Assessment of Radioactivity Content of Quarry Dust in Abakaliki, Nigeria.

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ABSTRACT

The average concentration of radionuclide in dust particles produced from quarry plants in the urban area in Abakaliki, Nigeria were estimated from measured samples. The mean specific activity using Gamma spectrometry NaI (Γi) Canberra detector Model 802.4 and Alpha-Beta spectrometry. The photopeaks observed with reliable regularity belonged to naturally occurring series decay radionuclides headed by ^{238}U / ^{226}Ra and ^{232}Th as well as the non series type ^{40}K. Eight samples of the dust particles were prepared and coded 1.1 - 1.8. The activity of the occurring radionuclides in each of the sample were measured and the average taken for both alpha (α) and beta (β) particles including the count rate of γ-radiation were obtained.

(Keywords: radionuclides, naturally occurring, uranium, radium, thorium, potassium, gamma spectrometry, alpha / beta spectrometry)

INTRODUCTION

Radioactive materials, namely the members of the ^{238}U and ^{232}Th series together with ^{40}K, have always been known to be present in some natural media and form the main natural contributors to external exposures from γ-radiation (Straden, 1979; UNSCEAR, 1988).

Radionuclides formed in environmental matrices such as soil, coal and rocks and emanating from various physiochemical reactions in the presence of source suitable reactants in the environment contribute in alternation of trace element levels of some of these matrices. Starting from when man became conscious of the deleterious effects of exposure to ionizing radiation; tremendous efforts aimed at locating and controlling these sources have been intensified (Fasasi et al., 1999).

In Nigeria, surveillance of this specific activity in environmental fields commenced about 1960, following the atmospheric weapon test reportedly carried out in Sahara region. Some of these works include reports on the hazards in the mines at Jos area by Nwosu, et al. (1974) and determination of the natural radionuclides in soils and water around nuclear research establishment in Ile-Ife by Olaomo, et al. (1994).

Osibote, et al., 1999 have studied radioactivity in milk consumed in Nigeria 10 years after the Chernobyl reactor accident while the occurrence of natural radionuclides and fallout cesium-137 in the dry season throughout the agricultural farmlands of south-western Nigeria. Additional studies of radioactivity in the community water supplies of Ife Central and Ife East Local Government areas of Osun State were investigated by Fasasi, et al. (1999) and Tchokossa, et al. (1999), respectively.

Estimates of the concentration of the primordial radionuclide for different building materials (Olaomo, et al., 2003) including paints have been studied by Miller (1992) and Makobia, et al. (2003) apart from quarry dust. Though quarry industries are not so common in some areas of the country, there may still be a certain proportion of the dust emanating from the industry and resulting in human expsoure.

However, in Abakaliki, the quarry industry is sited in almost every major street in the urban region as a result of the large quantity of these

operations. Dust particles from these operations are released into the atmosphere forming particulate matter of different sizes ranging from 1.0 micron to 2.5 microns and impose environmental and human health hazards in urban areas. They are also being transported over large distances by wind and other factors into residential areas of the town. The inhabitants do inhale the dust, especially the workers in the quarry plants. This exposure is compounded with problems of visibility imposed by the presence of dust within the environment.

This study intends to determine and identify the presence and concentration of radioactive materials in this quarry dust using gross alpha-beta counting and gamma spectroscopy (sodium-iodine detector) so that people could be educated on possible threats posed by this environmental pollutant.

MATERIALS AND METHODOLOGY

The dust samples were collected by suspending in a well cleaned metallic plate below the crusher for about 20 minutes, in order to enhance the capturing of some dust particles. The collected dust sample particles were sieved and packed in a cylindrical, plastic container of dimensions 7.2cm diameter and 6.0cm high in order to achieve the selection optimal sample container height.

Each container accommodated, approximately 350 – 1g of dust sample and were subjected to three stages of sealing processes and stored for equilibration for a minimum period of 28 days for gamma spectroscopy. In the case of Alpha-beta spectrometry, the same sample as prepared previously was measured out by 2.5 gram portions into eight samples each being held by a binder and fused into pellets with the help of a die and hydraulic press and finally dropped into planchet for the alpha-beta spectrometry. A NaI (Γi) Canberra detector model 802 – 4 with a 7.6 x 7.6cm^2 crystal and a photo–multiplier / preamplifier (model 2007) were used. The lead is a Canberra model 726 well loading system whose cover is of the same material. The NaI (Γi) detector was used in the radionuclide identification and the analyses were made with the same detector used for the dust samples, which were mounted on the surface of the detector and counted for 6hrs in reproducible sample – detector geometry.

A computer-based multi-channel analyzer system with an ASUSPECC program was used for data acquisition and analysis of gamma spectra. The 176Kev γ-line of ^{214}Bi was used in assessing the activity concentration of ^{236}Ra while 2614Kev γ-line of ^{208}Ti was used for ^{232}Th and single 1460Kev γ-line of ^{40}K used in its content evaluation. All the data obtained were converted to conventional units using the calibration factor (CD_h, CF_{ra}, and CF_{Tb}) to determine the elements and the activity concentration of the radionuclide of interest.

RESULTS AND DISCUSSION

The result obtained was based on the characterization of the detection and measurement of radioactivity in the quarry dust samples collected from quarry plants within Abakaliki localities. The background measurements of the different modes were taken. These include alpha-beta mode, alpha mode, and gamma mode. Table 1 shows the count rates and specific activities of the samples, while Table 2 presents the alpha activity, and Table 3 shows beta activity.

The data as indicate from Table 1 shows that the sample contains more Thorium than Uranium. The count rate for Thorium is 0.223±0.009 (CPS) while that of ^{238}U and ^{226}Ra is 0.019±0.013 (CPS) while the specific activity for ^{232}Th and ^{238}U are 254±10.9 (Bq) and 22.0±15.06 (Bq), respectively. The presence of other radionuclides existing in the sample is assumed to be negligible.

The summary of the count rate and specific activity of the identified radionuclides in the samples indicate the average activity of alpha-particles (α) is recorded to be 0.6975±0.719 Bq, the average activity of Beta-particles (β) is 213.9±2.23, while the gamma emissions are 213.9±19.54 with gross gamma count 0.159±0.014 (CPS). The activity concentration of all the detected elements for all the analyzed samples indicate that there are traces of ^{238}U / ^{226}Ra, ^{232}Th and ^{40}K in the dust samples with ^{232}Th being larger than others. The count rate ^{40}K is 0.235±0.021 with activity 22.0±3.265 Bq which shows that it is highly present in the dust samples. Our results indicate that all of these radionuclides found present in the stone from where the dust is being produced contributes to the natural radioactivity of the area.

Table 1: Count Rate and Specific Activity for the Sample.

Radionuclide	Count rate (CPS)	Specific activity (Bq)
^{40}K	0.235±0.021	22.0±3.265
^{238}U / ^{226}Ra	0.019±0.013	22.0±15.06
^{232}Th	0.223±0.009	254±109
Gross γ Gamma count	0.159±0.014	

Table 2: Activity of Alpha (α) Particles for Every Sample in (Bq).

No of plates	Raw α	Rate	Activity	Sigma
1.1	23.60	0.393	1.13	0.750
1.2	16.20	0.270	0.92	0.700
1.3	16.40	0.273	0.10	0.730
1.4	16.00	0.267	0.00	0.780
1.5	21.80	0.363	1.11	0.720
1.6	21.40	0.357	0.64	0.770
1.7	17.80	0.297	0.63	0.680
1.8	18.00	0.300	1.06	0.620
Average			0.6975	0.719

Table 3: Activity of Beta (β) Particles for Every Sample in (Bq).

No of plates	Raw α	Rate	Activity	Sigma
1.1	104.20	1.74	0.31	1.64
1.2	88.60	1.48	3.08	2.62
1.3	111.60	1.86	2.35	1.77
1.4	308.00	5.13	29.40	2.82
1.5	105.40	1.76	2.61	1.90
1.6	76.60	1.33	1.67	1.87
1.7	99.00	1.65	0.96	2.06
1.8	89.60	1.49	3.90	2.85
Average			5.598	2.229

Therefore, the dust particles from local quarries certainly increase the presence of introduced radioactivity content emanating from other sources other than naturally atmospheric pathways. The inhalation of this dust in addition to the contribution already imposed via natural background, some food ingredients, and buildings materials such as paints, may increase the danger of total exposure to our system.

CONCLUSIONS

This work is aimed at measuring the presence and concentration of radionuclides in the dust produced from quarry plants in Abakaliki in South-Eastern Nigeria. The results of this study indicated that the average specific activity concentration of ^{40}K, ^{238}U, ^{226}Ra, and ^{232}Th in quarry dust in Abakaliki is substantial with the average alpha, beta, and gamma activities recorded to be 0.698±0.719 Bq, 5.598±2.230 Bq and 213.9±19.54 Bq.

Based on this study, it is recommended that all workers in quarry plants in Abakaliki should use face masks and possibly thermoluminescent dosemeters (TLDs) to protect themselves from the dangers of radioactive contamination, apart from crystalline silica, which is a common constituent of the dust that may also cause problems human respiratory systems.

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