

Original Research Article

Evaluation of Excess Lifetime Cancer Risk in Some Selected X-Ray Diagnostic Centers in Port Harcourt, Rivers State, Nigeria

ABSTRACT

The evaluation of background ionizing radiation in some selected X-rays diagnostic centers in Port Harcourt has been carried out. This research was achieved with the used of Radex (RD 1212) radiation meter to measure the exposure rate due to ionizing radiation, and geographical coordinate system was employed to record the coordinates of the sampled locations. The exposure rate ranged from 0.14 to 0.22 μ Sv/h with a mean value of 0.18 \pm 0.03 μ Sv/h, this value was quite higher than the acceptable limit of 0.133 μ Sv/h set by the international commission on radiological protection (ICRP). The computed annual equivalent dose ranged from 0.25 to 0.39 mSv/y with a mean value of 0.31 \pm 0.05 mSv/y, the annual effective dose equivalent (AEDE) dose varied from 0.17 to 0.27 mSv/y with a mean value of 0.22 \pm 0.35 mSv/y. This value is lesser than the safe limit of 1 mSv/y as recommended by ICRP. The excess lifetime cancer risk (ELCR) ranged from 0.64 $\times 10^{-3}$ to 0.77 $\times 10^{-3}$ mSv/y with a mean value of 0.76 \pm 0.12 $\times 10^{-3}$ mSv/y which is quite higher than the safe limit of 0.29 $\times 10^{-3}$ (UNSEAR). Therefore, the diagnostic centers in Port Harcourt may not be radiologically safe to both occupational workers and patients who are radiologically diagnosed from the general public. Even though the signs of health risk issues are not physically pronounced the chances of contracting radiological health relative issues is still significant. Therefore, it is recommended that adequate steps should be taken to ensure that radiation leakage should be contained, if possible to the barest minimum.

Keywords: Radiation, Exposure rate, Annual effective dose equivalent, Excess lifetime cancer risk

1.0 INTRODUCTION

Ionizing radiation is a type of energy released by atoms in the form of electromagnetic wave or particles. Humans are exposed to natural and anthropogenic sources of ionizing radiation. Man is exposed to this radiation through, soil, water, consumption of food, as well as the used of technically enhanced machines such as X-rays and gamma-ray devices [1]. Ionizing radiation has many beneficial applications, including uses in medicine, industry, agriculture and research. As the use of Ionizing radiation increases, so does the potential for health hazards when not properly used or contained. Serious health effects such as skin burns, or cancer can occur when dose of ionizing radiation exceeds certain threshold limits. Low doses of ionizing radiation can increase the risk of longer-term effects such as cancer [2]. Ionizing radiation is mostly used daily in hospitals and clinics to perform diagnostic procedures. which are necessary for accurate diagnosis of disease and injury treatment. These procedures provide important information about our health to the medical practitioner and to ensure that we receive the appropriate treatment [3]. Nevertheless, certain procedures have the potential to expose large number of people to higher dose especially when the exposure rates are higher and exceeds the occupational dose limit of 20

mSv/y. When compared to the acceptable limit of the International Commission of Radiological Protection to the general public[4].

Radiographers and healthcare workers in X-ray diagnostic centers are concerned with the handling/operation of radiological materials/procedures in medical facilities such as plain radiography, mammography, fluoroscopy, angiography, and computed axial tomography, which when operated exposes patients to low-dose ionizing radiation. Hematopoietic cells/tissues are highly sensitive to ionizing radiation and can be used to predict health impacts. Full blood counts and differentials, cellular morphologies, and other hematological indices are examples of basic hematological indicators. Ionizing radiation exposure at X-ray diagnostic facilities has been linked to the etiology of illnesses such as hematological cancers, sarcomas, and ocular defect/malignancies, as well as embryological/foetal abnormalities in exposed people's offspring.[5-7].

X-ray background ionizing radiation is a measure of the level of ionizing radiation present in x-ray diagnostic centers, hospitals or laboratories at a particular location. Background radiation is defined by the International Atomic Energy Agency as "attributable to all sources of ionizing radiation both natural and anthropogenic present in the environment[8].

Consequently, there is a general lack of awareness and knowledge about the level of ionizing radiation to which patients and radiation workers in the radiological laboratories are exposed to. These ionizing radiations when they ionized living tissues, may probably be harmful to living cells, which may result to chromosomal aberrations and carcinogenic effects [9]. Ionizing radiation can randomly cause damage to all cellular components and induces a variety of DNA defects. So, X-rays are utilized in well-preventive and protective conditions [10]. The last two decades have witnessed a technological revolution in diagnostic and therapeutic medical imaging. However, minimizing the risk of ionizing radiation exposure in x-ray diagnostic and imaging centers is still a big challenge[11].

This study is therefore carried out to estimate the level of ionizing radiation in Ten (10) selected X-ray diagnostic centers in Port Harcourt local government area in Rivers State, Nigeria. X-ray diagnostic centers could pose serious health hazards to both staff and patients who receive radiological diagnosis. This is as a result of the fact that the environment is exposed to certain doses of x-ray radiation in the course of medical administration. However, the continual exposure to the background ionizing radiation in X-ray diagnostic laboratories over an extended period of time have the tendency to result in non-lethal mutation, which could increase the health risk of workers and patients even though it might not be pronounced. Based on stochastic effect, no matter how insignificant the dose may be, it has the potential to an induced cancer risks and other radiological health issues. The radiological Laboratory workers as well as the patients could not be radiologically safe from the health hazard of ionizing radiation, hence the aim of this research was to estimate the level of ionizing radiation as well as its excess lifetime cancer risk (ELCR) health risk parameter in Ten (10) selected X-ray diagnostic centers in Port Harcourt, Rivers State, Nigeria.

2.0 MATERIALS AND METHODS

In-situ measurement of the background ionizing radiation (BIR) level was carried out using Radex (RD 1212) radiation meter which measured ionizing radiation level rate in micro-Sievert per hour ($\mu\text{Sv/h}$). The meter is a handheld digital radiation detector which detects gamma radiation, X-ray radiation and beta radiations with a dose power range of 0.05 to 999 $\mu\text{Sv/hr}$ and

a linear energy response to gamma radiation between 0.1 to 1.25 MeV, readings were taken within the hours of 13:00 and 16:00 hours, because the radiation meter has a peak sensitivity to environmental radiation within these hours [12-14]. During operation the meter was maintained at a gonadal height of 1 m above the ground surface and at 2.5 meters away from the active x-ray machines in the surveyed diagnostic centers, three readings were recorded (at the entrance, center of the X-ray room, and X-ray scanning area) and the values were average to a single value and recorded [15]. In addition, Geographical positioning system (GPS) was employed to record the coordinates of the sampled locations.

2.1 Radiological Parameters

2.1.1 Annual Effective Dose Equivalent (AEDE)

UNSCEAR [16] recommended that the indoor occupancy factor of 0.8 is used to the time during which an individual is exposed to radiation ionizing radiation. To compute the exposure rate to annual equivalent dose (E_i) the equation below was used [17,18].

$$E_i (\text{mSv/yr}) = \chi (\mu\text{Sv/hr}) \times \mu \times 8760 \text{hrs/yr} \times 0.001 \quad (1)$$

Where:

E_i represent the Annual equivalent dose,

χ ($\mu\text{Sv/hr}$) is the mean indoor exposure rate

μ represents the indoor occupancy factor (0.8) represents (16/24) hrs spend in indoor environment daily.

The annual effective dose equivalent (AEDE) is obtained by multiplying the annual equivalent dose (E_i) by the conversion factor of 0.7 Sv/yr [17].

2.1.2 Excess lifetime Cancer Risk (ELCR)

The excess lifetime cancer risk (ELCR) is based on the chances of cancer-induced incidence in a population, in other words is state the possible carcinogenic consequence due to exposure to ionizing radiation for a given period of lifetime. In other words, the ELCR computes the possibility of developing cancer after receiving dose of ionizing radiation for a specific period of lifetime. The excess lives cancer risk (ELCR) was computed using by Equation 2, [13,17].

$$\text{ELCR (mSv/yr)} = \text{AED} \times \text{DL} \times \text{RF} \quad (2)$$

Where: DL = Is the average life exposition expectancy = 70 yrs

RF = Is the fatal cancer risk factor per Sievert = 0.05

3. Results and Discussion

The result of the field measurement of the *in-situ* exposure rate as well as the radiological parameters of the selected X-ray diagnostic centers in Port Harcourt, Rivers state is presented in Table 1, The exposure rate ranged from 0.14 to 0.22 $\mu\text{Sv/h}$ with a mean value of $0.18 \pm 0.03 \mu\text{Sv/h}$, this value is quite higher than the acceptable standard of 0.133 $\mu\text{Sv/h}$ of ICRP as illustrated in Figure 1. However, the values measured in this research in the Ten (10) X-rays diagnostics centers are all higher than the ICRP safe limit of 0.133 $\mu\text{Sv/hr}$. This result of this research in agrees with the previously reported work on background radiation dose in selected X-ray facilities in southwest Nigeria [19], and the evaluation of background ionizing radiation levels

in some X-ray centers in Owerri, Imo State, Nigeria [20]. This indicates that the diagnostic centers within Port Harcourt local government areas may not be safe for both occupational workers and patients of the general public who receive radiological diagnosis evaluation. However, there is presently no reported case of any radiological hazards within these areas.

The contour map of the study location shows that the sampled locations surveyed indicate that the North-East direction approaching towards the central of the study location tends to have the highest level of exposure rate, and decreased uniformly towards the North-East direction, but as one approaches towards the South-East there seems to be a decrease in the level of the exposure rate. While other cardinal points of the location show a significant decrease in level of the exposure rate, as it extends towards the North-East, South-East, and significantly towards the North-East cardinal locations of Port Harcourt local government area respectively. The high levels of the exposure rate is predominantly significantly as you approach from the North-East towards the central, this might have been attributed to the fact that most of the X-ray diagnostic centers are located towards within these areas as a result of urban development thereby increasing the need of more X-rays diagnostics center to satisfy the need of the rising urban **populations**.

Table 1. Mean values (BIR), Annual Equivalent Dose and Annual Effective Dose the sampled X-ray diagnostic centers.

SN	Location	GPS reading		Mean Exposure Rate	Annual Equivalent Dose	Annual Effective Dose Equivalent	Excess lifetime Cancer Risk (ELCR)
		Latitude (N)	Longitude (E)	χ ($\mu\text{Sv/h}$)	E_i (mSv/y)	AEDE (mSv/y)	ELCR $\times 10^{-3}$
1	X-Ray DC-1	4.81394	7.04371	0.15	0.26	0.18	0.64
2	X-Ray DC-2	4.89436	6.91432	0.18	0.32	0.22	0.77
3	X-Ray DC-3	4.82416	7.00517	0.22	0.39	0.27	0.94
4	X-Ray DC-4	4.77502	7.01262	0.20	0.35	0.25	0.86
5	X-Ray DC-5	4.82550	7.00979	0.17	0.30	0.21	0.73
6	X-Ray DC-6	4.81640	7.06424	0.20	0.35	0.25	0.86
7	X-Ray DC-7	4.90106	6.92281	0.15	0.26	0.18	0.64
8	X-Ray DC-8	4.81641	7.06427	0.14	0.25	0.17	0.60
9	X-Ray DC-9	4.82550	7.00971	0.21	0.37	0.26	0.90
10	X-Ray DC-10	4.79623	7.00046	0.16	0.28	0.20	0.69
Average				0.18\pm0.03	0.31\pm0.05	0.22\pm0.35	0.76 \pm 0.12

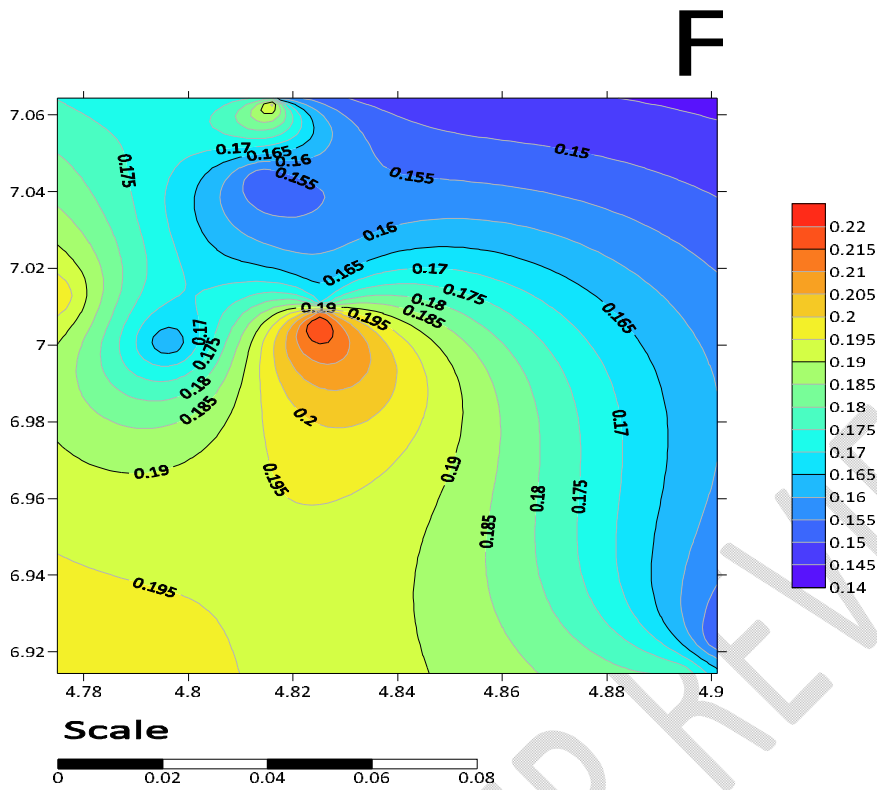


Figure 1. Contour map of background Ionization radiation of the sampled X-ray diagnostics centers

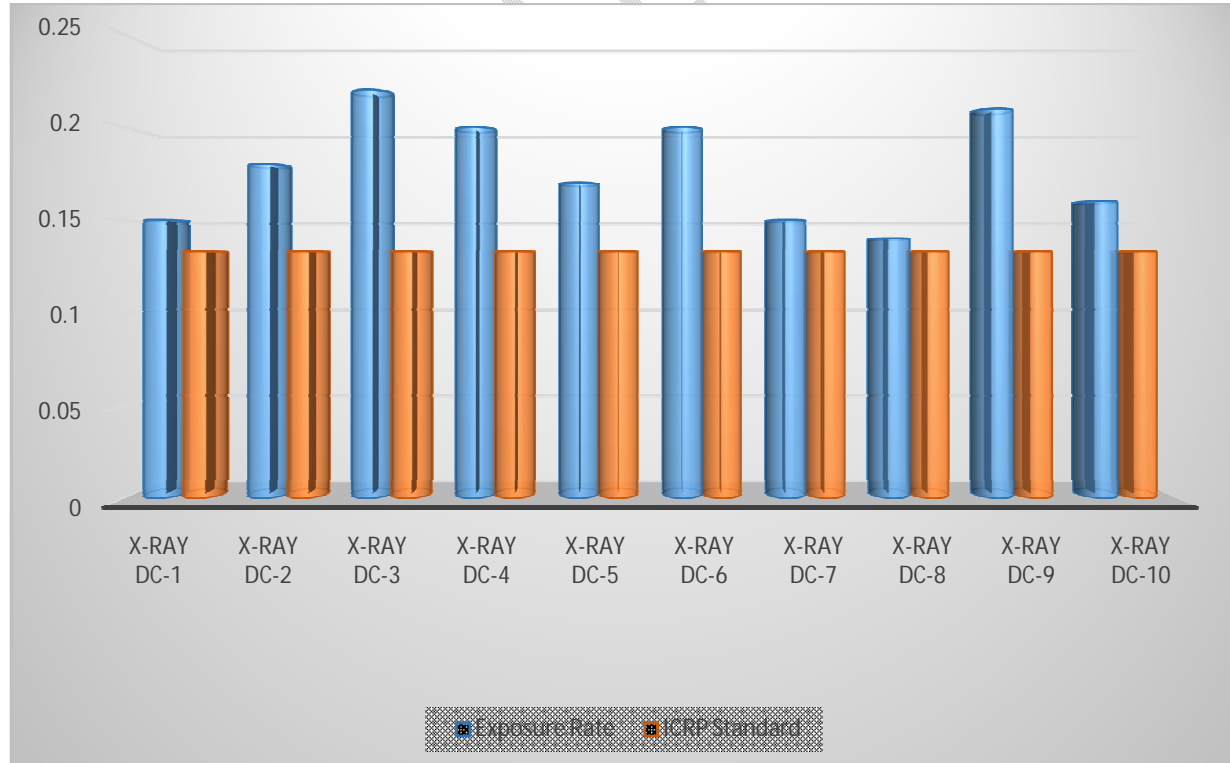


Figure 2. Exposure rate of the sampled X-ray diagnostic centers with ICRP, 2003

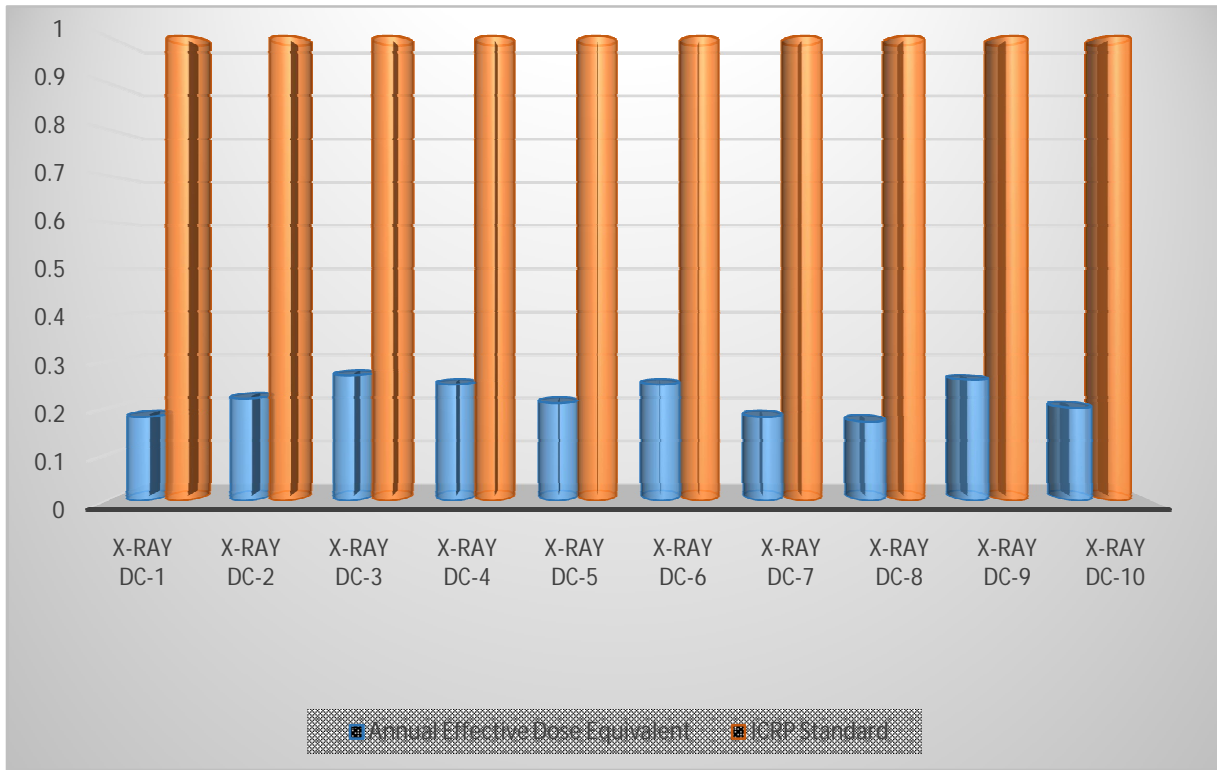


Figure 3. Annual Effective Dose Equivalent of the sampled X-ray diagnostic centers with ICRP, 2003

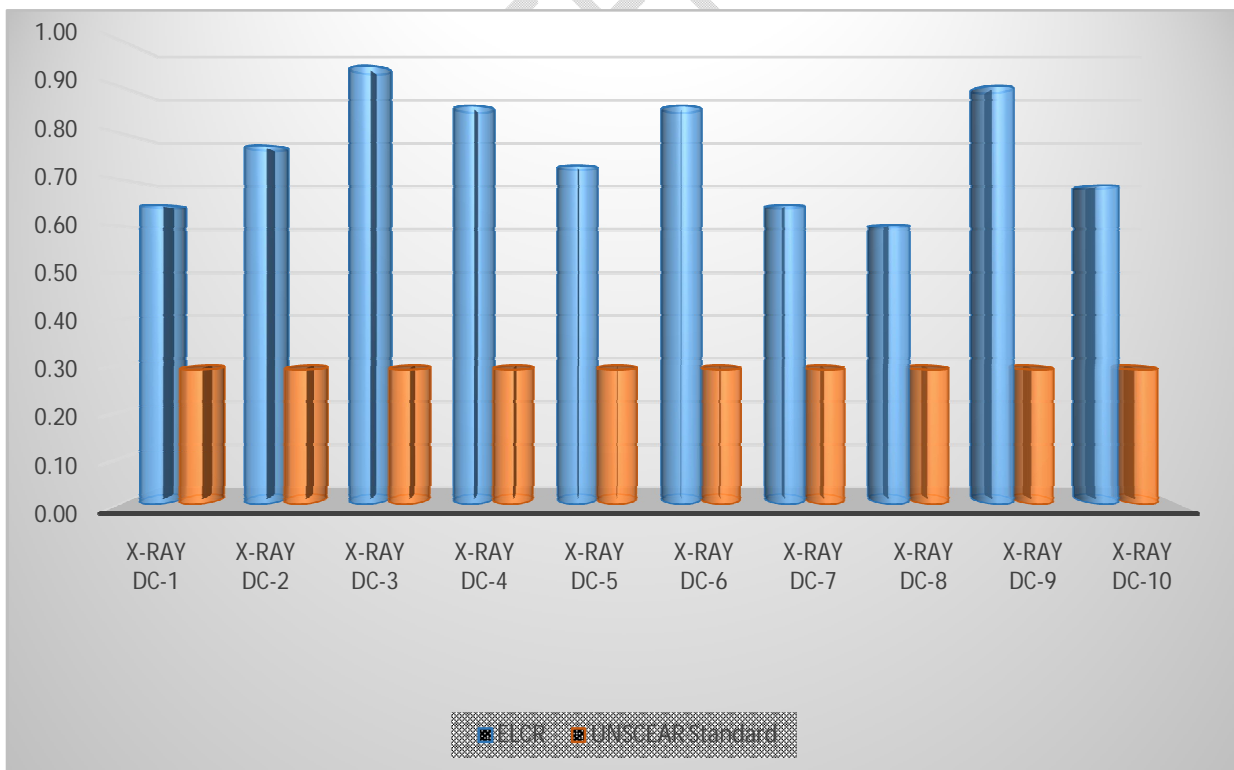


Figure 4. Excess Lifetime Cancer Risk of the sampled X-ray diagnostic centers with UNSCEAR, 2008

The estimated annual equivalent dose ranges from 0.25 to 0.39 mSv/y with a mean value of 0.31 ± 0.05 mSv/y, the annual effective dose equivalent (AEDE) as depicted in Figure 3, ranged from 0.17 to 0.27 with a mean value of 0.22 ± 0.35 mSv/y. This value is lesser than the safe limit of ICRP [4]. All the values the X-ray diagnostic centers are lower than the ICRP recommended value for public exposure of 1.0 mSv/y. This interprets that occupational workers and patients exposed to the facilities of X-ray machines are safe from the threat from radiological health related issues. The findings from this work is in harmony with the work previously report by [18], on the estimation of indoor and outdoor background ionizing radiation levels of Kwali general hospital in Abuja.

The excess lifetime cancer risk ranged from 0.64×10^{-3} to 0.77×10^{-3} mSv/y with a mean value of 0.76 ± 0.12 mSv/y which is quite higher than the safe limit of [17], as demonstrated in Figure 4. This result indicates that even though visible signs are not pronounced the chances of contracting radiological health issues relating to cancer is significant according to UNSCEAR[17].

This means, occupational workers, and patients from the general public in these particular X-ray diagnostics centers may be at a risk of developing cancers, hence extreme care and caution should be employed. Studies have demonstrated that ionizing radiation has acute or chronic adverse effects on human beings. Based on Stochastic concepts no threshold level exists below which harmful effects do not occur. The result from this study were similar to the research carried out in Saudi Arabia., Palestine, and Kenya[21-23].

Exposures to low level of radiation could potentially cause lethal effects, which could progress silently and undetected. The knowledge, awareness and practice of radiographers in X-ray diagnostic centers should be taken seriously in X-ray diagnostic centers. In addition, the use of personal protecting equipment is efficient to avoid health issues that may arise from radiation dose exposure [24, 25].

4. CONCLUSION

Conclusively, this study successfully estimates the level of Ionizing radiation in Ten (10) selected X-ray diagnostic center in Port Harcourt, Nigeria as well as the mean exposure rate, annual equivalent dose, annual effective dose equivalent, and excess lifetime cancer risk of the sampled locations. Results have shown that all obtained mean values are higher than the safe limit except for the annual effective dose equivalent as recommended by the International Commission of Radiological Protection (ICRP). Even though there is no visible effect of radiological health related incidence, but the chances of induces cancer risk is significant. Therefore, it is highly recommended to contain the leaks of radiation exposure to the barest minimum from the used of these X-rays machines or and the used of personal protection equipment should be adopted as this play a significant role in the long run. It is recommended based on this research that Regular assessment of background ionizing radiation in X-ray diagnostic centers should be done for the safety of both the radiographers, workers and patients of the general public who received radiological diagnosis, by reducing the exposure rate to the barest minimum.

References

- [1] Essien IE, NYoung AB. Research assessment of Ionizing Radiation protection awareness in diagnostic radiology services in Akwa-Ibom State Nigeria. World Journal of applied Science and Technology 2016;8(2):118-125.

- [2] Sadiq AA, Liman MS, Agba EH, Abdulahi E. Assessment of exposure to Ionizing Radiation at selected mining sites in Nasarawa State, Nigeria. *International Journal of natural and applied sciences*.2010; 6(4):478-451.
- [3]González AB, Darby SC. Risk of cancer from diagnostic X-rays: estimates for the UK and 14 other countries.2004; 363, 345–351.
- [4] ICRP, International Commission on Radiological Protection. Publication 115. Lung cancer risk from radon and progeny and statement on radon. 2003.
- [5] Nagashima H, Shiraishi K, Ohkawa S, Sakamoto Y, Komatsu K, Matsuura S, Tachibana A, Tauchi H. Et al., (). Induction of somatic mutations by low dose X-rays: The challenge in recognizing radiation induced events. *Journal of Radiation Research*, 2018; 59 (2): 11-17.
- [6] Usikalu MR, Aweda MA, Alimba CG, Achuka JA. (). Chromosomal aberration after exposure to 2.45 Ghz microwave radiation.*Research Journal of Applied Sciences*.2016;11(5): 232-234.
- [7] Kawamura K, Qi F, Kobayashi J. Potential relationship between the biological effects of low dose irradiation and mitochondrial ROS production, *Journal of Radiation Research*.2018; 59(2): 91-97.
- [8] Amiri SO, Essien IE, Egbe NO. Perception of Quality control by personnel in Diagnostic Radiology facilities in Akwa-Ibom State, Nigeria. *Nigeria Journal of Medicine*.2015;24(4): 1115-2613.
- [9] Oyeyinka O. Faraj KA, Ali RT, Saeed AO. Quality control and radiation dose rates measurement from diagnostic x-ray examination at different places. *IJRRAS*, 16(August), 2018; 318–325.
- [10] Joseph DZ, Uba, ZS, Garba I, Sidi M, UmarMS, ShemBS et al. Assessment of Radiation Leakage from Diagnostic Rooms of Radiology Department of a Teaching Hospital in Kano, Northwestern Nigeria. *Journal of Nuclear Technology Applied Sciences* 2018;6(1):15- 32
- [11] Sadiq AA, Agba EH (). Background Radiation in Akwanga, Nigeria. *Working and Living Protection*, 8(1),7-11.
- [12] Ebong, I. D. U. Alagoa, KD. Estimates of gamma Ray background air exposure at a fertilizer plant. *Discovery and Innovation*, 1992;4(4):25-28.
- [13] Sokari SA, Ononugbo CP, Gbarato OL. (). Radiological Health Risk from Gamma Radiation of Coastal Communities in Okrika Local Government Area of Rivers State, Nigeria. *Asian Journal of Physical and Chemical Sciences*. 2022;10(1): 38-59.
- [14] Louis AE, Etuk ES, Essian K. Environmental radioactive levels in Ikot Ekpene Nigeria. *Nig. J. Space Res*. 2005; 1:80-87.
- [15] Chiaghanam NO, Esien-umo E, Ogolodom MP, Asuquo C, Maurice C, Omita E, Ugwuanyi DC, Ezugwu EE. Safety of Ionizing Radiation in Selected Conventional X-ray Diagnostic Centres in Calabar and Uyo metropolises, Nigeria. *European Scientific Journal, ESJ*, 2022;18 (21), 1. <https://doi.org/10.19044/esj.2022.v18n21p1>

- [17] UNSCEAR, Effects and Risks of Ionizing Radiation. New York: United Nations Scientific Committee on the Effects of Atomic Radiation. Report to the General Assembly with Scientific Annexes. United Nations, New York; 2008
- [17] Esseini E, Yong AB, Akankpo AO, Ekott EE, Umoh UA, Inyang AJ et al. Baseline Evaluation of Background Ionizing Radiation in Cocoa Plantation in Uyo, Akwa Ibom State, Nigeria. Radiation Science and Technology. 2017;3(2), 13-17.
- [18] James UI, Moses Vandi JN, Ikoh UE. Measurement of Indoor and Outdoor Background Ionization Radiation Levels of Kwali General Hospital, Abuja. Journal of Applied Science Environmental management, 2015;19(1):89-93.
- [19] Achuka JA, Usikalu MR, Aweda MA, Onumojor CA, Babarimisa IO. Background Radiation Dose in Selected X-Ray Facilities in Southwest Nigeria. Journal of Physics. 2019;1-5.
- [20] Orji EC, Eke CB, Amakom MC, Nwoko OE, Okafor CC. Evaluation of Background Ionizing Radiation Levels in Some X-Rays Centres in Owerri, Imo State, Nigeria, International Journal of Current Research. 2016; 8(3):28527-28529.
- [21] Salama KF, Al-Obireed A, Al-Bagawi M, Al-Sufayan Y, Al-Serheed M. Assessment of occupational radiation exposure among medical staff in healthcare facilities in the eastern province, Kingdom of Saudi Arabia. Indian Journal of Occupational and Environmental Medicine. 2016; 20(1): 21-25.
- [22] Abu-Zer SS, Khadoura KJ, Yassin SS, Agha MR. Ionizing radiation leakage in radio diagnostic centers at Gaza Strip hospitals, Palestine. Asian Review of Environmental and Earth Sciences. 2016;3(1):18-26.
- [23] Korir GK, Wambani JS, Korir IK. Estimation of annual occupational effective doses from external ionising radiation at medical institutions in Kenya. SA Journal of radiology. 2011; 15(4):116-119
- [24] Eze KC, Nzotta CC, Marchie TT, Okegbunam B, Eze TE. The state of occupational Radiation protection and monitoring in public and private x-ray facilities in Edo state, Nigeria. Niger Journal of clinical practice. 2011; 14(3): 308-310.
- [25] United States Environmental Protection Agency (USEPA). Radiation protection guidance for diagnostic and interventional X-ray procedures. Federal Guidance Report No 14, EPA-402-R-10003, Washington D.C. 2014