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Assessment of Background Gamma Radiation within Geo Works Quarry site in Dutse Local Government Area Jigawa State.

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Abstract
Assessment of radioactivity concentrations of 40K, 238U and 232Th in surface soil samples of some selected quarry sites at Dutse Local Government area Jigawa Statehad been determined by gamma spectrometry using Sodium IodideThallium doped NaI (TI) detector coupled with a pre-amplifier base to a multiple channel analyzer (MCA). Total of 15 soil samples, were collected, 5 samples from each of the three selected quarry sites: Sabuwar Tasha, Kachi Villageand Dan Masara. Highest radioactivity concentrations of 40K, 232Th and 226Ra were obtained from Dan Masara soil samples with values 1126.28 ± 4.15 Bq/kg, 112.83 ± 16.35Bq/kg and 40.72±3.12 Bq/Kgrespectively. The mean external hazard index (H_{ex}) and mean internal hazard index (H_{in}) for all the soil samples from Sabuwar Tasha were calculated to be 0.581Bq/kg and 0.684Bq/kg respectively, and that of Kachi Village were 0.557 Bq/kg and 0.618Bq/kg respectively. Also for Dan Masara the mean values were calculated to be 0.645 Bq/kg and 0.720Bq/kg respectively. All the values obtained were less than 1.0 Bq/kg as recommended for safety and therefore have no negative radiological health implication to the people within the geo quarry sites in Dutse local government of Jigawa Stateand their environs.

Key words: *Gamma, Radiation, Radioactivity, External hazard index and Internal hazard index.*

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I. Introduction

At all points of our existence, we are exposed to one form of radiation or the other.Human beings are continuously exposed in their houses and ionizing radiation emitted byfrom building materials. Materials derived from rock and soil contains mainly the naturalradionuclides of the uranium (226Ra) and thorium (232Th) series, and 40K. These radionuclidescan cause external and internal radiation exposure to occupants. The external exposure iscaused by direct gamma radiation. The internal radiation exposure, affecting the respiratorytract, is due to radon and radon decay products which emanate from building materials [1]. The radioactive elements and their radiations are rather an indispensable part of nature. Their impact on living organisms is crucial and very vital to study [2]. Often, radioactive materials with the characteristics of organizing radiation are present in our environment both in nature, in living organisms as well as in our bodies. There are two sources of natural radiation in our environment: the Cosmic and the earth's crust. The cosmic radiation which comes from the sun and deep space coupled with radiation from the earth's crust were actively effective before life began in the earth. Mankind developed and is continuously developing in a field of radiation. As it were, the presence of natural radioactive materials is inevitable. They can be found in construction materials, in the soil, air, food and drinking water, rocks as well as in our body. Radon gas poses significant health concerns, and is the number two cause of lung cancer in the United State behind smoking [3]. Living things, precisely human owe their lives and health to man-made radiation. Medical and dental X-rays have been very vital in discerning hidden problems. Other forms of radiation have been used to diagnose and treat ailments with careful applications [4]. Various tissues respond to radiation differently. To characterize this non uniform sensitivity of tissues to radiation, we define the effective dose as sum of the products of the equivalent doses ($H_{T,\,R}$) received by an organ times the tissue weighting factor (w_T), as shown in the equation below[5]:

$$E = \sum(H_{T,R}\, x\, W_T) \qquad 1$$

The sum of all the electrical charges (Q) of one sign produce by X- or gamma rays in a given mass (m) of dry air at standard temperature and pressure (STP) is referred to as exposure, written mathematically as:

$$X = {}^{Q}/_{m2}$$

Knowledge of the basic radiological parameters such as radioactive content in buildingmaterials is important in the assessment of possible radiation exposure to the population. Thisknowledge is essential for the development of standards and guidelines for the use of thesematerials.

II. Materials and Method

The soil samples were collected from various querry sites around Dutsemetropolice, the Jigawa State capital. A total number of fifteen (15) soil samples were collected using the composite sampling method around three query sites of different locations in the study area, namely Sabuwar Tasha (ST), Kachi Village (KV), Dan Masara(DMS).They were all labeled appropriately. The samples were double bagged to prevent cross contamination of samples.

Table 1 – Sample Location and Mass

Sample Location	Sample Mass (g)				
	1	2	3	4	5
SabuwarTasha (ST)	322.8	323.6	337.1	328.0	253.4
Kachi Village (KV) 324.1		318.9	310.4	312.3	336.5
Dan Masara (DM) 312.6		324.9	338.9	263.7	327.9

All the samples were air-dried to avoid loss of radio nuclides [6]. The dried samples each were thoroughly grinded
to ensure equal representation of samples. The samples were distinctly packed in plastic containers measuring 8.0
cm in diameter by 6.5 cm in height and width made to fit on the high purity germanium detector and labelled with
codes 1, 2, 3, 4 and 5 for each sample. The packaging in each case were triply sealed. The sealing process included
smearing of the inner rims of each container lid with Vaseline jelly, filling the lid assembly gap with candle wax to
block the gaps between lid and container and tight sealing lid container with masking adhesive tape. They were left
for 21 days for short-lived radionuclide to allow radon and its short-lived progenies attain secular equilibrium. The
activity counting was carried out using the high purity germanium detector with the gamma vision software for the
computation.The method of gamma spectrometry was adopted for the analysis of the samples collected in order to obtain data on 40K, 226Ra and 232Th. The spectrometer used was a Canberra lead shielded 7.6cm x 7.6cm NaI (Tl)
detector coupled to a multichannel analyzer (MCA) through a preamplifier base. The system was calibrated using standard point sources of gamma emitting isotopes. The resolution of the detector is about 10% at 0.662MeV of 137Cs. For the analysis of 40K, 226Ra and 232Th, the photo peak regions of 40K (1.46 MeV), 214Bi (1.76 MeV) and 208TI (2.615 MeV) were respectively used.
The cylindrical plastic containers holding the samples were put to sit on the high geometry 7.6cm x 7.6cm NaI (TI) detector. High level shielding against the environmental background radiation was achieved by counting in a Canberra 10cm thick lead castle. The counting of each sample was done for 10.0 hours because of suspected low activities of the radionuclides in the samples. The areas under the photo-peaks of 40K, 226Ra and 232Th were computed using the Multichannel Analyzer system. The concentrations of the radionuclides were calculated based on the measured efficiency of the detector and the net count rate under each photopeak over a period of 10.0 hours using equation 3.0 [6]

$$A = \frac{N(E_\gamma)}{\epsilon(E_\gamma) I_\gamma M t_C} \qquad (3)$$

Where
$N(E\gamma)$ = Net peak area of the radionuclide of interest
$\epsilon(E\gamma)$ = Efficiency of the detector for the γ- energy of interest
$I\gamma$ = Intensity per day for the γ- energy of interest
M = Mass of the sample
t_c = Total counting time in seconds (36000 S)

External hazard index (H_{ex})

The external hazard index is a relation that quantifies the exposure factor [8].
A widely used hazard index (reflecting the external exposure) called the external hazard index H_{ex}. The external hazard index is an evaluation of the hazard of the natural gamma radiation. [8 and 9] :as expressed in equation 4.0 [7]

$$H_{ex} = \frac{C_K}{4810} + \frac{C_{Th}}{259} + \frac{C_{Ra}}{370} \leq 1 \qquad 4$$

Internal hazard index (H_{in}) as expressed in equation 5.0 [7] were used as radiological indicators to estimate the radiological implications of the natural radionuclides in the surface soil on the people in the study area.

$$H_{in} = \frac{C_K}{4810} + \frac{C_{Th}}{259} + \frac{C_{Ka}}{185} \leq 1 \qquad 5$$

Where,C_k, C_{Th} and C_{Ra} are the radioactivity concentrations of 40K, 232Th and 226Ra respectively.

III. Results and Discussion

The highest radioactivity concentration of 40K from SabuwarTasha soil sample was obtained to be 994.36± 3.46Bq/kg and the lowest was 694.38 ± 2.95 Bq/kg. For 226Ra, the highest radioactivity concentration value was 32.26 ± 2.53Bq/kg and the lowest value was obtained to be 14.08 ± 1.86Bq/kg. Also 232Th had the highest radioactivity concentration value of 110.02 ± 14.85Bq/kg and lowest value of 52.73 ± 7.76Bq/kg as shown in table 2.0. Concerning all the radionuclides, 40K had the highest radioactivity concentration value while the lowest was from 232Ra. No artificial radionuclide was detected in all the samples.The highest external hazard index (H_{ex}) was obtained to be 0.688Bq/kg while the lowest was 0.480Bq/kg . The mean value was calculated to be 0.581Bq/kg. Furthermore, the highest internal hazard index (H_{in}) was obtained to be 0.775Bq/kg while the lowest was 0.548Bq/kg. The mean value was calculated to be 0.684Bq/kg.

For Kachi Village soil samples, the highest radioactivity concentration of 40K was obtained to be 1124.85± 6.58Bq/kg and the lowest was 748.68 ± 3.01 Bq/kg. For 226Ra, the highest radioactivity concentration value was 27.35 ±3.14Bq/kg and the lowest value was obtained to be 18.92 ± 2.92Bq/kg. Also, 232Th had the highest radioactivity concentration value of 97.34 ± 12.04Bq/kg and lowest value of 56.24 ± 8.02Bq/kg as shown in table 3.0. Concerning all the radionuclides, 40K has the highest radioactivity concentration value while the lowest was from 226Ra as shown in table 3.0. No artificial radionuclide was detected in all the samples. The highest external hazard index (H_{ex}) was obtained to be 0.627Bq/kg while the lowest was 0.470Bq/kg . The mean value was calculated to be 0.557Bq/kg. Furthermore, the highest internal hazard index (H_{in}) was obtained to be 0.701Bq/kg while the lowest was 0.521Bq/kg. The mean value was calculated to be 0.618Bq/kg.

Also, for Dan Masara soil samples, the highest radioactivity concentration of 40K was obtained to be 1126.28± 4.15Bq/kg and the lowest was 798.16 ± 2.25 Bq/kg. For 226Ra, the highest radioactivity concentration value was 40.72 ± 3.12Bq/kg and the lowest value was obtained to be 15.48 ±1.76Bq/kg. Also, 232Th had the highest radioactivity concentration value of 112.83 ±15.35Bq/kg and lowest value of 72.95 ±8.02Bq/kg as shown in table 4.0. Concerning all the radionuclides, 40K had the highest radioactivity concentration value while the lowest was from 238U as shown in table 4.0. No artificial radionuclide was detected in all the samples. The highest external hazard index (H_{ex}) was obtained to be 0.746Bq/kg while the lowest was 0.566Bq/kg. The mean value was calculated to be 0.645Bq/kg. Furthermore, the highest internal hazard index (H_{in}) was obtained to be 0.823Bq/kg while the lowest was 0.624Bq/kg. The mean value was calculated to be 0.720Bq/kg. The mean values are less than 1.0 Bq/kg as recommended for safety globally [10].

Table 2: Radioactivity concentrations of ^{40}K, ^{232}K, ^{226}Ra (Bq/Kg), external and internal hazard indices of soil sample of Sabuwar Tasha(ST)

Samples' No.	Radioactivity Concentrations (Bq/Kg)			**H_{ex} (Bq/Kg)**	**H_{in} (Bq/Kg)**
	^{40}K	**^{232}Th**	**^{226}Ra**		
1	845.26±3.05	110.02±14.85	32.26±2.53	0.688	0.775
2	785.32±2.37	98.68±12.07	24.42±2.41	0.610	0.675
3	694.38±2.94	104.12±13.14	26.57±2.43	0.618	0.690
4	925.47±3.07	52.73±7.76	31.04±2.51	0.480	0.733
5	994.36±3.46	68.59±7.92	14.08±1.86	0.510	0.548

Table 3: Radioactivity concentrations of 40K, 232K, 226Ra (Bq/Kg), external and internal hazard indices of soil sample collected from Kachi Village (KV)

Samples' No.	Radioactivity Concentrations (Bq/Kg)			H_{ex} (Bq/Kg)	H_{in}(Bq/Kg)
	^{40}K	^{232}Th	^{226}Ra		
1	796.43±3.24	96.76±11.45	24.23±2.99	0.605	0.670
2	824.36±3.26	68.15±8.75	20.76±2.87	0.491	0.547
3	1124.85±6.58	82.76±9.73	27.35±3.14	0.627	0.701
4	969.24±3.37	56.24±8.02	18.92±2.92	0.470	0.521
5	748.68±3.01	97.34±12.04	22.17±2.76	0.591	0.651

Table 4: Radioactivity concentrations of 40K, 232K, 226Ra (Bq/Kg), external and internal hazard indices of soil sample collected from Dan Masara (DM)

Sample's No.	Radioactivity Concentrations (Bq/Kg)			H_{ex} (Bq/Kg)	H_{in} (Bq/Kg)
	^{40}K	^{232}Th	^{226}Ra		
1	865.94±2.54	85.10±8.37	21.35±2.32	0.566	0.624
2	768.16±2.25	101.27±11.08	15.48±1.78	0.599	0.641
3	984.36±3.26	104.18±12.14	32.74±2.16	0.695	0.784
4	1092.47±4.05	72.95±8.02	40.72±3.12	0.619	0.729
5	1126.28±4.15	112.83±15.35	28.25±2.45	0.746	0.823

IV. Conclusion

The radiological safety of the people within the geo query work sites in the study area had been assessed and the results obtained show that the mean external and internal hazard indices values are less than 1.0 Bq/kg, the limit recommended by European Commission on Radiation Protection[10]. This means that the exposure of the people in the study area to the radiation from the surface soils does not pose any negative radiological effect on them and their environs.

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