ISSN: 2690- 912X

Research Article

Journal of Genetic Engineering and Biotechnology Research

Assessment of the Naturally Occurring Radioactive Materials (Norm) In Jos North, Nigeria. A Case Study of the Utan Artisanal Tin Mining Sites

Ini Godwin[1*], Valentina Yakovleva[1], Ninyio Noel Nyabai[2]

[1]*National Research Tomsk Polytechnic University, Lenin Ave, 30, Tomsk, Russia*

[2]*Nuclear Technology Centre, Sheda, Abuja, Nigeria*

[*]Corresponding author
Ini Godwin, National Research Tomsk Polytechnic University, Lenin Ave, 30, Tomsk, Russia.

Submitted: 09 Aug 2022; **Accepted**: 16 Aug 2022; **Published**: 25 Aug 2022

Citation: *Godwin I*, Yakovleva V, Nyabai NN. (2022). Assessment of the Naturally Occurring Radioactive Materials (Norm) In Jos North, Nigeria. A Case Study of the Utan Artisanal Tin Mining Sites. J Gene Engg Bio Res, 4(2), 303-309.*

Abstract

Tin mining and milling can be an avenue for economic and technological development. Mining of this mineral contributes significantly to the distortion of the natural distribution of radioisotopes in the environment. This study assesses the concentration of natural radioactivity due to radioactive elements such as 40K, 238U and 232Th. Soil samples were taken from 20 distinct locations within the Utan mining sites, Jos North, Plateau State, Nigeria. Potassium, radium, and thorium in soil samples from mining sites were determined by measuring their concentration activities using the gamma-ray spectroscopy method. Activity concentrations of potassium, radium and thorium were determined. In soil samples, activity concentrations of 40K, 226Ra and 232Th were established. 40K 196.07±4.91 to 608.07±1.44 with an average of 386.48, 226Ra 0.71±0.02 to 5.11±0.07 with an average of 2.35 and 232Th 14.91±0.74 to 63.71±0.97 with average activity concentrations of 54.78. The average concentration activity of potassium and thorium was slightly above the world recommended average of 370.00 and 40.00 respectively, while radium was below the recommended average. The mines mean absorbed and annual effective dose rates were 14.27-nGy h−1and 18.62 µSvy-1, respectively. This average calculated absorbed dose rate in the air was found to be much less, than the global average of 57-nGy h−1. The absorbed dose is considered low compared to the external natural radiation of about 2000 µSv.y-1, to which no harmful effect is expected directly. However, the mean measured dose rate and calculated dose parameters for the mine were higher than the regulatory limit for public exposure.

Keywords: Radionuclides, Soil, Mining, Activity Concentration, Jos; NORMs.

Introduction

Naturally, Occurring Radioactive Materials (NORMs) are composed of environmentally occurring elements such as potassium, thorium, and uranium, which are radioactive in nature. These radioactive elements (radon and radium) are rich in their decay products and are usually generated from anthropogenic activities. NORMs are radioactive isotopes in which the nucleus spontaneously disintegrates (decays) with the emission of a particle. However, a trace of radioactive elements is contained in ground minerals, plant fibres, air and water [1]. Radioactive elements occurs almost everywhere. NORMs are endemic to many geological materials and, as a result, are encountered in geological activity. Radiation protection from exposure to natural sources has evolved over the decades. Over the last two decades, developments related to exposure to NORMs have led to a broad international consensus on how to manage exposure to NORMs. However, especially in developing countries where regulatory resources are limited, standards and regulatory approaches adopted at the national level need to be harmonized [2].

A survey on solid mineral carried out in northern Nigeria between 1904 and 1909 revealed the abundance of tin ore over a wide area of modern-day Jos, Plateau State, Nigeria. In addition, more cassiterite and columbite have been discovered [3]. Thus, mining activities have been happening in Jos and its environs for more than a century. The mining procedures came with associated unavoidable environmental damage and hazards [4, 5]. The indiscriminate dumping of tailings with high concentrations of monazite, thorite and radioactive metals around the mining sites is evident and raises issues of concern. Radioactive elements such as 40K, 238U and 232Th in ores and processed mining waste during mining, milling, and processing of Tin has long been proven [6]. Mineral exploration thus leads to the mining of minerals, this leads to the heightening of NORMs distribution in the environment and, as a result, an elevation in background ionizing radiation originating from them in the soil and water around mining fields [7, 8]. Based on radiological protection standpoint, the health of dwellers and mineworkers within the vicinity of mines is of significant concern. The indiscriminate dumping of mine tailings presents a source of chemical and radiological pollution to man and his environment. The piles of dumped tailings are usually high in background ionizing radiation. Therefore, weathering, massive desertification, erosion and other stripping can result in long-distance transport to residential areas, farmlands, and larger bodies of water. Hence, the increased background radiation is transported far from the source. In 2008, it was discovered that many foods grown near mining areas contained high radium concentrations, which is a harmful radionuclide. Furthermore, the tin mining landfills reported by within the Algadama region in Jos showed high radiation parameters associated with concentration activities of 40K, 238U and 232Th in the landfill soil. Also, due to environmental and health concerns, it is important to recognize the fact that unregulated mining activities in the Northern part of Jos continue to be affected by radiation and risk assessment of mining activities for miners, the general public and the environment. For these reasons, it is imperative to carry out this study. This work is aimed at investigating and assessing the concentration activity of these radionuclides (40K, 238U and 232Th) in soils, in and around the Utan Tin mine sites. The study aims to determine the extent of the contribution of mining sites to the concentration effect of the radioactivity of NORM using Radiochemical methods.

Study Location

Jos is the capital city of Plateau state, in the North-Central region of Nigeria. It lies between Latitude 9º 56'21.7" N and Longitude 8º 54' 8" E of the Greenwich meridian with an average elevation of 1,295 meters above sea level and an approximate population of 572,700. The people are of Afizere, Anaguta, Bache Irigwe and Berom ethnic groups [9]. Climatically, it is dominated by tropical dry and wet conditions with annual rainfall and temperature ranging between 1500 – 2000 mm and 20˚C – 25 ˚C, respectively. The topography is characterized by variable heights and flat topography series of highlands. In addition, the vegetation consists of stunted trees, tall grasses and shrubs [9].

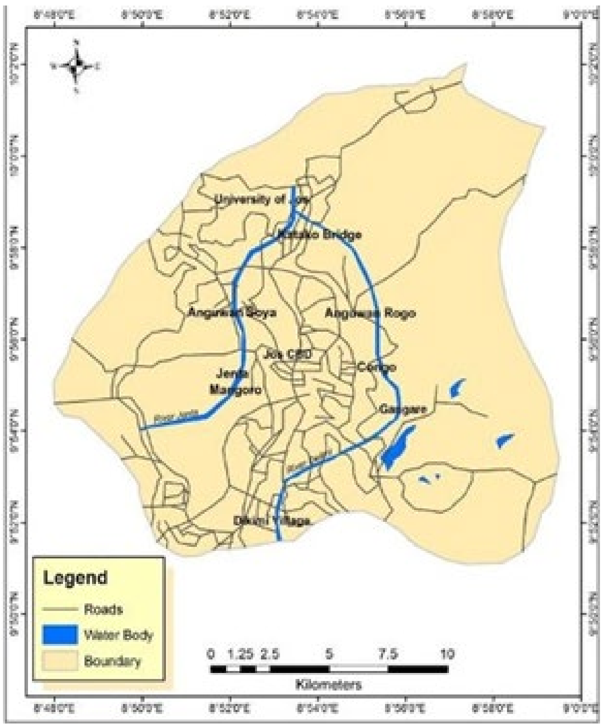

Figure 1: Geological Map of Jos (Plateau-people 2020)

Method and Materials

Soil Sample Collection and Preparation

Samples were taken from twenty different locations within the mine pits, processing areas and non-mining activities around the Utan village. The soil samples were taken at a depth of about 10cm deep (topsoil) and sun-dried for about 48 hours, after which they were packed in polythene bags of non-radioactive material sealed and labelled A1-A20 (with respect to their locations) for easy identification and to prevent mix-up. For the accuracy of collected data, measurements were repeated five times at each sampling point and averaged. The collected samples were brought into the laboratory and left open for a minimum of 24hrs at room temperature to dry. A tabletop ceramic mortar and pestle, followed by a pulverizer, were used to grind them into a fine powder. The fine soil particles were then packaged into radon-resistant cylindrical plastic containers with a height of 7 cm and a diameter of 6 cm. This method fulfilled the chosen ideal sample container height as well as the detector shape. Each container would be able to hold about 300 g of samples [10, 11]. To prevent 222Ra from escaping, each package was fitted with a three-stage sealing device. Smearing Vaseline on the inner rims of each container lid; filling the lid assembly gap with candle wax to plug the gaps between lid and container; and tightly sealing the lid container with masking adhesive tape are the steps involved. After that, the sample was kept for 30 days to allow radon and its progenies to attain equilibrium before the gamma spectroscopy measurements.

Gamma Spectroscopy Analysis

Gamma spectrometry using a NaI (Tl) detector is the major nuclear technique used in background activity analysis [12].

Results

Table 1: Shows Concentration Activity for ^{40}K, ^{238}U and ^{232}Th

Locations	^{40}K (Bq/kg)	^{226}Ra (Bq/kg)	^{232}Th (Bq/kg)
A1	411.03±7.21	4.56±0.02	54.34±0.14
A2	601.07±0.19	2.57±0.21	59.26±1.18
A3	344.05±4.54	0.91±0.07	22.05±0.15
A4	550.01±4.34	4.73±0.67	63.71±0.97
A5	410.13±7.22	1.98±0.03	57.09±0.90
A6	201.32±3.05	2.08±0.30	31.43±0.68
A7	301.75±0.33	2.79±0.02	207.77±4.71
A8	196.07±4.91	1.71±0.74	14.91±0.74
A9	402.17±6.02	0.71±0.02	79.81±0.43
A10	509.61±9.02	0.19±0.07	61.97±0.99
A11	398.02±7.91	0.73±0.06	81.07±2.08
A12	302.09±6.09	2.48±0.02	41.69±1.71
A13	511.09±9.04	5.11±0.07	61.09±0.91
A14	559.12±2.03	3.96±0.19	61.83±0.83
A15	407.05±5.76	1.27±0.57	19.06±0.75
A16	608.07±1.44	4.16±0.26	59.93±0.61
A17	298.98±6.22	2.15±0.04	49.91±0.96
A18	252.19±3.16	1.82±0.21	31.73±071
A19	267.16±0.81	1.17±0.87	16.92±4.61
A20	198.58±2.09	1.90±0.12	20.01±0.29

Table 2: Soil Sample Statistical Analysis

Location Identity	N	Minimum value	Maximum value	Average
^{40}K	20	196.07	608.07	386.478
^{226}Ra	20	0.19	5.11	2.349
^{232}Th	20	14.91	81.07	54.779

Table 3: Gamma Absorbed Dose Rate for each location (nGyh-1)

Sample	**Absorbed Dose** Rate (nGyh-1)
A1	16.18±3.08
A2	10.31±1.94
A3	14.74±0.93
A4	11.33±3.11
A5	15.77±1.79
A6	16.02±2.98
A7	13.99±0.96
A8	10.01±3.76
A9	15.55±3.83
A10	15.79±2.91
A11	14.88±3.43
A12	11.20±3.30
A13	16.88±3.81
A14	16.75±3.44
A15	13.08±2.88
A16	15.25±3.52

A17	10.47±2.38
A18	16.90±2.14
A19	15.66±1.22
A20	14.70±3.55
Minimum	10.01
Maximum	16.90
Mean	14.273

Table 4: Annual Effective Dose Equivalent (µSvy-1)

Sample	Annual Effective Dose Equivalent (µSvy-1)
AI	20.21±4.50
A2	22.23±4.42
A3	18.99±3.11
A4	20.81±4.07
A5	17.32±3.93
A6	21.76±4.09
A7	21.89±4.98
A8	19.33±3.86
A9	22.26±4.84
A10	20.49±2.56
A11	16.11±1.91
A12	19.06±3.77
A13	18.75±0.53
A14	18.63±0.94
A15	16.19±0.85
A16	15.90±1.31
A17	15.41±0.87
A18	14.88±3.15
A19	16.71±0.66
A20	15.53±2.70
Minimum	14.88
Maximum	22.26
Mean	18.623

Table 5: Values of concentration activity of radionuclides in soil samples (Bq kg-1) from research carried out around the world

Country	238U	232Th	40K	Reference
Russiafa, Jordan	48.3-523.2	8.7-27.1	44-344	Al-Jundi (2002)
Istanbul, Turkey	21	37	342	Karahan and Bayulken (2000)
Syria	19	24	336	Al-Masri et al., (2006)
Kalpakkam, India	5-71 (16)	15-776 (119)	200-854 (406)	Kannan et al., (2002)
Tripoli, Libya	10.5	9.5	270	Shenber (1997)
World Average	40	40	370	UNSCEAR (2000)

Table 6: Values of Annual Dose Rate (ADR) of research conducted in different regions and countries (µSvy-1)

Region/Country	Location	Annual Dose Rate(µSvy-1)	Reference
Johor, Malaysia	High radiation area	0.07-1.44	Ramli, et al., 2015
Jos, Nigeria	Tin mine	6-28	Ademola, 2008
Utan, Jos North, Nigeria	Tin mine	0.21-2.14	This study
Perseus, Ghana	Gold mine	0.04-0.12	Faanu et al., 2016
Ede, Nigeria	Columbite, Tantalite mine	0.02-11	Ademola et al., 2015
Bukuru, Nigeria	Tin mine	5-80	Funta and Elegba, 2005
World mean value *Safety limit*	Mine sites	0.05	UNSCEAR, 2000

*Atipo et al-JASEM, 2020

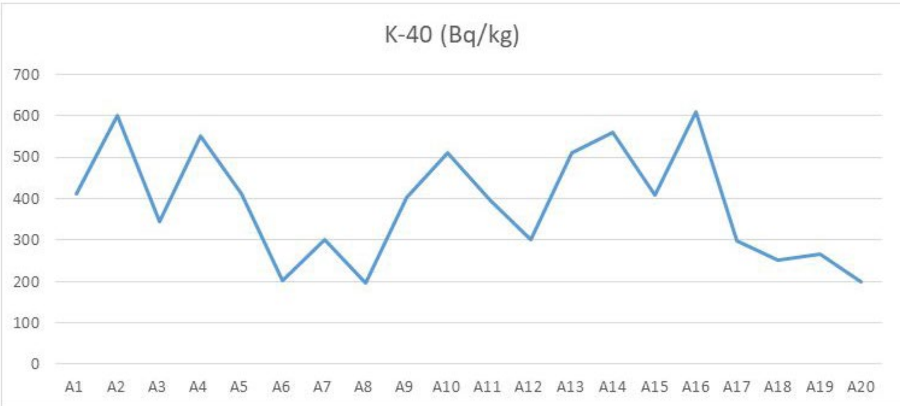

Figure 1: Graph Showing K-40 Activity Concentration

Figure 2: Graph Showing Ra-226 Activity Concentration

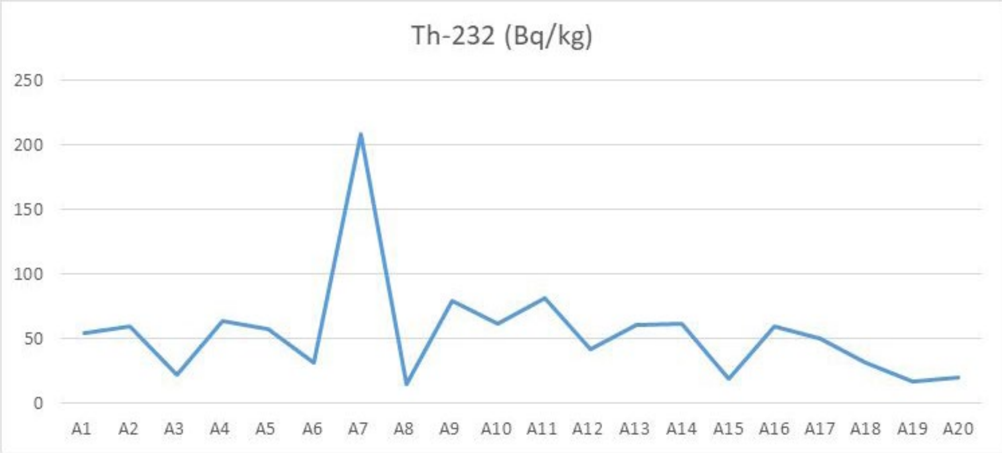

Figure 3: Graph Showing Th-232 Activity Concentration

Discussion of Results

The radionuclide analysis in soil samples carried out across the twenty locations within Utan village and its environs revealed that the basic components of soil's radioactive elements in UI include 40K, 238U, and 232Th. From the result, table 1, 40K shows the mean activity concentrations to be 386.478 Bq/kg, with a concentration activity range from 196.07±4.91 to 608.07±1.44 Bq/kg. The mean value for 40K was slightly higher than UNSCEAR's 2000 reported value of 370 Bq/kg as the world average. The 226Ra activity level ranged from 0.19±0.07 to 5.11±0.07 Bq/kg with an average activity level of 2.349 Bq/kg. The 232Th activity level ranged from 14.91±0.74 to 207.77±4.71 Bq/kg, with an average value of 54.779 Bq/kg1. This result shows that the average activity level for 226Ra is 2.349 Bq/kg1, which is lower compared to the international standard value of 35 Bq/kgl. For 232Th with an average of 54.779 Bq/kg, is above the world average of 40 Bq/kg, as reported by UNSCEAR, 2000 [13]. Figures 1, 2, and 3 are 40K, 226Ra, and 232Th radioactivity concentration plots. The study results show data for activity levels 40K, 226Ra, and 232Th. direct gamma spectroscopy analysis was used to quantify the activity concentrations for 40K, 226Ra, and 232Th that the population might be exposed to.

Tables 3 and 4 show the location coordinates and elevations above sea level. Table 4 shows that the ADR values of the mine site areas varied from 14.88 to 22.26 µSvh-1 with a mean value of 18.623 µSvh-1. From results obtained in Table 4, shows that ADR values of the mine site areas varied from 14.88 to 22.26 µSvh-1 with a mean value of 18.623 µSvh-1. These figures are in the range of 5 to 80 µSvh-1 reported in the Tin mine at Bukuru, Nigeria and 6 to 28 µSvh-1 reported by Ademola, 2008, in Jos, Nigeria. However, the value (14.88 to 22.26 µSvh-1) obtained is above the world safety limit (mean value) of 0.05 µSvh-1, UNSCEAR, 2000 [14].

Conclusion

The assessment of the Naturally Occurring Radioactive Materials (Norm) in Jos North and in some selected artisanal tin mining sites was conducted. The investigated radionuclides showed higher specific activity in terms of their mean values compared to the world's average safe and acceptable limit. This slight increase can be attributed to the geological structure of the investigated area. Also, the variation recorded in the Annual Dose Rate (ADR) in the investigated area compared to values obtained around the world can be attributed to the rocks, soil type, and anthropogenic activities around the assessed area. It was, however, observed that the selected radionuclides investigated were slightly above the recommended world average safety limits [15]. Therefore, it is imperative to deploy continuous monitoring of the miners, dwellers, and soils around the investigated area to avoid hazardous radiation-related issues for humans and the environment.

Article Highlights

• Radioactive elements, which occur naturally, are usually associated with both underground and surface mining. This research work recorded a high concentration of these elements, namely potassium, radium, and uranium, in the soils around the Utan mine area.

• The radiation rays consisting of particles known as ionizing radiation (gamma radiation) were determined. It has been recorded that the mines around the Utan area had a dose of radiation inhaled by the miners and dwellers. These dose rates were certified high when compared with the approved average safety limits by UNSCEAR and other values recorded around the world.

• If necessary precaution is not provided to these mining activities, miners and dwellers by continuous estimation of these elements in Utan mines and its environs, it may result in severe disease outbreaks and life-threatening diseases such as cancer.

Acknowledgements

National Research Tomsk Polytechnic University development program

Funding

The author declare that no funds and grants received prior or during the research period'

References

1. Raymond L.M. (2000). Nuclear Energy An Introduction to the concept, system and Application of Nuclear Processes Fifth Edition.
2. Kriz, Z., & Ruatti, D. (1999). 10th anniversary of the Interna-

tional Nuclear Event Scale (INES) (No. INIS-XA-C--015)..
3. Bitrus, M. F., Igeoma, I. O. M., Rangmou, D. R., Ibrahim, J. D., & Michael, Y. N. (2015). Cancer risk due to radionuclides concentration in tin ores and sediments at Barkin-Ladi, Plateau State, North Central, Nigeria. Int. J. Environ. Monit. Anal, 3(5), 260-264.
4. UNSCEAR, U. (2000). Sources and effects of ionizing radiation. United Nations Scientific Committee on the Effects of Atomic Radiation.
5. Arogunjo, A. M., Höllriegl, V., Giussani, A., Leopold, K., Gerstmann, U., Veronese, I., & Oeh, U. (2009). Uranium and thorium in soils, mineral sands, water and food samples in a tin mining area in Nigeria with elevated activity. Journal of environmental radioactivity, 100(3), 232-240.
6. Jibiri, N. N., Farai, I. P., & Alausa, S. K. (2007). Estimation of annual effective dose due to natural radioactive elements in ingestion of foodstuffs in tin mining area of Jos-Plateau, Nigeria. Journal of environmental radioactivity, 94(1), 31-40.
7. Olise, F. S., Oladejo, O. F., Almeida, S. M., Owoade, O. K., Olaniyi, H. B., & Freitas, M. C. (2014). Instrumental neutron activation analyses of uranium and thorium in samples from tin mining and processing sites. Journal of Geochemical Exploration, 142, 36-42.
8. Ademola, J. A. (2008). Exposure to high background radiation level in the tin mining area of Jos Plateau, Nigeria. Journal of radiological protection, 28(1), 93.
9. Http.//www.plateaustate. gov.ng/plateau the-people
10. Wapwera, S. D., Ayanbimpe, G. M., & Odita, C. E. (2015). Abandoned mine, potential home for the people: A case study of jos plateau tin-mining region. Journal of Civil Engineering and Architecture, 9(4), 429-445.
11. Aliyu, A., Abdulyakeen, K. A., Belel, S. A., Babanyara, Y. Y., Salis, A., Ibrahim, A., & Is'haq, D. B. (2019). Heavy Metals in Water and Plants along Rivers Dilimi and Jenta, Jos. Plateau State, Nigeria. American Journal of Engineering Research, 8(3), 32-8.
12. Ibeanu, I. G. E. (2003). Tin mining and processing in Nigeria: cause for concern?. Journal of environmental radioactivity, 64(1), 59-66.
13. Abu-Haija, O. (2012). Determination of natural radionuclides concentrations in surface soil in Tafila/Jordan. Modern Applied Science, 6(3), 87.
14. Majolagbe, S. B., Faromika, O. P., & Jeje, S. O. (2014). Determination of natural radioactivity in soil samples of some locations in Akure, Ondo State, Nigeria. International Journal of Scientific & Engineering Research, 5(7).
15. Atipo, M., Olarinoye, O., Awojoyogbe, B., & Kolo, M. (2020). High terrestrial radiation level in an active tin-mine at Jos South, Nigeria. Journal of Applied Sciences and Environmental Management, 24(3), 435-442.