

Short Communication

Assessment of radioactivity level in bore hole-soil in Nigeria

Omeje C. U.^{1*}, Kareem A. I.¹, Onoja M. A.², Adamu A. M.³ and Ummkulthum S. I.⁴

¹Department of Science Laboratory Technology, School of Applied Science, Nuhu Bamalli Polytechnic, P. M. B. 1061, Zaria.

²Department of Physics, Ahmadu Bello University, Zaria.

³Department of Applied Sciences, Collage of Science and Technology, Kaduna Polytechnic, Kaduna.

⁴Department of Mathematics, Statistics and Computer Science, Collage of Science and Technology, Kaduna Polytechnic, Kaduna.

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Radioactivity level in six soil samples from different boreholes in Zaria, Nigeria was assessed. The presence of ^{40}K , ^{226}Ra and ^{232}Th were analyzed using γ -ray spectrometry with sodium iodide thallium, {NaI(Tl)} detector. Mean specific activity of 1020.4 ± 12.4 , 123.1 ± 2.3 and $25.7 \pm 2.0\text{Bq/kg}$ for ^{40}K , ^{226}Ra and ^{232}Th , respectively were obtained. The radioactivity level for each location was calculated to ascertain the risk involved in using these boreholes. This radiation index revealed that all the locations are safe except two locations having radioactivity level of approximately 1.02 and 1.30 Bqkg^{-1} , respectively, which are well above the world quoted value of unity. This shows that the concentration levels for these two areas are high and it is therefore recommended that none of these boreholes' water be consumed in order to avoid unnecessary exposure and absorption of dosage of radiation that will be threatening to life.

Key words: Radioactivity level, borehole-soil, γ -ray.

INTRODUCTION

Human beings are exposed to ionizing radiation from numerous sources in the environment. Among them include the cosmic rays and natural radioactivity sources in air, food and drinking water (NCRP, 1976). The γ -radiation from natural radioactive and cosmic rays constitutes the external exposure while those derived from food and drinking water constitutes internal exposure to human. In the environment, artificial sources may be present due to human activities such as nuclear and atomic bomb testing, nuclear reactor explosions, industrial wastes and effluent from factories. International Atomic Energy Agency, IAEA (1986) estimate of dose contribution in the environment shows that over 85% of radiation dose received by man are derived from the natural radionuclides while the remaining 15% is from

cosmic rays and nuclear processes.

Radiation absorbed by any part of the body will deposit energy which causes damage to the tissue. Sunlight which contains ultraviolet rays and infrared rays also causes damage to human tissue. If the human body is exposed to a large amount of radiation at one time, the resultant negative effect of it to human includes eye cataracts and bone cancer (Nelkon and Parker, 1995). Measurement of natural radioactivity in soil is very important to determine the amount of change of the natural background activity with time as a result of any radioactive release (UNSCEAR, 1988; Sroor et al., 2001). This work is aimed at measuring the natural radionuclides in the soil from some boreholes in Zaria using γ -ray spectrometry, because the earth crust is radioactive (Ewa et al., 2000; Kebwaro et al., 2011) and constantly emitting radiation, and specifically to create awareness on the level of radiation within our environment by assessing the natural radioactivity level.

Radioactive substances can be dangerous to the body

*Correspondence author. E-mail: omejecornelius@yahoo.com.
Tel: +234(0)8038896280.

Table 1. Sample site locations with date of collection.

S/N	Date of collection	Sample label	Location in zaria
1	24-3-09	SS01	Hayindogo, Samaru
2	29-3-09	SS02	Congo
3	31-3-09	SS03	Sabon Gari
4	27-03-09	SS04	Dogarawa
5	01-4-09	SS05	Kwantaresha, H/Ojo
6	01-4-09	SS06	Tudun-muntsira, Chikaji

If one is exposed to it for a long time or even short time when it is of high dose since the penetrating power of α -particle is small, they do not penetrate the skin appreciably, but β -rays and γ -rays which have more penetrating power than that of α -particle, if allowed to penetrate the body in large quantities, or even in small quantity for a long period of time, can destroy the cells in the tissue and upset natural chemical reactions. Therefore it is important to know the radioactivity level of the natural radionuclides in the soil samples of these boreholes which subsequently would be transferred to the water inside.

MATERIALS AND METHODS

Sample collection

Soil samples were collected from six different locations in Zaria, each weighing 325 g and were packaged in a polythene bag and were taken to the laboratory for preparation. Table 1 shows the site locations with date of collection. The wet soil samples were collected during excavation of the boreholes at a depth of about 9.8 m using polythene hand gloves to avoid cases of contamination.

Sample preparation and measurement

For easy identification, the soil samples were labeled as shown in Table 1. The known weights of the soil samples were properly sealed in plastic containers each weighing 25 g using candle wax and masking tape and left to equilibrate for thirty days to allow for secular equilibrium to be established among the radium progeny which was necessary to ensure that radon gas is confined within the volume and that the daughters will also remain in the sample (Sroor et al., 2001; Ewa et al., 2006).

The soil samples were analyzed using γ -ray spectrometry technique after the detector calibration, where each of the soil samples were counted for a period of 29000 seconds with a NaI(Tl) detector. The full details of measurement are as described in Ewa et al. (2000).

RESULTS AND DISCUSSION

The results of the activity concentration of the radionuclides and the calculated radioactivity level in the analyzed soil samples from the six boreholes collected at

the different locations in Zaria are presented in Table 2.

The radionuclides identified includes: ^{40}K , ^{226}Ra and ^{232}Th . The specific activity values are in the ranges of (870.8 \pm 2.8 – 1138.9 \pm 16.9 Bq/kg) for ^{40}K , (17.7 \pm 4.5 - 54.3 \pm 3.2 Bq/kg) for ^{226}Ra and (52.5 \pm 1.1 – 220.1 \pm 5.2 Bq/kg) for ^{232}Th which show that the specific activities differ from one radionuclide to another. This could be attributed to the different levels of concentration in radionuclides.

In the sample (SS01), ^{226}Ra was not detected, however, mean specific activity concentrations of 1020.4 \pm 12.4, 123.1 \pm 2.3 and 25.7 \pm 2.0 respectively were calculated for ^{40}K , ^{226}Ra and ^{232}Th radionuclides in the soil samples, showing very high mean specific activity for ^{40}K which may be due to fertilizer application or other human activities within the area. The risk of exposure to people using water from these boreholes and the excavated soil for building and other things were considered by calculating the radioactivity level using the expression stated by (Beretka and Mathew, 1985; Ruixiang, 1986; Omeje et al., 2009):

$$\frac{A_{\text{Ra}}}{370} + \frac{A_{\text{Th}}}{259} + \frac{A_{\text{K}}}{4810} \leq 1 \quad (1)$$

Where A_{Ra} , A_{Th} and A_{K} are the activity concentrations of ^{226}Ra , ^{232}Th and ^{40}K in Bq/kg, respectively. This radiation index is presented in Table 2 (column 5) which was found to be less than unity except for the two locations, Sabon Gari and Tudun-muntsira, Chikaji and having radioactivity level of 1.02 and 1.30Bq/kg, respectively.

It is therefore a source of concern to note that the borehole in these two locations is not safe since the value of the radiation index calculated is above unity. This is because residents of these two locations are constantly being exposed to some doses of radiation as they use the water from the borehole or the excavated soil for building. It is important to note that exposures to these radionuclides over long period of time can destroy their cells, tissues and upset natural chemical reactions in their body leading to genetic changes or other hereditary effects, resulting in cancer and at times may lead to death (Omeje et al., 2009). The other locations are therefore safe since their radioactivity level is less than unity.

Table 2. The specific activity concentration levels in the samples.

Sample label	⁴⁰ K (Bq/kg)	²²⁶ Ra (Bq/kg)	²³² Th (Bq/kg)	Radioactivity level (Bq/kg)
SS01	870.8±2.8	ND	52.5±1.1	0.38
SS02	1182.2±11.4	54.3±3.2	83.5±2.7	0.71
SS03	884.0±29.5	30.6±0.5	196.9±3.0	1.02
SS04	1030.0±4.2	19.5±1.6	92.7±1.2	0.62
SS05	1016.3±9.3	32.2±2.3	92.7±0.7	0.66
SS06	1138.9±16.9	17.7±4.5	220.1±5.2	1.30

ND, Not detected.

Conclusion

With regards to the objectives of this research, and the results obtained, the current study has provided useful information and a baseline for the future along with continuous studies on the radioactive elemental concentration in boreholes. Generally, the results revealed specific activity for the three natural occurring radionuclides: ⁴⁰K, ²²⁶Ra and ²³²Th and showed that Sabon Gari and Tudun-muntsira, Chikaji have high radioactivity level of 1.02 and 1.30Bq/kg, respectively. Therefore, this work recommends that the water from the borehole in these two locations should not be used since using it will only expose the user to some doses of radiation which could be life threatening.

REFERENCES

- Beretka J, Mathew PJ (1985). *Health Physics*. 48: 87-95.
- Ewa IOB, Oladipo MOA, Umar IM, Mallam SP (2000). *Natural Radioactivity in Building Materials: Preliminary Investigations*. C.E.S. Proceedings. pp. 44-48.
- Ewa IOB, Oladipo MOA, Umar IM (2006). Trace Element Levels In Terrestrial and Aquatic Environments near the Nigerian Research Reactor. *Journal of Environmental Systems*, Bay wood Publishers, New York, USA. 32(1): 17-26.
- International Atomic Energy Agency, (IAEA) (1986). *Facts about Low Level Radiation Exposure*. IAEA Publications No. A. N. E. pp. 985-6482.
- Kebwaro JM, Rathore IVS, Hashim NO, Mustapha AO (2011). Radiometric Assessment of Natural Radioactivity Levels around Mrima Hill, Kenya, *Int. J. Phy. Sci.*, 6(13): 3105-3110.
- National Council on Radiation Protection and Measurement, (NCRP) (1976). *Environmental Radiation Measurement Report*. p. 50.
- Nelkon M, Parker P (1995). *Advance Level Physics*. 7th Edition, CBS Publishers & Distributors, New Delhi, India. pp. 873-874.
- Omeje CU, Adamu A, Onoja MA, Agbo PE (2009). *Natural Radioactivity Measurement in some Building Materials used in Zaria, Nigeria*. *New Era Journal of Engineering, Science and Technology*, Publication of De-Caritas centre for studies in human development in Africa. 2(3-4): 29-34.
- Ruixiang L (1986). *Atom. Energ. Sci. Technol.*, 20(5): 596-601.
- Sroor A, El-Bahi SM, Ahmed F, Abdel-Haleem AS (2001). *Natural radioactivity and radon exhalation rate of soil in southern Egypt*. *J. Appl. Radiat Isot. Elsevier Sci. Ltd*, 55: 873-879.
- United Nations Scientific Committee on the Effects of Atomic Radiation, (UNSCEAR) (1988). *Sources, Effects and Risks of Ionizing Radiation Reported to the General Assembly*. United Nations, New York.