ASSESSMENT OF BACKGROUND GAMMA RADIATION LEVELS ACROSS MAJOR MARKETS IN SOUTHERN SENATORIA DISTRICT OF CROSS RIVER STATE, NIGERIA

ABSTRACT

Human exposure to ionizing radiation from natural and artificial sources is unpreventable phenomenon on earth. Radiation profile and dose at for some markets in Cross River State, Nigeria have been ascertained using 451p ion chamber survey meter and the following indices of radiation absorb dose, annual effective dose equivalent, and excess life cancer risk, were calculated. the dose rate measures at the seven market are as follows; Biase 0.02μsv/h to 0.09μsv/h, Akamkpa 0.02μsv/h to 0.09μsv/h, Odukpani 0.02μsv/h to 0.09μsv/h marian market 0.06μsv/h to 0.19μsv/h, Calabar South, 0.05 μsv/h to 0.30 μsv/h, Akpabuyo 0.02 μsv/h to 0.19 μsv/h, Bakassi 0.02 μsv/h to 0.16 μsv/h. The mean value for dose is mean 0.047 $\pm$ 0.018 for Biase, 0.043 $\pm$ 0.018 for Akamkpa, 0.043 $\pm$ 0.017 for Odukpani, 0.110 $\pm$ 0.036 for Marian, 0.106 $\pm$ 0.059 μsv/h for Calabar South, 0.104 $\pm$ 0.056 μsv/h for Akpabuyo and 0.053 $\pm$ 0.031 μsv/h for Bakassi. Mean values of 0.073 $\pm$ 0.026msvy^{-1}, 0.067 $\pm$ 0.029msv/y, 0.095 $\pm$ 0.08msv/y, 0.158 $\pm$ 0.072msv/y, 0.134 $\pm$ 0.114msv/y, 0.159 $\pm$ 0.084msv/y and 0.223 $\pm$ 0.654 for AEDE were observed respectively for within the markets. Similarly, 0.259 $\pm$ 0.092 x 10^{-3}, 0.235 $\pm$ 0.095 x 10^{-3}, 0.338 $\pm$ 0.265 x 10^{-3}, 0.552 $\pm$ 0.252 x 10^{-3}, 0.470 $\pm$ 0.397 x 10^{-3}, 0.558 $\pm$ 0.29 x 10^{-3}, and 0.265 $\pm$ 0.097 x 10^{-3} were recorded for ELCR, with the marketer the AEDE values are with the permissible limit as recommended by the international bodies, the ELCR values are also within permissible limit. The implication of the AEDE & ELCR values is that the markets sides is radiation safe for any radiological health burdens that might arise due to absorb dose from BIR, but the probability of are developing cancer over a life time exposure in market places is high. It's recommended that periodic BIR monitory and evaluation and radioactive concentration of nuclides in soil and rocks of the area be carried out by local authority.

Keyword: Background ionizing radiation, radiation dose rate, market environmental, excess lifetime cancer risk (ELCR)

INTRODUCTION

The levels of monitoring radiation in human-inhabited environments is imperative to avoid public exposure (Mojisola et al, 2023, AFRIN SULTANA et al, 2019). Everywhere in the world, man generally is exposed to background ionizing radiation and this radiation can come from different sources. Natural radioactivity from our environment has three components, cosmic rays' terrestrial radiation from the earth's crest (soil, rocks). Radiation may also be man-made, especially in medical imaging and radiotherapy, security screening equipment, and smoke detectors. The market environment is not left out. The natural sources of radiation are mainly due to cosmic rays and naturally occurring long-lived radioactive nuclides that originated from the earth's crust and are present everywhere in the environment including the human body itself (UNSCEAR, 2008). It is a fact that naturally occurring radionuclides contribute significantly to the exposure of humansto background ionizing radiation (Bamidele, 2013; Jibiri, 2003, Ibrahim *et al*., 2014). Among these radionuclides are the radioactiveisotope of potassium 40K and the radionuclides that originate from the decay of 238U and 3Th series, both widely spread in soil and rocks of the earth's crust (Ibrahim *et al*., 2014). Radiation from these radionuclides mainly depends on geological and geophysical conditions of the environment and it is higher in igneous and lower in sedimentary rocks except for shale and phosphate rocks which in some cases may have a high content of radionuclides (Enyinna and Onmuka, 2014).

It has been estimated that the global average dose of background ionizing radiation received by humans is about 0.274μsv/hr, of which 80% comes from nature while the remaining 20% results from exposure to man-made radiation sources (UNSCEAR, 2008). It is not safe to stay permanently in an environment whose annual effective outdoor dose rate is more than 1 $mSvyr^{-1}$ as this can lead to health hazard (E. O. Isaac et al, 2022, W. E. MANGSET et al, 2022).

A variety of factors, including background radiation levels, climate, and farming techniques, have been linked to changes in natural radionuclide levels observed in food items. People's internal radiation exposure is known to be mostly caused by these radionuclides. When it comes to radiation protection, the naturally occurring radionuclides in the decay series of ^{238}U, ^{232}Th, and ^{40}K are of great concerns (Rukia et al, 2024).

The assessment of the radiation level and its impact on the environment has received great attention worldwide. This is because of the negative health effect ionizing radiation has on biological tissues, when highly energetic ionizing radiation interacts with biological tissues, it causes ionization with subsequent release of charged particles and free radicals thereby causing alteration in cell structure and damage to deoxyribonucleic acid (DNA).Damage to DNA results in gene mutation, chromosomal aberration, and breakages or cell death (Emelue *et al*., 2014). Some of the health effects of long-term exposure to radiation and the inhalation/ingestion of radionuclides and chronic lung disease, acute leucopenia, anemia necrosis of the mouth, cataracts, chronic lung cancer, and leukemia (Qureshi *et al*., 2014; and Ononugbo *et al*., 2016). Cancer will remain one major harmful effect produced by ionizing radiation.

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 $5^0$45'N, and $8^0$30'E Cross River comprises three senatorial districts, the Northern Cross River Central and the South senatorial district. Observations were made in the Southern senatorial district that comprises seven (7) local governments.

Field Measurement

An 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, x-ray particles with a high sensitivity μsv/hr measurement of rate and dose simultaneously from various radiation sources. Readings were taken within the hours of 11 am and 4 pm hours. The survey meter was used to measure the dose rate of gamma radiation in micro sievert per hour within the seven markets and a total of 20 sampling points were taken from 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

Radiological parameters

Absorbed dose rate (ADR)

The data obtained for the external dose rate in μsv/h^{-1} were converted into the absorb dose rate in nGyh^{-1} using the conversion factor

$$1\mu svh^{-1} = 1000nGyh^{-1} \quad - \quad - \quad - \quad - \quad - \quad (1)$$

Annual effective dose equivalent (AEDE)

The computed absorbed dose rate was used to calculate the annual effective dose equivalent (AEDE) received by the market users and in calculating AEDE, the dose conversion factor of 0.75sv/Gry and the occupancy factor for outdoor of 0.25 (i.e. 6th out of 24h) was used and the occupancy factor for outdoor was calculated upon an interview with market users.

The annual effective dose equivalent was estimated using the following relation

AEDE (Outdoor) ($mSvy^{-1}$) = ADR ($nGyh^{-1}$) x 8760h x $\frac{0.7sv}{Gy}$ x 0.25

Excess life cancer risk (ELCR)

The annual effective dose calculated was used to estimate the excess life cancer risk (ELCR) using the equation is

ELCR = AEDE x Average duration of life x Risk facto RF - - - (3)

Where AEDE, DL, and RF are the annual effective dose equivalent, duration of life (70 years) and risk factor (sv^{-1}) fatal cancer risk per sievert. For low-dose background radiation which is considered to produce stochastic effect, ICRP to uses values of 0.05 for the public exposure.

RESULTS

The in-situ measurement of radiation dose rating of seven major markets in Cross River South Nigeria are presented in Table 1 to 7.

Table 1: Radiation dose rate measured in Akpabuyo market

Location	Dose rate μSvh^{-1}	Absorbed dose Rate ($nGyh^{-1}$)	AEDE ($msvy^{-1}$)	ELCR X 10^{-3}
N_1	0.17	170	0.26	0.91
N_2	0.13	130	0.20	0.70
N_3	0.11	110	0.17	0.59
N_4	0.10	100	0.15	0.53
N_5	0.07	70	0.11	0.39
N_6	0.16	160	0.25	0.88
N_7	0.19	190	0.29	1.02
N_8	0.14	140	0.21	0.74
N_9	0.15	150	0.23	0.81

N_{10}	0.19	190	0.29	1.02
N_{11}	0.11	110	0.17	0.59
N_{12}	0.12	120	0.18	0.63
N_{13}	0.14	140	0.21	0.71
N_{14}	0.03	30	0.05	0.18
N_{15}	0.07	70	0.11	0.39
N_{16}	0.04	40	0.06	0.21
N_{17}	0.03	30	0.05	0.18
N_{18}	0.07	70	0.11	0.39
N_{19}	0.02	20	0.03	0.11
N_{20}	0.03	30	0.05	0.18
Mean±SD	**0.10±0.06**	**103±55.7**	**0.16±0.08**	**0.56±0.29**

Table 2: Radiation dose rate measured at around Akamkpa

Location	**Dose rate μSvh^{-1}**	**Absorbed dose Rate ($nGyh^{-1}$)**	**AEDE ($msvy^{-1}$)**	**ELCR X 10^{-3}**
D_1	0.05	50	0.08	0.28
D_2	0.04	40	0.06	0.21
D_3	0.02	20	0.03	0.11
D_4	0.09	90	0.14	0.49
D_5	0.04	40	0.06	0.21
D_6	0.04	40	0.06	0.21
D_7	0.03	30	0.05	0.18
D_8	0.05	50	0.08	0.28
D_9	0.03	30	0.05	0.18
D_{10}	0.03	30	0.05	0.18
D_{11}	0.03	30	0.05	0.18
D_{12}	0.07	70	0.11	0.34
D_{13}	0.05	50	0.08	0.28
D_{14}	0.04	40	0.06	0.21
D_{15}	0.02	20	0.03	0.11
D_{16}	0.05	50	0.08	0.28
D_{17}	0.07	70	0.11	0.39
D_{18}	0.05	50	0.08	0.28
D_{19}	0.02	20	0.03	0.11
D_{20}	0.03	30	0.05	0.18
Mean±SD	**0.04±0.02**	**42.5±18.3**	**0.07±0.03**	**0.24±0.09**

Table 3: Radiation dose rate measured at around Calabar South Market

Location	Dose rate μSvh^{-1}	Absorbed dose Rate ($nGyh^{-1}$)	AEDE ($msvy^{-1}$)	ELCR $X\ 10^{-3}$
G_1	0.07	70	0.11	0.39
G_2	0.12	120	0.18	0.63
G_3	0.05	50	0.08	0.28
G_4	0.08	80	0.01	0.04
G_5	0.08	80	0.01	0.04
G_6	0.08	80	0.01	0.04
G_7	0.10	100	0.15	0.53
G_8	0.09	90	0.14	0.49
G_9	0.10	100	0.15	0.51
G_{10}	0.06	60	0.09	0.32
G_{11}	0.15	150	0.23	0.81
G_{12}	0.13	130	0.20	0.70
G_{13}	0.21	210	0.32	1.12
G_{14}	0.08	80	0.01	0.04
G_{15}	0.08	80	0.01	0.04
G_{16}	0.06	60	0.09	0.32
G_{17}	0.30	300	0.46	1.61
G_{18}	0.07	70	0.11	0.39
G_{19}	0.13	130	0.20	0.70
G_{20}	0.07	70	0.11	0.39
Mean±SD	**0.11±0.06**	**105±59.2**	**0.13±0.11**	**0.47±0.39**

Table 4: Radiation dose rate measured at around Calabar (Marian Market)

Location	Dose rate μSvh^{-1}	Absorbed dose Rate ($nGyh^{-1}$)	AEDE ($msvy^{-1}$)	ELCR $X\ 10^{-3}$
Z_1	0.09	90	0.14	0.49
Z_2	0.19	190	0.29	1.02
Z_3	0.14	140	0.21	0.74
Z_4	0.14	140	0.21	0.71
Z_5	0.07	70	0.11	0.39
Z_6	0.06	60	0.10	0.35
Z_7	0.11	110	0.17	0.59
Z_8	0.17	170	0.26	0.91
Z_9	0.08	80	0.01	0.04
Z_{10}	0.10	100	0.15	0.53
Z_{11}	0.07	70	0.11	0.39
Z_{12}	0.15	150	0.23	0.81
Z_{13}	0.10	100	0.15	0.53
Z_{14}	0.08	80	0.01	0.04
Z_{15}	0.12	120	0.18	0.63
Z_{16}	0.15	150	0.23	0.81
Z_{17}	0.07	70	0.11	0.39
Z_{18}	0.11	110	0.17	0.59
Z_{19}	0.09	90	0.14	0.49
Z_{20}	0.11	110	0.17	0.59
Mean±SD	**0.11±0.04**	**110±36.4**	**0.16±0.07**	**0.55±0.25**

Table 5: Radiation dose rate measured at around Bakassi Market

Location	**Dose rate μSvh^{-1}**	**Absorbed dose Rate ($nGyh^{-1}$)**	**AEDE ($msvy^{-1}$)**	**ELCR X 10^{-3}**
J_1	0.16	50	0.08	0.28
J_2	0.03	30	0.05	0.18
J_3	0.07	70	0.11	0.39
J_4	0.06	60	0.09	0.32
J_5	0.02	20	0.03	0.11
J_6	0.05	50	0.08	0.28
J_7	0.04	40	0.06	0.21
J_8	0.03	30	0.05	0.18
J_9	0.07	70	0.11	0.39
J_{10}	0.05	50	0.08	0.28
J_{11}	0.02	20	0,03	0.11
J_{12}	0.03	30	0.05	0.18
J_{13}	0.07	70	0.11	0.39
J_{14}	0.03	30	0.05	0.18
J_{15}	0.06	60	0.09	0.32
J_{16}	0.07	70	0.11	0.39
J_{17}	0.06	60	0.09	0.32
J_{18}	0.04	40	0.06	0.21
J_{19}	0.03	30	0.05	0.18
J_{20}	0.07	70	0.11	0.39
Mean±SD	**0.05±0.03**	**47.5±18.0**	**0.22±0.65**	**0.27±0.09**

Table 6: Radiation dose rate measured at around Odukpani Market

Location	**Dose rate μSvh^{-1}**	**Absorbed dose Rate ($nGyh^{-1}$)**	**AEDE ($msvy^{-1}$)**	**ELCR $X\ 10^{-3}$**
A_1	0.05	50	0.08	0.28
A_2	0.05	50	0.08	0.28
A_3	0.03	30	0.05	0.19
A_4	0.03	30	0.05	0.19
A_5	0.04	40	0.06	0.21
A_6	0.03	30	0.05	0.19
A_7	0.04	40	0.06	0.21
A_8	0.06	60	0.09	0.32
A_9	0.02	20	0.31	1.08
A_{10}	0.04	40	0.06	0.21
A_{11}	0.05	50	0.08	0.28
A_{12}	0.05	50	0.08	0.28
A_{13}	0.02	20	0.31	1.08
A_{14}	0.03	30	0.05	0.19
A_{15}	0.08	80	0.12	0.42
A_{16}	0.03	30	0.05	0.19
A_{17}	0.03	30	0.05	0.19
A_{18}	0.07	70	0.11	0.39
A_{19}	0.07	70	0.11	0.39
A_{20}	0.03	30	0.05	0.19
Mean±SD	**0.04±0.02**	**42.5±18.3**	**0.09±0.08**	**0.34±0.27**

Table 7: Radiation dose rate measured at around Biase

Location	Dose rate μSvh^{-1}	Absorbed dose Rate ($nGyh^{-1}$)	AEDE ($msvy^{-1}$)	ELCR $X\ 10^{-3}$
M_1	0.05	50	0.08	0.28
M_2	0.06	60	0.09	0.32
M_3	0.04	40	0.06	0.21
M_4	0.06	60	0.09	0.32
M_5	0.02	20	0.03	0.11
M_6	0.03	30	0.05	0.18
M_7	0.06	60	0.09	0.32
M_8	0.04	40	0.06	0.21
M_9	0.03	30	0.05	0.18
M_{10}	0.03	30	0.05	0.18
M_{11}	0.03	30	0.05	0.18
M_{12}	0.06	60	0.09	0.32
M_{13}	0.04	40	0.06	0.21
M_{14}	0.06	60	0.09	0.32
M_{15}	0.09	90	0.14	0.49
M_{16}	0.03	30	0.05	0.18
M_{17}	0.07	70	0.11	0.39
M_{18}	0.03	30	0.05	0.18
M_{19}	0.05	50	0.08	0.28
M_{20}	0.06	60	0.09	0.32
Mean±SD	**0.05±0.02**	**47.0±17.8**	**0.07±0.03**	**0.26±0.09**

DISCUSSION

Assessment of radiation profile and dose rate from some major markets in southern senatorial district of Cross River State, Nigeria has been carried out using a well-calibrated ionization chant survey meter. The mean dose rate measured across the seven markets ranges from $0.043 \pm 0.017\mu$sv/h in the Odukpani market to $0.110 \pm 0.036\ \mu$sv/h in Marian market, Calabar Municipal.

Assessment of radiation profile and dose rate for the seven major market across the seven southern senatorial districts of Cross River State, have been carried out using a well calibrated ionization chamber survey meter. The dose rate measured ranges from 0.02 μsv/h to 0.30 μsv/h with the mean value of $0.043 \pm 0.017\ \mu$sv/h to $0.110 \pm 0.036\ \mu$sv/h which is lower than the world standard value of 1msv/hr for members of the public (ICRP, 1991). The location that recorded the highest dose rate, absorb dose, annual effective dose and excess life cancer risk is Marian market in Calabar Municipal local government area. This is due to increase in human and economics activities within the area.

The absorbed dose measured ranges from 70nGy/hr to 3000nGy/hr with mean value of 42.500 ± 17.130nGy/hr to 110.000 ± 36.419nGy/hr. The location with the highest recorded value of absorbed dose is also Marian market in Calabar Municipal Local Government Area and the high values can be attributed to the radon gases trapped by buildings and building materials in the market.

The annual effective dose (AEDE) measured ranges from 0.14msv/y to 0.30msv/y with mean value of 0.067 ± 0.029msv/y to 0.223 ± 0.654msv/y. This is lower than the world standard value of 0.48msv/y. The excess lifetime causes ELCR measured ranged from 0.39×10^{-3} to. 1.61×10^{-3} with mean value of 0.259×10^{-3} to 0.558×10^{-3} which is higher when compared with the world standard value of 0.29×10^{-3}.

The excess lifetime cancer risk estimated from the annual effective dose in some markets like Odukpani market, Marian market, Calabar South market and Akpabuyo market exceeded the world weighted average of 0.29×10^{-3}. We can say that there is a probability of developing cancer for long term exposure to radiation in this area. This suggest further studies to be carried out on soil, water and crops from the study area.

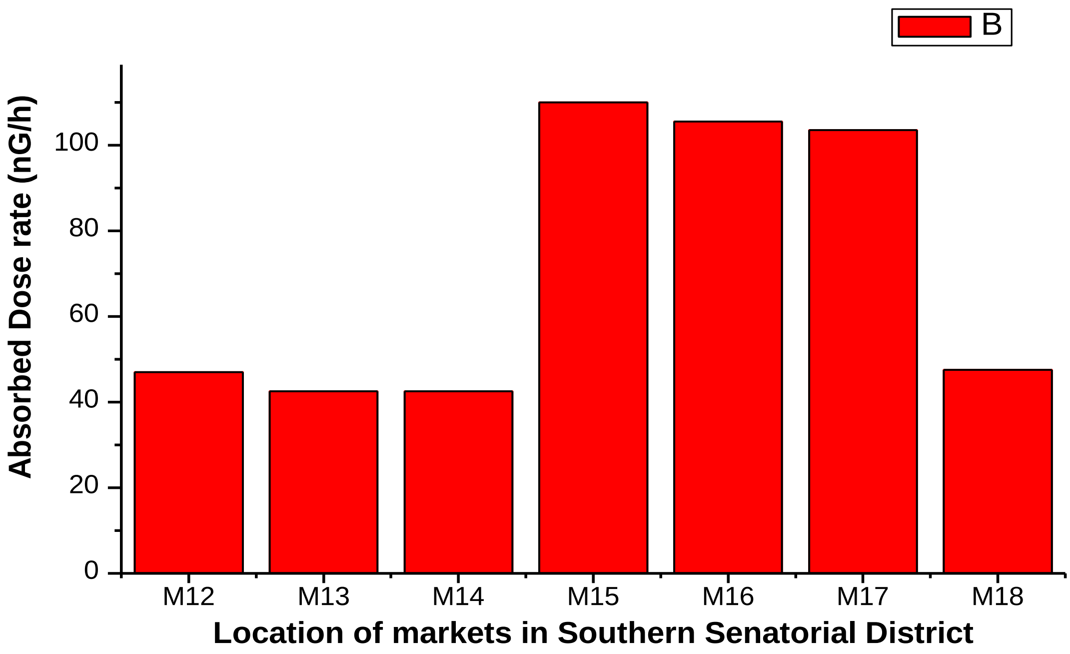


Fig1: Bar chart showing the average exposure in Southern Senatorial District

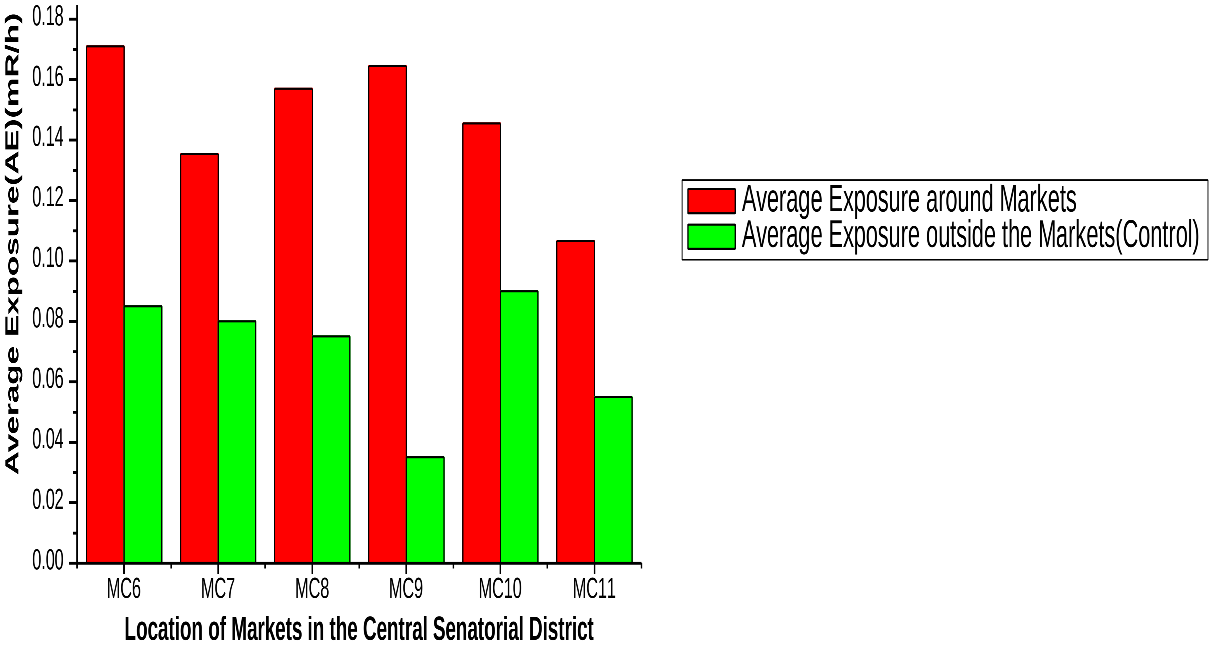


Fig2: Bar chart showing the dose rate of background gamma radiation in and outside the market in Southern Senatorial District of Cross River State.

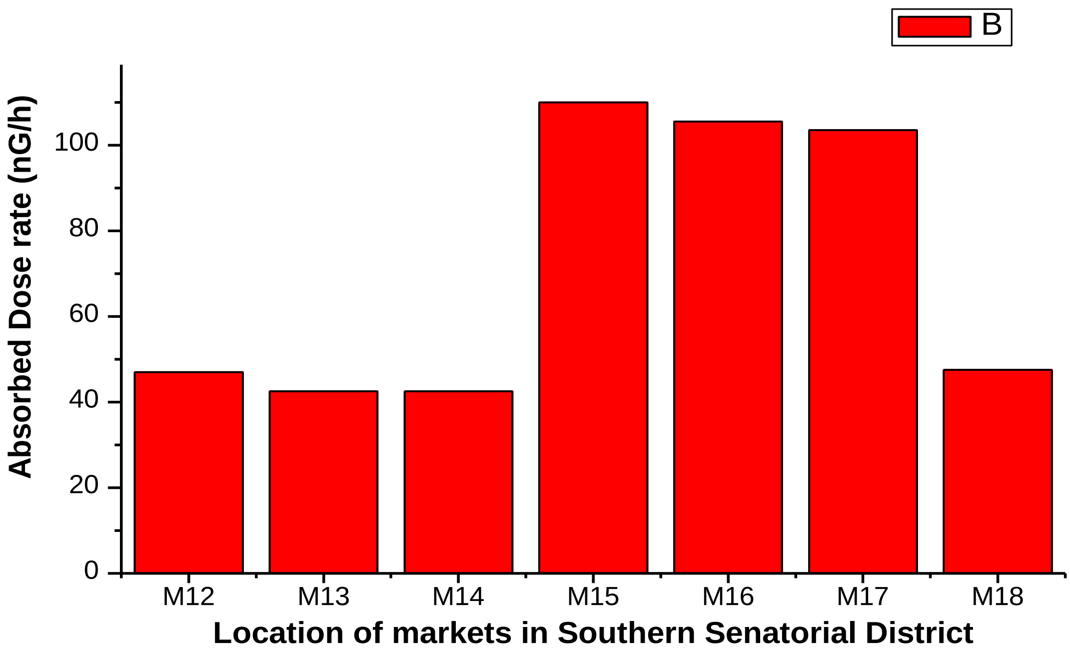


Fig3: Bar chart showing the absorbed dose rate of background gamma radiation in the Southern Senatorial District

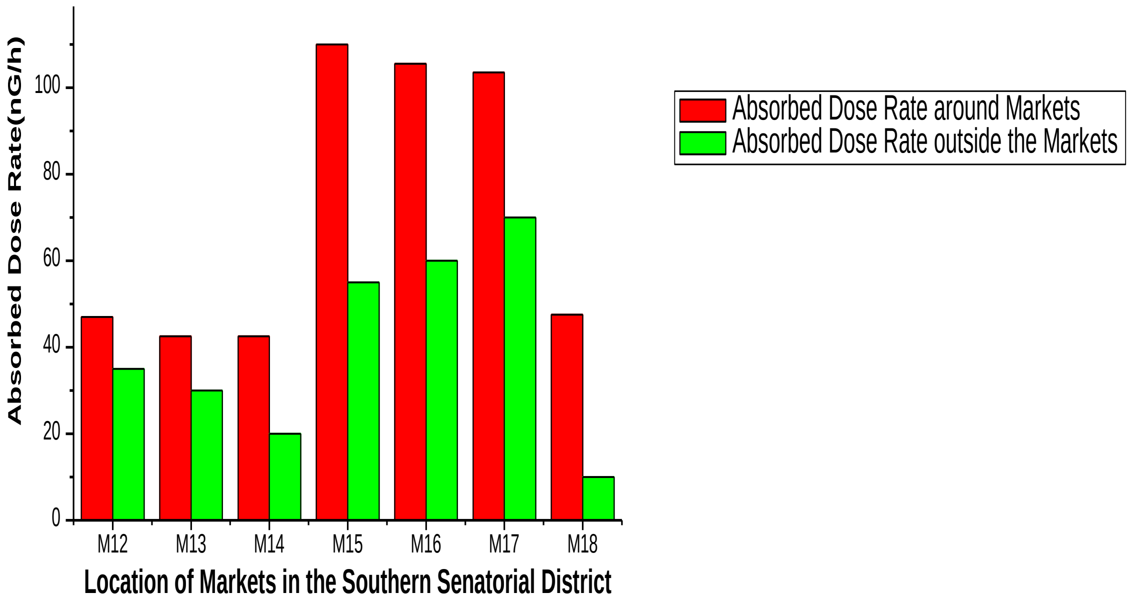


Fig4: Bar chart showing absorbed dose rate of background gamma radiation in and outside the markets in the Southern Senatorial District

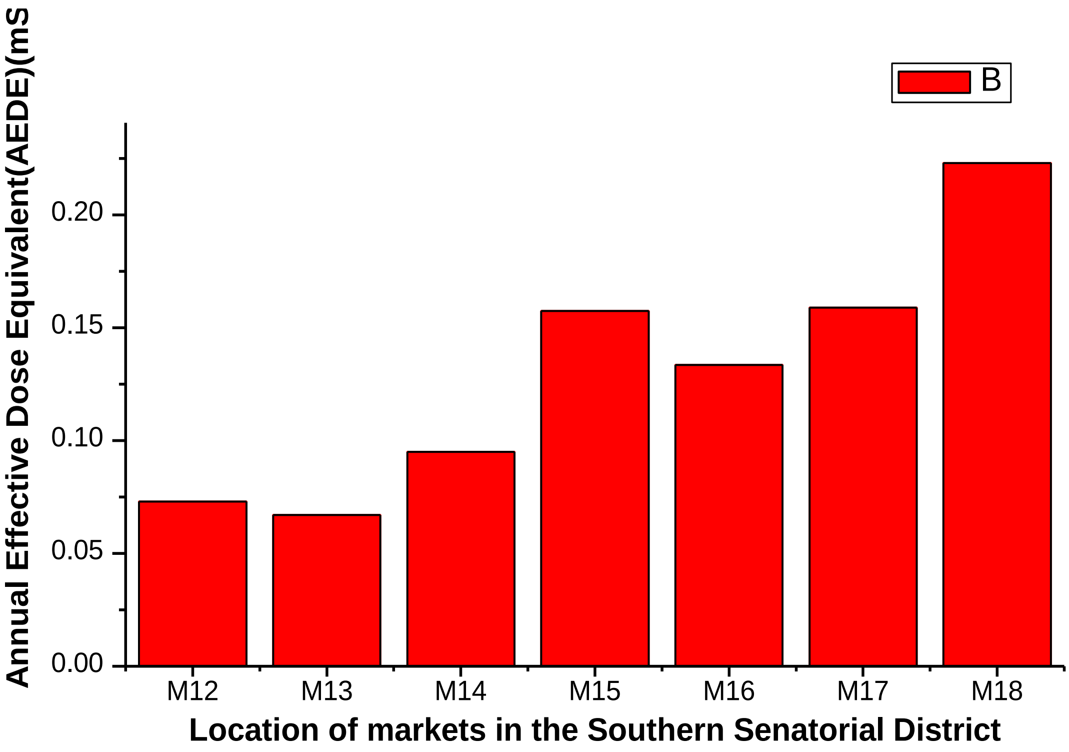


Fig5: Bar chart showing the Annual effective dose equivalent(AEDE) of gamma radiation in the Southern Senatorial District

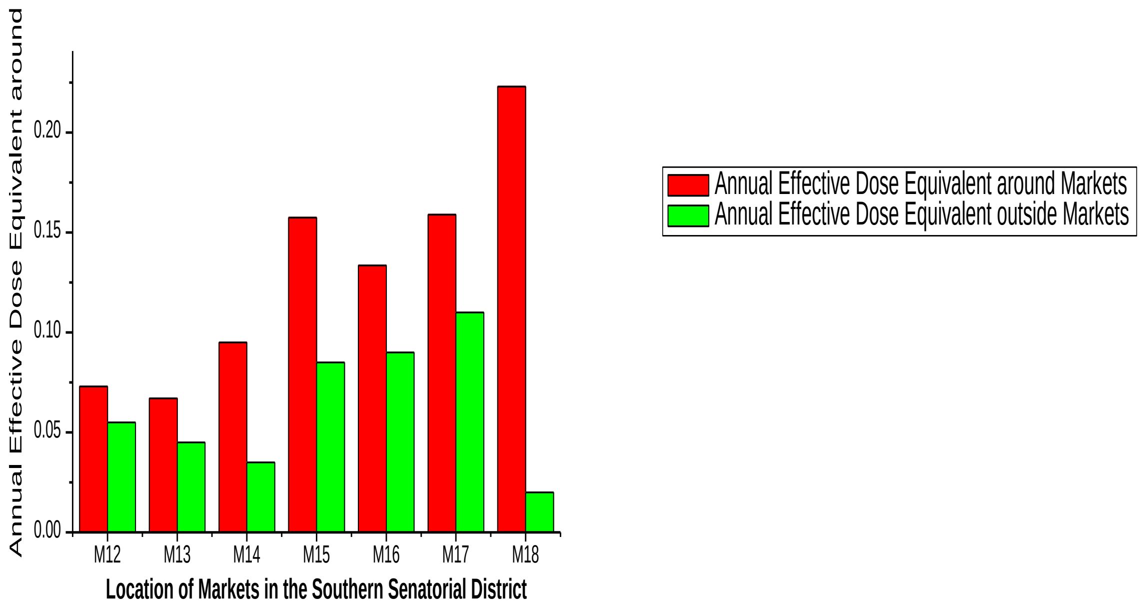
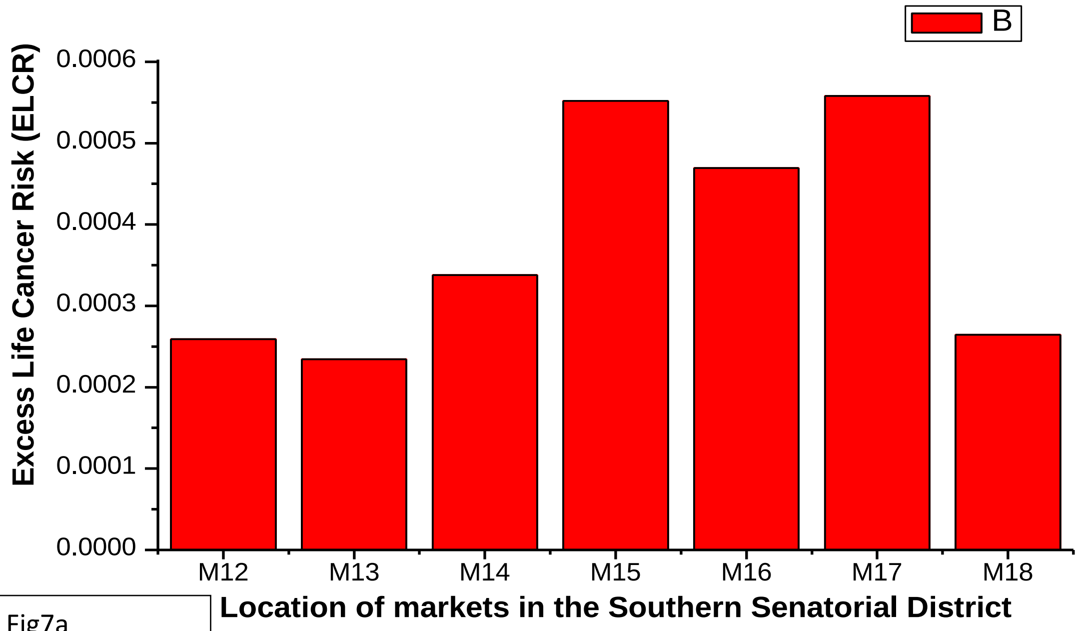


Fig6: Bar chart showing annual effective dose equivalent of gamma radiation within and outside the markets in the Southern Senatorial District


B
Excess Life Cancer Risk (ELCR)
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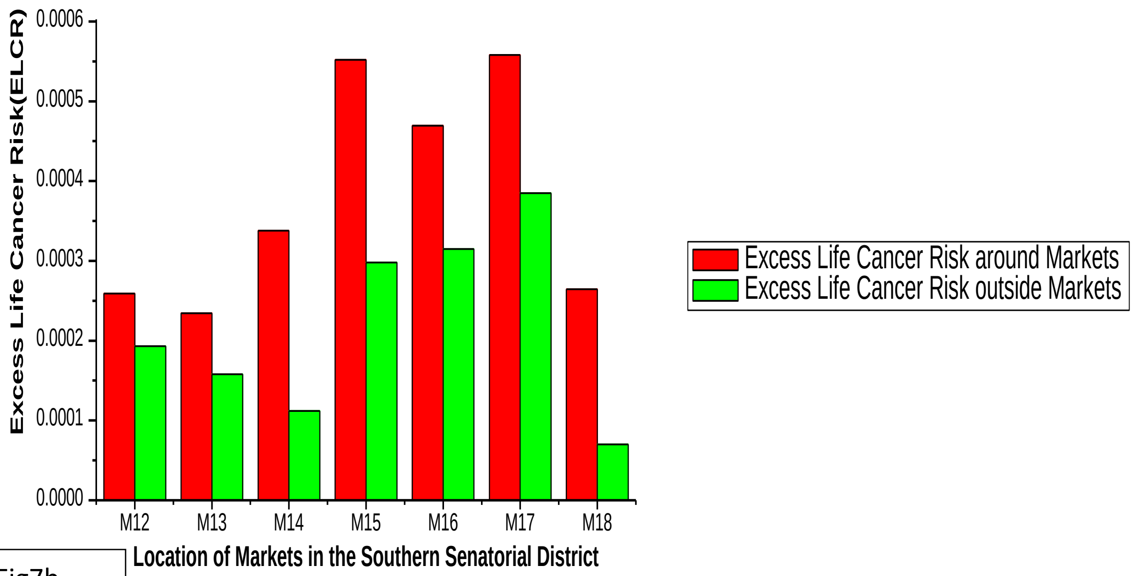
Location of markets in the Southern Senatorial District

Fig7a


Excess Life Cancer Risk(ELCR)
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Location of Markets in the Southern Senatorial District
Excess Life Cancer Risk around Markets
Excess Life Cancer Risk outside Markets

Fig7b

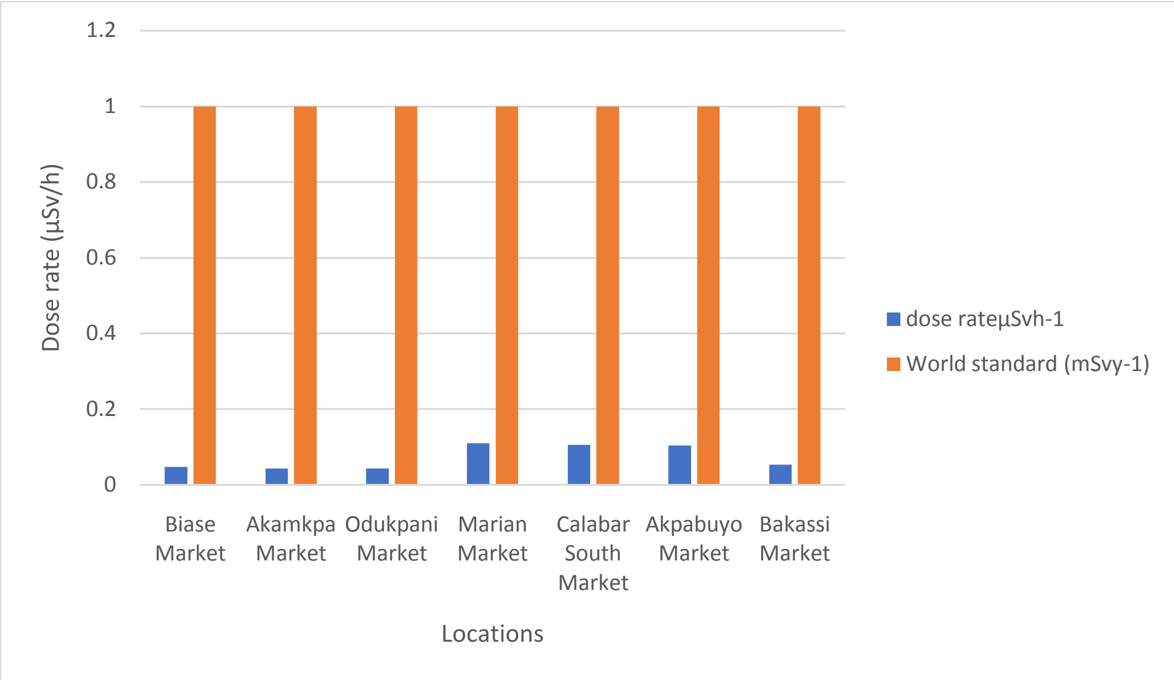

Fig8: COMPARISM OF DOSE RATE WITH WORLD AVERAGE.

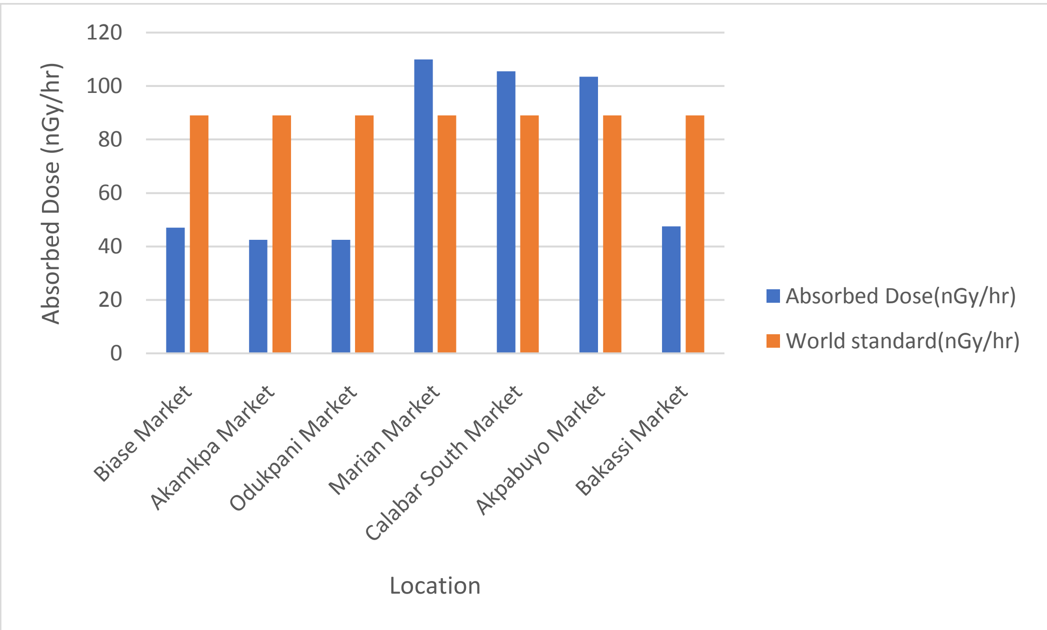

Fig9:COMPARISM OF ABSORBED DOSE WITH WORLD AVERAGE STANDARD.

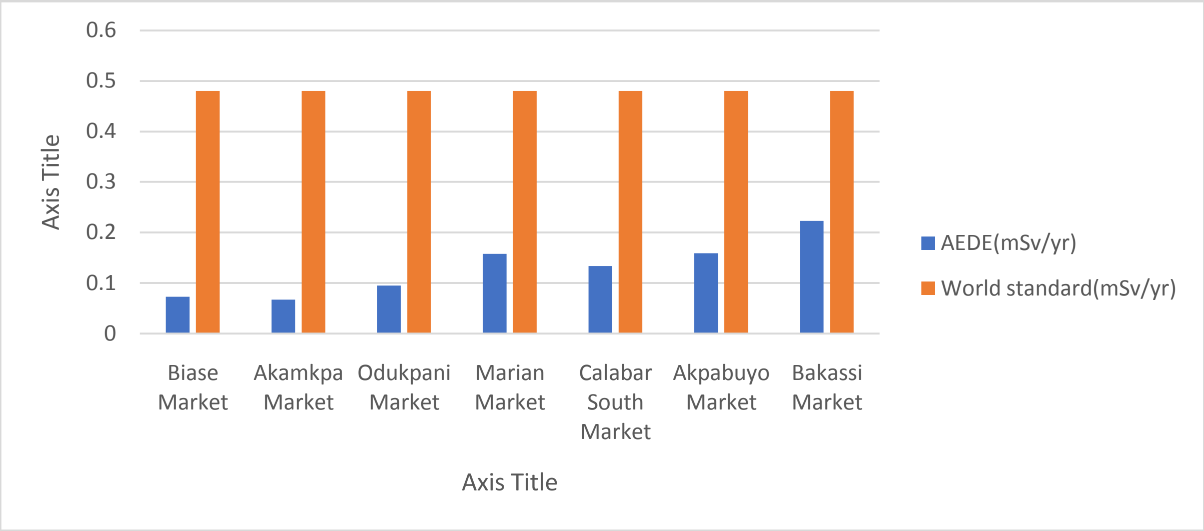

Fig 10: COMPARISM OF AEDE WITH WORLD STANDARD

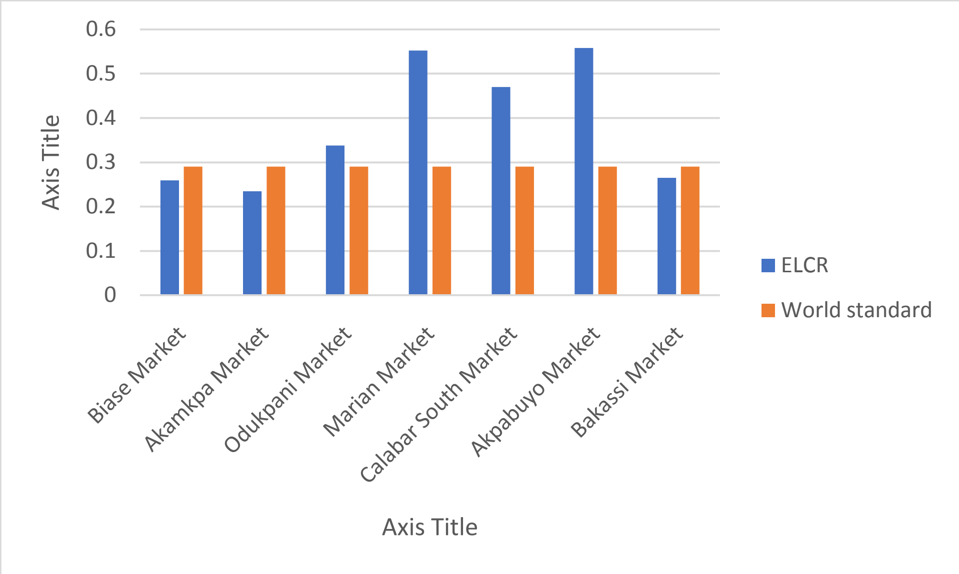

Fig11: COMPARISON OF ELCR WITH WORLD AVERAGE

CONCLUSION

The natural background radiation of seven major markets in the Southern Senatorial District of Cross River State have been measured, the radiation profile of the markets are relatively low both in the market and outside the markets, though the values obtained from the markets environments are all higher than those obtained outside the market. Therefore, sellers and buyers in these markets are within the internationally accepted safe limit for members of the public. The excess lifetime cancer risk which was higher in some markets than the safe values may not lead to immediate health problem but has to be checked for long term exposure.

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