BERKELEY PUBLICATION
03.31.2020 AND RESEARCH INTERNATIONAL
Journal of Med., Biological and Pharm. Sci. Vol. 12 No. 3

THE DOSIMETRY OF X-RAY LINE SOURCE IN TISSSUES

***AREMU S.O **HAQUE M.F. *ODELAMI K.A. *NDAWASHI M.**
**Federal polytechnic Bauchi **Abubakar Tafawa Balewa University Bauchi.*

ABSTRACT

The absorbed doses in tissues due to X-ray line sources was computed as a function of exposure time, Photon energy, attenuation angles and the length of the source. The absorbed dose is found to increase linearly with exposure time and attenuation angles while it increases gradually and approaches towards a stationary value as the length of the source is increased. With the increase in Photon energy, the absorbed dose is found to increase almost linearly while it decreases exponentially as the distance between the source and the target is increased.

Keywords: Dosimetry, X-Ray, Line, Source Tisssues.

accurate measurement of doses imparted to the target volume. The history of radiation dosimetry is fraught with many sometimes confusing concepts and

Introduction:

Medical imaging is a widely expanding field of development and research. Techniques such as X-ray computed tomography (CT) and more recently magnetic resonance imaging (MRI) have revolutionized diagnosis and treatment of a wealth of illnesses. The contrast presented by a medical image is a consequence of the type of interactions occurring between probing radiation and the different tissues that compose the body. X-rays yield images where bones are prominent since X-rays are far less absorbed by most other tissues in the body. Magnetic Resonance imaging (MRI) images examine the response of molecules to changes in magnetic field. Such techniques involve an definitions. Dosimetry will be measured using definitions define by the International Commission on Radiological Units (ICRU) and measurements in their 1962 report 10a "Radiation quantities and units" [1].

Absorbed dose is a measure of energy deposited in a medium divided by the mass of the medium. If a large mass element is chosen and the energy deposited is measured, a value of

$(E/m)_1$ will be obtained as indicated in figure 1. If a smaller mass element is chosen and the value $(E/m)_2$ is measured, it will be found out that $(E/m)_2$ will be larger than $(E/m)_1$. When m is large enough to cause significant attenuation of the primary radiation, the fluence of the charged particles in the mass element under consideration is not uniform. This causes the ratio E/m to increase as the size of the mass m is decreased [1-3].

As m further reduces a region in which the charged particle fluence is sufficiently uniform it will be found that the ratio E/m is constant. It is in this region that the ratio represents the absorbed dose. At the other extreme, m must not be so small that the energy deposition is caused by a few interactions. If m is further decreased from the region of constant E/m, it will be found that the ratio will diverse that is as m gets very small the energy deposition is determined by whether or not a charged particle interacts within m. Consequently, E will be zero for many mass elements and very large for others. These fluctuations occur because charged particles lose energy in discrete steps. Hence, the limiting process requires that the mass element m be large enough so that the energy disposition is caused by many particles and many interactions. Similar idea may be applied for other quantities (e.g. Particle (Photon) fluence $= \frac{N}{A}(\frac{particles}{m^2})$, Particle (Photon) flux density $\varphi = \frac{N}{At}(\frac{particles}{m^2 s})$, Energy fluence $F = \frac{NE}{A}(\frac{Mev}{m^2})$

Energy flux density $I = \frac{NE}{At}(\frac{Mev}{m^2 s})$ e.t.c.) and macroscopic quantities must be varied so that a limiting process as described above has occurred[4-7].

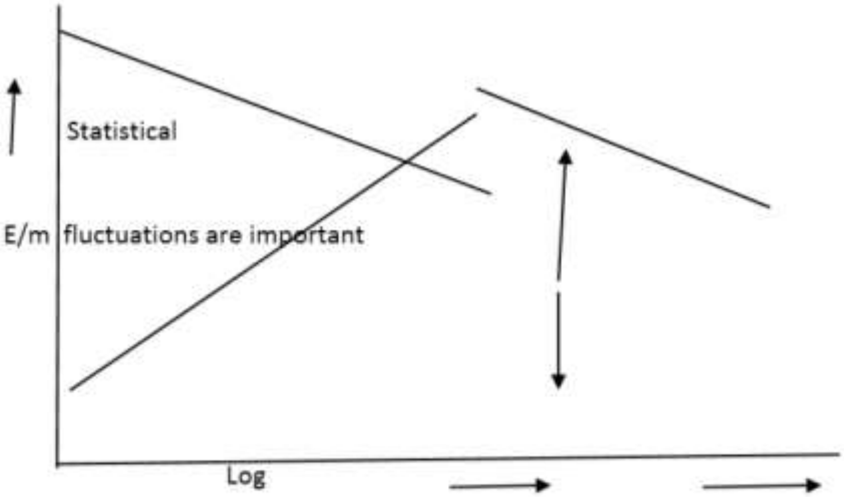

Fig. 1: Energy density as a function of mass for which energy density is determined.

Method

Particle fluence at a point P from a line source of length L depends on the location of P with respect to the line. Three points as indicated in fig.3 will be considered (Fitzerland *et.al.*, 1967)

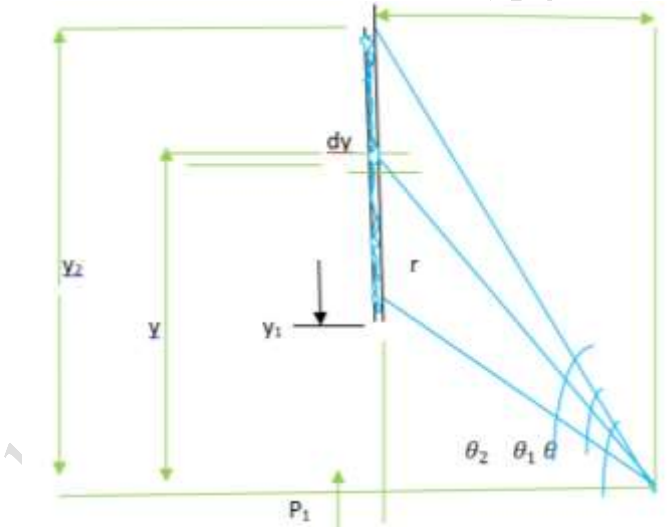

Fig. 2: A figure showing the line isotropic source dimensions for $\emptyset_1$

At P_1, $\emptyset_1 = \frac{S_L}{4\pi h}(\theta_2 - \theta_1)$ . . . (1)

For the situation where the point of interest P_3 is on the axis of the line source:

$$\emptyset_3 = \frac{S_L}{4\pi nl}[n-1] \quad . \quad . \quad . \quad (2)$$

A line source can be approximated by a point source as can be seen in the following simplest geometrical situation (Morgan and Twiner, 1967)

$$\emptyset_2 = \frac{S_L}{4\pi h}(\theta_2 + \theta_1) \quad . \quad . \quad . \quad (3)$$

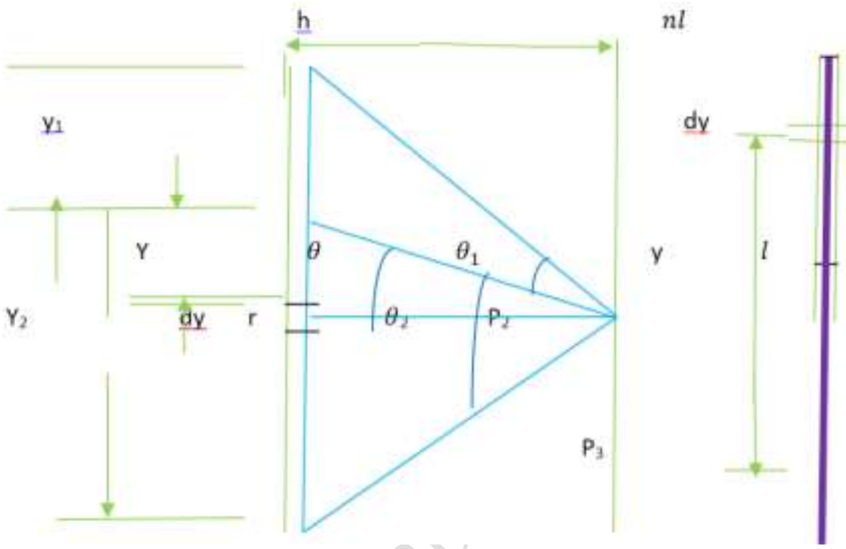

Fig. 3: A figure showing the line isotropic source dimensions for $\emptyset_2$ and $\emptyset_3$

The relationships between the radiation dose absorbed by tissues and the line source function parameters were investigated by varying a parameter and keeping others constant at various times till all the parameters were evaluated with respect to the radiation dose absorbed by the tissues at three different filament currents of 4.2A, 4.4A and 4.6A. 0.1s – 1s interval was used

for exposure time while Photon energy varies from 20 – 130MeV, 50 – 150MeV and 60 – 160MeV for filament current 4.6A, 4.4A and 4.2A respectively.

$$D(\mathrm{rad}) = \frac{1}{100}\emptyset E\left({}^{\mu_{en}}/_{\rho}\right)$$

$$\text{For line source, } \emptyset_3 = \frac{S_L}{4\pi nl}(n-1)$$

$$\emptyset_2 = \frac{S_L}{4\pi h}(\theta_2 + \theta_1)$$

$$\emptyset_1 = \frac{S_L}{4\pi h}(\theta_2 - \theta_1)$$

$$S_L = \text{No of Photons X mAs}$$

E = Photon Energy

μ_{en} = Mass Energy coefficient

ρ = Density of air

h = Distance between the source and the target

Result and Discussion

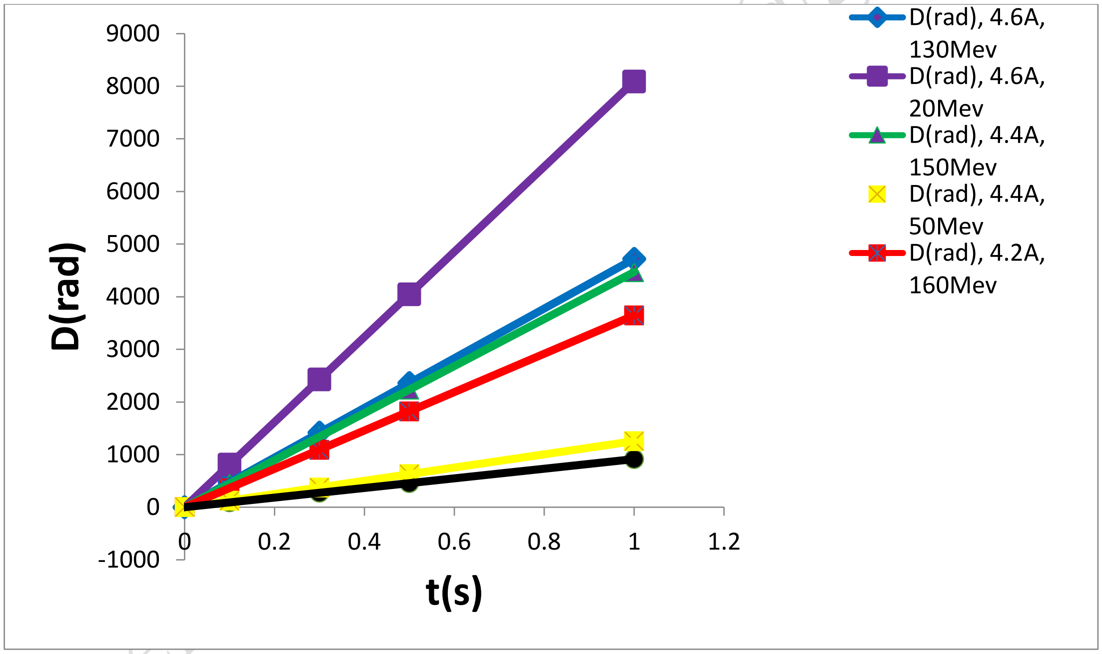

Fig. 1: Plots of absorbed dose (Rad) vs exposure time for line source (ϕ_2) with constant photon energy. h= 1cm, $\theta_1 + \theta_2 = 10^0$

Absorbed doses were plotted against the time of exposure for filament current 4.6A, 4.4A and 4.2A at constant photon energy 130Mev and 20Mev for 4.6A, 150Mev and 50Mev for 4.4A and 160Mev and 60Mev for 4.2A for line source(ϕ_2) . Constant distance of 1cm and angles sum of 100^0 were used for all the filament currents considered. At all the three filament current, absorbed dose increases linearly with time of exposure for line source (ϕ2) at distance 1cm irrespective of the Photon energy. Irrespective of radiation factors considered the more the time of exposure of target to radiation source, the more the radiation photon reaching the target and hence the higher the absorbed radiation dose by the target. However at constant distance, time and filament current, the absorbed dose by the target increases with the filament current as indicated by figure 1.The absorbed doses in this figure are high due to high angles sum used. As the sum of angles decreases the absorbed dose by target will also decrease.

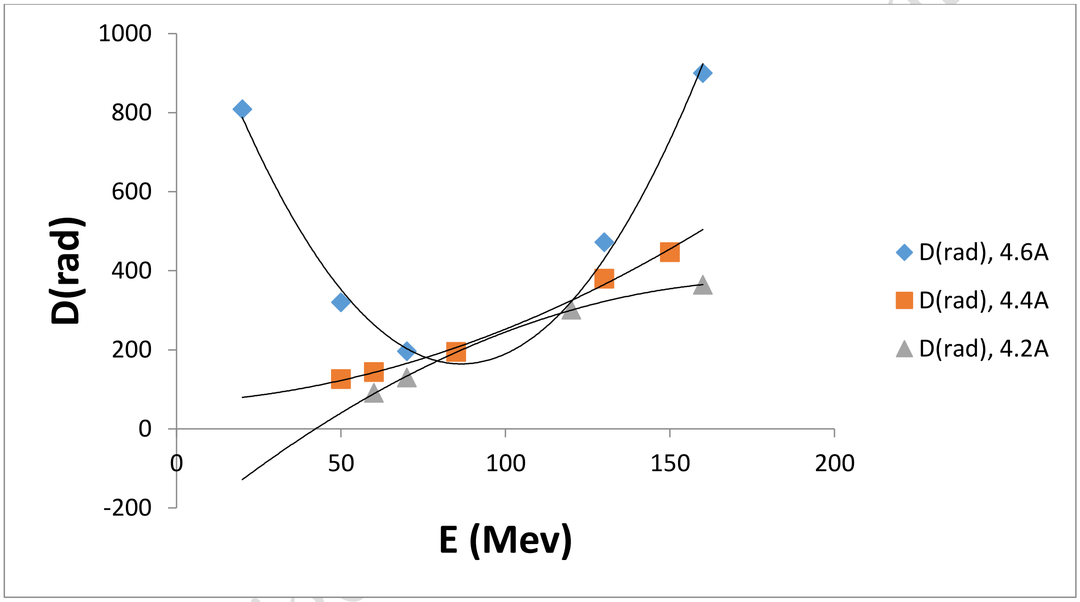

Fig. 2: Plots of absorbed dose vs photon energy for line source (ϕ2) at constant exposure time. Exposure time = 0.1s, h = 1cm, $\theta_1 + \theta_2 = 100^0$

Absorbed dose by the target was plotted against the photon energy for filament current 4.6A, 4.4A and 4.2A at constant distance of 1cm, constant time of 0.1s and constant attenuation angle of 100^0 for line source (ϕ2). For filament current 4.6A The Photon energy is quadratically related to the absorbed dose the target .The absorbed dose decreases with energy increase and started increasing with Photon energy at 95MeV. However, for filament current 4.4A and 4.2A the absorbed dose increases almost linearly as Photon energy increases. This is because the more the photon hitting a target at constant time and distance, the higher is expected to be the dose absorbed by the target. This was true for filament current 4.4A and 4.2A. At higher filament current the absorbed dose with energy increase at low energy and increases with photon energy at higher photon energy. At high filament current like 4.6A the number of scattered photon is high at low energy hence the number of photon reaching the target is low. However when the photon energy is high irrespective of the filament current the absorbed dose increases with photon energy.

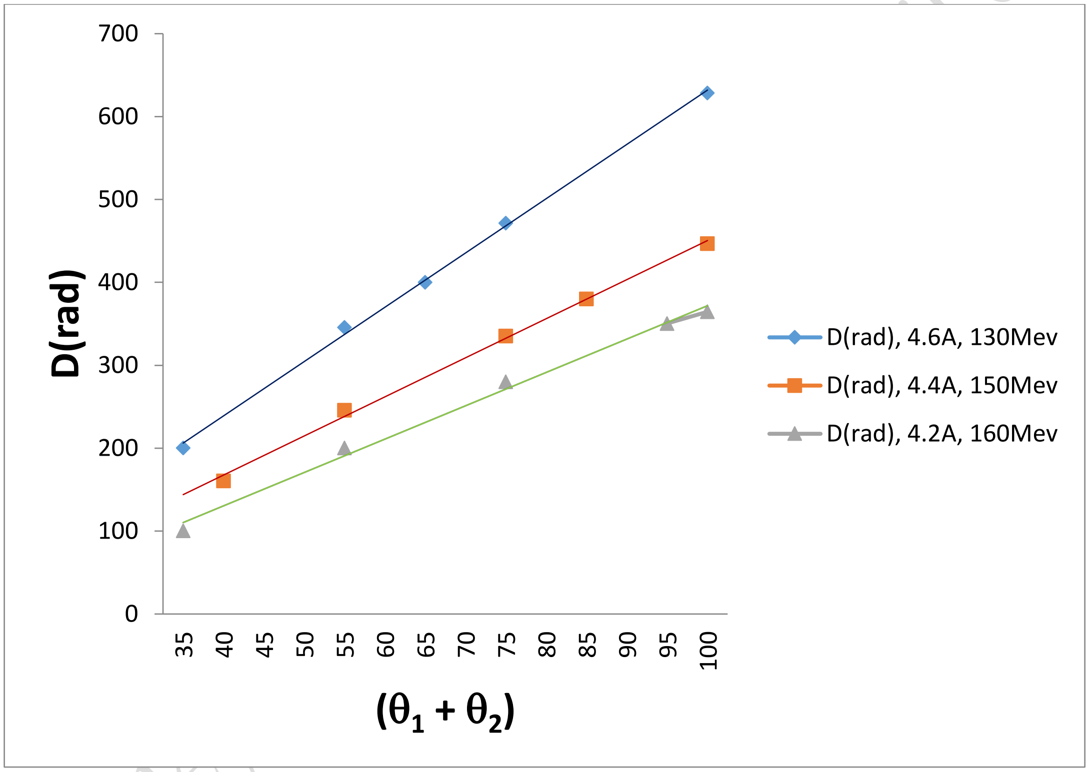

Fig. 3: Plots of absorbed dose vs angle ($\theta_1 + \theta_2$) for line source (ϕ_2) at constant photon energy distance and exposure time. Exposure time = 0.1s, h = 1 cm.

Absorbed dose by the target was plotted against the attenuation angle sum at constant photon energy, distance and exposure time. The absorbed dose increases as ($\theta_1 + \theta_2$) increases irrespective of photon energy at all filament currents. However, it was observed from the figure that the higher the filament current the higher the absorbed dose by the target at constant ($\theta_1 + \theta_2$).

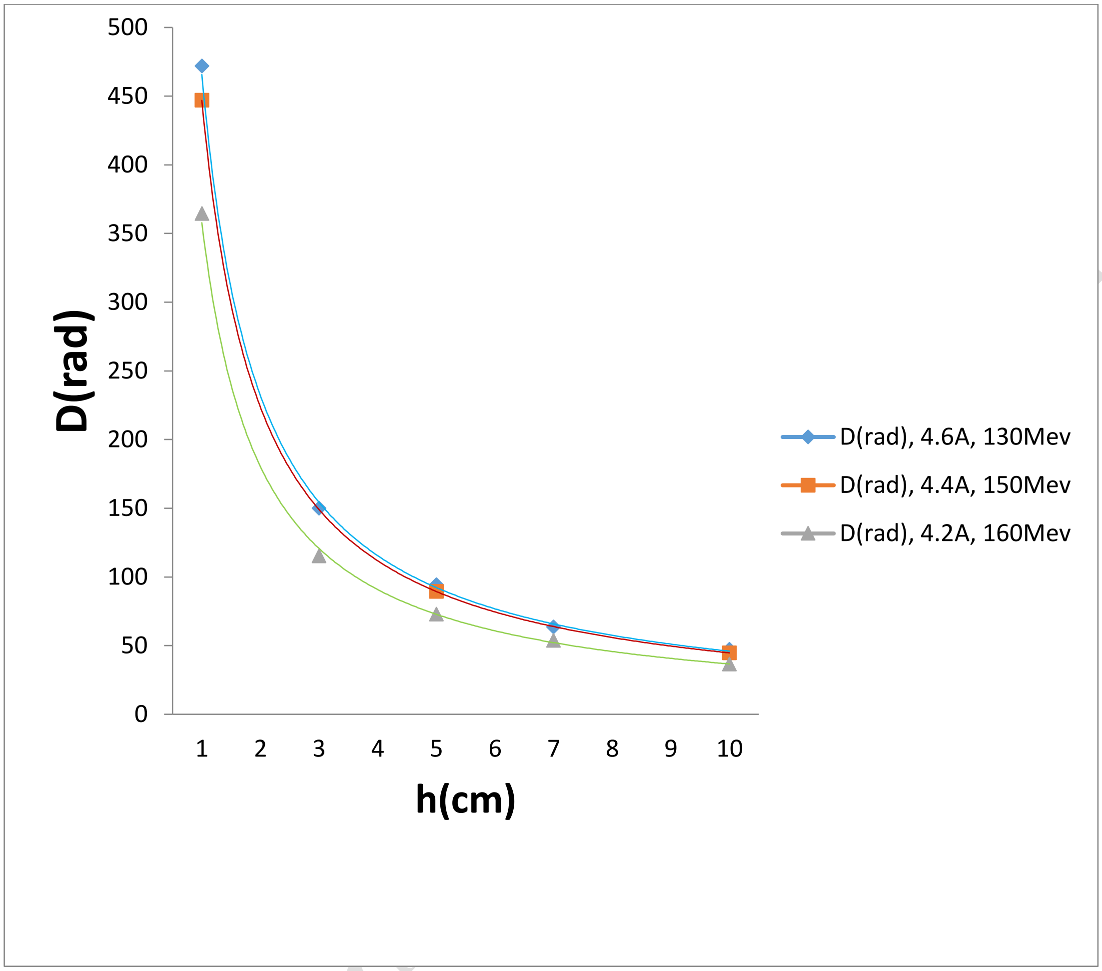

Fig. 4: Plots of absorbed dose vs height (h) for line source (ϕ_2) at constant photon energy and exposure time. Exposure time = 0.1s, $(\theta_1 + \theta_2) = 100^0$

Absorbed doses by the target were plotted against the height of the source at constant time of 0.1s and constant filament current 4.6A, 4.4A and 4.2A at constant photon energy 130Mev for 4.6A, 150Mev for 4.4A and 160Mev for 4.2A for line source (ϕ_2). At all filament current irrespective of photon energy the absorbed dose decreases with increase in distance. The amount of scattered radiation photon increases with increase in height of the source hence decreasing the amount of radiation photon reaching the target which in turn leads to low absorbed radiation dose. However at constant height, time and photon energy the absorbed dose by the target increases with increase in filament current.

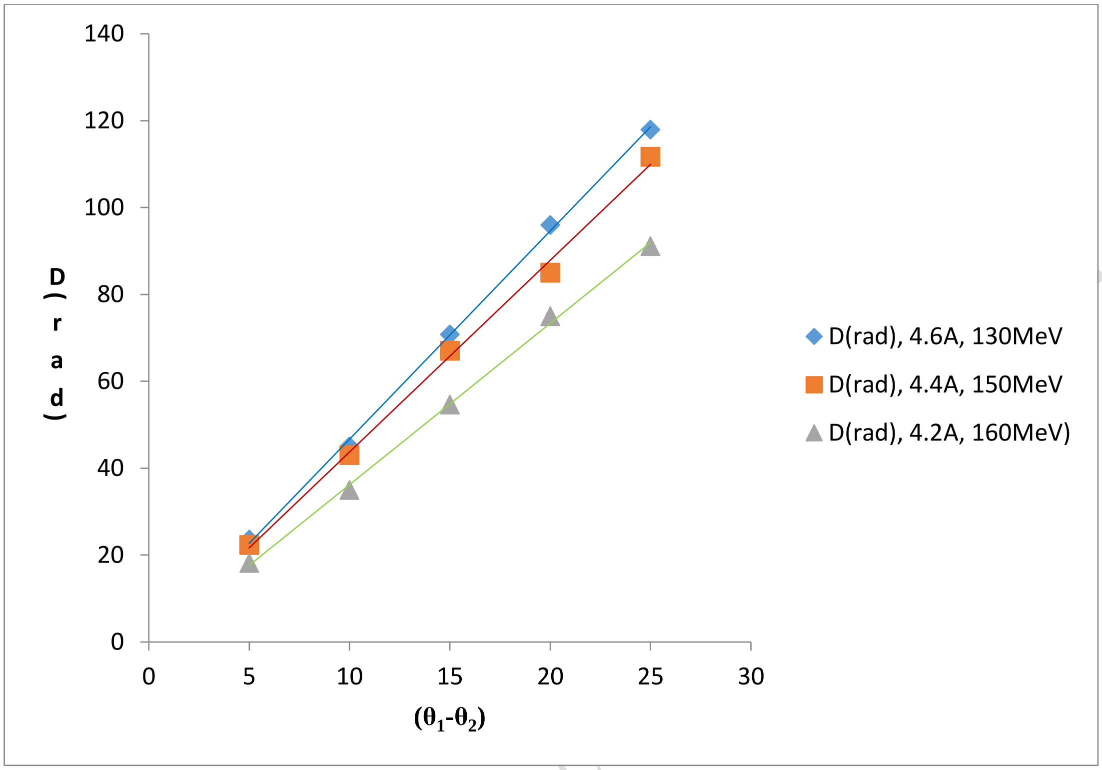

Fig. 5: Plots of absorbed dose vs angles (θ_1-θ_2) for line source ϕ_1 at constant photon energy and exposure time. Exposure time = 0.1s, h= 1cm Absorbed dose by the target was plotted against the attenuation angle difference at constant photon energy 130Mev, 150Mev and 160Mev, distance of 1cm and exposure time of 0.1s. The absorbed dose increases as (θ_1 - θ_2) increases irrespective of photon energy at all filament currents. However, it was observed from the figure that the higher the filament current the higher the absorbed dose by the target at constant (θ_1 - θ_2).

Conclusion

The relationships between the radiation dose absorbed by tissues and the line source function parameters were investigated by varying a parameter and keeping others constant at various times till all the parameters were evaluated with respect to the radiation dose absorbed by the tissues at three different filament currents of 4.2A, 4.4A and 4.6A. 0.1s – 1s interval was used for exposure time while Photon energy varies from 20 – 130MeV, 50 – 150MeV and 60 – 160MeV for filament current 4.6A, 4.4A and 4.2A respectively. The investigation implies that the dose absorbed by the tissues from a line source is directly proportional to exposure time, Photons energy, attenuation angles and length of the source. The dose is however inversely proportional to the distance between the source and target. The behavior of all the parameters was the same for $\phi_{1,}$ ϕ_2 and ϕ_3

References

Princeton N.J. (1956), Reactor Shield Design manual:D.Van Nostrand Co. Inc.

Engineering Compedium on Radiation Shielding Vol 1(1968), Shielding fundamentals and methods: Springer- Verlag New York.

Taylor J.J. and Obershain F.E.(1953), USAEC report WAPD-RM-213: Westing house electric Corp.

Spencer L.V. and Fano U. (1951), Phy rev. 81, 464

Goldstein H. and Wilkins J.E.(1954), Calculations of the penetration of Gamma rays: USAEC Report NYO.3075 Nuclear Development Association Inc.

Fitzgerald T.T., Brownell G.L. and Mahoney T.J. (1967), Mathematical theory of Radiation Dosimetry: Gordon and Breach, New York.

Morgan K.Z. and Twiner J.E.(1967), Principles of radiation protection: Willey and sons, New York.