



IONISING RADIATION MONITORING OF 5km AWAY SOROUNDING THE REACTOR OF CENTRE FOR ENERGY RESEACH AND TRAINING AHMADU BELLO UNIVERSITY ZARIA,NIGERIA

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ABSTRACT

Nuclear radiation arise from hundred of different kinds of unstable atoms; nuclear energy is widely used in medicine, industries, research and agriculture. Although it has beneficial applications, yet it is always accompanied with dreadful consequences, in any event of identified nuclear accident. The recorded in-situ dose rate measurement obtained ranged from 0.12 to 0.38 for dry and rainy season respectively. In addition the measuring activity concentration level in the soil sediment samples were in the range of 357 to 948(^{40}K) 16 to 62 (^{226}Ra) and 85 to 233Bqkg $^{-1}$ (^{232}Th).The activity concentration level where also measured in the soil sediment samples, both in dry and rainy season using gamma ray spectroscopy technique. There is no significant different in the two seasonally acquired data in both the indoor and outdoor measurements. The important radiation monitoring to asses the environmental radiological impact of Nigerian Reseach Reactor (NIRR-1) of centre for energy reseach and training Ahmadu Bello University, Zaria cannot be over emphasized. It is therefore recommended that the personel and monitoring as done should be continued to check the state of the stack filters and have the protection of personel, public and environment,. The data provides the mean activity concentration levels of the analyzed soil and sediment samples with their corresponding mean measure dose rates for both rainy and dry season in Nigeria. The point were selected for the determination of nuclear effect of NIRR-1 on the neighboring communities was shown in the table.

Keyword. Radiation, environment, personnel.

Introduction

Environmental radiation originates from a number of naturally occurring and human-made sources. Radioactive materials occur naturally every where in the environment (e.g., uranium, thorium and potassium-40). By far the largest proportion of human exposure to radiation comes from natural sources – from external sources of radiation, including cosmic and terrestrial radiation, and from inhalation or ingestion of radioactive materials.

The United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR, 2000) has estimated that the global average annual human exposure from natural sources is 2.4mSv/year. Some sources (e.g., uranium) can be concentrated during extraction by mining and other industrial activities. There are large local variations in human exposure to radiation, depending on a number of factors, such as height above sea level, the amount and type of radionuclides in the soil (terrestrial exposure), the composition of radionuclides in the air, food and drinking-water and the amount taken into the body via inhalation or ingestion. There are certain areas of the world, such as parts of the Kerala state in India and the Pocos del Caldas plateau in Brazil, where levels of background radiation are relatively high. Levels of exposure for the general population in such areas may be up to 10 times higher than the average background level of 2.4mSv.

Several radioactive compounds may be released into the environment from human activities and human-made sources (e.g., from reactors both power and research, medical or industrial use of radioactive sources). The worldwide per capita effective dose from diagnostic medical examination in year 2000 was 0.4mSv/year (typical range is 0.04–1.0mSv/year, depending on level of health care). There is a very small worldwide contribution from nuclear power production and nuclear weapons testing. The worldwide annual per capita effective dose from nuclear weapons testing in the same year 2000 was estimated at 0.005mSv; from the Chernobyl accident, 0.002mSv; and from nuclear power production, 0.0002mSv (UNSCEAR, 2000).

The base line data (natural background levels) of the environment and the data also serve as a base for comparing data obtained in other monitoring stage. A comparison of the pre-operational and operational levels can thus establish the increment of radiological impact produced by the facility. In addition, the pre-operational data can provide guidance on the establishment of general plan for

subsequent monitoring in the operational period and handling routine and accident releases. The base line radiation measurement is also needed for reliable for a safety analysis report (SAR) for the facility. In the light of the above discussion Centre For Energy Research and Training Ahmadu Bello University, Zaria (CERT) background research monitoring was set in 1999 and mandate to routinely carry out radiation surveillance monitoring of reactor hall (workplace/immediate reactor environ) and some selected settlements within the 5km radius of the reactor hall and surrounding in-situ dose rate measurements.

Thermo luminescent material can be used to detect ionizing radiation. The electrons in thermo luminescent materials are raised to forbidden bands when energy from incident radiation is absorbed. These electron are then trapped at higher levels until the material undergoes specific heating pattern (at above 300°C or above) the energy is released as light. This light can then be converted into an electrical signal which can be related to the amount of incident radiation. Various thermo luminescent materials are commercially available depending on the application. Lithium based thermo luminescent dosimeter (TLDs) are preferable for personal dosimeters because of their tissue-equivalence. Calcium base TLDs are more useful for environment monitoring due to their high sensitivity.

Objectives:

The main objective of the research is to provide information of routine monitoring service: Using the Thermo-Luminescence Dosimeter (TLD), and ensuring that radiation services in established laboratories within the 5km radius are strictly adhere-to in terms of radiation safety measures as specified by the federal radiation protection unit. Other objectives include;

Uses of equipment available in CERT such as; RADOS-120 SURVEY METER and Harshaw Reader to measure the levels of radiation absorbed by the environ.

- For positive derivation of the associated benefits with minimal risks
- Basic and applied research to conduct basic research in nuclear science and technology as well as applied research, so as to enhance the cooperation of research reactor to improve on the development of nuclear energy.

- To have safety operational basis in subsequent monitoring in the operational period and handling routine
- Strengthening and enlisting neighborhood' involvement in the entire processes of preparing sound conduction of research activities set to be achieved.

Materials and Methods

Materials.

The followings are some the materials used to carry out the research work, these includes;

1. RADOS-120 SURVEY METER. (Two)
2. Shovel.
3. Hoe.
4. Polythene bags and adhesive masking tape.
5. Marker.
6. NaI(Tl) Detector.

METHODS

Sampling. (Environmental Monitoring)

Nineteen soil samples from different strategic locations that cover about five kilometres, making the reactor (NIRR-1) as reference point were collected. At each location, the background radiation measurement is taken using the Rados survey meter and recorded. The statistical mean value is also taken and recorded. Then a little quantity of top soil would be collected into a very clean polythene bags using hoe and shovel. The soil sample will be labeled in order to avoid cross-contamination and mixing up of samples. The top soil is collected to determine the level of radiation as a result of NIRR-1 existing in the neighborhood. The samples well packaged were transported into Centre for Energy Research and Training, Health Physics and Radiation Biophysics Section where the samples were prepared.

Sample preparation.

The soil samples along with the extraneous materials were dried at ambient temperature until there was no detectable change in the mass of the sample. The dried samples were thoroughly crushed, grounded and pulverized to powder.

The powder was passed through a 2mm sieve. Due to the limited space of the detector shield only 200g - 300g of the soil samples (dry- weight) were used for analysis since, this is quantity it could conveniently take.

The samples after weighing were transferred to radon-impermeable cylindrical plastic containers of uniform size (60mm height by 65mm diameter) and were sealed for a period of about 30 days. This was done in order to allow for Radon and its short-lived progenies to reach secular radioactive equilibrium prior to gamma spectroscopy. The reference soil was also transferred to a container of the same material and dimensions as were used for the soil samples. A lead-shielded 76 × 76 mm NaI(Tl) detector crystal (Model No. 727 series, Canberra Inc.) that is coupled to a Canberra Series 10 plus Multichannel Analyzer (MCA) (Model No.1104) through a preamplifier was used for the radioactivity measurements. It has a resolution (FWHM) of about 8% at energy of 662.0KeV (^{137}Cs) which is considered adequate to distinguish the gamma ray energies of interest in the present study. The choice of gamma-ray peaks of the radionuclides to be used for measurements was made considering the fact that the NaI(Tl) detector used in this study had a modest energy resolution. This was to ensure that the photons emitted by the radionuclides would only be sufficiently discriminated if their emission probability and their energy were high enough, and the surrounding background continuum low enough. Therefore, the activity concentration of ^{214}Bi (determined from its 1760 KeV γ - ray peak) was chosen to provide an estimate of ^{226}Ra (^{238}U) in the samples, while that of the daughter radionuclide ^{208}Tl (determined from its 2615 KeV γ - ray peak) was chosen as an indicator of ^{232}Th (^{232}Th). Potassium-40 was determined by measuring the 1.460 MeV γ -rays emitted during its decay. The soil samples were placed symmetrically on top of the detector and measured for a period of 29000 seconds (8 hours). The net area under the corresponding peaks in the energy spectrum was computed by subtracting counts due to Compton scattering of higher peaks and other background sources from the total area of the peaks.

RESULT

Table 1: Mean Measured Activity Concentration Levels and Dose Rates- Rainy Season

Sample Code	Activity Concentration (Bq/kg)			Measured Dose (nSv/h)
	^{40}K	^{226}Ra	^{232}Th	
C1	585.3±29.7	44.5±13.6	115.2±12.9	123.6± 25.6
C2	424.5±34.8	34.8±10.8	118.4±12.6	144.2±20.4

C3	596.5±4.23	63.3±3.13	175.6±14.6	120.5±18.6
C4	638.3±42.6	43.2±14.2	182.8±13.3	135.8±25.5
C5	738.7±35.6	38.4±12.5	132.5±11.6	125.7±23.4
C6	445.3±30.9	54.6±14.3	093.2±11.6	145.2±22.7
C7	631.4±33.7	64.4±11.8	114.2±14.1	120.7±22.5
C8	408.5±32.5	61.5±12.6	116.3±15.6	100.6±22.8
D	349.8±4.51	36.8±17.3	171.5±15.4	144.6±24.4
AS	516.3±33.6	35.2±12.5	129.6±12.4	121.7±23.7
B	840.2±43.6	48.6±13.2	228.7±17.9	138.6±24.5
M	522.5±31.4	39.3±12.8	103.5±11.8	125.8±21.6
J	613.2±38.4	38.2±13.8	133.1±12.8	139.3±17.4
Y1	428.2±39.6	54.6±14.7	123.1±11.9	118.6±23.8
Y2	638.8±37.7	18.4±10.8	112.2±14.5	124.6±22.6
ZA	524.7±33.5	22.6 ±11.2	132.4±13.8	141.3±19.9
S	604.3±30.9	56.4±12.3	143.12.8	132.6±26.7
N	563.6±38.6	43.1±11.2	BDL	111.7±25.8
KR	838.8±36.5	58.8±14.2	138.3±13.3	158.4±25.7

SAMPLE CODES:

C1- C8----- CRMP/00/01 - CRMP/00/08, D- ABU DAM, Y1- YADDAU 1, KR- KUBANI RIVER, AS- AVIATION SITE II, Y2- YADDAU 2, B- BASSAWA, M- MAIGAMO, J- JAMA'A, ZA- ZARIA AIRPORT, S- SAMARU, N- NAIBI.

Table 2: Mean Measured Activity Concentration Levels and Dose Rates- dry season

Sample Code	Activity Concentration (Bq/kg)			Measured Dose (nSv/h)
	⁴⁰ K	²²⁶ Ra	²³² Th	
C1	459.10±28.3	45.9±11.8	078.2±10.9	121.4± 23.0
C2	555.67±24.5	48.6±12.5	131.3±11.3	120.5±16.3
C3	442.45±33.7	40.5±11.2	145.8±12.4	135.5±22.1
C4	446.52±23.3	23.6±12.34	0.68.2±12.5	138.6±12.4
C5	791.29±31.2	33.6±13.7	183.7±11.4	125.6±22.4
C6	384.29±23.6	36.1±14.1	100.3±12.5	129.8±21.6

C7	451.52±33.4	28.5±12.1	077.4±10.5	109.6±22.6
C8	423.33±31.5	33.4±13.3	101.3±11.6	121.4±14.8
D	555.52±29.7	34.4±11.6	121.4±11.6	110.6±25.3
AS	607.93±33.3	48.9±14.8	118.8±12.6	117.8±13.9
B	694.40±37.2	40.67±13.9	159.5±11.7	144.7±28.7
M	531.88±31.8	28.5±12.0	128.3±12.5	122.3±24.5
J	746.96±32.7	34.3±13.2	179.1±13.2	129.2±16.5
Y1	613.99±34.3	BDL	136.4±13.3	120.2±22.3
Y2	702.5±33.2	28.7±12.2	BDL	113.8±24.3
ZA	560.96±32.8	443.6±11.5	112.8±12.6	134.8±22.5
S	503.27±28.5	BDL	110.2±11.8	140.8±25.8
N	693±30.5	34.3±10.8	129.3±01.4	137.6±24.6
KR	578.31±31.6	60.3±14.3	130.3±12.6	124.7±22.7

SAMPLE CODES:

C1- C8----- CRMP/00/01 - CRMP/00/08, D- ABU DAM, Y1- YADDAU 1, KR- KUBANI RIVER, AS- AVIATION SITE II, Y2- YADDAU 2, B- BASSAWA, M- MAIGAMO, J- JAMA'A, ZA- ZARIA AIRPORT, S- SAMARU, N- NAIBI.

Tables 1 and 2 shows the results of the natural occurring radioactive materials (NORMs) obtained from the soil/sediment samples collected at the locations for laboratory activity concentration measurements of natural radionuclides of Interest. The data provides the mean Activity concentration levels of the analyzed soil and sediment samples with their corresponding mean measured dose rates for both rainy and dry season in Nigeria. The points were selected for the determination of nuclear effect of NIRR-1 on the neighboring communities was shown below:

In addition the measuring activity concentration level in the soil sediment samples were in the range of 357 to 948(^{40}K) 16 to 62 (^{226}Ra) and 85 to 233Bqkg⁻¹ (^{232}Th), it can be observed that there was small increase in the results obtained for the ^{40}K and ^{232}Th , while for ^{226}Ra , there was no significant difference. The increase in the ^{40}K could be attributed to the fertilizer application on the farms during the rainy season. There was small increase in the results obtained for the ^{40}K and ^{232}Th , while for ^{226}Ra , there was no

significant difference. The increase in the ^{40}K could be attributed to the fertilizer application on the farms during the rainy season.

CONCLUSION

The neutron and gamma dose rate measurements taken at full power reactor operation and at shut down were as expected and highly within safety margin for the reactor operation. The exception of measurements taken on the reactor pool top, when at full power contributed in justifying the inherently safe nature of the miniature Neutron Source Reactor (MNSR).

The obtained data from the investigation replicated expected data from the environment. This is an indication of lack of activity concentration enhancement of radionuclides of interest. When the activity concentrations of the rainy season is compared to that of the dry season of the same year (2018), it can be observed that there was small increase in the results obtained for the ^{40}K and ^{232}Th , while for ^{226}Ra , there was no significant difference. The increase in the ^{40}K could be attributed to the fertilizer application on the farms during the rainy season. There was small increase in the results obtained for the ^{40}K and ^{232}Th , while for ^{226}Ra , there was no significant difference. The increase in the ^{40}K could be attributed to the fertilizer application on the farms during the rainy season. This shows that there within the standard according to International Commission for Radiological Protection (ICRP, 1991) and the United States Environmental Protection Agency (USEPA) and the World Health Organization (WHO).

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