

Assessment of radiation dose level in farm soils of mission quarters, Wukari, Taraba State, Nigerian

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ABSTRACT

The study has assessed the amount of radiation exposed to farm soils in mission quarters Wukari, Taraba State. Assessment of radiation dose level is very important, especially in soil since man depends on Soil for his food. Assessment of radiation will help to know the radiation dose in the soil. The objective of this work is to determine radiation dose in soils and to provide necessary information of human health risks associated with radioactivity in soil and its effects on plant materials as well as human being. Different soil samples were collected and the Radiation Alert Inspector EXP, was used to measure the level of radiation exposure in the soil samples. The results showed low amount of radiation dose level. The average dose values ranging between 0.035 ± 0.097 to 0.333 ± 0.289 , an absorbed dose rate ranging between $3.50 \times 10^{-8} \pm 0.097$ to $3.33 \times 10^{-7} \pm 0.289$ and annual dose rate ranging between 0.059 ± 0.097 to 0.758 ± 0.289 . These results revealed that the dose rates do not exceed the recommended values by International Commission on Radiological Protection (ICRP) is 1mSvyr^{-1} for the general public. It is less and in compliance with the recommended radiation dose level. Therefore do not pose a significant health hazard. The radiation dose level has no negative effect on both the plants and the dwellers. Therefore the study area is safe for human activities.

Keywords Assessment of radiation, Dose level, Soils of mission quarters, Wukari

1. Introduction

Radiation is the movement or transfer of energy either as wave or in the form of stream of moving particles, such as gamma rays, beta rays and alpha ray. The term normally called to as electromagnetic radiation [1]. Radiation is omnipresent, including in the soil [2]. The amount of absorbed radiation dose is the energy imparted or deposited per unit mass of medium in a given radiated material sample [3-5]. It is employed in measuring the exposure to human body that enables ascertaining the quantity or amount of radiological hazards to living things [6, 7] due to the concentrations of radionuclides (e.g. ^{226}Ra , ^{232}Th and ^{40}K) in soil [6]. Radiation harm or destruction to tissue and/or organs relies on the dose of radiation received or the absorbed dose [3].

The radiation in soil and air are the ones that effects man greatly. Soil is the warehouse of radiation and radionuclides. Hence it is the main source where must materials are being contaminated. Maximum permissible dose (MPD) for none occupationally exposed individual is put at 1mSv/yr while that of nuclear energy workers is put at 20mSv/yr [8]. Soil is a natural medium for growth of land plants. It has many purposes and applications. Structures are built on soil and crops are also cultivated on soil [9]. The most important use of soil to man is farming. The soil may be contaminated with high dose of radiation or pollution. High radiation dose will impose danger to man and plants while low radiation dose will not impose danger to man nor plant.

Human beings are exposed to radiation arising from such sources as cosmic rays, natural radionuclides in water, air, soil and plants and the artificial radioactivity originating from medical applications and the fallout after nuclear testing. Generally, the natural radioactivity concentration or levels relies or depend on geological aspects, which is majorly on the rocks and soil. The terrestrial parts of the natural background radiation are relies or depends on the compositions of the soils, which consisting natural radionuclides [10]. Humans are also exposed through contamination of the food chain which takes place as a result of direct deposition of radionuclides on plant leaves, root uptake from contaminated soil, sediment or water [11], also from direct ingestion of contaminated water [12]. The major potential hazard from the natural radiation is from external exposure either by direct exposure to the soil or as they enter in many building material [13].

Ionizing radiation becomes dangerous at high doses; therefore, knowledge of the level of radiation within our living and working environment becomes necessary, considering the health implications [14]. The soil that retains radioisotopes in varying amounts is the major source of continuous exposure of man to either internal or external ionizing radiation [15]. The main aim of this work is to determine radiation dose in soils and also to provide necessary information of human health risks associated with radioactivity radiation in soil and its effects on plant materials.

2. Materials and Methods

2.1. The study area

The study area is mission quarters, Wukari, Taraba State. Wukari local government lies within latitude $7^{\circ}51'\text{N}$ of the equator and $9^{\circ}47'\text{E}$ of the meridian with the land area of approximately $4,308\text{km}^2$. It is located at the southern part of Taraba State, Nigeria (Figure 1).

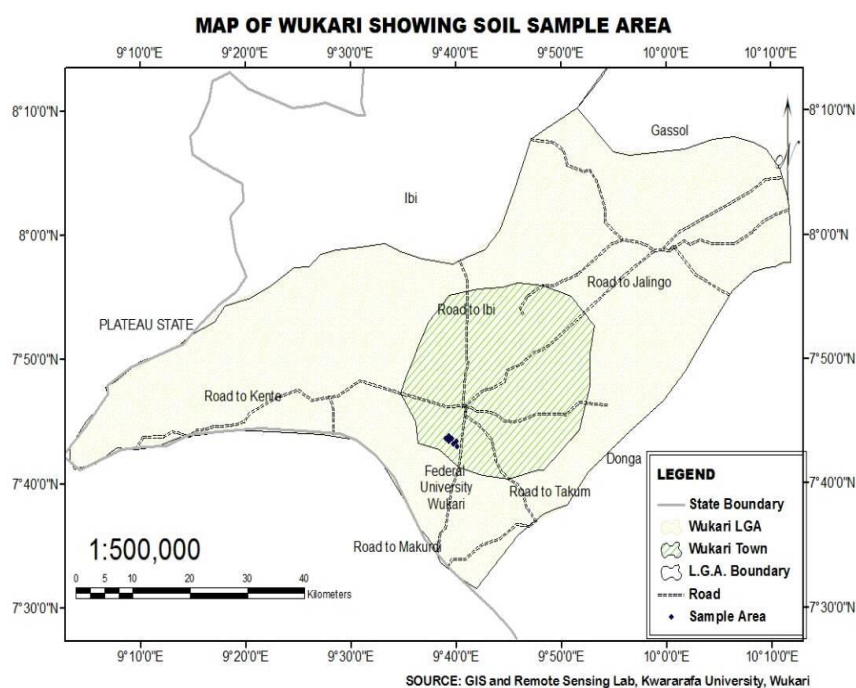


Figure 1 Map of Wukari, showing soil sample area.

The following materials were used, soil auger, black polythene bags, masking tape and pen radiation alert inspector.

2.2. Sample collection

All the soil samples were collected in labeled black polythene bag applying the soil auger, from different locations in mission quarter's farm area, Wukari, Taraba State. The soil samples collected from the farm were kept in room with ambient temperature for few days and then taking to the laboratory for analysis.

2.3. Methods of analysis

Radiation alert inspector Exp. was applied to determine the level of radiation in the soil samples. The inspector was held 1 to 2cm above each soil sample for one minute and the radiation level in the soil samples were registered on the inspector as counts, the average or mean radiation were then measured and computed. The measured values in CPM from the Radiation Alert Meter were converted to $\mu\text{Sv/hr}$, the Equivalent dose rate in $\mu\text{Sv/hr}$ was converted to annual dose rate in mSv/yr using the mathematical relationship [16].

$$\text{HTC} = \frac{\delta \times \mu \times 24 \times 365}{1000} \quad (1)$$

$$\delta = \frac{\text{HT}}{Q} \quad (2)$$

Where,

HT = Equivalent dose in μSvhr^{-1}

HTC = Equivalent dose in mSvyr^{-1}

δ = Absorbed dose in Gyhr^{-1}

μ = Outdoor occupancy factor

Q = Quality factor = 1

3. Results and discussion

The result of the analysis is shown in Table 1, 2 and 3. In Tables 1, the measured dose rate (μSvh^{-1}) ranges from 0.035 ± 0.097 to 0.333 ± 0.289 . In Table 2, annual dose rate (mSvh^{-1}) ranges from 0.059 ± 0.097 to 0.758 ± 0.289 , while in Table 3, absorbed dose rate (Gyh^{-1}) ranges from $3.50 \times 10^{-8} \pm 0.097$ to $3.33 \times 10^{-7} \pm 0.289$.

Table 1 Average dose rate in (μSvh^{-1}). The mean value is 0.140 ± 0.076 .

S/NO	Soil sample	Average dose rate(μSvh^{-1})
1.	SS1	0.124 ± 0.083
2.	SS2	0.188 ± 0.103
3.	SS3	0.038 ± 0.108
4.	SS4	0.062 ± 0.089
5.	SS5	0.225 ± 0.188
6.	SS6	0.136 ± 0.121
7.	SS7	0.172 ± 0.125
8.	SS8	0.259 ± 0.212
9.	SS9	0.138 ± 0.082
10.	SS10	0.035 ± 0.097
11.	SS11	0.250 ± 0.169
12.	SS12	0.070 ± 0.083
13.	SS13	0.153 ± 0.140
14.	SS14	0.137 ± 0.059
15.	SS15	0.102 ± 0.126
16.	SS16	0.112 ± 0.063
17.	SS17	0.070 ± 0.069
18.	SS18	0.333 ± 0.289
19.	SS19	0.090 ± 0.083
20.	SS20	0.116 ± 0.131
21.	SS21	0.264 ± 0.104
22.	SS22	0.128 ± 0.157
23.	SS23	0.114 ± 0.092
24.	SS24	0.112 ± 0.107
25.	SS25	0.081 ± 0.077

Mean average dose rate (μSvh^{-1}): 0.140 ± 0.076 .

Table 2 Annual dose rate (mSvyr⁻¹). The mean value is 0.256 ± 0.153 .

S/NO	Soil sample	Annual dose (mSvyr ⁻¹)
1	SS1	0.218 ± 0.083
2	SS2	0.330 ± 0.103
3	SS3	0.067 ± 0.108
4	SS4	0.108 ± 0.089
5	SS5	0.394 ± 0.188
6	SS6	0.239 ± 0.121
7	SS7	0.301 ± 0.125
8	SS8	0.454 ± 0.212
9	SS9	0.241 ± 0.082
10	SS10	0.059 ± 0.097
11	SS11	0.439 ± 0.169
12	SS12	0.123 ± 0.083
13	SS13	0.267 ± 0.140
14	SS14	0.246 ± 0.059
15	SS15	0.215 ± 0.126
16	SS16	0.197 ± 0.063
17	SS17	0.122 ± 0.069
18	SS18	0.758 ± 0.289
19	SS19	0.179 ± 0.083
20	SS20	0.203 ± 0.131
21	SS21	0.462 ± 0.104
22	SS22	0.224 ± 0.157
23	SS23	0.200 ± 0.092
24	SS24	0.214 ± 0.107
25	SS25	0.134 ± 0.077

Mean annual dose rate (mSvyr⁻¹): 0.256 ± 0.153 .**Table 3** Absorbed dose rate (Gyh⁻¹). The mean value is 3.029 ± 2.472 .

S/NO	Soil sample	Absorbed dose rate (Gyh ⁻¹)
1.	SS1	$1.24 \times 10^{-7} \pm 0.083$
2.	SS2	$1.88 \times 10^{-7} \pm 0.103$
3.	SS3	$3.80 \times 10^{-8} \pm 0.108$
4.	SS4	$6.70 \times 10^{-8} \pm 0.089$
5.	SS5	$2.25 \times 10^{-7} \pm 0.188$
6.	SS6	$1.36 \times 10^{-7} \pm 0.121$
7.	SS7	$1.72 \times 10^{-7} \pm 0.125$
8.	SS8	$2.59 \times 10^{-7} \pm 0.212$
9.	SS9	$1.38 \times 10^{-7} \pm 0.082$
10.	SS10	$3.50 \times 10^{-8} \pm 0.097$
11.	SS11	$2.50 \times 10^{-7} \pm 0.169$
12.	SS12	$7.00 \times 10^{-8} \pm 0.083$
13.	SS13	$1.53 \times 10^{-7} \pm 0.140$
14.	SS14	$1.37 \times 10^{-7} \pm 0.059$
15.	SS15	$1.02 \times 10^{-7} \pm 0.126$
16.	SS16	$1.12 \times 10^{-7} \pm 0.063$
17.	SS17	$7.00 \times 10^{-8} \pm 0.069$
18.	SS18	$3.33 \times 10^{-7} \pm 0.289$
19.	SS19	$9.00 \times 10^{-8} \pm 0.083$
20.	SS20	$1.16 \times 10^{-7} \pm 0.131$
21.	SS21	$2.64 \times 10^{-7} \pm 0.104$
22.	SS22	$1.28 \times 10^{-7} \pm 0.157$
23.	SS23	$1.14 \times 10^{-7} \pm 0.092$
24.	SS24	$1.12 \times 10^{-7} \pm 0.107$
25.	SS25	$8.10 \times 10^{-8} \pm 0.077$

Mean absorbed dose rate (Gyh⁻¹): 3.029 ± 2.472

Also, from Figure 1 and 2, the chart have shown that sample 10 contains the lowest average dose rate and annual dose rate and sample 18 contains the highest but it is still below the recommended value for dose rate. From Figure 3, the average dose rate increases as the annual dose rate increases. Between 0.05 -0.14 the average dose decrease also between 0.1- 0.24 the annual dose also decrease. Above these ranges of dose, the average dose increase as the annual dose increase. The maximum permissible exposed dose limit recommended by ICRP is 1mSv for the general public, and the results in this research revealed that the dose rates do not exceed the recommended value, less and in compliance with the recommended radiation dose level. Therefore do not pose a significant health hazard. The radiation dose level has no negative effect on the plants and the dwellers. Therefore, human being will not be exposed to radiation. Hence, there is no risk associated with any activity such as farming and building in soil farm land of mission quarters.

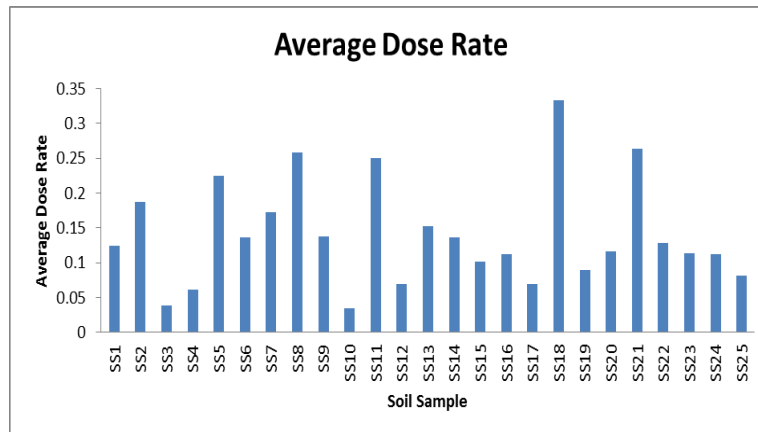


Figure 1 Column chart for average dose rate.

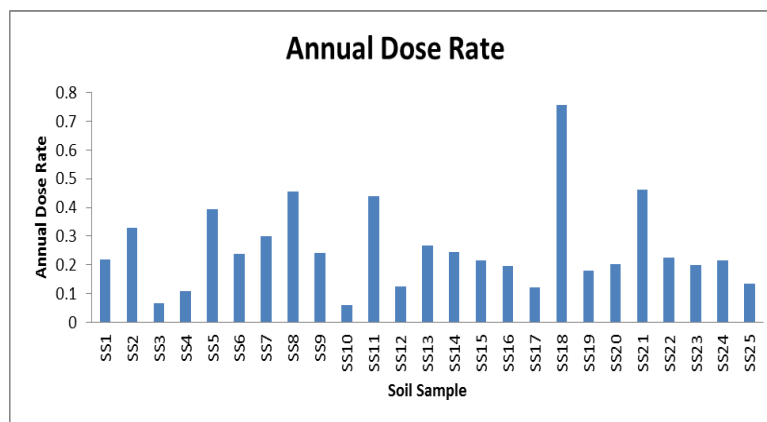


Figure 2 Column chart for annual dose rate.

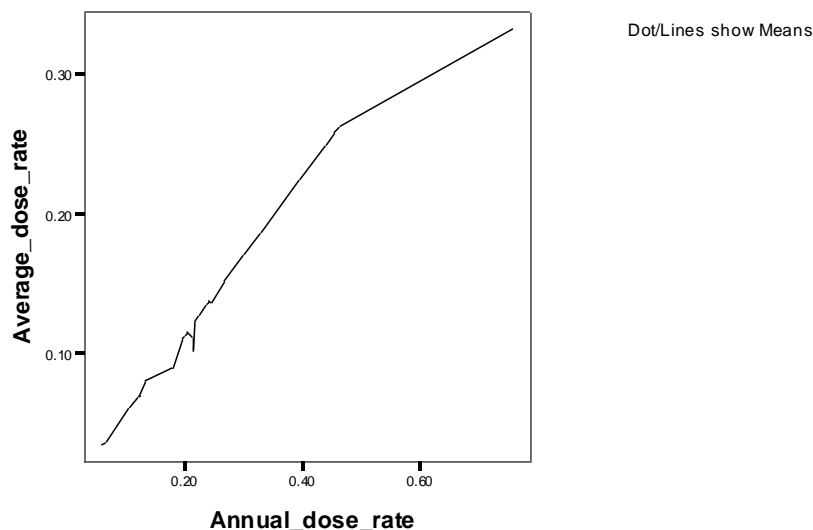


Figure 3 Graph of average dose rate against annual dose rate.

4. Conclusion

From this study, assessment of radiation dose level in farm soils of mission quarters, Wukari, Taraba State shows the average dose rate values ranging between 0.035 ± 0.097 to 0.333 ± 0.289 , an absorbed dose rate ranging between $3.50 \times 10^{-8} \pm 0.097$ to $3.33 \times 10^{-7} \pm 0.289$ and annual dose rate ranging between 0.059 ± 0.097 to 0.758 ± 0.289 . The obtained values of average dose rate, absorbed dose rate and annual dose rate were found to be below the recommended safety limits. These are indications that the study area is safe for human activity.

Conflict of Interest

No conflict in this research work.

References

- [1] Rama A.R, Raju B.L (2006). Dictionary of physics. *Educational Printing And Publishing Academic's. Academix (Indian) Publishers, New Delhi-11008*, 388p.
- [2] United states environmental protection (2006). Radionuclides in soil. *Agency Office of Radiation and Indoor Air (6608J) / EPA 402-F-06-051*, 1-3.
- [3] Senthilkumar R.D, Narayanaswamy R (2016). Assessment of radiological hazards in the industrial effluent disposed soil with statistical analyses, *Journal of Radiation Research and Applied Sciences*, 9: 1-4.
- [4] Abeokuta I.C, Okeyode A.O, Mustapha N.N, Jibiri V, Makinde F.G, Akinboro F.S, Saka D, Al-azmi (2017). Comparion of activity concentrations of natural radionuclides in soils collected at different depths of selected hand-dug wells. *Journal of Natural Science, Engineering and Technology*, 2: 119-130.
- [5] United nations scientific committee on the effects of atomic radiation (UNSCEAR) (2000). Sources and effects of ionizing radiation annex B: exposure on natural radiation. *Report on General Assembly. New York City, USA*, 1: 21-23.
- [6] Isinkaye N.N, Jibiri S.I, Bamidele L.A, Najam (2018). Evaluation of radiological hazards due to natural radioactivity in bituminous soils from tar-sand belt of southwest Nigeria using HpGe-Detector. *International Journal of Radiation Research*, 3: 351-362.
- [7] Araromi Olufunmbi I, Ojo Akinjide O, Olaluwoye Moromoke O, Odefemi Oluwafunmito B (2016). The concentration of natural radionuclides in soil samples from the practical year agricultural armland, university of Ibadan. *Journal of Applied Physics*, 4: 60-68.
- [8] Lewis B.J, Tune P, Benneth L.G.I, Pierre M, Green A.R, Cousin T, Hoffarth B.E, Jones T.A, Brisson J.R (1999). Cosmic radiation exposure on canadian-based commercial airline routes. *Radiation Protection Dosimetry. Nuclear Technology Publishing*, 1: 7-24.
- [9] Onudibia M. E, Opara I.J, Iseh A.J, Ayuni N.K, Ocheje J.A. Distribution pattern of elements of soils from haji kogi farms in agwan jaba area of Zaria, Nigeria. *Open Science Journal of Modern Physics*, 1: 1-6.
- [10] Mir F.A, Rather A.A, Radiat J (2015). Measurement of radioactive nuclides present in soil samples of district ganderbal of kashmir province for radiation safety purposes. *Radiation Research and Applied Sciences*, 8: 155.
- [11] Arogunjo M.A, Farai I.P, Fuwape I.A (2004). Impact of oil and gas industry to the natural radioactivity distribution in the delta region of Nigeria. *Nigerian Journal of Physics*, 16: 131-136.
- [12] Avwiri G. O, Agbalagba O.E (2007). Survey of gross alpha and gross beta radionuclide activity in okpare creek, delta state, Nigeria. *Information Journal on Applied Sciences*, 22: 3542-3547.
- [13] Muneer A.S, Ahmad T.R, Yasser A, Abubakar S.A (2013). Assessment of natural radiation levels and associated dose rate from surface soils in pontian district, Jahor, Malaysia. *Journal of Ovonic Research*, 1: 17-27.
- [14] Etuk S.E, George N.J, Essien I.E, Nwokolo S.C (2015). Assessment of radiation exposure levels within IkotAkpaden Campus of AkwaIbom State University, Nigeria. *Journal of Applied Physics*, 3: 86-91.
- [15] Olomo J.B (2006). The invisible tool: an inaugural lecture delivered at oduduwa hall, OAU Ile-Ife, Nigeria.
- [16] Marilyn E, Maguire J (1995). Radiation protection in health sciences. *World Scientific Publishing, Singapore*, 296-316.