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Gamma Radiation Levels of Some Selected Government Farms in Rivers State Nigeria

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Authors' contributions

This work was carried out in collaboration among all authors. Author GOA designed the study and author ANA performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors ANA and CPO managed the analyses of the study, and' managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Human are exposed to Background Ionizing radiation (BIR) due to the consumption of crops from fertilized farms within the study area.an in-situ measurement of BIR exposure rate in six fertilized farms and the unfertilized farm aws carried out using a well calibrated portable nuclear radiation detector (Digilert 200). and Geographical positioning system (GPS) for measuring the geographical location. The BIR of the selected local government area varies from 0.012 mR/hr to 0.022 mR / hr and the higher BIR value recorded in Khana, Obio / Akpor, Ahuoda east and Emuoha Local Government area (0.015 mR/hr, 0.015 mR / hr , 0.014 mR/hr , 0.014 mR / hr . While the mean value of Eleme and Gokana were within the permissible limit of 0.013 mR/hr and the BIR of the unfertilized farm was lower than the standard value of 0.013 mR/hr.the mean of absorbed dose varies from 1131 nGy / hr to 122.1nGy/hr which was higher than the recommended safe limit of 84.0 nGy / hr UNSCEAR 2008.The mean of ELCR varies from 0.63 to $0.72x10^{-3}$ which is higher than the world average value. The AEDE varies from 0.14 to 0.33 mSv / yr which are below the recommended permissible limit of 1.0 mSv / yr for general public. The effective dose to different body organs are below the recommended limit of 1.0 mSv / yr. The study shows that fertilized farms are contaminated due consistence application of fertilizers during cultivation, but the contamination does

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not have any direction health effect on individual who consumed crops from fertilized farms but there is the potential for long term health hazards in future such as Cancer due to consistence consumption of crops from fertilized farms.

Keywords: Outdoor; background; effective dose; ADP; organ dose.

1. INTRODUCTION

Human activities within the environment has increased drastically over the years due to oil exploration, mining, fertilizer production, agricultural application of fertilizer and construction for human survival and it has altered the natural concentration of naturally occurring radioactive materials (NORM) Mokobia [1]. The Inhalation and ingestion of such levels of radioisotopes contribute enormously to the dose that people receive and which eventually increased the health risks IAEA [2]. The contributions from these anthropogenic activities gained momentum after the Chernobyl accident in Ukraine, where an enormous volume of radioactive matter was released into the environment. These materials finally diffused into the soil and vegetation, Arogunjo [3]. The contamination of the soil occurs by natural and fallout of radionuclides as a recurrent radiological effect since it is freely translated to humans via edible crops and waters. Ingestion is the primary cause of human vulnerability to radiation leading to internal radiation, Saeed [4]. The application of fertilizer in in cultivation (soil) are the major source of radiation exposure to the environment and also a means of migration for the transfer of radionuclide into the environment. Natural radioactivity in soil is mainly due to ^{238}U, ^{40}K, ^{226}Ra which cause external and internal radiological hazards due to emission of gamma rays and inhalation of radon and its daughters.

2. MATERIALS AND METHODS

2.1 Study Area

The study is carried in Selected fertilized farms within six local Government Aare of Rivers state. The In-situ measurement of background ionizing radiation exposure dose rate of the different sampling points was assigned different code for proper identification. The following Local Government Areas were considered for the study; Ahoada, Emohua, Obi / Akpor, Eleme, Khana and Gokana local Government Aare while an unfertilized Farm was use as the control as shown in Image1, this local Government Aare are considered due to their consistence's application of fertilizers during crops cultivation.

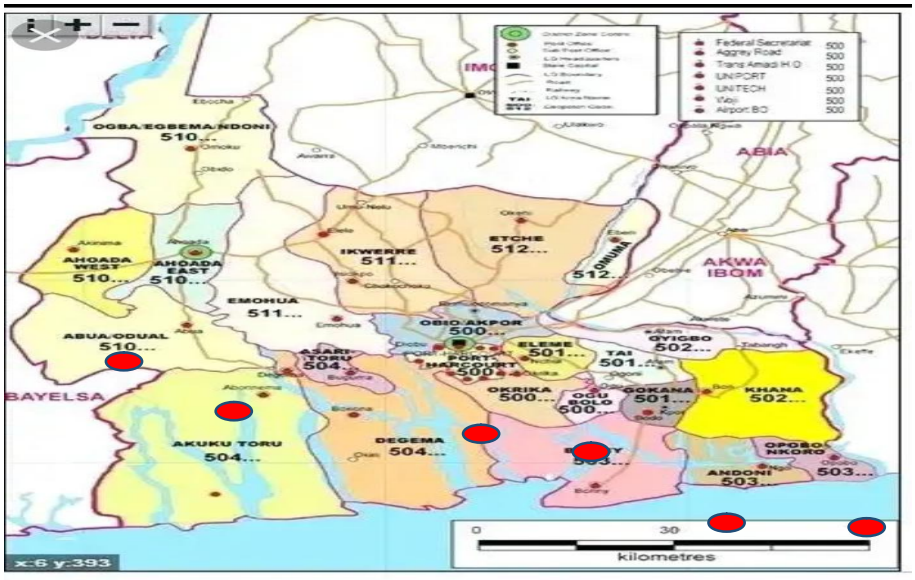

Image 1. Shows the Map of the study area

2.2 Materials

The instrument used in carrying the In-situ measurement of the outdoor BIR exposure level was Radalert metre (Digilert 200). The Nuclear radiation monitoring metre (S.E international Incorporation Summer Town USA), contains a Geiger-Muller tube capable of detecting alpha, beta and gamma radiation was used with in the temperature of 10^{o}c to 50^{o}c. The instrument was calibrated across a wide scale (0.01 up to 1000.0 μSv / hr) The Global Positioning System (GPS) is used to estimate the geographical coordinates of the sample point. GPS Map76 Garmin product.

2.3 Methods

The Radalert metre was place at 1m above the ground level with its window facing the point under investigation. During the measurement three readings was taken at each of the sampling points and the average was calculated to represent the background ionizing radiation exposure level of the fertilized farms. While the standard deviation was calculated to account for errors. The exposure dose rate was recorded at Ten sampling points within the fertilized farms of the selected Local Government Areas using code in differentiating each of the fertilized farms such as; Ahoada A_1-A_{10}, Emohua EM_1-EM_{10}, Obio / Apkor OB_1-OB_{10}, Eleme EL_1-$EL_{10,}$ Khana KH_1-KH_{10}, and Gokana Local Government Areas GO_1-GO_{10} respectively.

2.3.1 Radiological risk parameters

This analysis is used in radiation studies to obtain relevant conclusion on the associated health hazard status of individual and environmental irradiation [5].

The following radiological equivalents were evaluated;

A. Absorbed dose rate

The absorbed dose rate is calculated in nGy/hr using the equation below.

Absorbed Dose = exposure dose rate x 8.7 (nGy/hr) (1)

1μR/hr =8.7 nGy/hr

B. The annual effective dose equivalent (AEDE)

The annual effective dose equivalent is in radiation assessment and protection to quantify the whole body absorbed dose per year. The values obtained from the calculated absorbed dose rate was used to calculate AEDE using equation 2.

AEDE $_{outdoor}$ (mSv/yr) = Dose rate (nGy/h)×8760h×0.75 Sv/Gy×0.25 (2)

C. Excess Life Cancer Risk (ELCR)

The excess lifetime cancer risk is used in radiation protection assessment to predict the probability of an individual developing cancer over his lifetime due to low radiation dose exposure, if it will occur at all.

ELCR= AEDE× (DL)×RISK factor (RF) (3)

where DL is average duration of life (70 years) and RF is the fatal cancer risk factor, uses a fatal cancer risk factor value of 0.05 for public exposure [6].

D. Effective dose to different body organs

The effective dose to organs (Dorgan) estimates the amount of radiation dose intake to various body organs and tissues. The Dorgan of the body due to inhalation was calculated using Equation 4.

Dorgan (mSv/yr) = (AEDE) X F (4)

Where AEDE is the annual effective dose equivalent and F is the conversion factor of organ dose from air dose. The F value for lungs, ovaries, bone marrow, testes, kidney, liver and whole body as given by ICRP [7] are 0.64, 0.58, 0.69, 0.82, 0.62, 0.46, and 0.68, respectively.

3. RESULTS AND DISCUSSION

The Radiation exposure level and Risk parameters of the six fertilized farms within the selected local Government Areas are presented on the Tables above. The exposure dose Rate of Ahoada east varies from 0.010 to 0.020 mR/hr with mean value of 0.014 mR/hr, Emohua varies from 0.011 to 0.016 mR/hr with mean of 0.014 mR/hr, Obio/Akpor varies from 0.012 to 0.017 mR/hr with mean of 0.015 mR/hr, Eleme varies from 0.012 to 0.014 mR/hr with mean of 0.013 mR/hr, Khana varies from 0.011 to 0.022 mR/hr with mean of 0.015 mR/hr and Gokana varies from 0.010 to 0.014 mR/hr with mean of 0.013 mR/hr. The exposure Rate was recorded in Khana and Obio/apkor local Government Areas (0.015 mR/hr, 0.015 mR/hr,) were higher than

the reported value of Osimobi et al., [8] with mean of 0.014mR/h^{-1} but it is within the reported value of BIR value reported by Ugbede et al., [9] with mean of 0.015mR/h^{-1}. And the exposure Rate of Ahuoda east and Emuoha local Government Areas (0.014 mR/hr and 0.014 mR / hr) respectively were within the reported value of Avwiri and Ebeniro (1998) with mean of 0.014mR/h^{-1} and lower than BIR value reported by Ugbede et al., [9]. Though the Exposure values at some of the selected points were greater than the ICRP [6] average value while some of the selected points were lower the ICRP standard value, these may be due to the consistence application of fertilizers during cultivation.

The mean value obtained from Eleme and Gokana were within the standard value of 0.013mr/hr. The BIR value obtained were within the range value reported by Agbalagba [10]. While the mean value of the BIR of the Control of Khana was below the permissible limit of 0.013mr/hr ICRP [6] and lower than the BIR values obtained from the ADP Farm and also lower than the value reported by Benson [11], this may be due to the inconsistence application of fertilizers during the cultivation period in Khana Local Government Area.

The estimated absorbed dose rate from radiation values obtained from the ADP farmS are; Ahoada east varies from 87.0 to 174.0 nGy/hr with mean of 11.17 nGy/hr, Emouha varies from 95.7.0 to 147.0 nGy/hr with mean of 122.17 nGy/hr,0bio/akpor varies from 113.0 to 174.0 nGy/hr with mean of 127.0 nGy/hr, Eleme varies from 87.0 to 147.0 nGy/hr with mean of 13.1 nGy/hr, Khana varies from 95.7 to 139.2 nGy/hr with mean of 117.16 nGy/hr, Gokana varies from 95.7 to 130.5 nGy/hr with mean of 109.0 nGy/hr. while the control of Khana varies from 87.0 to 130 nGy/hr with mean of 94.54.0 nGy/hr. The absorbed obtained from Ahoada east and Obio/Akpor fertilized farms are higher than the value obtained from Emuoha, Eleme,Khana and Gokana. The mean value of absorbed dose within the selected local government area (11.17 nGy/hr 122.1 nGy/hr 127.0 nGy/hr 113.1 nGy/hr, 117.16 nGy/hr and 109.0 nGy/hr) respectively are lesser than the value reported by Ugbede [9] with mean of 126.0$\pm$5.10 nGy/hr and higher than the recommended safe limit of 84.0 nGy/hr UNSCEAR [12].

Table 1. Mean of Radiation Exposure Rate measurement at Ahoada East Local Government Area ADP Farm

Sampling points	GPS reading	Digilert 200 (mR/hr)	Equivalent dose (mSv/y)	Absorbed dose (nGy/hr)	AEDE Outdoor (mSv/y)	ELCR × 10^{-3}
A1	N05^{O}06.113' E006^{0} 37.990'	0.010$\pm$0.001	0.841	87.0	0.14	0.49
A2	N05^{O}06.111' E006^{0} 37.986'	0.014$\pm$0.002	1.177	121.8	0.20	0.70
A3	N05^{O}06.104' E006^{0} 37.985'	0.014$\pm$0.002	1.177	121.8	0.20	0.70
A4	N05^{O}06.099' E006^{0} 37.983'	0.020$\pm$0.001	1.682	174.0	0.33	0.89
A5	N05^{O}06.097' E006^{0} 37.979'	0.015$\pm$0.004	1.261	130.5	0.21	0.74
A6	N05^{O}06.090' E006^{0} 37.986'	0.012$\pm$0.003	1.009	104.4	0.17	0.60
A7	N05^{O}06'.088' E006^{0} 37.997'	0.016$\pm$0.001	1.346	139.2	0.22	0.77
A8	N05^{O}06.085' E006^{0} 37.990'	0.014$\pm$0.001	1.177	121.8	0.20	0.70
A9	N05^{O}06.084' E006^{0} 37.015'	0.013$\pm$0.001	1.093	113.1	0.19	0.67
A10	N05^{O}06.084' E006^{0} 37.031'	0.012$\pm$0.001	1.009	104.4	0.17	0.60
Mean		0.014$\pm$0.002	1.141$\pm$0.003	108.75	0.20	0.69

Table 2. Mean of Radiation Exposure Rate measurement at Emohua Local Government Area ADP Farm

Sampling points	GPS reading	Digilert 200 (mR/hr)	Equivalent dose (mSv/y)	Absorbed dose (nGy/hr)	AEDE outdoor (mSv/y)	ELCR × 10^{-3}
EM1	N05^{O}00'.517" E006^{0}44'856"	0.015±0.001	1.261	130.5	0.24	0.74
EM 2	N05^{O}00'.514" E006^{0}44'856"	0.014±0.002	1.177	121.8	0.20	0.70
EM 3	N05^{O}06'.517" E006^{0}45'975"	0.014±0.002	1.177	121.8	0.20	0.70
EM 4	N04^{O}55'.786" E006^{0}47'842"	0.014±0.001	1.177	121.8	0.20	0.70
EM 5	N04^{O}55'.780" E006^{0}47'835"	0.016±0.004	1.346	147.9	0.23	0.81
EM 6	N04^{O}55'.775" E006^{0}47'820"	0.012±0.003	1.009	104.4	0.17	0.60
EM 7	N04^{O}55'.765" E006^{0}47'800"	0.014±0.001	1.177	121.8	0.20	0.70
EM 8	N04^{O}55'.106" E006^{0}49'478"	0.013±0.001	1.093	113.1	0.19	0.67
EM 9	N04^{O}57'.586" E006^{0}49'872"	0.013±0.001	1.093	113.1	0.19	0.67
EM 10	N04^{O}57'.586" E006^{0}50'514"	0.016±0.001	1.346	139.2	0.22	0.77
Mean		0.014±0.002	1.186±0.001	123.5	0.20	0.71

Table 3. Mean of Radiation Exposure Rate measurement at Obio/Akpor Local Government Area ADP Farm

Sampling points	GPS reading	Digilert 200 (mR/hr)	Equivalent dose (mSv/y)	Absorbed dose (nGy/hr)	AEDE outdoor (mSv/y)	ELCR × 10^{-3}
OB1	N04^{O}52'.605" E007^{0}00'186"	0.013±0.001	1.093	113.1	0.19	0.67
OB 2	N04^{O}52'.602" E007^{0}00'185"	0.020±0.002	1.6821	174.0	0.33	0.89
OB 3	N04^{O}52'.607" E007^{0}00'178"	0.016±0.002	1.346	139.2	0.22	0.77
OB 4	N04^{O}52'.613" E007^{0}00'172"	0.015±0.001	1.261	130.5	0.21	0.74
OB 5	N04^{O}52'.617" E007^{0}00'164"	0.015±0.004	1.2611	130.5	0.21	0.74
OB 6	N04^{O}52'.623" E007^{0}00'173"	0.014±0.003	1.177	121.8	0.20	0.70
OB 7	N04^{O}52'.595" E007^{0}00'192"	0.012±0.001	1.009	104.4	0.17	0.60
OB 8	N04^{O}52'.594" E007^{0}00'195"	0.017±0.001	1.429	147.9	0.23	0.81
OB 9	N04^{O}52'.597" E007^{0}00'197"	0.012±0.001	1.009	104.4	0.17	0.60
OB 10	N04^{O}52'.599" E007^{0}00'186"	0.013±0.001	1.093	113.1	o.19	0.67
Mean		0.015±0.002	1.236±0.001	127.9	0.21	0.72

Table 4. Mean of Radiation Exposure Rate measurement at Eleme Local Government Area ADP Farm

Sampling points	GPS reading	Digilert 200 (mR/hr)	Equivalent dose (mSv/y)	Absorbed dose (nGy/hr)	AEDE outdoor (mSv/y)	ELCR × 10^{-3}
EL1	N04^{O}46'.998" E007^{0} 07'854"	0.014±0.001	1.177	121.8	0.20	0.70
EL 2	N04^{O}47'.002" E007^{0} 07'856"	0.014±0.002	1.177	121.8	0.20	0.70
EL 3	N04^{O}47'.003" E007^{0} 07'859"	0.017±0.002	1.429	147.9	0.23	0.81
EL 4	N04^{O}47'.001" E007^{0} 07'860"	0.013±0.001	1.093	113.1	0.19	0.67
EL 5	N04^{O}46'.997" E007^{0} 07'859"	0.014±0.004	1.177	121.8	0.20	0.70
EL 6	N04^{O}46'.996" E007^{0} 07'863"	0.014±0.003	1.177	121.8	0.20	0.70
EL 7	N04^{O}46'.992" E007^{0} 07'862"	0.014±0.001	1.177	121.8	0.20	1.70
EL 8	N04^{O}46'.992" E007^{0} 07'859"	0.012±0.001	1.009	104.4	0.17	0.70
EL 9	N04^{O}46'.988" E007^{0} 07'852"	0.010±0.001	0.841	87.0	0.14	0.49
EL 10	N04^{O}46'.997" E007^{0} 07'853"	0.012±0.001	1.009	104.4	0.17	0.60
Mean		0.013±0.002	1.13±0.001	116.58	0.19	0.68

Table 5. Mean of Radiation Exposure Rate measurement at Khana Local Government Area ADP Farm

Sampling points	GPS reading	Digilert 200 (mR/hr)	Equivalent dose (mSv/y)	Absorbed dose (nGy/hr)	AEDE outdoor (mSv/y)	ELCR × 10^{-3}
KH1	N04^{O}40'.329" E007^{0} 23.066"	0.022±0.001	1.261	130.5	0.21	0.74
KH2	N04^{O}40'.329" E007^{0} 23.062"	0.016±0.002	1.346	139.2	0.25	0.77
KH3	N04^{O}40'.333" E007^{0} 23.061"	0.014±0.002	1.177	121.8	0.20	0.70
KH4	N04^{O}40'.335" E007^{0} 23.060"	0.014±0.001	1.177	121.8	0.20	0.70
KH5	N04^{O}40'.336" E007^{0} 23.061"	0.014±0.004	1.177	121.8	0.20	0.70
KH6	N04^{O}40'.336" E007^{0} 23.064"	0.014±0.003	1.177	121.8	0.20	0.70
KH7	N04^{O}40'.334" E007^{0} 23.067"	0.012±0.001	1.009	104.4	0.17	0.60
KH8	N04^{O}40'.332" E007^{0} 23.069"	0.013±0.001	1.093	113.1	0.19	0.67
KH9	N04^{O}40'.329" E007^{0} 23.067"	0.012±0.001	1.009	104.4	0.17	0.60
KH10	N04^{O}40'.329" E007^{0} 23.065"	0.012±0.001	1.009	104.4	0.17	0.60
Control	N04^{O}40'.306" E007^{0} 23.145"	0.011±0.003	0.0942±0.002	97.44	0.12	0.50
	Mean	0.014±0.002	1.140±0.001	118.32	0.196	0.68

Table 6. Mean of Radiation Exposure Rate measurement at Gokana Local Government Area ADP Farm

Sampling points	GPS reading	Digilert 200 (mR/hr)	Equivalent dose (mSv/y)	Absorbed dose (nGy/hr)	AEDE outdoor (mSv/y)	ELCR× 10^{-3}
GO1	N04^{O}38'.986" E007^{0} 16.938"	0.014±0.001	1.177	121.8	0.20	0.70
GO 2	N04^{O}38'.987" E007^{0} 16.938"	0.011±0.002	0.925	95.7	0.16	0.57
GO 3	N04^{O}38'.986" E007^{0} 16.938"	0.012±0.002	1.009	104.4	0.17	0.60
GO 4	N04^{O}38'.985" E007^{0} 16.985"	0.012±0.001	1.009	104.4	0.17	0.60
GO 5	N04^{O}38'.987" E007^{0} 16.933"	0.015±0.004	1.261	130.5	0.21	0.74
GO 6	N04^{O}38'.988" E007^{0} 16.931"	0.013±0.003	1.09	113.1	0.19	0.67
GO 7	N04^{O}38'.989" E007^{0} 16.929"	0.014±0.001	1.177	121.8	0.20	0.70
GO 8	N04^{O}38'.989" E007^{0} 16.928"	0.014±0.001	1.177	121.8	0.20	0.70
GO 9	N04^{O}38'.991" E007^{0} 16.925"	0.014±0.001	1.177	121.8	0.20	0.70
GO 10	N04^{O}38'.986" E007^{0} 16.920"	0.011±0.001	0.925	95.7	0.16	0.57
Mean		0.013±0.002	1.093±0.002	113.06	0.19	0.66

Table 7. Organ Dose of the Selected Local Government Area

S/N	Local Govt Area	Lungs (mSvy^{-1})	Ovaries (mSvy^{-1})	Bone marrow (mSvy^{-1})	Testes (mSvy^{-1})	Kidney (mSvy-1)	Liver (mSvy^{-1})	Whole body (mSvy^{-1})
1	Ahoada	0.132	0.119	0.142	0.169	0.128	0.0952	0.140
2	Emuoha	0.129	0.117	0.139	0.165	0.120	0.093	0.137
3	Obio/Akpor	0.134	0.121	0.144	0.171	0.129	0.096	0.142
4	Elemen	0.119	0.108	0.128	0.153	0.115	0.086	0.127
5	Khana	0.108	0.098	0.117	0.139	0.105	0.078	0.115
6	Gokhana	0.115	0.105±	0.124	0.148	0.112	0.083	0.123
7	Unfertilized	0.108	0.098	0.117	0.139	0.105	0.078	0.115
	Average	0.124	0.112	0.133	0.159	0.119	0.089	0.132

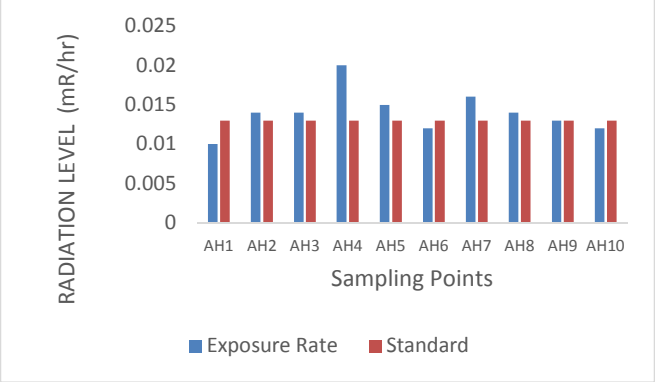

Fig. 1. Comparison of outdoor radiation level of Ahoada L.G.A with the standard

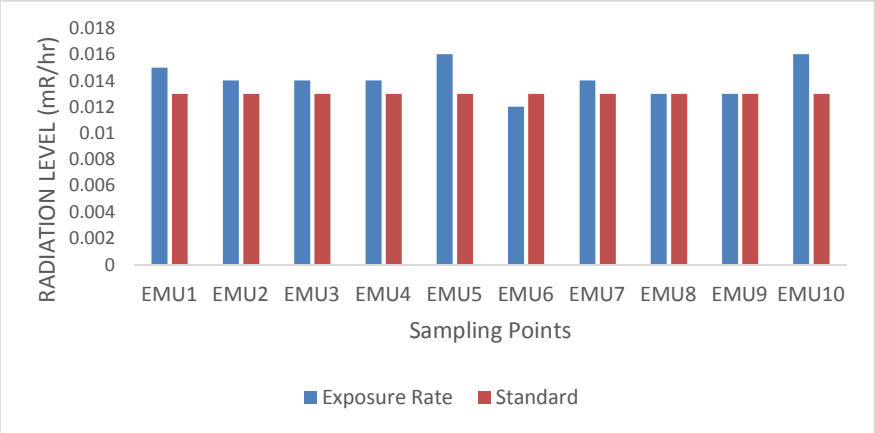

Fig. 2. Comparison of outdoor radiation level of Emohua LGA with the standard

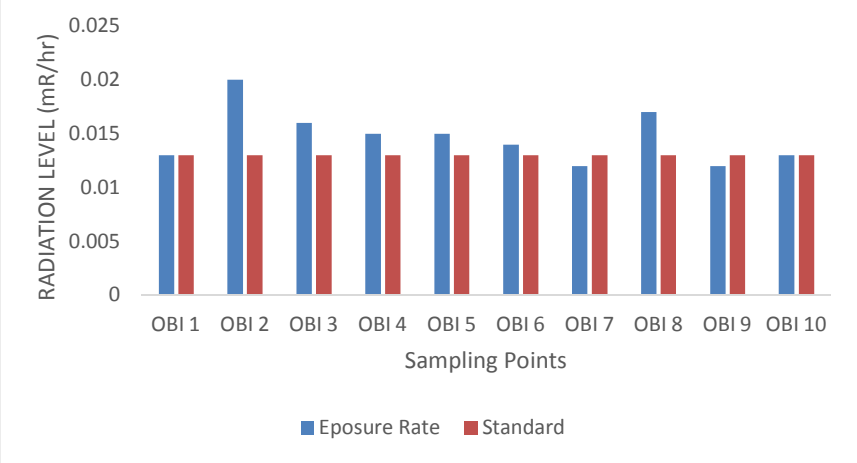

Fig. 3. Comparison of outdoor radiation level Obio/Akpor LGA with the standard

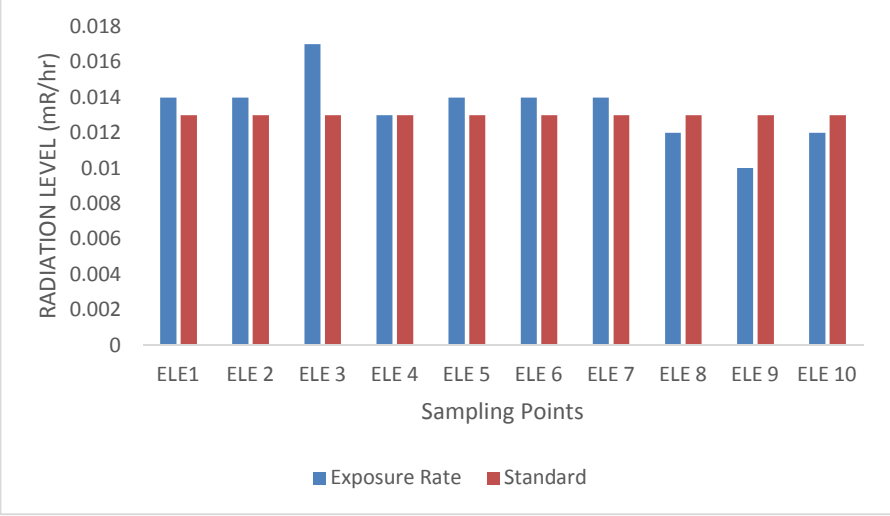

Fig. 4. Comparison of outdoor radiation level of Eleme LGA with the standard

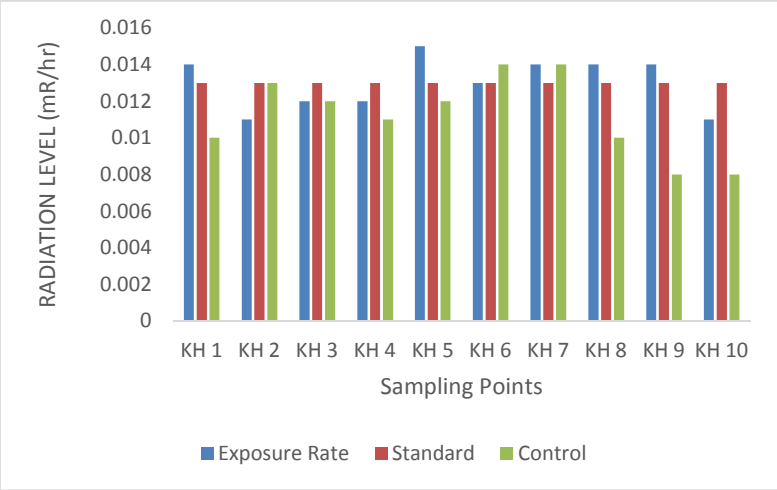

Fig. 5. Comparison of outdoor radiation level of Khana LGA with the standard

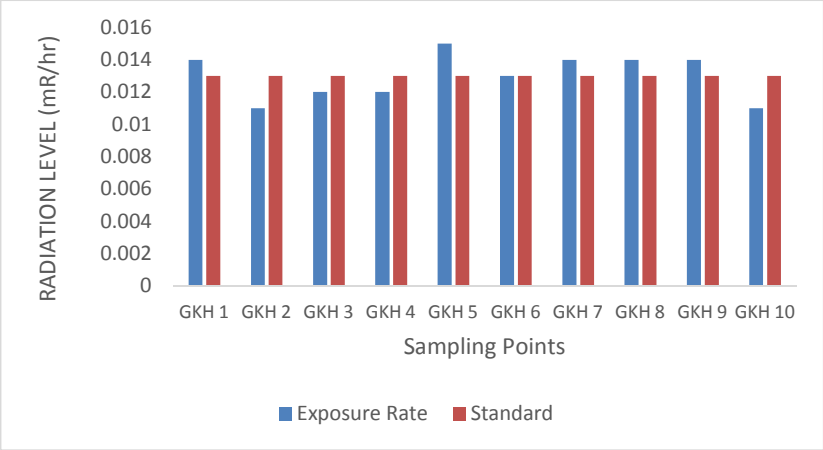

Fig. 6. Comparison of outdoor radiation level of the control in khana LGA with the standard

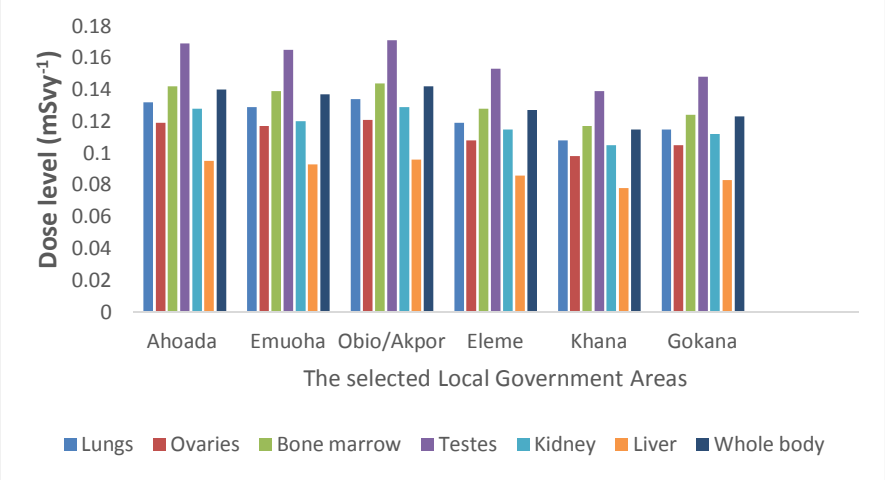

Fig. 7. Comparison of the mean values of the different body organ of the selected LGA

The AEDE value of Ahoada range 0.14 to 0.21mSv/yr with mean of 0.20mSv/yr, Emohua range 0.17to0.21mSv/yr with mean of 0.21 mSv/yr, Obio/Akpor range from 0.19 to 0.33 mSv/yr with mean of 0.21 mSv/yr Eleme range from 0.14 to 0.23 mSv/yr with mean of 0.19 mSv/yr, Khana range from 0.16 to 0.25 mSv/yr with mean of 0.19 mSv/yr, Gokana range from 0.14 to 0.21 mSv/yr with mean of 0.18 mSv/yr. The mean value obtained for AEDE are within the range reported by Ononugbo [13]. and it is within the UNSCEAR and ICRP recommended permissible limit of 1.0mSv/yr for general public ICRP [6].

The mean value of ELCR of Ahoada east, Emohua, Obio/akpor, Eleme, Khana and Gokana are; (0.65,0.70,072,0.65,067,0.63) × 10^{-3} respectively and the highest value was recorded at Emohua, Obio/akpor 0.70 and 0.72 × 10^{-3} while the lowest value was recorded at Gokana (0.63× $10^{-3)}$. The ELCR obtained from the study area are higher than the value reported by Ugbede [9]) and also higher than the world average value of 0.29. This shows that there is a high possibility of Cancer development by an individual who depend totally on crops from fertilized farms within the study area in all their life time.

The estimated mean value of the different dose organ for the lungs, ovaries, bone marrow, testes, kidney, liver and whole body due to radiation exposure of the ADP farms within the study area are 0.124, 0.112, 0.133, 0.159, 0.119, 0.089 and 0.132 $mSvy^{-1}$ respectively and highest value of 0.159 $mSvy^{-1}$ was recorded at the Testes which agreed with the report of Ugbede [9] and Darwish [14]. These results are all below the international tolerable limits of 1.0 mSv/yr annually.

5. CONCLUSION

The in-situ measurement ADP farms in Ahoada east, Emohua, OAbio/Akpor, Eleme,Gokana and Khana all in Rivers State has been carried out using a well calibrated radiation metre. The Background Ionizing radiation (BIR) of khana,Obio/Akpor, Ahoada east and Emohua Local Government Areas were higher than the standard value of 0.013 mR/hr, due to consistence applications of fertilizers during cultivation while Gokana and Eleme farms were lower than the standard value due to inconsistences application of fertilizer during cultivation. The absorbed dose of the selected Local Government Areas were higher than the recommended safer value of 84.0 nGy/hr. The ELCR of the study areas were higher than the world average value of $0.29x10^{-3}$ .The effective dose to different body organ within the study area was high in the Testes but these values were lower than the recommended safe limit of 1.0mSv/yr.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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