

Determination of Exposure Rate to Ionizing Radiation and Excess Lifetime Cancer Risk in Kano Abattoir, Kano State, Nigeria.

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Abstract-- Exposure to ionizing radiation is part and parcel of the environment. This study aimed at the determination of exposure to ionizing radiation level and excess lifetime cancer risk within kano central Abattoir situate in Fagge L.G.A area of Kano state, Nigeria. The study area was divided into Four areas, and a well calibrated Digilert 200 radiation survey metre and a Geographical Positioning Device (GPS) were used. The study found that, the mean exposure rate in the zones were (0.154, 0.170, 0.200, 0.208 and 0.226) mR/h. The calculated absorbed dose rates and annual effective doses were lower than the world acceptable values. The mean values of the Excess Lifetime Cancer Risk (ELCR) were (0.633, 0.698, 0.821, 0.855 and 0.929) $\times 10^{-3}$. These values are above the ICPR standard value of 0.29×10^{-3} . The study concluded that the study area has been radiologically contaminated, but may have no immediate radiological health consequences to the populace, but long-term health risks, such as cancer, are a possibility in the future due to accumulated doses.

Keywords-- background, radiation, dose, cancer, risk.

I. INTRODUCTION

Abattoir is a facility or premises for the hygienic slaughtering, roasting and inspection of animals, and processing for human consumption. It is one of the highly active areas for slaughtering rams, cows, camels, goats and other animals. The abattoir has several furnaces for roasting locally made from firewood and metal wires. The major source of fuel used in the furnace includes firewood and charcoal.

All living species have been and continue to be exposed to radiation from the beginning of time (UNSCEAR, 2000; 2008). Radiation has been with us since the birth of the universe. As a result, humans are constantly exposed to radiation from both natural and man-made sources (IAEA, 2007). Human activities and practices can potentially affect the degree of radiation exposure in the

environment (Karahan and Bayulken, 2000). Activities such as industrialization, application of fertilizers on farmlands, oil exploration, and mining activities have been reported to influence a higher degree of radionuclides in an environment (NRC, 1999; Ajayi and Dike, 2016; Abiola et al., 2021).

Thus, activities at the abattoir will strongly influence the degree of radiation in the area and, therefore, increase the indoor and outdoor radiation exposure levels, contributing significantly to irradiated doses through inhalation and direct contact. The study on radiation levels in the different environment components helps assess the public dose rates due to radiation exposure (Ghazwa et al., 2016). Despite various disputes over the stochastic effect of low radiation exposure, subsequent investigations have demonstrated that low radiation exposure, regardless of dose, can cause DNA damage (Usikalu et al., 2016; Kawamura et al., 2018; Ali et al., 2020).

Background radiation is part of the natural environment and as such humans and other living organisms are continuously exposed. The main source of radiation includes cosmic rays that enter the earth from outer space and the naturally occurring radioactive elements of the uranium and thorium series and non – series radioactive potassium (Benson and Ugbede, 2018) which are characterized with half-lives comparable to the age of the earth and are present everywhere in the environment; in rocks, soil, water, sediments, foods and including the human body itself (UNSCEAR, 2008). The concentration and gamma radiation from the radioactive nuclides vary significantly, depending on the geological and geographical features of the region (Sharma et al., 2017). Radioactivity in our environment which consists of three important radionuclide series of Uranium, Thorium and Actinium has been known to contribute immensely to absorbed dose of an individual exposed to them (Oyebanjo et al., 2012). The use of radiation sources in medical diagnosis and therapy, nuclear weapons, nuclear power plants, fertilizers production, research institutions as well as in consumers' products have contributed to increase in the background radiation exposure and doses. High radiation levels and doses in the environment are detrimental to human health, Ionizing radiations are highly energetic particles with characteristic high penetration power, when such radiation passes through the biological cell, it causes both excitation and ionization which alters the cell structure (Emelue et al., 2014).



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Exposure to high levels of gamma radiation causes a number of harmful effects in man such as mutation and cancer of various types and different kinds of diseases (Taskin et al., 2009).

Estimation of the radiation dose distribution is vital in assessing the health risk to a population and serves as a reference for documenting changes in environmental radioactivity due to anthropogenic activities (Obed *et al.*, 2005). As a result, the purpose of this study is to determine the level of background radiation exposure and its associated radiological hazard indices within Kano main abattoir in Fagge local government area of Kano state, Nigeria, and ascertain the level of radiation exposure safety within the study area. The study will also contribute to the preservation of reference data to check probable changes in

environmental radioactivity as a result of nuclear, industrial, and other human activities.

II. MATERIALS AND METHODS

2.1 Study Location

The study was conducted in Kano central Abattoir situated in Fagge Local Government Area of Kano State in Nigeria. It is one of the important commercial towns in Kano State and covers an area extending between latitude $12^{\circ} 00' N$ and $24^{\circ} N$ as well as between longitude $8^{\circ} 31' E$ and $45^{\circ} E$ (NPC 2006).

Five points/areas were selected for this study, namely; Slaughtering area, Selling area, Roasting area Refuse dumping area and entrance area.

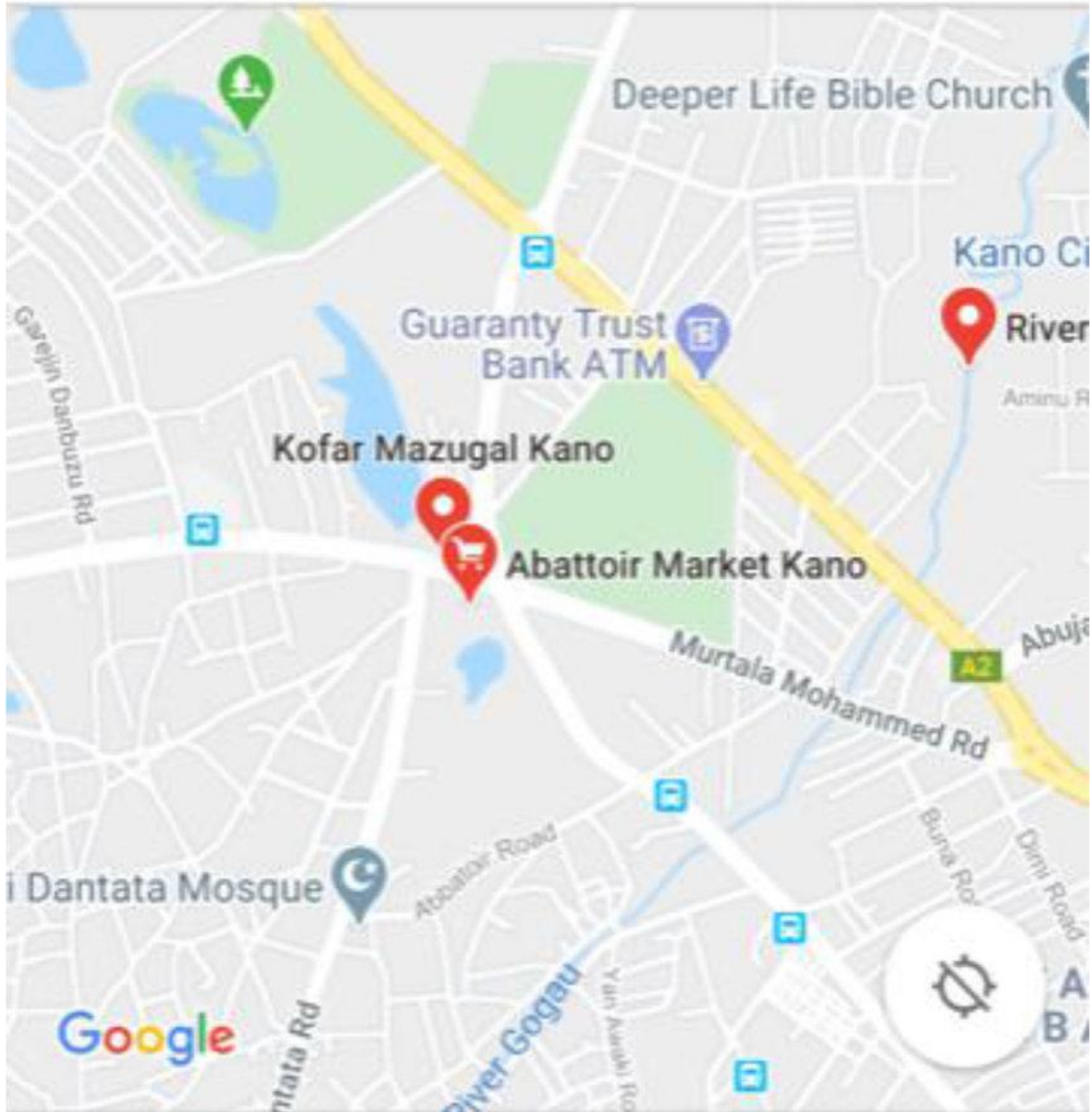


Figure 1: Map of study area showing the study site (kano central abattoir)



Figure 2: Roasting of Animal skin and hide in Kano Abattoir

2.2 Field Measurement:

An *in-situ* approach of background radiation measurement was preferred and adopted to enable samples maintain their original environmental characteristics. The measurement of background ionizing radiation within Kano main Abattoir and its everons was conducted using a well calibrated Digilert – 200 nuclear radiation monitoring meter (S.E. International Inc, Summer Town, USA) containing a Geiger-Muller tube capable of detecting alpha, beta, gamma and X-rays within the temperature range of – 10°C and 50°C was used to measure radiation levels. The Gieger muller tube generates a pulse current each time radiation passes through the tube and causes ionization (Avwiri *et al.*, 2012, Ononugbo *et al.*, 2016). Each pulse is electronically detected and registered as a count.

The radiation meters were calibrated with a ^{137}Cs source of a specific energy and set to measure exposure rate in milli-Roetgen per hour.

A geographical positioning system (GPS) was used to measure the precise position of sampling points. A number of five (5) sampling points were considered for measurement at each of the selected areas, three readings were taken at each sampling points and an average were taken and recorded at 5 minutes intervals at each point of the selected areas. The readings were taken within the hours of 1300 and 1600 hours because exposure rate meter has a maximum response to environmental radiation within these hours (Louis *et al.*, 2005). The tube of the radiation meter was raised to a height of 1.0m above the earth surface with its window facing first the earth surface and then vertically downwards (Avwiri *et al.*, 2007, Ononugbo *et al.*, 2011).

Absorbed Dose Rate (ADR): The absorbed Dose Rate is calculated in nGy/h. Data obtained for the external exposure rate in $\mu\text{R/h}$ was converted into absorbed dose rate nGy/h using the conversion factor given by Rafique *et al.*, (2014), to get equation 2.1a.

$$\text{Absorbed dose rate} = \text{Exposure dose rate} \times 8.7(\text{nGy/h}) \quad 2.1a$$

$$1\mu\text{R/h} = 8.7 \text{ nGy/h} \quad 2.1b$$

The Annual Effective Dose Equivalent (AEDE): Measured absorbed gamma dose rates were used to calculate the annual effective dose equivalent (AEDE) received by individuals within and around the Elele-Alimini palm oil processing clusters. In calculating AEDE, dose conversion factor of 0.7 Sv/Gy and the occupancy factor for outdoor of 0.25 (6/24) was used. The annual effective was determined using equation 2.2 (UNSCEAR, 2000):

$$\text{AEDE outdoor (mSv/y)} = \text{Dose rate(nGy/h)} \times 8760\text{h} \times 0.75\text{Sv/Gy} \times 0.25 \quad 2.2$$

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.

$$\text{ELCR} = \text{AEDE} \times \text{DL} \times \text{RF} \quad 2.3a$$

Where DL is the average duration of life (70 years) and RF is the fatal cancer Risk Factor which uses a fatal cancer factor value of 0.05 for public exposure, (0.5 fatal cancer risk per sievert). For low dose background radiations which are considered to produce stochastic effects, ICRP 60 uses values of 0.05 for the public (Muhammad *et al.*, 2014). Therefore,

$$\text{ELCR} = \text{AEDE} \times 70 \times 0.05 \quad 2.3b$$

Equivalent Dose Rate: To estimate the whole-body equivalent dose rate over a period of 1 year, the National Council on Radiation Protection and Measurement (NCRPM) recommendation;

$$1\text{mR/h} = \frac{0.96 \times 24 \times 365}{100} \text{ mSv/y} \quad 2.4$$

III. RESULTS AND DISCUSSION

3.1 Results

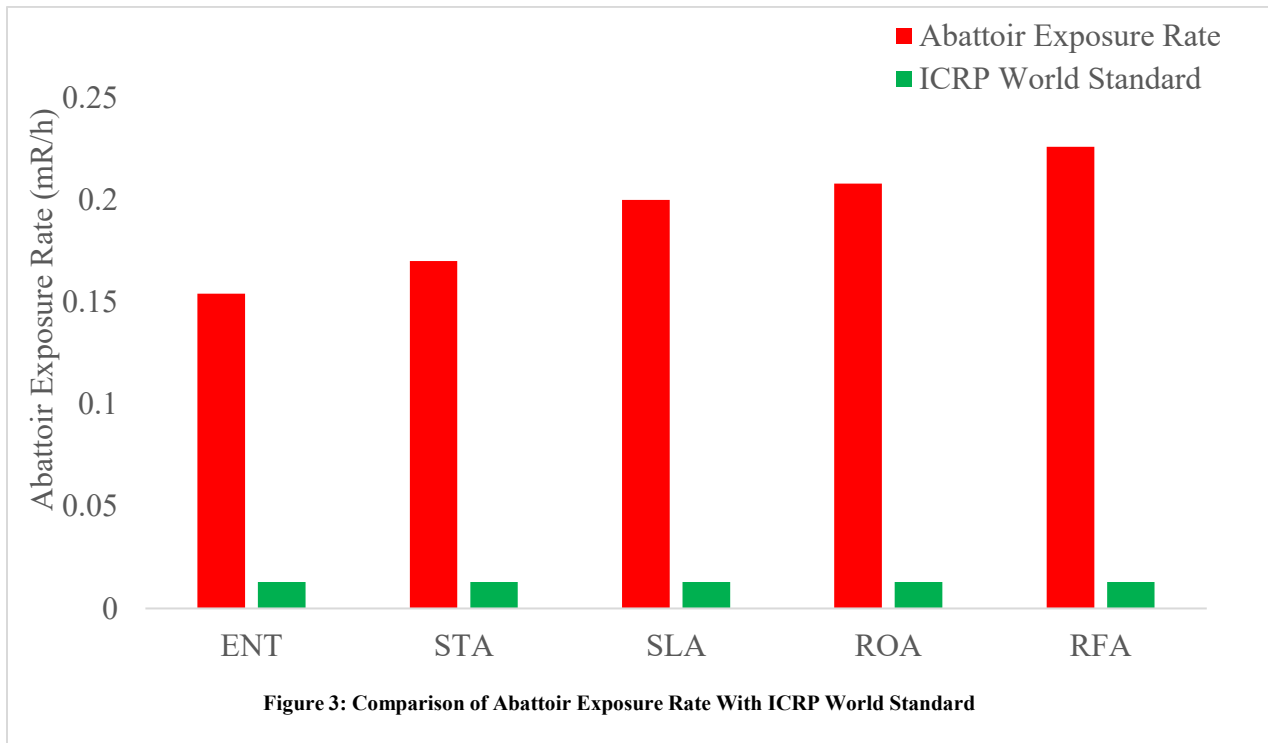
The results for the *in-situ* measurement of background ionizing radiation level and the calculated values for gamma dose, annual effective dose equivalent (AEDE) and excess lifetime cancer risk (ELCR) of the five selected areas within the study area are presented together in Tables 1 while Table 2 presents the summary of parameters calculated. Figures 3-6 show the comparison of the calculated parameters with average world standard for the five selected areas respectively.

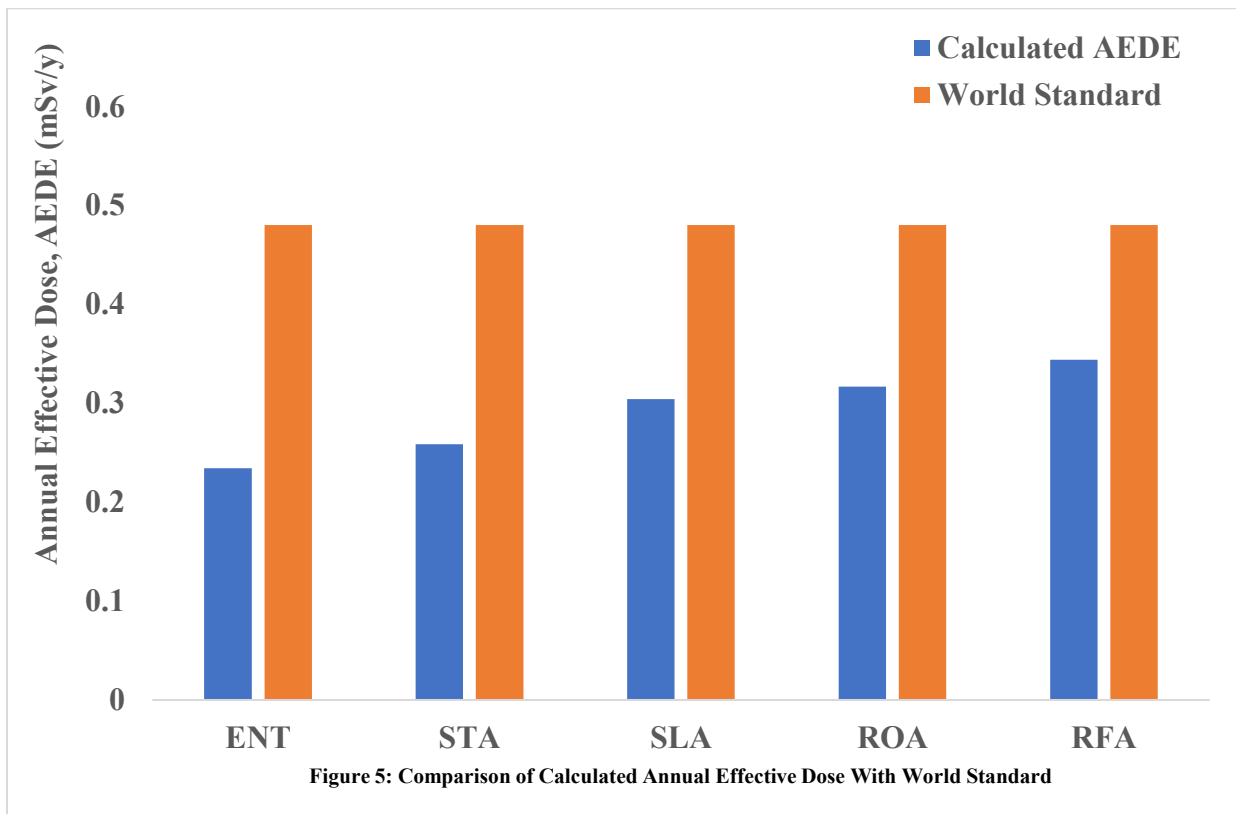
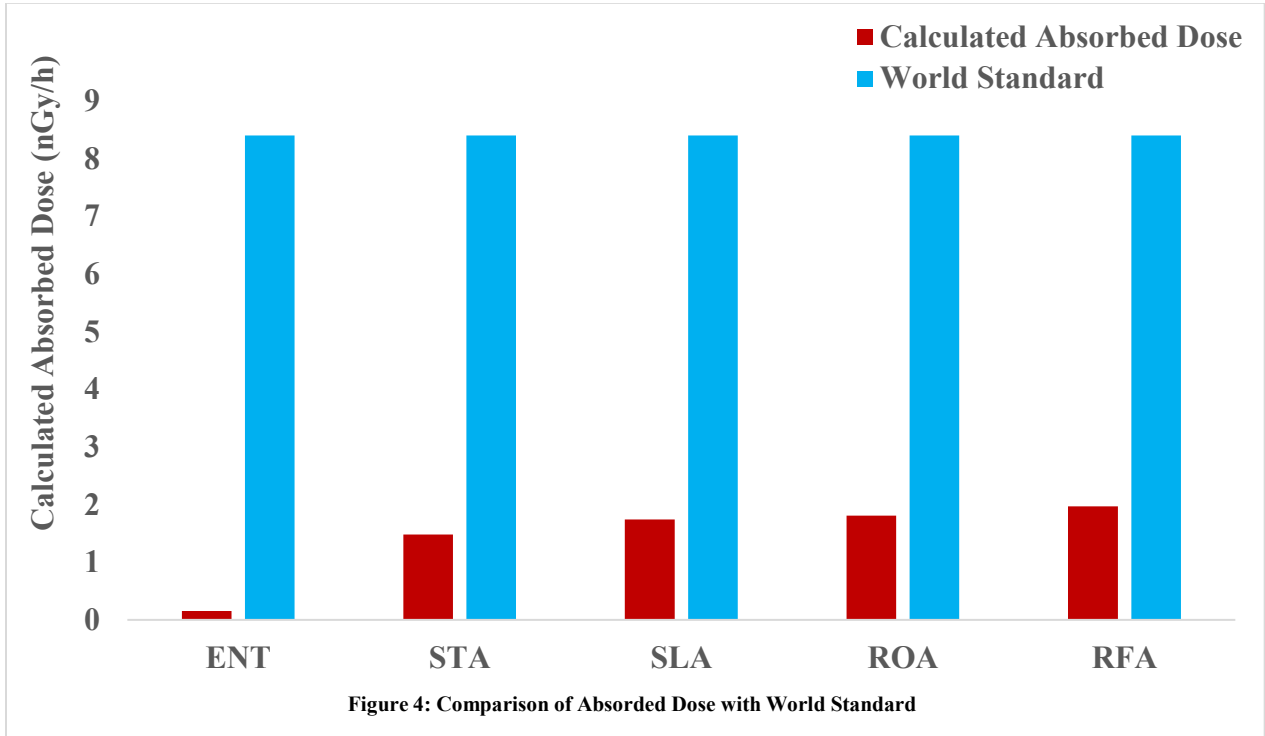
Table 1:
Radiation Exposure Rate of Kano Abattoir and Associated Radiological Parameters

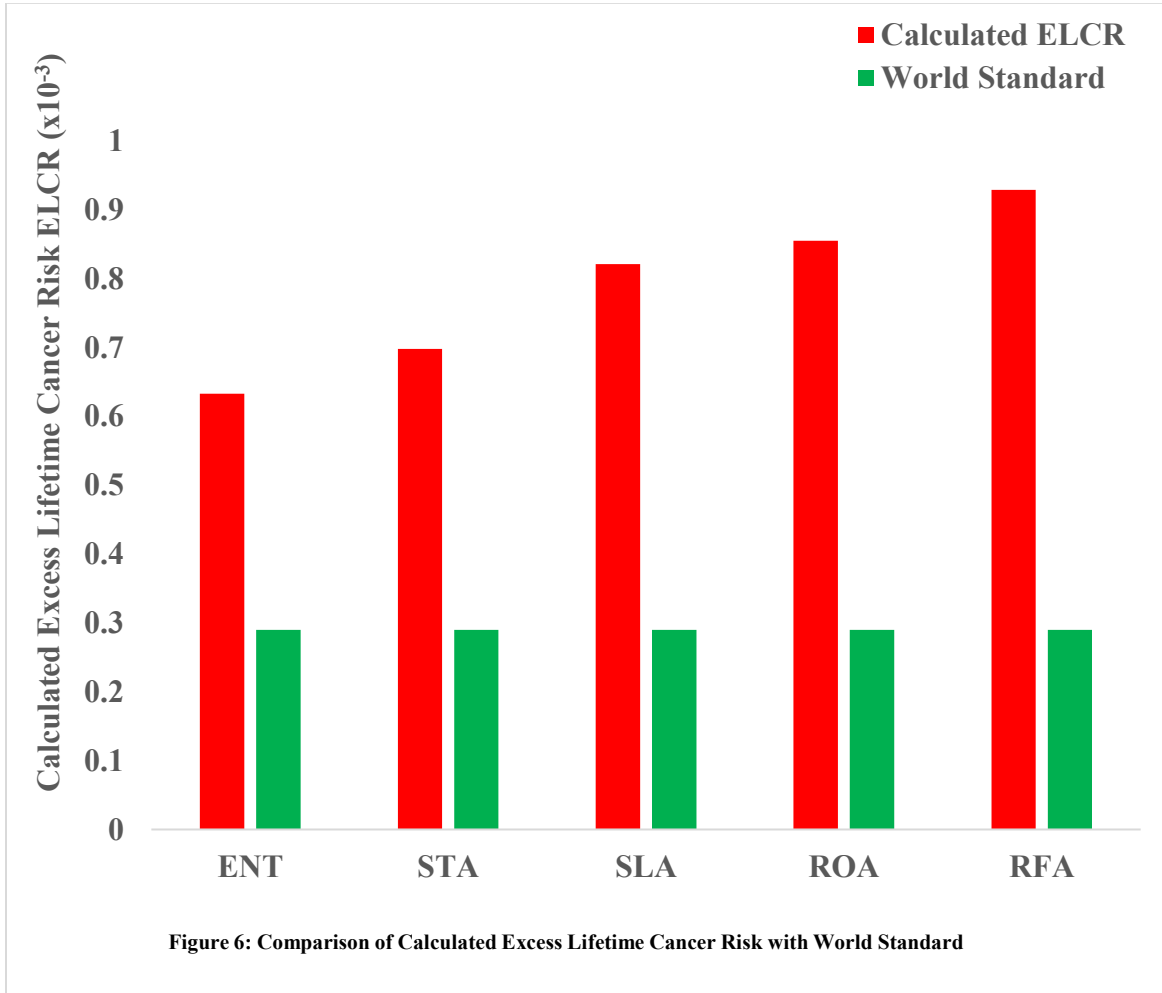
| S/N | Sampling Point | GPR Readings | Exposure Dose Rate (mR/h) | Absorbed Dose (nGy/h) | AEDE (mSv/y) | ELCR $\times 10^{-3}$ |
|----------------------------|----------------|-------------------------|---------------------------|-----------------------|--------------|-----------------------|
| Slaughtering Area | | | | | | |
| 1 | Point 1 | N12.011882 E8.521321 | 0.22 | 1.914 | 0.335 | 0.905 |
| 2 | Point 2 | N12.011725 E8.520936 | 0.21 | 1.827 | 0.319 | 0.861 |
| 3 | Point 3 | N12.009036 E8.521806 | 0.11 | 0.957 | 0.167 | 0.451 |
| 4 | Point 4 | N12.011951 E8.520989 | 0.11 | 0.957 | 0.167 | 0.451 |
| 5 | Point 5 | N12.011966 E8.520678 | 0.2 | 1.74 | 0.305 | 0.823 |
| Selling Area | | | | | | |
| 6 | Point 6 | N12.013198 E8.521168 | 0.22 | 1.914 | 0.334 | 0.901 |
| 7 | Point 7 | N12.013307 E8.520493 | 0.15 | 1.305 | 0.228 | 0.616 |
| 8 | Point 8 | N12.013362 E8.520720 | 0.2 | 1.74 | 0.305 | 0.823 |
| 9 | Point 9 | N12.013072 E8.521186 | 0.19 | 1.653 | 0.289 | 0.78 |
| 10 | Point 10 | N12.013452 E8.520686 | 0.24 | 2.088 | 0.365 | 0.986 |
| Roasting Area | | | | | | |
| 11 | Point 11 | N12.012155 E8.521467 | 0.17 | 1.479 | 0.259 | 0.699 |
| 12 | Point 12 | N12.012235 E8.520160 | 0.26 | 2.262 | 0.396 | 1.069 |
| 13 | Point 13 | N12.012484 E8.521735 | 0.11 | 0.957 | 0.167 | 0.452 |
| 14 | Point 14 | N12.012134 E8.521184 | 0.25 | 2.175 | 0.381 | 1.028 |
| 15 | Point 15 | N12.012231 E8.521134 | 0.25 | 2.175 | 0.381 | 1.028 |
| Refuse Dumping Area | | | | | | |
| 16 | Point 16 | N12.012688 E8.520358 | 0.24 | 2.088 | 0.365 | 0.987 |
| 17 | Point 17 | N12.012608 E8.520688 | 0.2 | 1.74 | 0.304 | 0.822 |
| 18 | Point 18 | N12.012936 E8.520561 | 0.24 | 2.088 | 0.365 | 0.987 |
| 19 | Point 19 | N12.012955 E8.520479 | 0.24 | 2.088 | 0.365 | 0.987 |
| 20 | Point 20 | N12.012480 E8.521030 | 0.21 | 1.827 | 0.32 | 0.863 |
| Entrances Areas | | | | | | |
| 21 | Point 21 | N12.012411 E8.521604 | 0.11 | 0.11 | 0.167 | 0.451 |
| 22 | Point 22 | N12.012318 E8.521276 | 0.13 | 0.13 | 0.198 | 0.535 |
| 23 | Point 23 | N12.012338 E8.518834 | 0.23 | 0.23 | 0.35 | 0.945 |
| 24 | Point 24 | N12.012399 E8.521387 | 0.13 | 0.13 | 0.198 | 0.535 |
| 25 | Point 25 | N12.012353 E8.521801 | 0.17 | 0.17 | 0.259 | 0.699 |

Table 2:
Mean Radiation Exposure Rate and their Associated Radiological Parameters

| S/N | Sampling Area | Sampling Code | Exposure Dose Rate (mR/h) | Absorbed Dose (nGy/h) | AEDE (mSv/y) | ELCR ($\times 10^{-3}$) |
|-----|-------------------|---------------|---------------------------|-----------------------|--------------|---------------------------|
| 1 | Entrance | ENT | 0.154 | 0.154 | 0.2344 | 0.633 |
| 2 | Slaughtering Area | STA | 0.17 | 1.479 | 0.2586 | 0.6982 |
| 3 | Selling Area | SLA | 0.2 | 1.74 | 0.3042 | 0.8212 |
| 4 | Roasting Area | ROA | 0.208 | 1.8096 | 0.3168 | 0.8552 |
| 5 | Refuse Area | RFA | 0.226 | 1.9662 | 0.3438 | 0.9292 |







3.3 Discussion

The background radioactivity level and radiation health risk parameters of the five selected areas within Kano central Abattoir, situated in Fagge Local Government Area of Kano State in Nigeria was measured with Nuclear Radiation Monitors (Digilert 200) and presented in Tables 1. The values of radiation exposure level ranges from 0.110mR/h to 0.220 mR/h for slaughtering area, 100% of the values obtained are higher than the ICRP standard of 0.013 mR/h for normal background ionizing radiation. That of selling area ranges from 0.150mR/h to 0.240mR/h; while that of roasting area ranges from 0.11mR/h to 0.250mR/h. The highest value of radiation Exposure level was recorded in the roasting area, which is 0.250mR/h.

The values of radiation exposure level in the Refuse dumping area ranges from 0.200mR/h to 0.240mR/h, and 100% of the values obtained are higher than the ICRP standard of 0.013mR/h for normal background ionization radiation; and the values of radiation exposure level in the Entrance areas ranges from 0.110mR/h to 0.230mR/h. The mean exposure dose rate of the selected areas within the study area are higher than the recommended safe limit of 0.013mR/h as stipulated by International Committee of Radiological Protection ICRP (2008). The mean value of the results obtained were found to be higher than the result obtained at Jimeta and Yola Towns in Adamawa state by Musa, et al. (2024), and lower than the results obtained at Yan- Babbaka abattoir kano by Mansur, et al. (2021).

The background ionization radiation variation within the study area might be due to the present of radionuclide within the environment.

The absorbed dose varies from (0.957 to 1.914) nGy/h for Slaughtering area; (1.305 to 2.088) nGy/h for Selling area; (0.957 to 2.262) nGy/h for Roasting area; (1.740 to 2.088) nGy/h for Refuse dumping area and (0.110 to 0.23) nGy/h for Entrance areas, with mean values of 1.479nGy/h, 1.740nGy/h, 1.8096nGy/h, 1.9662nGy/h and 0.154nGy/h respectively. The mean absorbed dose of all the selected areas were below the standard value of 84.0nGy/h as stipulated by ICRP (2008), and also lower than the reported work at Enugu by Benson and Ugbede (2018). The mean absorbed dose are also lower than the reported work at Lafia metropolis by Mohammed, et al. (2021) and higher than the reported work at Ikpoba slope, Benin city by Giwa and Osahon (2020)

The Annual Effective Dose Equivalent (AEDE) of the slaughtering area, the selling area, the roasting area, the refuse dumping area and the entrance areas varies from (0.165 to 0.3335) mSv/y with mean of 0.2586mSv/y; (0.228 to 0.365) mSv/y with mean of 0.3042mSv/y; (0.167 to 0.396) mSv/y with mean of 0.3168mSv/y; (0.304 to 0.365)mSv/y with mean value of 0.3438mSv/y; and (0.167 to 0.350) mSv/y with mean of 0.2344mSv/y, respectively. The AEDE of the study area are higher than the stipulated value of ICRP (2008) of 0.3mSv/y and is higher than the reported work at Ikpoba Slope Benin City by Giwa and Osahon (2020) higher than the work reported at Jimeta and Yola towns by Musa et al. (2024), and lower than the report of work done at Yan-Babbaka abattoir, Kano by Mansur, et al. (2021).

The mean value of the Excess Life Cancer Risk (ELCR) of the study area were 0.6982×10^{-3} ; 0.8212×10^{-3} ; 0.8552×10^{-3} ; 0.9292×10^{-3} and 0.6330×10^{-3} for slaughtering area, selling area, roasting area, refuse dumping area and entrance areas respectively. The result of the Excess Life Cancer Risk obtained were higher than the standard value of 0.29×10^{-3} . The variation in the ELCR within the study area may be due to alteration of the concentration of radionuclides and also human activities within the area. The Excess Life Cancer Risk (ELCR) of all the selected areas are higher than the stipulated value of ICRP of 0.29×10^{-3} . The ELCR of the slaughtering area and entrance areas are lower the work reported by Musa et al. (2024) and Mohammed et al. (2021) while those of the roasting area, selling area and refuse dumping area are higher. This implied that the residents of the area may develop cancer in future if continuously exposed to the high value of radiation within the area.

IV. CONCLUSION

This study assessed the background radiation exposure around selected areas in kano central abattoir in Fagge Local Government Area of Kano State, using Digilert – 200 and Global Positioning System (GPS). Its associated radiological hazard indices such as the absorbed dose rate, annual effective dose equivalent and the excess lifetime cancer risk were calculated.

The following results were obtained from this study:

1. The highest exposure rate of 0.226mR/h was measured at Refuse dumping area, followed by 0.208mR/h at the Roasting area.
2. Minimum and maximum Absorbed dose rate value of 0.154 nGy/h and 1.9662 nGy/h respectively were obtained from Entrance areas and Refuse Dumping area respectively.
3. Mean values of outdoor gamma doses of all the selected areas were found to be less than the world population weighted average dose rates of 89.0 nGyh-1 (UNSCEAR, 2008)
4. Estimated mean values of Annual Effective Dose Equivalent for outdoor exposure has a maximum of 0.3438mSv/y and a minimum of 0.2344mSv/y in Refuse dumping area and Entrance areas respectively.
5. ELCR for outdoor exposure has a maximum of 0.9292×10^{-3} , in Refuse dumping area and a minimum of 0.6330×10^{-3} in the Entrance areas.

Though our results showed high level of gamma dose rates, it may not have any immediate health hazards but could lead to some radiological problems for long term exposure of people living or working within the study areas.

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