



# EVALUATION OF EXCESS LIFE CANCER RISK DUE TO BACKGROUND GAMMA RADIATION IN CENTRAL CROSS RIVER, NIGERIA

IGOMAH G. O., OKAYIM P. E., UMUNNAH R. A., AKPOBASAHAN E. A., ULEM C. A.,  
VALENTINE N. H., KELECHI D. C., OGAR S. I., OGBAJI V. J., MKPANG W. E.,  
ABEH J. U., ODUM-EGOM O. M., AND ITEM I. F.

Corresponding author's email: [igomahg@gmail.com](mailto:igomahg@gmail.com)

(Received 20 June 2025; Revision Accepted 18 July 2025)

## ABSTRACT

Human exposure to ionizing radiation from natural and artificial sources is an unavoidable phenomenon on Earth. Radiation indices and dose rate for some markets in Cross River State, central senatorial district Nigeria, have been measured utilizing a 451p ion chamber survey meter, and the following parameters of radiation were calculated; annual effective dose equivalent, and excess life cancer risk. The ranges of dose dose rate measured within Six major markets are as follows; Boki:  $0.04\mu\text{sv/h}$  to  $0.510\mu\text{sv/h}$ , Ikom:  $0.08\mu\text{sv/h}$  to  $0.253\mu\text{sv/h}$ , Etung:  $0.00\mu\text{sv/h}$  to  $0.500\mu\text{sv/h}$ , Obubra:  $0.08\mu\text{sv/h}$  to  $0.320\mu\text{sv/h}$ , Yakurr:  $0.05\mu\text{sv/h}$  to  $0.250\mu\text{sv/h}$ , and Abi:  $0.06\mu\text{sv/h}$  to  $0.160\mu\text{sv/h}$ . The mean value for the dose rate was  $0.17 \pm 0.099$  for Boki,  $0.135 \pm 0.046\mu\text{sv/h}$  for Ikom,  $0.157 \pm 0.112$  for Etung,  $0.165 \pm 0.053$  for Obubra,  $0.107 \pm 0.039\mu\text{sv/h}$  for Abi,  $0.146 \pm 0.053\mu\text{sv/h}$  for Yahurr. Mean values of  $0.379 \pm 0.510\text{msv}^{-1}$ ,  $0.210 \pm 0.081\text{msv/y}$ ,  $0.271 \pm 0.267\text{msv/y}$ ,  $0.252 \pm 0.090\text{msv/y}$ , and  $0.223 \pm 0.081\text{msv/y}$ ,  $0.163 \pm 0.059$  for AEDE were observed respectively for Boki, Ikom, Etung, Obubra, Yakurr, and Abi within the markets. Similarly,  $0.622 \pm 0.238 \times 10^{-3}$ ,  $0.643 \pm 0.158 \times 10^{-3}$ ,  $0.876 \pm 0.853 \times 10^{-3}$ ,  $0.514 \pm 0.167 \times 10^{-3}$ , and  $0.628 \pm 0.233 \times 10^{-3}$ , were recorded for ELCR, within the markets. The AEDE values are within the permissible limit as recommended by the international bodies, the ELCR values are also within the permissible limit. The AEDE & ELCR values indicates that the market areas are radiation safe for any radiological health burdens that might arise due to absorbing doses from background ionizing radiation, but the probability of occupants developing cancer over a lifetime exposure in market places is high. It is recommended that periodic background ionizing radiation monitoring and evaluation should be carried out, and radioactive concentration of nuclides in soil and rocks are been checked by local authority.

**KEYWORD.** Ionizing radiation, Dose rate, markets, annual effective dose equivalent (AEDE).  
Excess lifetime cancer risk (ELCR)

## INTRODUCTION

It is imperious that the dose of background gamma radiation levels is monitored and checked to avoid public exposure (Moisola et al, 2023). Everywhere in the world man generally is expose to background gamma radiation, and the radiation can come from different sources.

Background radiation is that which is naturally and inevitably present in our environment. Human beings are exposed to background radiation that stems both from natural and man-made sources (Igomah et al, 2024). In general, approximately 85% of the annual total radiation dose of any person comes from natural radionuclides of both terrestrial and cosmogenic origin (Belivermis et al. 2010; UNSCEAR 2000).

IGOMAH G. O., Department of Physics, University of Calabar, Calabar, Nigeria  
OKAYIM P. E., Department of Physics, University of Calabar, Calabar, Nigeria  
UMUNNAH R. A., Department of Physics, University of Calabar, Calabar, Nigeria  
AKPOBASAHAN E. A., Department of Radiography, University of Benin, Benin City, Nigeria  
ULEM C. A., Department of Physics, University of Calabar, Calabar, Nigeria  
VALENTINE N. H., Department of Physics, University of Calabar, Calabar, Nigeria  
KELECHI D. C., Department of Physics, University of Calabar, Calabar, Nigeria  
OGAR S. I., Department of Physics, University of Calabar, Calabar, Nigeria  
OGBAJI V. J., Department of Physics, University of Calabar, Calabar, Nigeria  
MKPANG W. E., Department of Physics, University of Calabar, Calabar, Nigeria  
ABEH J. U., Department of Physics, University of Calabar, Calabar, Nigeria  
ODUM-EGOM O. M., Department of Physics, University of Calabar, Calabar, Nigeria  
AND ITEM I. F., Department of Physics, University of Calabar, Calabar, Nigeria

The worldwide annual effective dose from natural sources is estimated to be 2.4mSv (UNSCEAR 2000). The earth crust contains various radioactive isotopes such as uranium, thorium, radon, tritium, carbon and potassium among others (Aziz et al, 2014). These isotopes and their decay products have differences in their half- life, which emits various types of radiation such as alpha, beta, and gamma rays additionally, cosmic radiation from the sun, contributes to gamma rays surrounding the human body (Aboalfazi et al 2021). Conversely, the controlled man-made artificial background radiations result from several sources such as fall out of weapon testing, radioactive waste, and the use of radioisotopes in radio-therapy. Both controlled and uncontrolled sources of radiation may have undesired biological effect of living species (Orwa et al, 2012). Small traces of many naturally occurring radioactive materials are present in the human body (Taskin at al, 2009). These comes mainly from naturally occurring radioactive nuclides present in the food we eat and in the air we breathe. And this isotope includes tritium ( $^3\text{H}$ ), carbon-14 ( $^{14}\text{C}$ ), and potassium-40 ( $^{40}\text{K}$ ) (Oyeyinka et al, 2012).

## MATERIALS AND METHOD

### Study area.

This research was carried out in Cross River State, in the south-south geopolitical zone of Nigeria, with the coordinates  $5^{\circ}45'\text{N}$ , and  $8^{\circ}30'\text{E}$ . Cross River State comprises of three senatorial districts: Northern Cross River, Southern Cross River, and Central Senatorial District. Observations were made in the central senatorial district which comprises of six local government areas, with six major markets across the senatorial district.

### Field measurement.

In-situ measurement of the background gamma radiation level was done by making use of a portable well-calibrated 451p ion chamber survey meter capable of detecting beta, gamma, and x-ray particles with a high sensitivity measurement of rate and dose simultaneously from various radiation sources. Readings were taken within the hours of 10 am and 4 pm hours. The survey meter was utilized to measure the dose rate of gamma radiation in  $\mu\text{Sv/hr}$  within the six markets and 20 sampling points were taken for each market. Measurement was done 1m above the

ground level, three measurements for each point were taken and then averages were calculated for each point.

## RESULTS AND DISCUSSION.

Calculated Radiological parameters.

### Absorbed dose rate (ADR)

#### Absorbed dose rate

The absorbed dose rate is calculated from the exposure rate using the conversion factor

$$1\mu\text{Sv/h} = 1000\text{nGy/h} \dots\dots\dots (1)$$

### Annual Effective Dose Equivalent (AEDE)

To enable the computation of annual effective dose equivalent (AEDE) in the study area, the already estimated absorbed dose rate was used in calculating AEDE, a dose conversion factor for the outdoors of 0.25 (6 hours out of 24 hours) was used. The occupancy factor for the outdoors was determined based on interaction with people. In the market (traders), it was discovered that they spend approximately 6 hours in the course of their daily activities within the study environment. The annual effective dose was calculated using the following relation.

$$\text{AEDE (outdoor) (mSv}^{-1}\text{)} = \text{Absorbed dose (nGy}^{-1}\text{)} \times 8760\text{h} \times \frac{0.75\text{v}}{\text{Gy}} \times 0.25 \dots\dots\dots (2)$$

### Excess Life Cancer Risk (ELCR)

The possibility of contacting cancer by the traders, buyers, sellers, and residents of the study area throughout their lifetime in this environment can be approximately obtained using the excess lifetime cancer Risk (ELCR). The estimation is given as;  
ELCR = AEDE x Average duration of life x Risk factor..... (3)

Where AEDE, DL, and RF are the annual effective dose equivalent, duration of life (70 yrs) and risk factor ( $\text{Sv}^{-1}$ ) fatal cancer risk per Sievert are considered to produce stochastic effects. ICRP 60 uses values of 0.05 for the public

## RESULTS.

The in-situ measurement of radiation dose rate of six major markets in Cross River central Nigeria is represented in Tables 1 to 6.

Table 1: Dose rate in Ikom market

Location	Dose rate	Absorbed Dose	AEDE	ELCR
	$\mu\text{Sv/h}$	Rate ( $\text{nGyh}^{-1}$ )	( $\text{msvy}^{-1}$ )	$\times 10^{-3}$
K <sub>1</sub>	0.11	110	0.17	0.595
K <sub>2</sub>	0.253	253	0.38	1.33
K <sub>3</sub>	0.22	220	0.34	1.19
K <sub>4</sub>	0.193	193	0.29	1.02
K <sub>5</sub>	0.17	170	0.26	0.91
K <sub>6</sub>	0.12	120	0.18	0.63
K <sub>7</sub>	0.15	150	0.23	0.81
K <sub>8</sub>	0.097	97	0.15	0.53
K <sub>9</sub>	0.08	80	0.12	0.42
K <sub>10</sub>	0.11	110	0.16	0.59
K <sub>11</sub>	0.11	110	0.16	0.59
K <sub>12</sub>	0.11	110	0.16	0.59
K <sub>13</sub>	0.127	127	0.19	0.67
K <sub>14</sub>	0.103	103	0.15	0.53
K <sub>15</sub>	0.09	90	0.14	0.49
K <sub>16</sub>	0.11	110	0.16	0.56
K <sub>17</sub>	0.107	107	0.16	0.56
K <sub>18</sub>	0.14	140	0.21	0.74
K <sub>19</sub>	0.127	127	0.19	0.67
K <sub>20</sub>	0.18	180	0.39	1.37

Table 2: Dose rate measured within Etung Market

Location	Dose rate	Absorbed Dose Rate	AEDE	ELCR
	$\mu\text{Sv/h}$	$(\text{nGyh}^{-1})$	$(\text{msvy}^{-1})$	$\times 10^{-3}$
T <sub>1</sub>	0.13	130	0.19	0.67
T <sub>2</sub>	0.13	130	0.19	0.67
T <sub>3</sub>	0.11	110	0.17	0.59
T <sub>4</sub>	0.10	100	0.15	0.53
T <sub>5</sub>	0.15	150	0.23	0.81
T <sub>6</sub>	0.12	120	0.18	0.63
T <sub>7</sub>	0.42	420	0.64	2.24
T <sub>8</sub>	0.10	110	0.17	0.59
T <sub>9</sub>	0.18	180	0.28	0.98
T <sub>10</sub>	0.17	170	0.26	0.91
T <sub>11</sub>	0.09	90	0.14	0.49
T <sub>12</sub>	0.11	110	0.17	0.59
T <sub>13</sub>	0.50	50	0.08	0.28
T <sub>14</sub>	0.18	180	0.28	0.98
T <sub>15</sub>	0.11	110	0.17	0.59
T <sub>16</sub>	0.14	140	0.21	0.74
T <sub>17</sub>	0.85*	850*	1.30	4.55
T <sub>18</sub>	0.16	160	0.25	0.88
T <sub>19</sub>	0.10	100	0.15	0.53
T <sub>20</sub>	0.14	140	0.21	0.74

Table 3: Dose rate measured within Yakurr (Ekor Market)

Location	Dose rate	Absorbed Dose Rate	AEDE	ELCR
	$\mu\text{Sv/h}$	( $\text{nGy h}^{-1}$ )	( $\text{msv y}^{-1}$ )	$\times 10^{-3}$
U <sub>1</sub>	0.14	140	0.21	0.74
U <sub>2</sub>	0.18	180	0.28	0.98
U <sub>3</sub>	0.19	190	0.29	1.02
U <sub>4</sub>	0.23	230	0.35	0.23
U <sub>5</sub>	0.11	110	0.17	0.59
U <sub>6</sub>	0.19	190	0.29	1.02
U <sub>7</sub>	0.17	170	0.26	0.91
U <sub>8</sub>	0.13	130	0.20	0.70
U <sub>9</sub>	0.18	180	0.28	0.93
U <sub>10</sub>	0.14	140	0.21	0.74
U <sub>11</sub>	0.17	170	0.26	0.91
U <sub>12</sub>	0.11	110	0.17	0.59
U <sub>13</sub>	0.11	110	0.17	0.59
U <sub>14</sub>	0.06	60	0.09	0.32
U <sub>15</sub>	0.05	50	0.08	0.28
U <sub>16</sub>	0.16	160	0.24	0.84
U <sub>17</sub>	0.25	250	0.38	1.33
U <sub>18</sub>	0.17	170	0.26	0.91
U <sub>19</sub>	0.08	80	0.12	0.42
U <sub>20</sub>	0.09	90	0.14	0.49

Table 4: Dose rate measured within Obubra Market

Location	Dose rate	Absorbed Dose Rate	AEDE	ELCR
	$\mu\text{Sv/h}$	$(\text{nGyh}^{-1})$	$(\text{msvy}^{-1})$	$\times 10^{-3}$
C <sub>1</sub>	0.16	160	0.25	0.88
C <sub>2</sub>	0.12	120	0.18	0.63
C <sub>3</sub>	0.08	80	0.12	0.42
C <sub>4</sub>	0.17	170	0.26	0.91
C <sub>5</sub>	0.16	160	0.25	0.88
C <sub>6</sub>	0.12	120	0.18	0.63
C <sub>7</sub>	0.23	230	0.35	1.23
C <sub>8</sub>	0.18	180	0.28	0.98
C <sub>9</sub>	0.19	190	0.29	1.02
C <sub>10</sub>	0.11	110	0.17	0.59
C <sub>11</sub>	0.18	180	0.28	0.98
C <sub>12</sub>	0.2	200	0.30	1.05
C <sub>13</sub>	0.25	250	0.38	1.33
C <sub>14</sub>	0.12	120	0.18	0.63
C <sub>15</sub>	0.18	180	0.28	0.98
C <sub>16</sub>	0.32	320*	0.49	1.72
C <sub>17</sub>	0.18	180	0.28	0.98
C <sub>18</sub>	0.08	80	0.12	0.42
C <sub>19</sub>	0.14	140	0.21	0.74
C <sub>20</sub>	0.12	120	0.18	0.63

Table 5: Dose rate measured within Boki Market

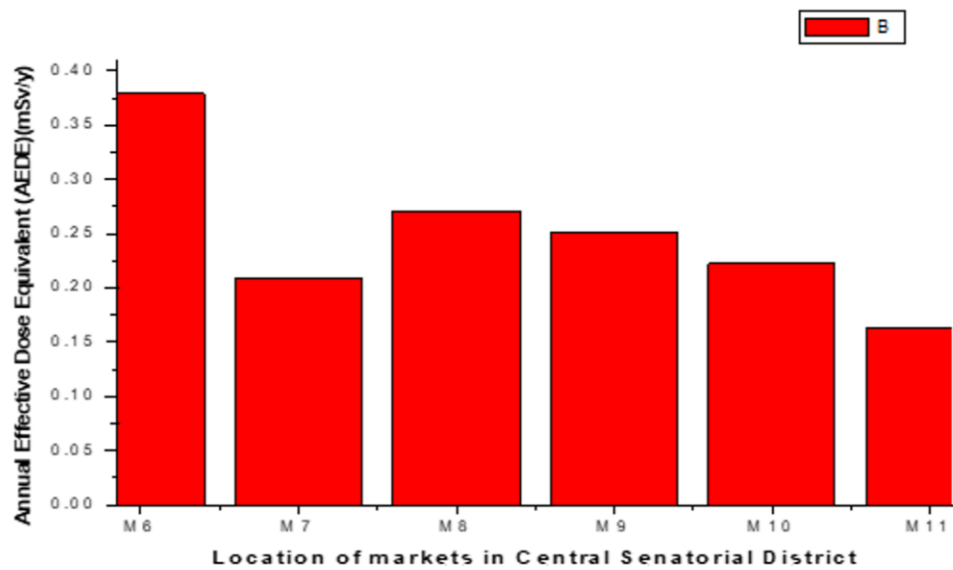
Location	Dose rate	Absorbed Dose Rate	AEDE	ELCR
	$\mu\text{Sv/h}$	$(\text{nGy h}^{-1})$	$(\text{msvy}^{-1})$	$\times 10^{-3}$
E <sub>1</sub>	0.07	70	0.11	0.39
E <sub>2</sub>	0.08	80	0.12	0.42
E <sub>3</sub>	0.04	40	0.06	0.21
E <sub>4</sub>	0.11	110	0.17	0.59
E <sub>5</sub>	0.11	110	0.17	0.57
E <sub>6</sub>	0.19	190	0.29	1.02
E <sub>7</sub>	0.16	160	0.25	0.88
E <sub>8</sub>	0.17	170	0.26	0.91
E <sub>9</sub>	0.15	150	0.23	0.81
E <sub>10</sub>	0.17	170	0.26	0.91
E <sub>11</sub>	0.22	220	0.34	1.19
E <sub>12</sub>	0.26	260	0.399	1.397
E <sub>13</sub>	0.16	160	2.45	8.58
E <sub>14</sub>	0.11	110	0.17	0.595
E <sub>15</sub>	0.13	130	0.199	0.697
E <sub>16</sub>	0.51	510	0.78	2.73
E <sub>17</sub>	0.25	250	0.38	1.33
E <sub>18</sub>	0.14	140	0.35	1.23
E <sub>19</sub>	0.23	230	0.35	1.23
E <sub>20</sub>	0.16	160	0.25	0.86

Table 6: Dose rate within Abi market

Location	Dose rate	Absorbed Dose Rate	AEDE	ELCR
	$\mu\text{Sv/h}$	$(\text{nGyh}^{-1})$	$(\text{msvy}^{-1})$	$\times 10^{-3}$
N <sub>1</sub>	0.10	100	0.15	0.53
N <sub>2</sub>	0.07	70	0.11	0.39
N <sub>3</sub>	0.08	80	0.12	0.42
N <sub>4</sub>	0.08	80	0.12	0.42
N <sub>5</sub>	0.09	90	0.14	0.49
N <sub>6</sub>	0.18	180	0.28	0.98
N <sub>7</sub>	0.19	190	0.29	1.02
N <sub>8</sub>	0.14	140	0.21	0.74
N <sub>9</sub>	0.06	60	0.09	0.32
N <sub>10</sub>	0.08	80	0.12	0.42
N <sub>11</sub>	0.09	90	0.14	0.49
N <sub>12</sub>	0.17	170	0.26	0.91
N <sub>13</sub>	0.11	110	0.17	0.59
N <sub>14</sub>	0.12	120	0.18	0.63
N <sub>15</sub>	0.06	60	0.09	0.32
N <sub>16</sub>	0.09	90	0.14	0.49
N <sub>17</sub>	0.14	140	0.21	0.74
N <sub>18</sub>	0.11	110	0.17	0.59
N <sub>19</sub>	0.08	80	0.12	0.42
N <sub>20</sub>	0.09	90	0.14	0.49

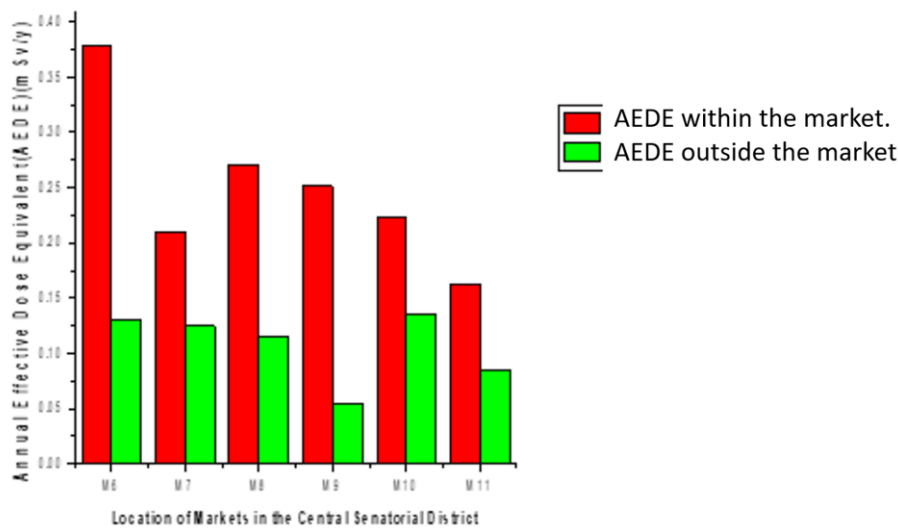
Assessment of radiation profile and dose rate from major markets in central senatorial district of cross river state, Nigeria was been measured using a well calibrated ionization chamber survey meter. The mean dose was measured across the six markets which range from  $0.107 \pm 0.039 \mu\text{Sv/h}$  in Boki market to  $0.171 \pm 0.099 \mu\text{Sv/h}$  in Abi market.





Bar chart showing the Annual effective dose equivalent(AEDE) of background gamma radiation in the Central Senatorial District

**Fig 1.** Bar chart showing the annual effective dose equivalent (AEDE) of the background gamma radiation in central senatorial district



Bar chart showing annual effective dose equivalent of background gamma radiation around and outside the markets in the Central Senatorial District

**Fig 2.** Bar chat showing the annual effective dose equivalent of background gamma radiation around and outside the market in central senatorial district. Bar chart showing the excess lifencancer risk in central cross river senatoria district.

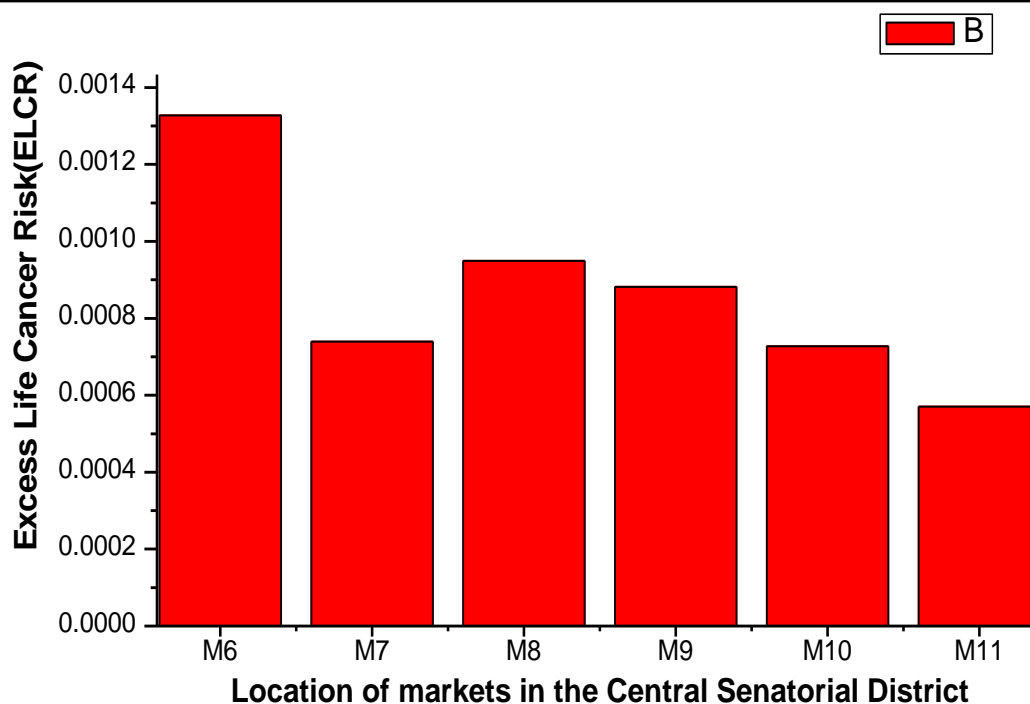


Fig 3. Bar chart showing the excess lifecancer risk in central cross river senatoria district.

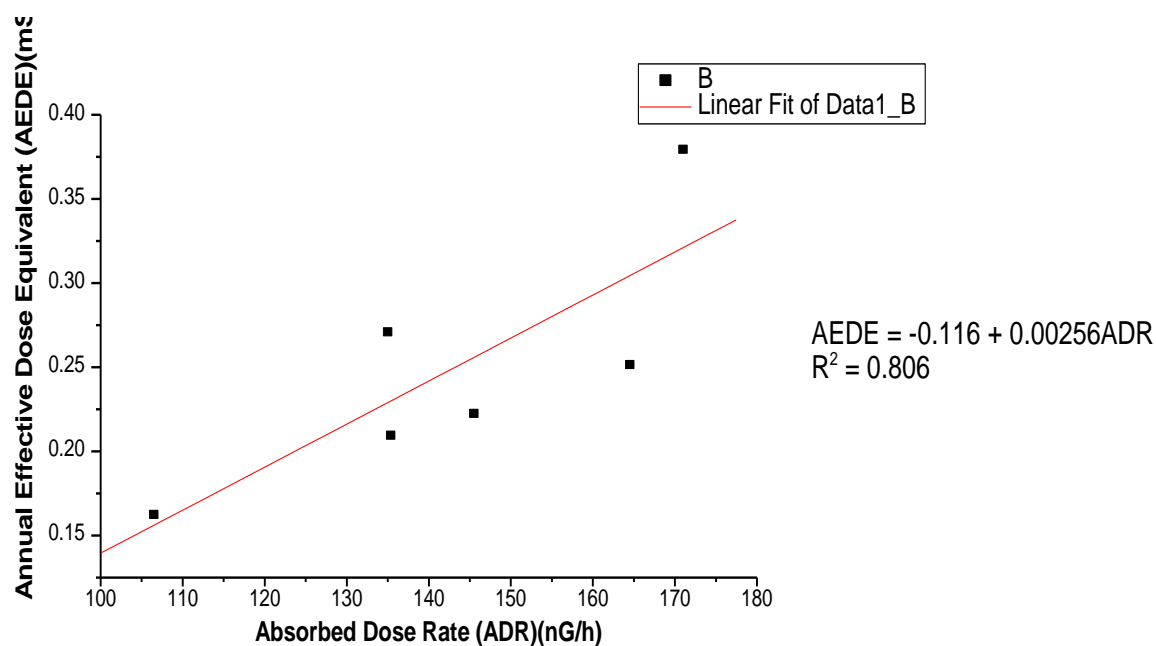
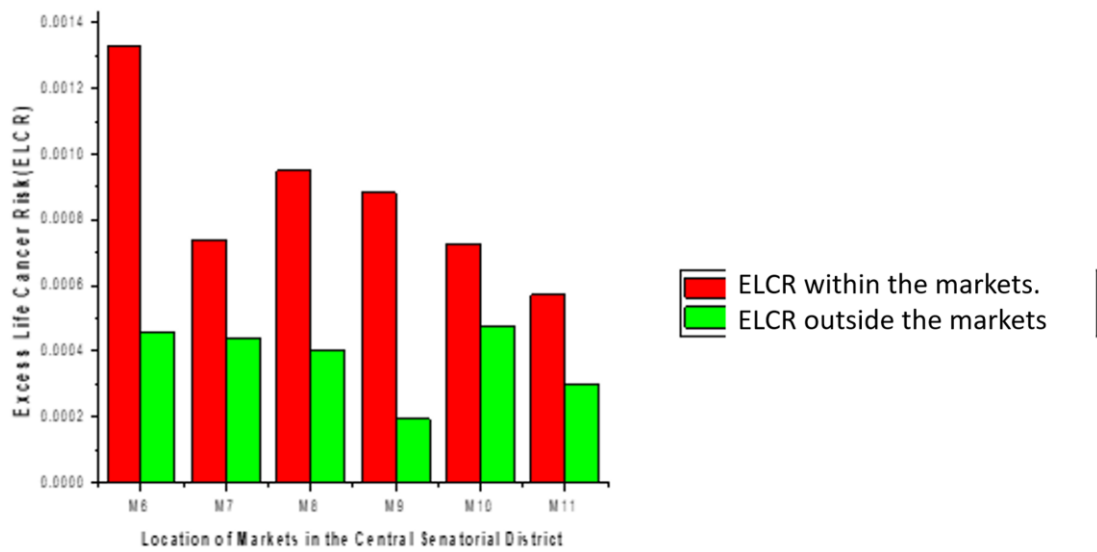


Fig 4. Bar chart showing the annual effective dose equivalent of background gamma radiation within and outside the markets in central senatorial district.



Bar chart showing excess life cancer risk of background gamma radiation within and outside the markets in the Central Senatorial District

Fig 4. Bar chart showing the annual effective dose equivalent of background gamma radiation within and outside the markets in central senatorial district

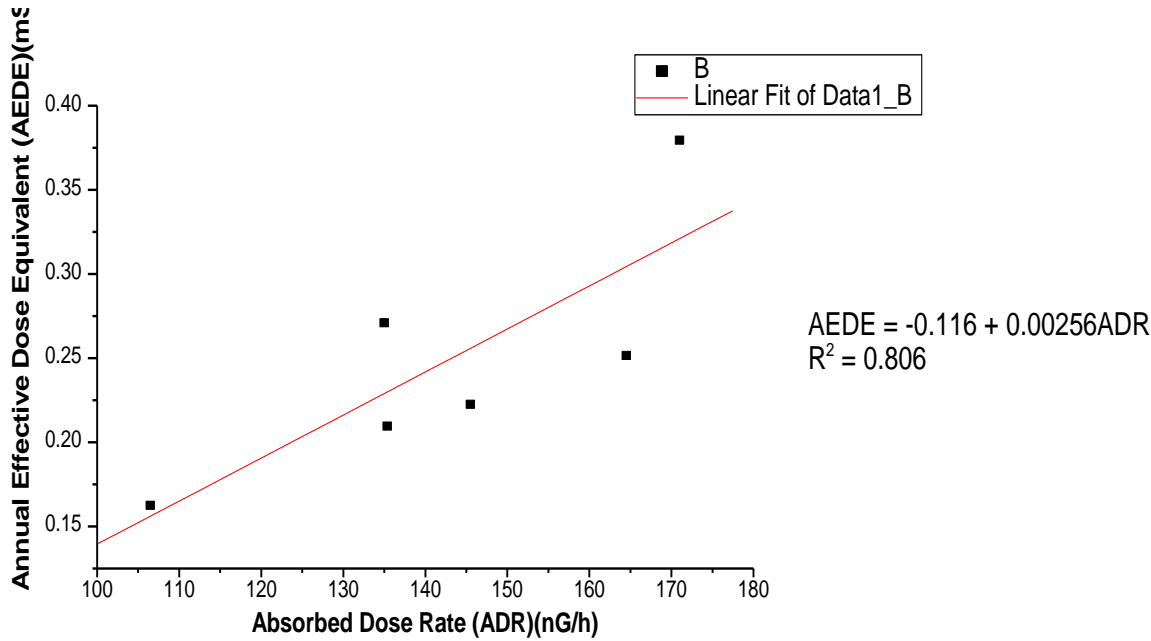


Fig 5. Correlation analysis in the central senatorial district

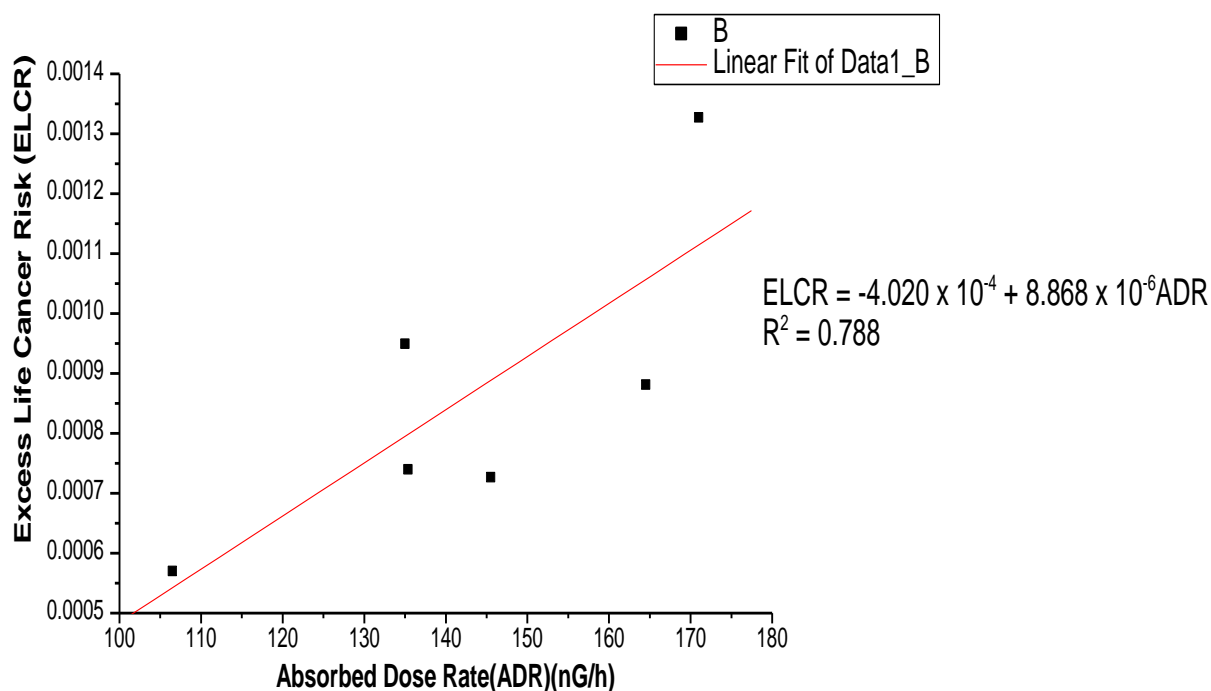


Fig.6 A graph of annual effective dose equivalent against absorbed dose rate in the central senatorial district

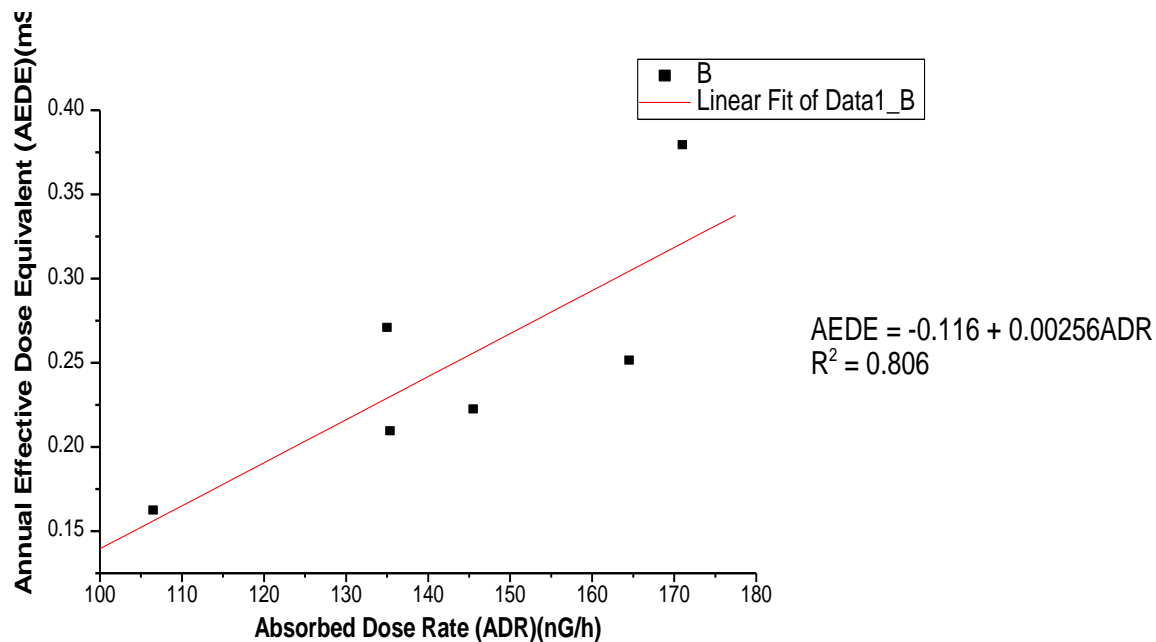


Fig.7 A graph of excess life cancer risk against absorbed dose rate in the central senatorial district

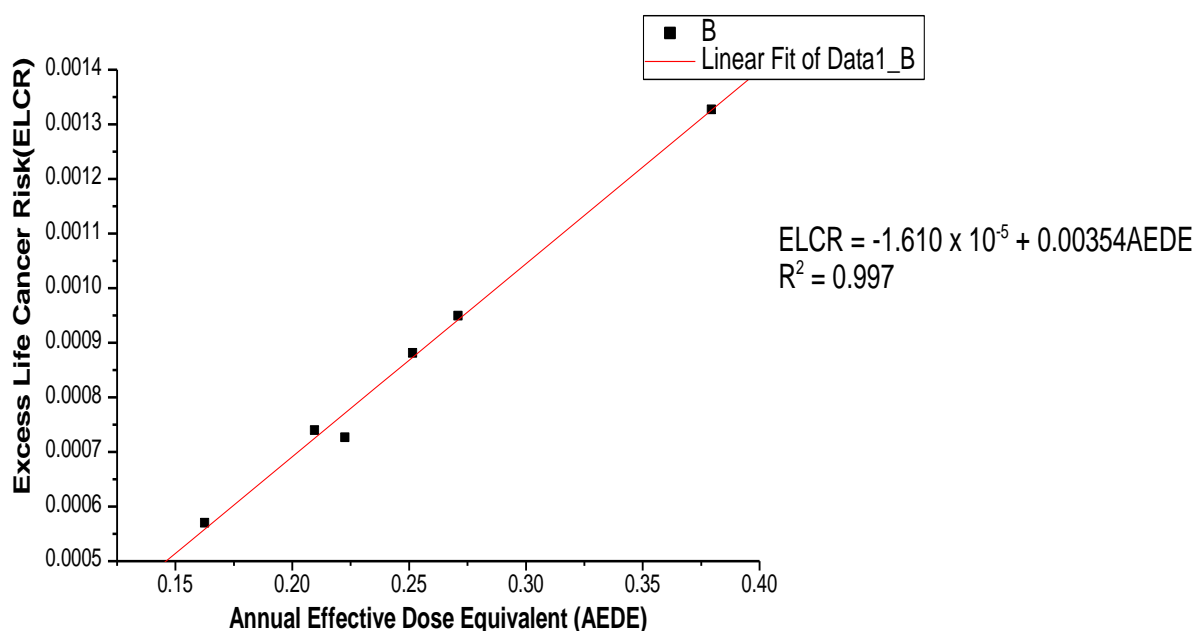


Fig. 8 A graph of excess life cancer risk against annual effective dose equivalent in the central senatorial district.

Table 7. Summary of regression equations in central senatorial district

S/N	Variables	Equation	$r^2$	Correlation status
1	AEDE ADR	$\text{AEDE} = -0.116 + 0.00256\text{ADR}$	0.806	High
2	ELCR ADR	$\text{ELCR} = -4.02 \times 10^{-4} + 8.868 \times 10^{-6}\text{ADR}$	0.788	High
3	ELCR AEDE	$\text{ELCR} = -1.610 \times 10^{-5} + 0.0035\text{AEDE}$	0.997	High

## DISCUSSION.

Assessment of radiation profile and excess life cancer risk from the six major markets across the central senatorial district of Cross River State was obtained utilizing a well-calibrated ionization chamber survey meter. The dose rate measured ranges from  $0.00\mu\text{Sv/h}$  to  $0.510\mu\text{Sv/h}$  with a mean value of  $0.107 \pm 0.039\mu\text{Sv/h}$  to  $0.171 \pm 0.09\mu\text{Sv/h}$ . This is lower than the world standard value of  $1\text{mSv/y}$  for members of the public (ICRP, 1991). The location that recorded the highest dose rate, absorbed dose rate, annual effective dose equivalent, and excess life cancer risk was Boki market. This may be due to the increase in economic activities, presence of rocks, and the building material present in the market having radon gases trapped in them.

The annual effective dose equivalent measured ranges from  $0.14\text{mSv/y}$  to  $0.30\text{mSv/y}$  with a mean value of  $0.067 \pm 0.029\text{mSv/y}$  to  $0.223 \pm 0.654\text{mSv/y}$ . This was far lower than the world standard value of  $0.48\text{mSv/y}$  (Agbalagba et al, 2016). The excess life cancer risk measured ranges from  $1.02 \times 10^{-3}$  to  $8.58 \times 10^{-3}$  with a mean value of  $0.570 \times 10^{-3}$ . To

$1.327 \times 10^{-3}$ . This is higher when compared to the world standard value of  $2.9 \times 10^{-4}$ . (UNCEAR, 2000)

We can clearly say that there's a probability of this accumulated dose resulting into cancer for long-term exposure especially in Abi and Etung market. This suggests further studies to be carried out on soil, water from the area.

The calculated excess life cancer risk (ELCR) values for some markets like Etung and Boki are higher than the world safe limit value of  $2.9 \times 10^{-4}$  (Aziz et al, 2014). Therefore, it can be said that there is a radiological risk, which may not lead to any immediate problem, but should be checked for long term exposure.

The study in Table 6 indicates that there was high correlation between AEDE and absorbed dose rate (ADR), ELCR and ADR, annual effective dose equivalent (AEDE) and excess life cancer risk (ELCR) in the central senatorial district of Cross River State. This indicates that from the regression equations, with the measurement of dose rate, one can predict the absorbed dose rate, annual effective dose equivalent and excess life cancer risk. Also with absorbed dose rate and annual effective dose equivalent, one can also predict excess life cancer risk in the area.

## CONCLUSION

The background ionizing radiation of the six major markets in central senatorial district of Cross River State Nigeria, have been measured, the dose level are relatively low both in the market and outside the market, this further informs us that sellers, buyers and nearby occupants are safe, and are within the internationally accepted safe limit for members of the public. Also we noticed from our measurement carried out that the calculated values of the excess lifetime cancer risk was higher in some markets than the safe internationally accepted value, this may not lead to immediate health problem but has to be checked for long term exposure.

## ETHICS

The article is original and has not been previously published. All the authors read and approved the manuscript without ethical issues.

## REFERENCES

- Agbalagba, O. E., 2017. Assessment of excess lifetime cancer risk from gamma radiation levels in Effurun and Warri city of Delta state, Nigeria. *Journal of Taibah University for Science*, 11, 367–380.
- Afrin Sultana, M.M., Mahfuz Siraz, Shikah Pervin, A.F.M. Mizahur Rahman, Suranajah Kumar Das and Selina Yeasmin, 2019. Assessment of radioactivity and radiological hazard of different food items collected in local market of Bangladesh, *J. Bangladesh Acad. Sci.*, Vol. 43, No. 2, 141-148
- Avwiri, G. O., Enyinna, P. I. and Agbalagba, E. O., 2007. Terrestrial radiation around oil and gas facilities in Ughelli Nigeria, *Journal of Applied Sciences*, 7(11):1543-1546.
- Bamidele S. I., Jibiri N. N., Najam, L. A, and Isinkaye, M.O., 2013. Evaluation of radiological hazard due to natural radioactivity in bitumino soil from tar-and belt of South West, Nigeria. *International Journal of Radiation Research*, 3(16), 257-267.
- Emelue, H.U., 2014. Excess life cancer risk due to gamma radiation in and around Wazazarri refining and petrochemical company, in Niger Delta, Nigeria. *British journal of medicine and medical research*, 4(13), 90-98.
- Enyinna P. and Onwuka M. N., 2014. Investigation of radiation exposure rate and noise levels within crush rock quarry site in Ishiagu, Ebonyi State, Nigeria. *International of Advance Research in Physical Science*, 6(1), 56-62.
- Isaac E. O., Essen I. M., Essien U. E., Okonna N.N. and Sampson I.A., 2019, Gamma Radiation dose rate levels and annual effective dose assessment in major market in Benin City, Nigeria. *International Journal of Advanced Academic Research*, ISSN: 2488-9849 Vol. 8, Issue 9.
- Igomah, G. O., Osahon, O, Eze, B. E., Ekong, I. B. and Azogor, W. E., 2024. Assessment of background gamma radiation levels across major markets in southern senatoria district of Cross River State, Nigeria. *Asian journal of physical and chemical sciences*. ISSN: 2456-7779, Vol XXX, issue XX
- Jibiri, N, Farai, I. P. and Alausa, S. k., 2007. estimation of annual effective dose due to natural radioactive elements in ingestion of food stuffs in tin mining area of Jos-Plateau, Nigeria, *Journal of Environmental Radioactivity*, 94(1), 31-40.
- Mangest, W. E., Sauri, K.A., Martins P.O. and Chenko, G.Y.N., 2022. An In-situ measurement of gamma radiation dose level of scrap metal markets in Jos Metropolis, Plateau State, Nigeria, *Journal of Applied Physical Science International* 14(2): 33-37.
- Mojisola R. Usikalu, Ruth O. Morakinyo, Muiyiwa M. Orosun, and Justina A. Achuka, 2023. Assessment of Background Radiation in Ojota Chemical Market, Lagos, Nigeria *Journal of Hazardous, Toxic, and Radioactive Waste*, 27(1), 45- 62
- Ononugbo, C. P., Avwiri, G.O., and Tutumeni, G., 2016. Measurement of natural radioactivity and evaluation radiation hazard in soil of Abua/ Odual District using multivariate statistical approach. *British Journal of environmental Science*, 4(1), 35-48.
- Qureshi, A.A., Shahina, T., Kamai, U.D., Shahid, M., Chiara C., and Abdul W., 2014. Evaluation excess lifetime cancer risk due to natural radioactivity in river sediments in Northern Pakistan. *Journal of radiation research and applied science*, 7(4), 438-447.

Rukia Jabar Dosh, Suha Hadi Kadhim, Ali Abid Abojassim, and Fares Abed Yasseen Hussein, 2024. Natural radioactivity foodstuff consumed in Iraq, Journal of Radiation Research and Applied Sciences (JRRAS), 17(1), 1023-1031.	United Nation Scientific Committee on the Effect of Atomic Radiation, 2008. Effect of Atomic Radiation sources to the General Assembly with annexes, report to the General Assembly, with Scientific annexes, New York, United Nation Publication.
---	--