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Interaction of gamma ray photons with some biological samples

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Gamma ray interaction with some biological samples such as bone, chlorophyll, cholesterol, flesh, glucose, haemoglobin, muscle and uric acid has been investigated at some incident photon energies, which are available from commonly used gamma ray sources such as Am241, Ba133, Hg203, Na22, Cs137, Mn54, Zn65 and Co60. In this energy range (59.54 - 1332 keV), Compton scattering is a dominant photon interaction process. The gamma ray photon interaction with biological samples has been visualized mainly in terms of mass attenuation coefficients and energy absorption buildup factors. From the present investigations, it has been concluded that while exposing large dimensional biological sample to the lower energy incident photons, care must be taken for buildup of the photons.

Key Words: Biological samples, energy absorption buildup factor

INTRODUCTION

With the ever increasing use of gamma rays, particularly in medical fields, the interaction of gamma ray photons with different type of biological materials is of utmost importance. Radiation therapy is a modern treatment technique where the results are faster. In radiation therapy treatment, penetrating gamma ray photons are allowed to incident on the affected region of body to destroy harmful cells.

Keeping in view, an attempt has been made to visualize gamma ray interaction with some biological samples (bone, chlorophyll, cholesterol, flesh, glucose, haemoglobin, muscle, uric acid) in terms of dosimetric parameters viz. mass attenuation coefficient (μ_m), equivalent atomic number (Z_{eq}) and energy absorption buildup factor (B_{abs}). The information about various parameters has been discussed in P.S. Singh *et al.* (2008)[1]. These parameters were computed at some experimentally available incident photon energies, so that these can be used to compare the results measured by experimentalists in future.

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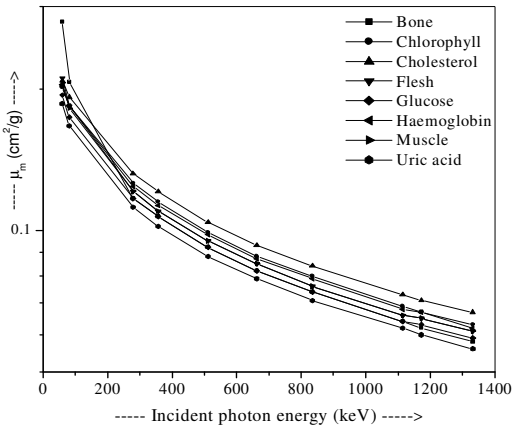
MATERIAL AND METHODS

The mass attenuation coefficient (μ_m) values for the selected biological samples have been generated using XCom database of Berger and Hubbell (1987)[2]. The computation of Z_{eq} and B_{abs} using G.P. fitting method of ANS/ANSI 6.4.3 (1991)[3] has been done as discussed in T. Singh *et al.* (2009)[4].

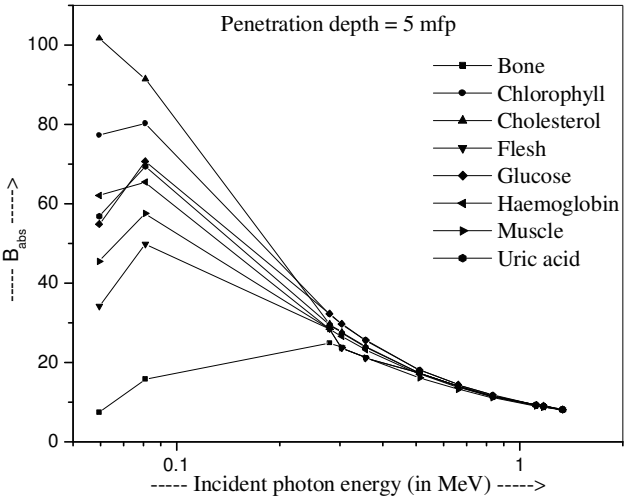
RESULTS AND DISCUSSION

The variation for μ_m with incident photon energy is shown in Fig. 1. The probability of photon interaction is more for lower gamma ray photon energy due to higher values of. With the increase in incident photon energy, μ_m values decreases, which may be due to the reason that in the selected energy range, there are two main photon interaction processes viz. photoelectric absorption and Compton scattering and dominance of both processes decreases with the increase in energy. Among the selected biological samples, bone has maximum Z_{eq} due to significant contribution of $_{20}$Ca (14.7%), whereas minimum Z_{eq} has been observed for cholesterol due to major contribution of $_6$C (75.0%). At lower photon energy (59.54 keV) in case of bone, due to its higher Z_{eq}, it has got maximum value for μ_m (0.207 cm^2/g). Because at low photon energy, photoelectric absorption (which varies with atomic number as Z^{4-5}) is the dominant photon interaction process hence results in major contribution to total μ_m.



B_{abs} has been investigated as a function of photon energy for fixed penetration depth of biological samples for 5 mfp as shown in Fig. 2. It has been observed that among the selected biological samples, B_{abs} has its maxima at about 81 keV (except for cholesterol and bone) and it decreases with increase in incident photon energy. As photon energy approaches 1 MeV, B_{abs} for all selected samples becomes almost same (i.e. becomes independent of biological samples). Higher value of B_{abs} means that gamma photon will suffer more Compton scatterings and will remain in the interacting material for longer span of time for further degradation of energy. So when the human body is exposed to the lower energy radiations, the photons will buildup in the sample i.e. exist in sample for longer time. Similar trend has been observed at other penetration depths of biological samples (not shown in Fig.).

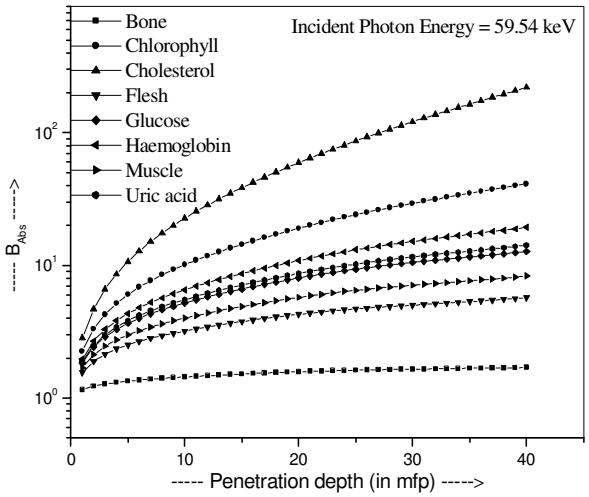
Fig. 3 shows the variation of B_{abs} with penetration depth of the biological samples. For all biological samples, B_{abs} increases with increase in penetration depth of the sample. It is due to the reason that increase in penetration depth of sample provides more possibilities of multiple interactions. Thus photons will buildup more in case of large dimensional biological sample as compared to smaller dimensional sample.



Conclusions

Care must be taken while exposing ***large*** dimensional biological sample to the ***lower*** energy incident photons due to large buildup factors.

For dose calculations to human body, the careful computation of gamma ray photon interaction parameters is very important.



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