Radiation measurement at X-ray room at different angles and distances at a hospital

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Abstract-- Due to the short wavelength, X-rays carry high energy to cause ionisation. These radiations cause ionisation of different biological and non-biological molecules in our body and pose a health hazard.This study highlights both occupational exposure for medical staffs at the hospital and non occupational exposure for people visiting the radiological department of the hospital. A digital personal dosimeter (LUDLUM MODEL 25) was used for the measurement of radiation at different angles and distances. The observations highlighted increased exposure for public irrespective of the distance or angle of observation whereas for occupational personells, it lies reasonably below the ICRP recommendations.

Keywords—Dosage, exposure dose, exposed population, ICRP, occupational exposure, unexposed population.

I. Introduction

Discovered by Rontgen, X-Ray is perhaps the most widely used diagnostic tool in medical profession. X-rays are Electromagnetic (EM) radiations having low wavelength and high energy. Due to their short wavelength and high energy, they exibit ionizing power. This property is responsible for its application in the medical field but aslo causes serious health risks. Besides cancer, exposure to high doses of radiation over a short period of time can cause radiation sickness and even death.

II. Materials and Methods

The study was done on a 200mA X-ray machine of M/S EMAI Ltd. make. The X-ray tube of the machine is rotating anode type, manufactured by Bharat Electronics. The machine was installed on June 2002.
Radiation was measured with the help of a personal digital dosimeter, Ludlum Model 25 at different distance and angle across the X-ray room and the X-ray control room at room no. 4 of Department of Radio-diagnosis, North Bengal Medical Collage and Hospital (NBMCH), Sushruta Nagar, Darjeeling from 10am to 2pm. The room was 24 feet x 17 feet and the machine was placed at 3m along its length from the entrance door. The dosimeter readings were recorded in mR/hr and converted to mSv/year and corresponding value of X-ray parameters such as kV, mA and exposure time were noted.

III. Observation and Discussions

Measurement were taken at various angles and distances and the average value of the parameter such as kV, mA and exposure time were found out to be nearly 60, 100 and 0.35 secs respectively.
The observed data are as follows:

Distance from the tube (m)	1m (Range)	1m (Mean)	1.5m (Range)	1.5 (Mean)	2m (Range)	2m (Mean)	Extreme Corner (Range)	Extreme Corner (Mean)
No. of readings	6	--	6	--	11	--	4	--
Exposure dose (mR/hour)	0.03-0.12	0.065	0.04-0.09	0.056	0.01-0.04	0.049	0.03-0.09	0.037
Exposure dose (mSv/year)	2.63-10.52	5.69	3.51-7.89	4.91	0.88-3.51	4.29	2.63-7.89	3.24

Table 1: Observations for unexposed population at different distances

Initial Dosimeter Reading (mR)	16.72
Final Dosimeter Reading (mR)	18.08
Working time (HH:MM)	02:15
No. of X-ray images taken	27
Calculated Dosage without shielding (mR/hour)	0.60
Calculated Dosage without shielding (mSv/year)	52.98
Quality Factor	0.68
Practical Dosage without shielding (mSv/year)	36.02
Practical dosage with shielding (mSv/year)	12
ICRP recommended limit (mSv/year)	<20

Table 2: Observations for exposed population.

Angle between tube and dosimeter (Degree)	Distance (m)	Exposure dose (mR/hour)
0	1	0.06
10	1	0.07
20	1	0.07
30	1	0.06
40	1	0.06
50	1	0.06
60	1	0.06
70	1	0.06
80	1	0.07
90	1	0.07

Table 3: Exposure dose observation for various angles at a fixed distance for 60kV, 100mA and 0.3secs exposure time.

Measurement angle (degree)	Exposure dose at 1m (mR/hour)	Exposure dose 1.5m (mR/hour)	Exposure dose 2m (mR/hour)
0	0.065	0.056	0.049
90	0.065	0.056	0049

Table 4: Radiation dose at various angles for fixed X-ray parameters.

IV. CALCULATION

Quality factor (approximate):
Total no. of official working days in a year= 261
Total no. of non-working days due to maintainance and repair of the machine in a year= 11
Total no. of practical working day in a years= 261-11=250
Quality factor= 250/365=0.68
Unit conversions- A milliroentgen/hour is the derived unit of ionizing radiation dose. 100 milliroentgens equal to 1 millisievert on condition that biological effects of ionizing radiation or other photon radiation, for example gamma radiation, is considered. A millisievert per year (mSv/y) is the SI derived unit of radiation absorbed dose rate. The sievert (Sv) is the SI derived unit of equivalent radiation dose, effective dose, and committed dose. 1 sievert is the energy absorbed by one kilogram of biological tissue, which has the same effect as one gray of the absorbed dose of gamma radiation. Therefore the sievert can be expressed in terms of other SI units as;
Sv = 1 J/kg. Therefore, 1 J/kg·s = 1 Sv/s = 3.15576 * 1010 mSv/y.
1 millisievert/year [mSv/year] = 0.0114077116130504 milliroentgen/hour [mR/h]

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V. Conclusion

The radiation dose limits as recommended by ICRP are as follows:
1. The annual average dose over five years should not exceed 20 mSv/year for occupational persons.
2. General population should not be exposed to more than an average of 1 mSv/year.

The radiation dose was found out to be equal at a fixed distance irrespective of the angle measured. It was also observed that the radiation dose was inversely propotional to the distance between the machine and the observation point.
The radiation dose level was found out to be well above the safe limits for non-exposed hospital visiting people accompanying the patients in the X-ray room. It was about 4.53 mSv/year, while converting the results obtained in a 7 day period against the safe limit of 1mSv/year as recommended by ICRP for general public.

For exposed population, such as techincians working in the hospital, the dosage without shielding was found out to be 36.02 mSv/year against the ICRP recommened safe limit of less than 20mSv/year whereas the dosage was withing the safety limit under shielded conditions.

We observe that there is well known health hazard risk for both the exposed and the non-exposed population visiting the X-ray room. It can be concluded that the exposed population working at these machines such as technicians, employees, maintainance workers have a threat of occupational exposure disease. In this case, there is a need of adequate and appropraite radiation protection for people visiting the X-ray room.

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