kg ^{238}U isotope [24]. The value of ^{238}U activity concentrations in the soil was found to vary from11.54Bq/kg to 103.83Bg/kg. This results show that 65% of the sample locations have values above the world recommended limit of 35Bq/Kg which is a concern for the health of the inhabitant of the areas [24].

A comparison of the results with other results elsewhere is shown in Table 2. As can be seen in Table 2 values in this work compare suitably with the intervals found by other authors for soils which are considered as polluted or having high natural radioactivity and are slightly higher than those found for samples supposed to be not polluted or having normal radioactivity levels.

Compared to the worldwide average concentrations in soils, the present results are higher in some places and as well lower than the world mean value. Averagely our result is higher than the world mean value with a factor of nine (9) indicating a possible accumulation of Uranium in Ajaokuta LGA which may be due to the steel rolling mills activities in the area.

4. Conclusion

The average ^{238}U content values obtained in this work for soil sample from Ajaokuta LGA were slightly above the worldwide value of 35Bg/kg. However 3.47indication that 2.62 to 103.83 the results obtained vary from 11.54 while some places do not pose little or any health hazard, some places are found to have significantly high activity concentration of ^{238}U above the world mean value. The present ^{238}U content interval determined in terms of ^{238}U activity concentration for soil samples is according to the results reported in the literature compatible with those found for areas considered as normal or slightly of natural radioactivity. The data obtained in this work can therefore reliably serve as reference values for the current assessment of Uranium activity in Ajaokuta LGA.

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