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Calibration of harshaw 4500 TLD reader and workplace monitoring of some selected diagnostic radiology centers in ibadan, Nigeria

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ABSTRACT

Calibration of Harshaw 4500 Thermo luminescence Dosimeter (TLD) Reader was carried out using standard X-ray beam. The response of the TLD reader to the increasing dose was found to be linear and the dose response characteristics measured were 0.68 mSv, 1.80 mSv and 3.39 mSv which were comparable respectively to 0.55 mSv, 1.87 mSv and 3.76 mSv obtained following manufacturers specification. However, at doses below 500 mSv deviation was observed between the two procedures. The supervised and controlled areas at the radiology diagnostic centers were monitored using TLD badges over a period of 60 days. The dose levels obtained ranges from 0.13 mSv/hr to 0.2 mSv/hr for the conventional x-ray rooms and 0.10 to 0.35 to 0.16 mSv/hr for the waiting areas. The readings obtained established that the diagnostics centers were free from under exposure to ionizing radiation.

Introduction

A well characterized and calibrated TLD system has gained wide acceptance worldwide for personnel and environmental monitoring[1]. It gives direct assessment of health effects of radiation since it provides information on the absorbed dose while counters which only provide information on the numbers of ionizing particles. A well calibrated system provides data to determine the contribution to the dose to public from man-made sources [2].

For the purpose, measurement are carried out starting from the radiological facility limits to country-wide locations. A permanent country-wide background monitoring result with passive dosimeters which serves as basis for calculation of the contribution to dose in accidental situations. However to arrive at an accurate measurement of data, a quantitative determination, under a controlled set of standard conditions, of the indication of an instrument as a function of the value measured must be well determined.

The aim of this work is to calibrating the TLD reader and comparing it with the existing calibration procedure, to assess the radiation level at the controlled and supervised area of some selected diagnostic radiology centres.

Materials And Method

Calibration of the TLD Reader

The X-ray Beam Irradiator Model X80 – 225 kV was used to provide irradiator system. The Harshaw Model 4500 TLD reader with WimREMS which consist of the TLD reader and the Window Radiation Evaluation and Management System (WinREMS) software resident on a personal computer (PC), which is connected to the Reader via a series communications ports was employed.

The Lithium Fluoride TLD cords were calibrated by exposing about eighty eight (88) TLD cards to a dose of 2 mSv in the Secondary Standard Dosimetry Laboratory (SSDL) at a distance of two metres away from the x-ray source. This is because the spherical ionization chamber which is the reference instrument was calibrated at two meters to the x-ray source. The TLD cards were left for 24 hours after exposure before reading in order to empty shallow traps. This is in accordance with the TLD readers manufacturer's specification. The TLD readout is called ECC. The x-ray beam quality and current used in this work was N100 and 18.7 mA respectively with a constant dose rate of 15 mSv/hr. the time of exposure were waved in order to get a range of standard dose needed.

In order to compare the existing calibration procedure with the current calibration procedure, two set of four TLD cards were exposed to doses 0.5 mSv, 1.5 mSv and 3.0 mSv respectively.

To generate the calibration factor, a set of four cards were exposed to different doses ranging from 0.2 mSv to mSv at distance two metres to the x-ray source at constant beam quality and current of N100 and 18.7 mA respectively at 15 mSv/hr dose rate. The exposure time was varied to vary the dose reacting the TLD badges as shown in Table 1 .

Table 1 TLD response nC with dose at the SSDL

Exposure time (sec)	Standard Dose (mSv)	TLD Reading (nC)	
		Deep dose	Surface dose
48	0.2	5.1± 0.5	5.4± 0.4
120	0.5	8.0 ± 0.7	8.1± 0.4
600	2.5	30.6 ± 1.7	37.6 ± 2.3
1200	5	62.2 ± 3.1	73.7± 5.6
1800	7.5	93.2 ± 1.3	107.9±4.6
2400	10	128.7 ± 12.2	143.4± 11.2
3000	12.5	153.7 ± 5.4	171.5 ± 6.0
3600	15	183.7 ± 7.4	208.1 ± 6.2
4200	17.5	215.0 ± 5.7	248.7±6.2
4800	20	238.3± 18.7	297.4±6.4

Measurement of Radiation

The radiological department of University College Hospital (UCH) and Twotees Diagnostic Center, were selected for area

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Table 2: Information on the x-ray machines at UCH and Twotees diagnostic center

		UCH	Twotees diagnostic
X-ray room 2	Name of manufacturer	GE Medical System	Picker International
	Model of equipment	TMX	Roentgen 201
	Max Kvp	125 kv	125 kv
	Type	Mobile	Fixed
X-ray room 1	Name of manufacturer	GE Medical System	Allengers
	Model of equipment	Silhouette VR	Allengers 525
	Max Kvp	125 kv	125 kv
	Type	Fixed	Fixed
Mammography room	Name of manufacturer	GE Medical System	Philips
	Model of equipment	Senographe DMR	Mamodiagnost
	Max Kvp	35KV	35 kv
	Type	fixed	fixed

Table 3: Surface dose readings after exposure of TLD badges to standard doses at the SSDL

Standard dose at SSDL (µSv)	Surface dose reading using existing procedure (µSv)	Surface dose reading (µSv) using current procedure	Surface dose reading using current procedure (nC)
3000	3420±358.9	4349.0±144.3	62.74±2.1
1500	1935.7±20.0	2063.3±102.6	30.07±1.5
500	796.7±29.3	741.0±94.5	11.17±1.4

Table 4: TLD readings after exposure to standard doses at the SSDL

Standard dose at SSDL (µSv)	Deep dose reading using existing procedure (µSv)	Deep dose reading (µSv) using current procedure	Deep dose reading current procedure (nC)
3000	3393±242.5	3764.81±478	48.07±6.1
1500	1809.5±35.9	1867±50.7	25.3±0.7
500	688.05±21.7	553.50±11.15	9.51±0.2

Table 5: Result of scattered radiation inside the x-ray rooms at Twotees diagnostic center

	x-ray room 1		*X-ray room 2*		*mammography*	
TLD distance to x-ray source (m)	1.37	1.83	1.83	1.98	2.29	2.59
Deep dose reading (µSv) using existing procedure	2886.2±84	2208± 79.5	1001±29.6	901.6±26.9	295±18.0	191±17.1
Deep dose reading (nC)	37.5± 1.6	29.6±0.8	16.3±0.5	16.2±0.4	4.3±0.1	3.02±0.3
Deep dose reading (µSv) using current procedure	2885.0± 123	2226.0± 60.3	1118.3± 34.6	1110.0± 27.5	119.1± 2.9	12.6± 2.1

Table 6: Result of scattered radiation inside the x-ray rooms at Twotees diagnostic center

	x-ray room 1		*X-ray room 2*		*mammography*	
TLD distance to x-ray source (m)	1.37	1.83	1.83	1.98	2.29	2.59
Skin dose reading (µSv) using existing procedure	3565.9±77.5	1993.4±40.9	1059.0±58.1	1006.1±52.5	301.0±19.1	205.0±17.2
Skin dose reading (nC)	55.6±1.5	30.5±1.1	20.0±1.3	19.3±1.0	4.1±0.1	3.7±0.4
Skin dose (µSv) using current procedure	3850.0±103	2093.4±75.2	1358.6±88.5	1310.0±68.2	246.0±6.5	218.0±26

Table 7: Radiation reading at the control panel of the x-ray rooms at Twotees Diagnostic Center Ibadan

	x-ray room 1	*x-ray room 2*	*Mammography room*
Skin dose (µSv)	225±.33.77	283±40.95	507.7±14.11
Deep dose (µSv)	216.95±14.30	263± 15.16	392.9±13.31

Table 8: Radiation reading at the control panel (occupational exposed area) of x-ray rooms at UCH

	x-ray room1	*x-ray room 2*	*x-ray room 3*	*mammography room*
*Skin dose (*µSv*)*	289.0 ± 37.0	219.2±15.1	197.66±22.96	150.0±15.35
Deep dose *(*µSv	260.9±14.87	230.3±3.2	181.95±10.9	155.98±4.45

Table 9: Radiation reading at the waiting/public area of UCH Ibadan and Twotees diagnostic center Ibadan

	UCH	Twotees
Skin dose(µSv)	178.59±23.9	229.37±17.0
Deep dose(µSv)	165.50±14.8	196.97±11.2

dose monitoring in this work because of the availability of different diagnostic radiology equipment in the two centers. Also, the two centres were the most visited for diagnostic radiology examinations in Ibadan.

The available diagnostic radiology equipment at the two centers are show in Table 2 four TLD badges each were placed at the x-ray room at both UCH and Twotees diagnostic centres to monitor the radiation reaching occupational exposed area. Also, another four TLD badges each were placed at the public area to monitor the radiation reaching the general public. The supervised and the controlled areas of these two diagnostic centers were monitored over a period of 60 days.

The two calibration procedure were also compared using the result of the scattered radiation inside the x-ray rooms of UCH and Twotees diagnostic centres by placing eight TLD badges each at selected points. The first set of four TLD badges were read using the existing (manufacturers) procedure with the other four were read using the current procedure.

The Lithium Fluoride TLD badges are then taken to the Secondary Standard Dosimetry Laboratory (SSDL) for reading after 60 days. The already calibrated Harshaw 4500 TLD reader was used for this purpose by heating the TLD material from ambient temperature up to 400^0C.

Result and discussion

The comparison of the two calibration procedure by exposing the TLD badges to standard dose at 0.6 mSv, 1.5 mSv and 3 mSv gave a deep dose reading of 0.68 mSv, 1.80 mSv and 3.39 mSv using the existing calibration procedure (Table 3) .The surface dose reading gave 0.79 mSv, 1.94 mSv, and 3.4 mSv for existing procedure and 0.75 mSv, 2.05 mSv and 4.3 mSv respectively using the current calibration procedure (Table 4).

The two calibration procedure were further compared using the result of radiation measurement inside the x-ray rooms of Twotees Diagnostic Center presented in Table 5 and table 6. The surface dose reading in (mSv) at x-ray room one using existing procedure gave 3565.9±77 and 1993.4±40.9 while the current procedure gave 3850±103 and 2093.4±75.2 respectively. The deep dose reading in (mSv) for x-ray rooms using existing procedure gave 2886.2±80.4 and 2208±79.5 while the current procedure gave 2885±123 and 2260±60.3 respectively.

At X-ray room two the surface dose reading using existing procedure gave 105±9.058.1 mSv and 1006.1±52 while the current procedure gave 1358.6±88.5 mSv and 1310.0±68.2 mSv respectively. The deep dose reading at x-ray room two gave 1001.0±29.6 mSv and 901.6±26.9 mSv while the current procedure gave 1118.0±34.6 mSv and 1110.0±27.5 mSv respectively. The surface dose reading at the mammography room using existing procedure gave 301.0±19 and 205.0±17.2 mSv whereas the current procedure gave 246.0±6.5 m and 218.0±26 mSv respectively. The deep dose reading using existing procedure gave 295.0±18.0 mSv and 191±17.1 mSv while the current procedure gave 191.0± mSv and 12.6±2.1 mSv respectively.

The mammography room of Twotees Diagnostic Center as the highest dose rate at the control area with 0.35 mSv/hr for surface dose rate and 0.27 mSv/hr for deep dose rate as indicated in Table 7 while the radiation level at x-ray room 2 was 0.20 mSv/hr for surface dose rate and 0.18 mSv/hr for deep dose rate. The readings at the control panel of x-ray room 1 were 0.16 mSv/hr for surface dose and 0.15 mSv/hr for deep dose rate.

The radiation level obtained at x-ray room 1 were 0.20 mSv/hr for surface dos rate and 0.18 mSv/hr for deep dose rate and x-ray room 2 has 0.15 mSv for surface dose rate and 0.16 mSv/hr for deep dose rate. While x-ray room 3 has 0.14 mSv for surface dose rate and 0.13 mSv for deep dose rate and mammography room has 0.10 mSv for surface dose rate and 0.11 mSv /hr for the deep dose rate.

Table 9 indicate radiation level at the public area of the two diagnostic centers, UCH has 0.12 mSv/hr for surface dose rate and 0.12mSv/hr for deep dose rate while at twotees diagnostic center, the radiation reading in the public area gave 0.14mSv/hr for surface dose rate and 0.13mSv/hr for deep dose rate.

The control dosimeter was issued to the two diagnostic centers. The control dosimetry for twotees diagnostic centre gave 0.125 mSv/hr and 0.12 mSv/hr for surface dose rate and deep dose rate respectively while the control dosimeter for UCH gave 0.11 mSv/hr and 0.11 mSv/hr for and deep dose rate respectively.

In this work, it was deduce that TLD material has linearity of response with dose. This is one of the properties of TLD[4]. The two calibration curve intercept the y-axis at 2.869 nC for deep dose and 0.585 nC for surface dose. These values represent the average residual charge in trapped in the TLD cards after annealing. It was observed that at doses lower than 0.5 mSv, the TLD cards have almost the same response for the both deep dose and skin dose. As doses increase above 0.5 mSv, the readings for surface dose were higher than deep dose.

At doses above 0.5 mSv, there were minimal difference between the result of the current calibration procedure and exiting calibration procedure. There were minimal difference from the result obtained from the radiation measurement inside the x-ray rooms of twotees diagnostic center.

The small variations between the two calibration procedure might be due to the natural variation in TLD material responsiveness and the physical mass of manufactured chip. This implies that the two calibration procedure can be used to calibrate Harshaw 4500 TLD reader. However, the comparison of the result of the two calibration procedures at doses lower than 0.5 mSv shows high variation in TLD reading. This is because values lower than 0.5 mSv are close to the background radiation and the lower detection limit at the TLD reader since the detection limit of the Harshaw 4500 reader has been established, doses lower than 0.5 mSv might be out of detection range the TLD reader which might contribution to the inconsistencies observed in the two calibration procedures at very low doses.

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