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RADIOLOGICAL DOSE IMPLICATIONS OF THE NATURAL RADIOACTIVITY IN SURFACE SOILS IN EKITI STATE, NIGERIA

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ABSTRACT

The radiological dose implications of the natural radioactivity in the surface soil across Ekiti State, Nigeria have been determined in this study by using a very sensitive gamma spectroscopic system of measurement. Effective dose at 1.0m above the ground in the State was found to vary between 0.037 and 0.227mSvy^{-1} while the fifty years integral dose obtained ranged from 1.85 to 11.5mSv with a mean of 5.4770± 2.926mSv. The estimated average effective dose equivalent for the State is 0.109± 0.058 mSvy^{-1}. This value is far below the 0.41 mSvy^{-1} estimated as the world average by UNSCEAR and the dose limit of 1.0 mSv per year recommended as the individual dose limit for members of the public by the International Commission for Radiological Protection (ICRP).

Keywords: Environmental, radioactivity, radiation, soil dose

INTRODUCTION

Ionizing radiation is ambient in the atmosphere because of both primordial radioactive elements and their decay products in the earth (mainly ^{238}U, ^{232}Th, ^{40}K) and extra terrestrial cosmic radiation. This is termed the natural or environmental background radiation (Oresegun and Babalola, 1993). The contribution of natural radioactivity in surface soil of an environment to the total background radioactivity of the environment has been established (Albert to et al 1995, Ibrahim et al, 1993. Naturally occurring radioactive materials are present in rocks, soils and other terrestrial materials like food, crops, animals and local vegetation (Robinson et at, 1997). Regional and local variation in the distribution and availability of the natural radionuclides in an environment are related to ancient geological processes and a combination of contemporary geological stresses; atmospheric conditions and intervention by man (Redinger et al, 1974 and Timble, 1968). Phosphate rocks are major raw materials for fertilizer production and are known to contain radionuclides in concentration far exceeding the average abundance of earth's crust (Jaworoski, 1982 and Ajayi et al, 1995). This can also contribute to point variation of these radionuclides in the soil.

The effect of the radioactivity due to the decay of these radionuclides in the recipients in the environment can be fatal if adequate information about them is not known. Many sicknesses and diseases which could have been effectively treated if information about the radiation level in an environment is available are being attributed to other factors and not so easily treated. For example, it has been reported that though exposure from natural sources of ionizing radiation only account for about 2% of the total cancer burden in the United States (Savisky et al, 1995), Lung cancer risk in man will be more pronounced due to random diffusion from soil, building walls and tiles. Increased radiation doses to the environment can be induced by human activity due to technological advancement.

The focus of this study is therefore to provide an environmental radiological dose assessment of Ekiti State SW Nigeria for proper and effective radioactive waste management, control and prompt cross contamination detection in the area. The radiological dose parameters used are absorbed dose rates D, the annual effective dose E, and 50 years integral effective dose I values.

The study area Ekiti State is one of the South Western States in Nigeria. It lies between longitude $4^0 3'$ and $6^0 00'$ east of Greenwich meridian and latitudes $5^0 45'$ and $8^0 15'$ North of the equator. It also lies within the tropics and covers area of about 7000Sq km with a population of about two million (Ajayi, 1994).

MATERIALS AND METHOD

Surface soil samples (0-6cm) collected in eighty four locations (see table 1) were analysed using a 7.6 cm x 76 cm NaI (Tl) scintillation counter mounted inside a well shielded counting chamber coupled to a Canberra series 10 plus Multichannel Analyzer (MCA) with a resolution of about 8.0% at 0.662 MeV gamma ray energy from ^{137}Cs. The samples were air dried,

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homogenized and sieved through a 2.00mm mesh .Each sieved sample was weighed and carefully sealed for four weeks in order for the parent radionuclides in them to reach secular equilibrium with their respective progeny (Mollah et al, 1986). The gamma spectrum for each soil sample was determined by counting for 7,200 seconds in an aluminium container seated with high geometry on the Nal (Tl) detector (having a resolution of about 8.0% at the 662 kev line from 137 Cs). The mean count for all samples from each location was obtained. The mean was related to the soil radionuclide concentration and exposure dose rate by the calibration procedure which was carried out using about 100g soil standard radionucclide source sample obtained fsrom Departent of Energy, Environmental Measurement Laboratory, New York, USA. This sample contains certified activities of the selected radionucledes. The radionuclide concentrations were calculated on the basis of comparison with same –day counts of background and the standard sample which has the same approximate density and dimensions a the soil samples and known radionuclide contents. (Ajayi and Ajayi, 1999).

The 1460 kev gamma energy of ^{40}k was used to determine the concentration of ^{40}K in the different samples. The gamma transitions of energy 1765 Kev (due to ^{214}Bi) was used to determine the concentration of ^{238}U while the gamma transition of energy 2615 kev (due to ^{208}Tl) was used to determine the concentration of ^{232}Th in the soil sample.

RESULTS

The activity concentration of the natural radionuclides are presented in Table 1. Table 2, shows the air absorbed dose rates D, the annual effective dose equivalent E and 50 years integral effective dose I. The exposure from the radionuclides at 1.0 m above the ground was calculated using the formula by Beck. (Beck et al, 1972).

$$D = 0.042\,S_K + 0.429S_U + 0.666S_{Th} \quad \ldots\ldots\ldots(1.0)$$

Where D is the absorbed dose rate in μGyh^{-1} due to the specific radionuclide concentration S_K, S_U and S_{Th} for ^{40}K, ^{238}U and ^{232}Th respectively in $BqKg^{-1}$. These values range from 0.006 to 0.037 μGy^{-1} with a mean of 0.018 -+ 0.0095 μGy^{-1} in the state. Effective dose was estimated using the conversion factor of 0.7 Svy^{-1} given by UNSCEAR 1988 (Kenneth, 1997) for dose rates in air. The values oscillate between 0.037 and 0.227 $mSvy^{-1}$ with a mean value of 0.109 $mSvy^{-1}$ for the state.

DISCUSSION

The highest estimated radiological parameters of absorbed dose rate of 0.037 μGvy^{-1} effective dose of 0.227 $mSvy^{-1}$ and consequently 50 years integral effective dose of 11.355 mSv are at Aramoko Ekiti. Ijero Ekiti has the next highest effective dose of 0.215 mSv and 50 years integral dose of 10.75 mSv. The lowest effective dose of 0.037 $mSvy^{-1}$ and 50 years integral

Table 1: The specific activities of radionuclides in Bg Kg^{-1} In surface soil and their exposure dose rates at 1.0m above the ground level in μGyh^{-1}.

S/N	Location	Number of samples	Average activity 40k	Concentration Bg kg^{-1} 238U	232Th	Dose rate $DuGy^{-1}$ at 1m above the ground
1	Ado-Ekiti	12	392.00±7.39	8.79±2.51	4.77±1.03	0.023
2	Aramoko-Ekiti	8	320.96±8.59	50.52±3.16	2.48±0.73	0.037
3	Ijero–Ekiti	10	316.0±8.83	43.74±5.66	4.15±1.06	0.035
4	Ikole–Ekiti	8	98.81±3.05	6.02±1.17	6.88±0.94	0.110
5	Otun–Ekiti	8	277.58±60	10.52±2.03	5.85±1.09	0.020
6	Ido-Ekiti	6	279.67±18.30	6.12±1.28	6.12±1.28	0.018
7	Oye–Ekiti	6	65.00±8.60	2.57±0.73	2.75±0.73	0.006
8	Igede–Ekiti	5	320.00±930	1.99±0.72	1.88±0.72	0.015
9	Ilawe–Ekiti	6	289.50±8.02	2.28±0.75	2.28±0.75	0.015
10	Omuo–Eikiti	6	122.55±7.80	2.76±1.55	2.76±1.55	0.008
11	Ise–Ekiti	5	167.96±4.54	0.66±0.16	0.66±0.16	0.008
12	Ikere-Ekiti	4	334.75±9.39	3.98±0.85	3.98±0.85	0.018
Avg.			248.73±9.39	11.65±1.71	3.74±0.91	0.018

Table 2: The air absorbed dose rates D in μGyh^{-1}, the annual Effective dose E in $mSvy^{-1}$ and 50 years integral effective dose I in mSv.

S/N	Location	D μGyh^{-1}	E $mSvy^{-1}$	I MSv
1	ADO-EKITI	0.023	0.1410	7.05
2	ARAMOKO-EKITI	0.037	0.227	11.35
3	IJERO-EKITI	0.035	0.215	10.75
4	IKOLE-EKITI	0.110	0.067	3.350
5	OTUN-EKITI	0.020	0.123	6.150
6	IDO-EKITI	0,018	0.110	5.500
7	OYE-EKITI	0.006	0.037	1.850
8	IGEDE-EKITI	0.015	0.092	40600
9	ILAWE-EKITI	0.015	0.092	4.600
10	OMUO-EKITI	0.008	0.049	2.450
11	ISE-EKITI	0.008	0.049	2.450
12	IKERE-EKITI	0.018	0.110	5.500
RANGE		0.006-0.037	0.037-0.227	1.85 to11.35
MEAN		0.018+0.009	0.109+0.058	5.47+2.936

effective dose of 1.850 mSv respectively are from Oye –Ekti. The results indicate that the mean effective dose equivalent of 0.109 $\pm$ 0.058 $mSvy^{-1}$ for the entire state is less than the 0.41 $mSvy^{-1}$ estimated for the world average by UNSCEAR 1988 (Kenneth, 1997). The value is also far below the individual dose limit of 1.0 $mSvy^{-1}$ recommended by the International Commission for Radiological protection (ICRP). (ICRP 1990). However, the estimated mean dose of 0.41 $mSvy^{-1}$ world-wide from external sources is far less than 2.4 mSy^{-1} recommended for both external and internal sources in 1993 by UNSCEAR (Robinson et al, 19997).

CONCLUSION

It can be inferred from the results obtained in this work that the dose implications resulting from the natural radionuclides in the soils in the state is within the acceptable limits of both the UNSCEAR and the ICRP and therefore does not constitute any abnormal dose burden or health hazard to the populace. The state can therefore be said to radiologically safe from nazardous natural radiation sources. However, it should be noted that low dose accumulation over the years can bring about complication in gonad, thyroid, skin and conception leading to miscarriages in a radiosensitive population. The 50 years integral dose can be used to provide risk estimate resulting from both external and internal exposure to ionising radiation of the inhabitants of the area in a further research work.

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