Asian Journal of Chemistry Vol. 21, No. 10 (2009), S225-228

Investigations of Building Materials as Gamma Ray Shielding Materials

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To check the feasibility of the use of some building materials such as cement, plaster of paris, lime and sand as gamma ray shielding materials, some parameters of dosimetric interest has been investigated at some incident photon energies (59.54 to 1332 keV). The photon interaction with building materials has been discussed mainly in terms of mass attenuation coefficients and exposure buildup factors. From the present investigations, it has been concluded that among the selected materials, lime acts as best gamma ray shielding material, due to its higher values for mass attenuation coefficient and least values for exposure buildup factor in the selected energy range.

Key Words: Building materials, exposure buildup factor.

INTRODUCTION

The use of gamma rays in different fields such as in medicine, agriculture, industry and research is increasing abruptly, however its exposure for longer duration can be very harmful for living objects. For the safer use of these highly penetrating gamma ray photons, proper shielding materials play very important role. Mostly high atomic number and high density materials such as lead (Z = 82) and mercury (Z = 80) are used for such purposes. However, the cost of these materials often put a constraint on using these at large dimensions.

So, an attempt has been made to check the feasibility of the use of some building materials with lower equivalent atomic number materials $Z_{eq} < 20$ such as cement, lime, plaster of paris and sand as gamma ray shielding materials. Since, these materials are available in abundance and can be easily designed as required. Moreover, in case of nuclear accidents, such data is very important as it tells about how safe we are in buildings made up of such materials. For the present investigations, some parameters of dosimetric interest viz. mass attenuation coefficient and exposure buildup factor have been computed for the selected building materials.

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MATERIAL AND METHODS

The mass attenuation coefficient (μ_m) values for the selected building materials have been generated using WinXCom software (2001)[1]. The computation of exposure buildup factors (B_{exp}) for the selected building materials at some experimentally available incident photon energies (59.54 to 1332 keV) up to 40 mean free path has been done using G.P. fitting method as discussed in T. Singh *et al.* (2009)[2].

RESULTS AND DISCUSSION

Fig. 1 shows the variation of mass attenuation coefficient with photon energy for all the selected materials. The mass attenuation coefficient values for all the selected materials show maximum value initially at the lower photon energy of 59.54 keV and decreases with the increase in incident photon energy up to 1332 keV. This decreasing trend of mass attenuation coefficient with incident photon energy can be explained on the basis of dominance of different partial photon interaction processes.

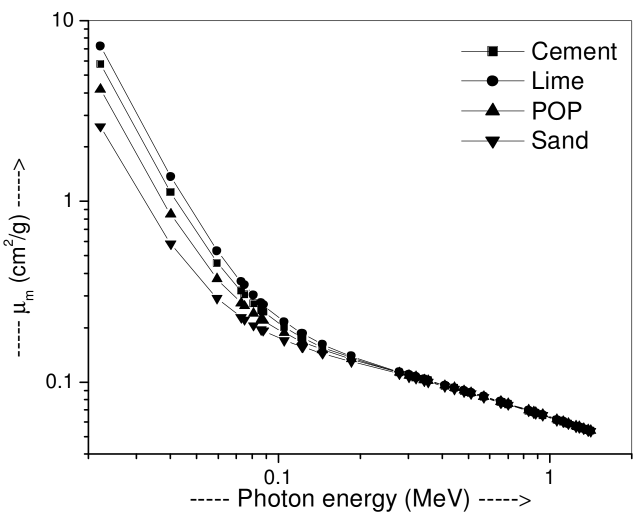

Fig. 1. Variation of μ_m with photon energy for building materials

Among the selected building materials, lime has maximum mass attenuation coefficient values due to major contribution of $_{20}$Ca (71.47%, hence higher equivalent atomic number), whereas sand has minimum mass attenuation coefficient due to major contribution of $_8O$ (51.28%, hence lower Equivalent atomic number).Comparing the mass attenuation coefficient values for photoelectric absorption and Compton scattering, it has been observed that at a particular photon energy (50-80 keV) for the selected materials, there is almost equal probability for a photon to interact via photoelectric and Compton effect. Above this energy region, photon has more probability for interaction via Compton scattering, which results in energy degradation only (not completely absorbed). So, photon will undergo multiple scatterings and remain in medium for longer time.

Exposure buildup factor determines the extent of such multiple scattered photons, which had crossed the thick layer of interacting medium and hence is a very important parameter while designing gamma ray shielding. In Figs. 2, Exposure buildup factor - values are observed to be minimum initially, increases with the increase in incident photon energy up to 300 keV. Above 300 keV, it decreases with the further increase in incident photon energy up to 1332 keV. It may be due to scattering process and in the lower as well as higher energy regions, absorption process is dominant (photoelectric absorption in lower energy region and pair production in higher energy region). Further, sand (lower Equivalent atomic number) has maximum value for Exposure buildup factor at all chosen photon energies, whereas minimum value for Exposure buildup factor has been observed for lime (higher Equivalent atomic number).

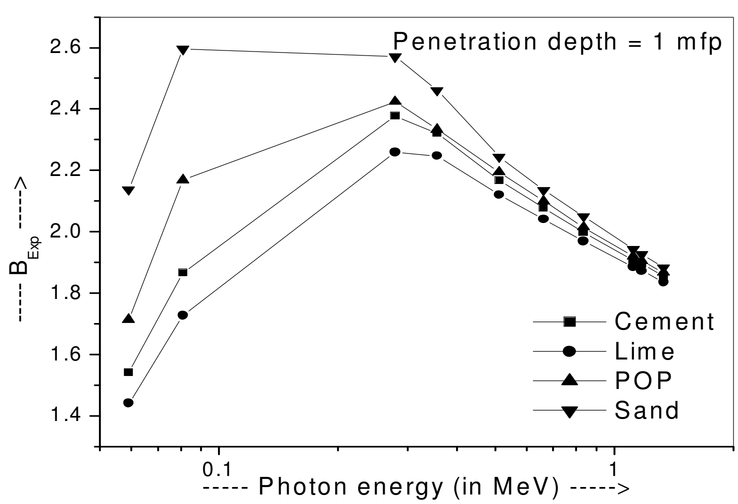

Fig. 2. Variation of B_{Exp} with photon energy for some building materials (1 mfp).

Comparison of Figs. 2 and 3, shows that with increasing the penetration depth of the material, Exposure buildup factor values increases significantly. For 1 mfp of selected building materials, Exposure buildup factor lies in between 1.4-2.6. Whereas for 10 mfp, Exposure buildup factor lies in between 10-50. This shows that thickness of interacting material contribute significantly in multiple scattering of photons.

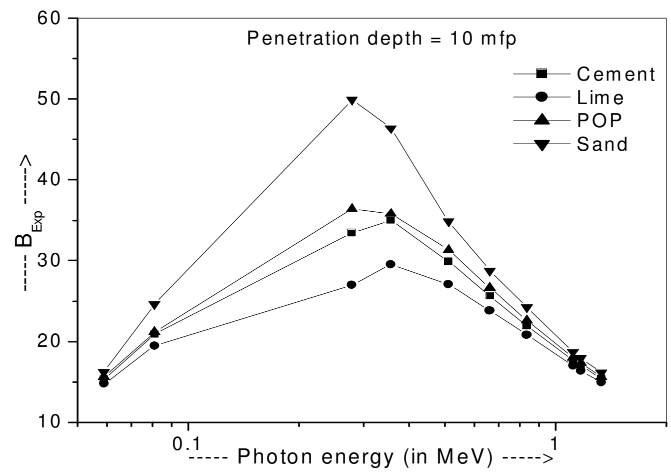

Fig. 3. Variation of B_{Exp} with photon energy for some building materials (10 mfp).

Conclusions

Among the selected building materials, lime is the better gamma ray shielding material (on the basis of mass attenuation coefficient and Exposure buildup factor).

Building materials can provide better shield from gamma ray, particularly for photon energy either < 100 keV or > 1.0 MeV (as Exposure buildup factor is less there).

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