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Assessment Of Occupational Dose Level from Conventional X-Ray on Personnel in Federal Medical Center, Jalingo Taraba State, Nigeria

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Abstract

Assessment of occupational dose level from conventional X-ray on personnel in Federal Medical Centre, Jalingo, waw measured and analysed . A total of twenty (20) personnel were monitored with the use of thermo-luminiscent dosimeters (TLDs) badges. Themo luminiscent dosimeter (TLD) badges made with Lithium Fluoride (LiF) material were worn at the upper left side of chest of the body for collection of radiation dose of the exposed personnel from six different categories of workers. These categories are: radiographers, dark room technicians, radiologist, cleaners, record staff and finance staff. The personnel were monitored using the TLDs badges for a period of thirty working days the badges were evaluated using TLD Reader available at Energy Research and Training Center, ABU Zaria, Nigeria. The results show that the dose received by the exposed workers range between 860µGy - 430µGy and the highest value of effective dose recorded was 7.44mSv/year and is been received by a radiographer. This means every worker recorded effective dose lower than 20mSv/year as recommended by ICRP. The results has also show that radiographers received the highest mean dose of 668.0µGy, followed by dark room technicians with 638.0µGy, then cleaners, record staff and finance staff recorded mean deep dose of 610 µGy, 580 µGy and 557 µGy respectively. The least mean dose goes to radiologist who received 430µGy. In addition, the skin dose obtained using TLD, showed that cleaners received the highest mean skin dose of (0.27) mGy, and the least is radiologists with (0.09) mGy. It is recommended that personnel monitoring should be carried out at least once a year to assess the risks associated with exposure to workers.

Keywords: Radiation dose, conventional X-ray, Thermoluminiscent Dosimeter (TLD).

INTRODUCTION

Radiation dose surveys from medical imaging examinations provide valuable information about human health and play an important role in helping the physicians to make accurate diagnosis.

(Zira *et al.,*2019). Radiographers in Nigeria are exposed to very high radiation risk because of their great dependence on refurbished x-ray equipment. kelvin *et al.,* (2024). The medical physicist has become more concerned recently about the somatic and genetic hazards associated with radiation exposure and absorbed dose to patients during CT scan examination

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(Alumuku *et al.,*2019). Radiological examination utilizing X-rays remain the most commonly used ionizing radiation in the field of medicine, responsible as the most substantial man-made source of radiation exposure to the world population (Karim *et al.,* 2016).

Appropriate levels of radiation protection of workers are essential for the safe and justified use of ionizing radiation. (IAEA 2018) One of the means to ensure that these levels are not exceeded is to control the exposure of workers periodically using appropriate dosimeters provided by approved individual monitoring services (IMSs).

The term occupational exposures arise from the ionizing radiation exposure to people at work from natural and man-made sources as a result of operations within a workplace. It was recommended for workers exposed to medical radiation sources to follow and apply all the requirements established in the International Basic Safety Standards for Protection against Ionizing Radiation and the Safety of Radiation Sources. The dose estimation for radiation workers is an important factor for government and organizations to evaluate radiation risks and establish protection measures. To protect the radiation worker, comforters/ volunteers and the general public from man-made sources, the golden principle of radiation protection (Time-Distance-Shielding abbreviated as T-D-S) is employed. TDS describes that less time be spent near the source and if spending less time is not possible due to the work nature then appropriate distance between the source and subject should be maintained to reduce radiation exposure. In case, when spending less time near the source and maintaining distance from the sources is not possible, the goal of dose reduction can be achieved by placing proper shielding between the source and subject (Sajjad, *et al.*, 2012).

Staff members in nuclear medicine receive highest radiation doses than any medical personnel in any hospital or medical outlets. In addition, the nurses, technicians, physicians, and others involved constitute the largest group of workers occupationally exposed to man-made radiation sources. Many hospitals workers are consequently subjected to routine monitoring of professional for radiation exposures (Kinsara and Nassef, 2017).

This study presents a comprehensive investigation into the occupational radiation exposure of staff of Federal Medical Center Jalingo involved in conventional X-ray procedures. The research focuses on conducting a comparative analysis between the measured and calculated absorbed doses. By examining the correlation between these two parameters, the study aims to provide insights into the accuracy of dose estimation and potential variations in radiation exposure among healthcare workers. The findings from this comparative analysis are crucial for enhancing radiation safety protocols and optimizing occupational dose management in healthcare settings.

METHODOLOGYOLOGY

Theory

Calculation of Absorbed Doses Measured Directly by TLD

Dose equivalent (H) is the product of absorbed dose and radiation weighing factor. is given by:

$$H = D\ X\ W_r$$

$$D = \frac{H}{W_r} = \frac{H}{1} = H \qquad (1)$$

where D is the absorbed dose in Gray (Gy) and W_r is the radiation weighting factor for every type of radiation. But radiation weighing factor (W_r) for X-ray is equal to 1 (ICRP, 1990). Effective dose is a radiation quantity which account for biological effect of radiation to body tissue or organ. given as follows:

$$E == \sum\left(H \times W_t\right) \qquad (2)$$

where W_t is the weighing factor of body tissue or organ. It is defined as the sensitivity of different body tissue/organ to radiation. However, when body is uniformly irradiated by external exposure, the weighting factor is summed up to one (ICRP, 2007).

Methodology

Sample size

A total of twenty (20) health workers used in this research are grouped according to their responsibilities and area of specializations. Such as: Radiologists (1), Radiographers (5), Dark room technicians (6), Cleaners (2), Record staff (3) and Finance staff (3) in the department. The total sample population of 20 health workers is justified by the sum of the individual groups mentioned.

Measurement of Personnel Dose using TLD

In this study, twenty (20) coded thermoluminescent dosimeters (TLD) badges were used. The coded TLD are worn by each of the participant to provide measurements of whole body absorbed dose. The TLD badges were worn at the upper side of chest outside the cloths to receive, accumulate and store radiation dose during working hours. The choice of the upper side of the chest of the body is because high radiation exposure is expected in this part of the body.

The dosimeters are worn by the personnels for a period of 30 working days , after which they were interpreted using TLD reader (Harsaw5400A) at Center for Energy Research and Training Ahmadu Bello University (ABU) Zaria . Also, effective dose calculated were then compared with the standard limits set by international commission on radiation protection (ICRP).

RESULTS AND DISCUSSION

The results of this research work are presented and discussed below. Table 1 presented the result of Radiation Dose Accumulated by TLDs/Personal, table 2 shows the result of Mean Value of Radiation Dose Received by Different Class of Workers, table 3 shows the result of Weekly Absorbed Dose and Effective Dose Incurred by Radiographers, table 4 shows the result of Absorbed Dose and Effective Dose Incurred by each Dark Room Technicians, table 5 shows the result of Weekly Radiation Dose and Effective Dose Incurred by Cleaners, table 6 shows the result of Weekly Radiation Dose and Effective Dose Incurred by Record Staff and lastly table 7 shows the result of Weekly Radiation Dose and Effective Dose Incurred by Finance Staff.

Table 1 Radiation Dose Accumulated by TLDs/Personnel

S/N	*TLD/Workers Label*	*Skin dose (mSv)*	*Depth dose (mSv)*	*Absorbed dose (mGy)*	*Absorbed depth dose (μGy)*
1	01F-01	0.23	0.69	0.69	690
2	01F-02	0.24	0.67	0.67	670
3.	01F-03	0.25	0.86	0.86	860
4.	01F-04	0.25	0.66	0.66	660
5.	01F-05	0.23	0.46	0.46	460
6.	02F-01	0.26	0.72	0.72	720
7.	02F-02	0.22	0.47	0.47	470
8.	02F-03	0.24	0.58	0.58	580
9.	02F-04	0.19	0.62	0.62	620
10.	02F-05	0.21	0.60	0.60	600
11.	02F-06	0.22	0.84	0.84	840
12.	03F-01	0.09	0.43	0.43	430
13.	04F-01	0.26	0.62	0.62	620
14.	04F-02	0.27	0.60	0.60	600
15.	05F-01	0.24	0.59	0.59	590
16.	05F-02	0.20	0.61	0.61	610
17.	05F-03	0.19	0.54	0.54	540
18.	06F-01	0.22	0.62	0.62	620
19.	06F-02	0.17	0.55	0.55	550
20	06F-03	0.20	0.50	0.50	500

01F: Radiographers, 02F: Dark Room Technicians, 03F: Radiologist, 04F: Cleaners, 05F Record staff, 06F: Finance staff.

The TLD reader available at Center for Energy Research and Training, ABU Zaria, was used to evaluate the amount of radiation dose accumulated by TLDs/personnel for a period of six weeks (30 working days). The results were interpreted and made available in terms dose equivalent (skin dose and depth dose) in milli seivert (mSv).The depth dose from the raw data has been considered and converted to absorbed dose in its SI unit by using equation (2), noting that the radiation weighing factor for X-ray equal to one (1) (ICRP, 2007). The results gives the amount of radiation dose incurred by each worker as presented in Table 2. It could be seen from the Table that the highest amount of radiation is 860 μGy and was incurred by a radiographer 01F-03, whereas the least dose has been received by the radiologist who recorded absorbed dose of 430 μGy. Figure 1 is a graphical representation of the radiation absorbed by each worker.

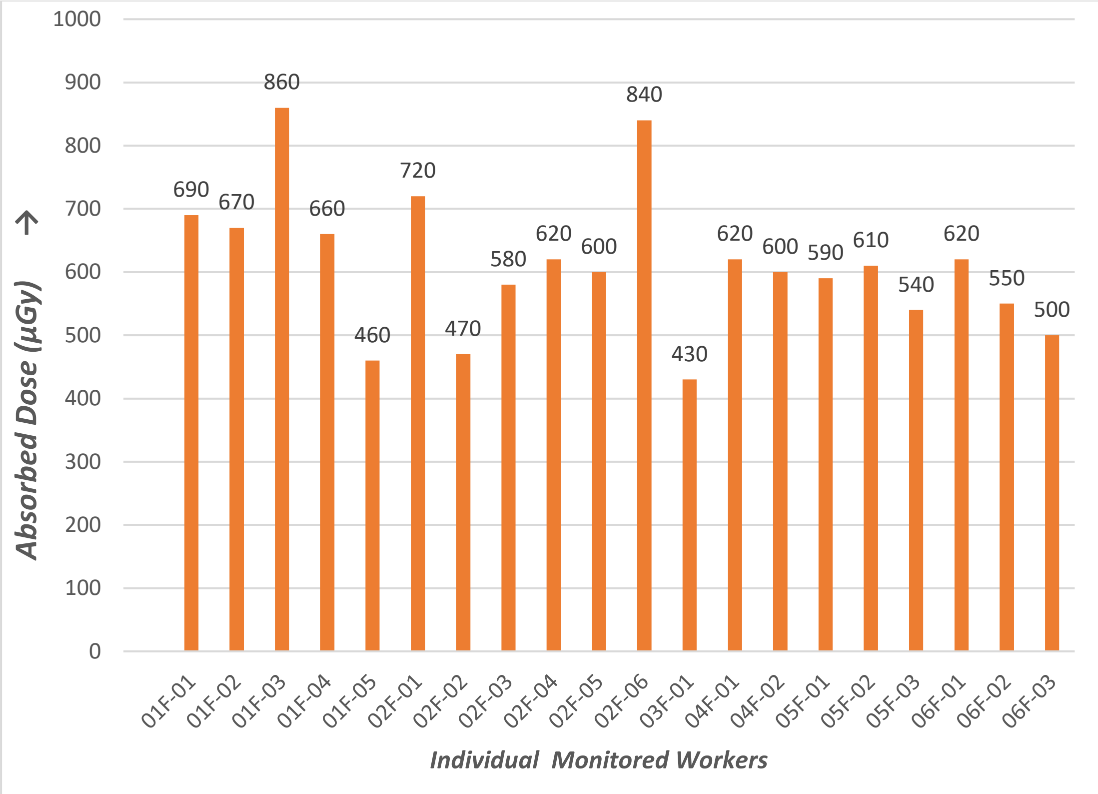

Figure 1 Chart of Radiation Dose Received by each Personnel.

Table 2. Mean Value of Radiation Dose Received by Different Class of Workers

S/N	Categories of worker	Mean dose equivalent (mSv)	Mean absorbed dose (mGy)	Mean absorbed dose (µGy)
1.	Radiographers	0.668	0.668	668.0
2.	Dark Room Technicians	0.638	0.638	638.0
3.	Radiologist	0.430	0.430	430.0
4.	Cleaners	0.610	0.610	610.0
5.	Record staff	0.580	0.580	580.0
6.	Finance staff	0.557	0.557	557.0

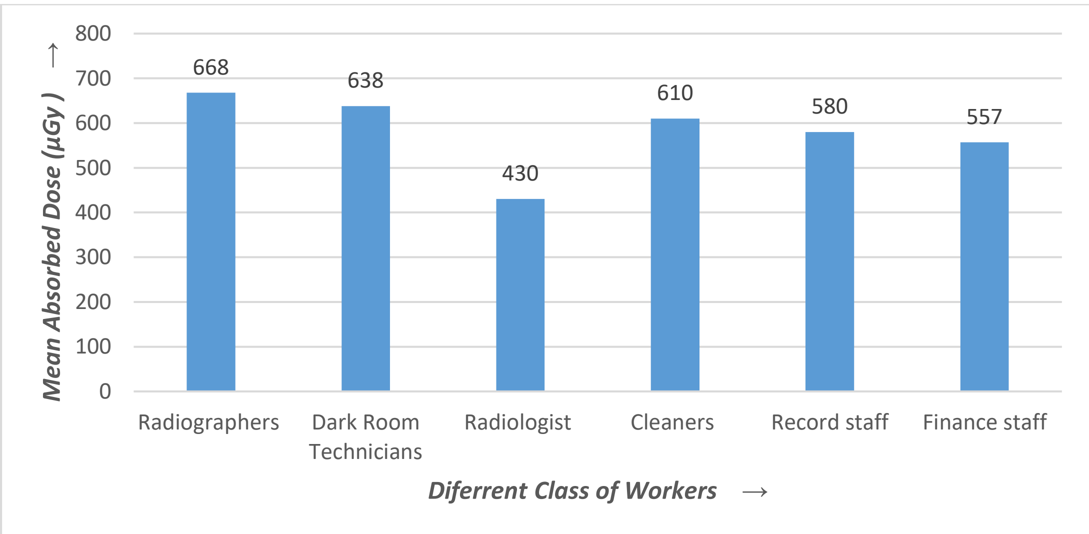

Figure 2. Chart of Mean Values of Radiation Dose Received by Different Class of Workers

Table 3. Weekly Absorbed Dose and Effective Dose Incurred by Radiographers

S/N	Radiographers	Depth dose equivalent (mSv)	Absorbed dose (mGy)	Absorbed dose rate (mGy/week)	Effective dose (mSv/week)	Effective dose (mSv/year)
1	01F-01	0.69	0.69	0.115	0.115	5.98
2	01F-02	0.67	0.67	0.112	0.112	5.82
3	01F-03	0.86	0.86	0.143	0.143	7.44
4	01F-04	0.66	0.66	0.110	0.110	5.72
5	01F-05	0.46	0.46	0.077	0.077	4.00

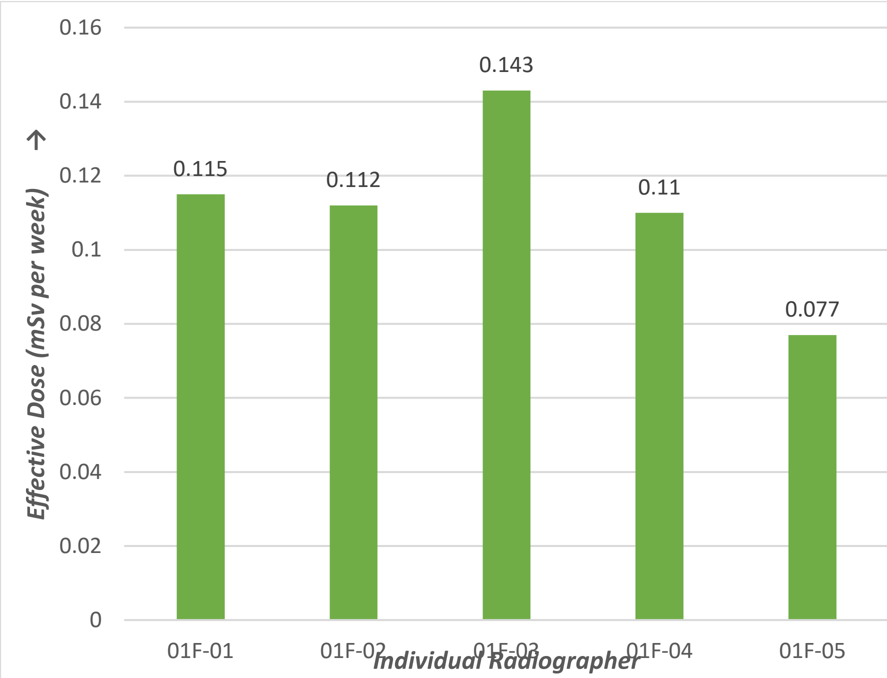

Figure 3. Charts Representing Effective Dose of Individual Radiographer

Table 4. Presents Absorbed Dose and Effective Dose Incurred by each Dark Room Technicians

S/N	Dark room technicians	Depth dose (mSv)	Absorbed dose (mGy)	Absorbed dose rate (mGy/week)	Effective dose (mSv per week)	Effective dose (mSv/year)
1.	02F-01	0.720	0.720	0.120	0.120	6.24
2.	02F-02	0.470	0.470	0.078	0.078	4.06
3.	02F-03	0.580	0.580	0.096	0.097	5.04
4.	02F-04	0.620	0.620	0.103	0.103	5.36
5.	02F-05	0.600	0.600	0.100	0.100	5.20
6.	02F-06	0.840	0.840	0.140	0.140	7.28

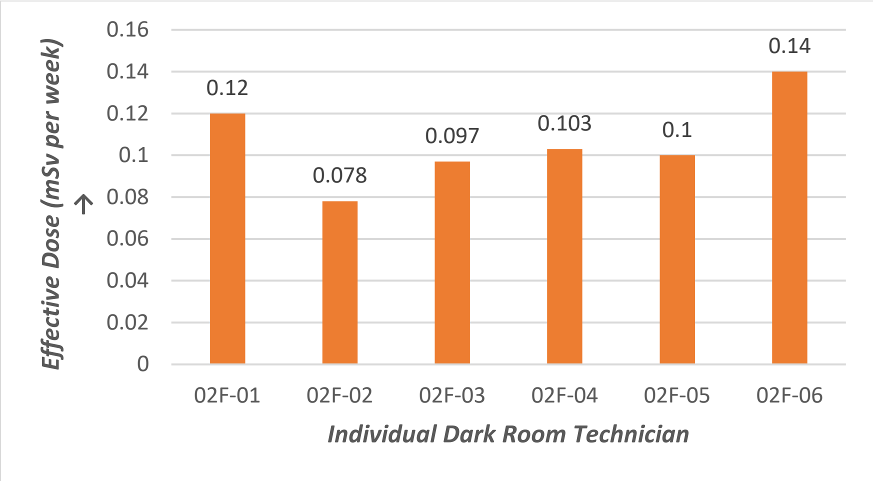

Figure 4. Chart of Effective Dose Incurred by each Dark Room Technicians

Table 5. Weekly Radiation Dose and Effective Dose Incurred by Cleaners

S/N0	Cleaners	Depth dose equivalent (mSv)	Absorbed dose (mGy)	Absorbed dose rate (mGy/ week)	Effective dose (mSv per week)	Effective dose (mSv/year)
1	03F-01	0.620	0.620	0.103	0.103	5.36
2	03F-02	0.600	0.600	0.100	0.100	5.30

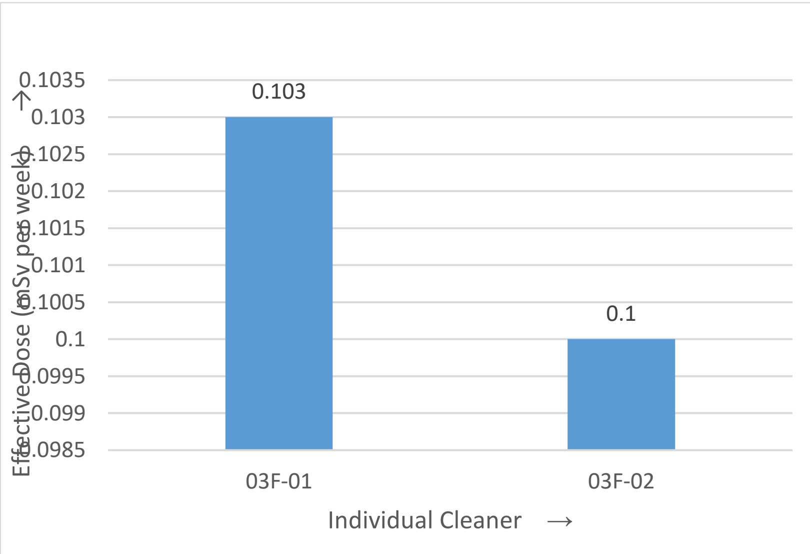

Figure 5: A pictorial representation of weekly effective dose incurred by cleaners.

Table 6. Weekly Radiation Dose and Effective Dose Incurred by Record Staff

S/N0	Record staff	Deep dose equivalent (mSv)	Absorbed dose (mGy)	Absorbed dose rate (mGy/week)	Effective dose (mSv per week)	Effective dose (mSv/year)
1	05F-01	0.590	0.590	0.098	0.098	5.10
2	05F-02	0.610	0.610	0.102	0.102	5.30
3	05F-03	0.540	0.540	0.090	0.090	4.68

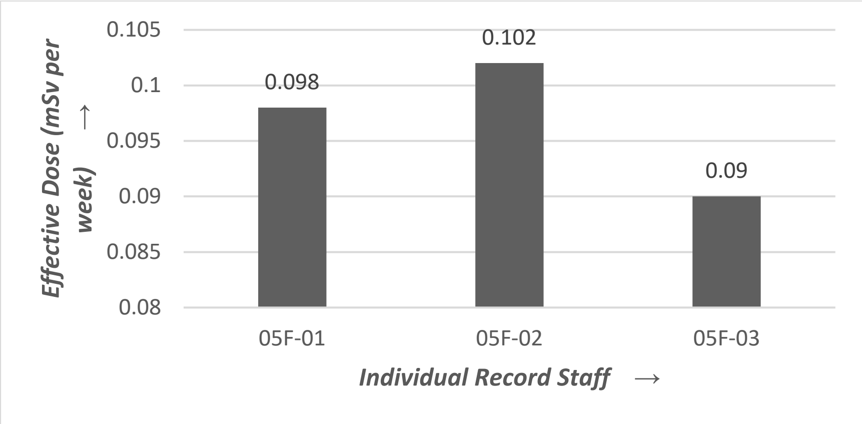

Figure 6. A Chart of Weekly Effective Dose Incurred by Record Staff

Table 7. Weekly Radiation Dose and Effective Dose Incurred by Finance Staff

S/N0	Finance staff	Deep dose equivalent (mSv)	Absorbed dose (mGy)	Absorbed dose rate (mGy/week)	Effective dose (mSv per week)	Effective dose (mSv/year)
1	06F-01	0.62	0.62	0.103	0.103	5.36
2	06F-02	0.55	0.55	0.092	0.092	4.78
3	06F-03	0.60	0.60	0.100	0.100	5.20

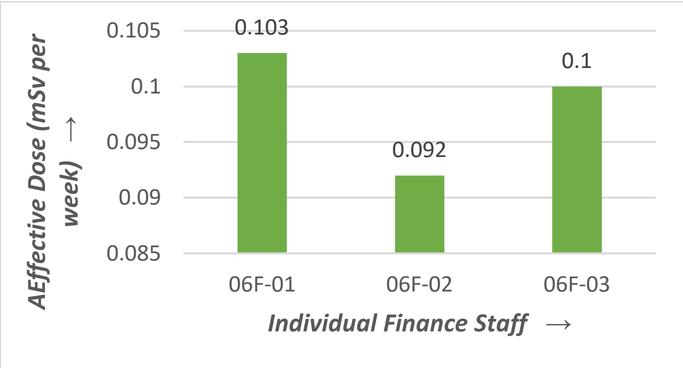

Figure 7. Chart of Weekly Effective Dose Incurred by Finance Staff

DISCUSSION

In this study, twenty (20) personnel were monitored with the use of thermoluminiscent dosimeters (TLDs) badges. The TLDs recorded the amount of radiation dose accumulated by each sampled participant from six (6) different categories of workers for a period of six working weeks. The TLDs were readout and evaluated with TLD Reading devices (Harshaw 4500A) with computer software application available at Center for Energy Research and Training, ABU Zaria. The results are produced as raw data in terms of Skin dose (mSv) and Deep dose (mSv). These results were analyzed, evaluated and presented in terms of absorbed dose and weekly effective dose accumulated by each monitored worker. These weekly effective doses were used for further calculations and projections for possible effective dose of workers over a period of one year, and was subsequently compared with the standard limits of 20 mSv per year for occupationally exposed worker as recommended by International Commission on Radiation Protection (ICRP).

Our result is similar to the result obtained by Ibitoye et al. (2011) (0.58msv), and Chida et al. (2013) (0.60msv), where their average annual doses were found to be well below the established standard.

The findings of this research can also be compared with the findings in a study that was conducted by Kelvin et al., (2024) on occupational radiation dose absorbed by radiographers in Port-harcourt, Rivers State Nigeria. It involved the use of interviews through a questionnaire and observation via the collected dose information of the radiographers from government hospitals and private imaging centres. According to their findings, mean annual doses of 0.2442 mSv for radiographers in government hospitals and 0.2732 mSv for those in private centres. By comparison, the average mean doses for both government hospitals and private centres are well below the occupational dose limit of 20 mSv set by International Commission on Radiological Protection (ICRP) throughout the period of study.

The results have also shown that radiographers received the highest mean dose of 668.0µGy, followed by Dark room technicians with 638.0µGy, then cleaners, record staff and finance staff recorded mean deep dose of 610 µGy, 580 µGy and 557 µGy respectively. The least mean dose goes to radiologist who received 430µGy.

CONCLUSION

The research focused to measuring and assessing the radiation dose received by personnel in conventional X-ray facility. This research has been the first of its type ever conducted in the study area. Although, Radiographers, Radiologist and Dark Room Technicians are aware of TLD as one of the personnel monitoring devices, they also need further education on its proper use. However, the results of this research showed that all the personnel received low level of exposure to radiation. The effective dose recorded by each worker were found to be less than ICRP recommended limits of 20 mSv/year for occupational worker. Therefore, workers have less fear of harmful effects of occupational exposure.

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