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Effect of Geometrical Constraints on the Intensity of Multiple Scattered Gamma Photons in Soil Medium

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Transverse thickness as well as the distance between source (^{137}Cs) and detector was varied in soil medium keeping fixed longitudinal thickness to investigate the variation of intensity of multiple scattered gamma rays with geometrical changes. The obtained results are in good agreement with previous findings in which source and detector were kept fixed and the dimensions of soil medium were varied. It is reported here that the intensity of multiple scatter photons depends on the thickness of the interacting medium between the source and detector not on the geometrical constraints.

Key Words: Multiple scattering, Geometrical changes, Soil medium.

INTRODUCTION

In spite of numerous benefits of radiations (X-ray and gamma rays) in industry, agriculture and medicine, it cannot be ignored that exposure to these radiations is not only threatening our health, but also the quality of our environment. We cannot eliminate radiations from our environment; but risks factor can be reduced by controlling radiation exposure with the help of shielding materials. The most effective gamma shielding materials are lead and mercury due to their high densities and high atomic numbers. But these materials are expensive and are frequently used where space is limited. In the situations where space is not a constraint and where structural strength is required concrete, cement and soil are used even though these are less effective shielding materials due to their low atomic numbers.

In the medium energy region ($E < 1.022$ MeV), gamma rays interact with material, mainly by two processes viz. photoelectric absorption and Compton scattering. The photoelectric absorption is predominant for low energy and high Z-materials, whereas for medium energy gamma rays Compton scattering is a dominant process. So the primary photon loses its energy due to successive Compton scatterings and comes to a lower energy region, where photoelectric absorption is a dominant process. But for low–Z materials, there is an energy region where both the processes Compton scattering as well as photo-absorption are less effective in energy degradation or absorption of the photon. Due to this, there is pile up of photons in a material, which gives rise to a peak, named as multiple scatter peak.

The work conducted by several investigators regarding the intensity of multiple scatter peak was concerned with transverse distance between the source and the detector for soil[1,2], longitudinal distance between the source and the detector for soil[3], air[4], water[5] and graphite[6], differential angular distribution for aluminium[7]. The data available regarding the multiple scatter peak is limited in composite materials. So in the present work, geometrical dependence of the intensity of multiple scatter peak has been studied by varying the position of the radioactive source within the soil medium.

EXPERIMENTAL

The experimental arrangement used in the present measurements is shown in Fig. 1. Five aluminium drums of different diameters (10, 20, 30, 40 and 50 cm) with the same height of 60 cm were chosen. A mono-energetic gamma radioactive source ^{137}Cs (662 keV) procured from BARC, India was used. For the detection of multiple scattered gamma rays through a soil medium, a NaI(Tl) detector (4.5 × 5.1 cm) was placed below the soil container in such a way that the source and the detector were in the same vertical axis. A computerized 2K MCA plug-in-card was used to record the pulse height spectra. A 70 cm long PVC pipe with bottom end closed with Perspex's thin sheet has been used to keep the source always in the center of the different drums and to easily vary the distance between the source and the detector. Since, the present experiment was performed mainly emphasizing on the scatter part of the transmitted spectrum, so a cylindrical piece of lead followed by a cylindrical piece of aluminium has been placed in the pipe to stop the direct transmission of gamma rays of ^{137}Cs as well as K X-rays of lead. The whole experimental setup was placed in the center of the room to avoid the contribution of scattered photons from the walls of the room. All the spectra were recorded for the sufficient time period, so as to have statistical error always less than 1 %.

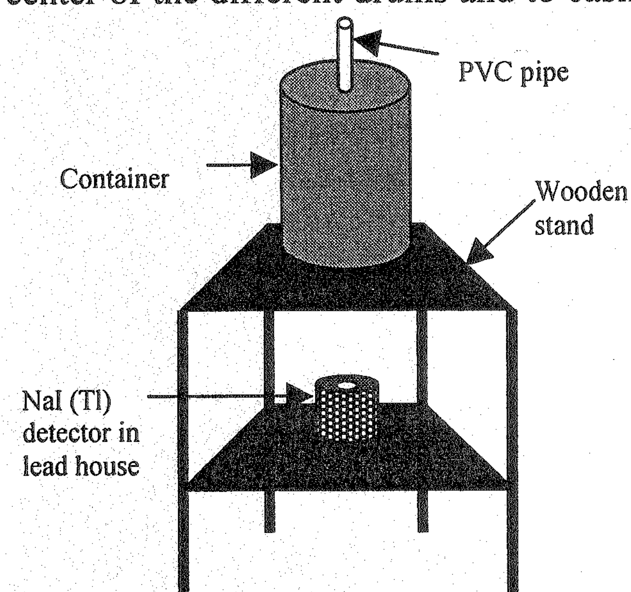

Fig. 1. Experimental setup

RESULTS AND DISCUSSION

The recorded spectra were analyzed and plotted using computer programs. In the Compton continuum of all the spectra, a broad peak has been found nearly at 100 keV, which is known as multiple scatter peak.

In the case of fixed transverse thickness (drum diameter) of the soil medium, when the source to detector distance has been increased, it results in the decrease of intensity of the multiple scatter peak, which is in good agreement with the previous findings of several researchers[1-6]. Fig. 2 shows the decrease in the intensity of multiple scatter peak with the increase in source-detector distance for fixed transverse thickness of 50 cm.

Fig. 3-5 shows the variation of intensity of multiple satter peak with transverse thickness for fixed distance between the source and the detector. It is observed that the intensity of multiple scatter peak increases with the increase in the transverse thickness when the distance between the source and the detector is increased upto 55 cm. However intensity of multiple scatter peak for different transverse thicknesses overlaps at the fixed distance of 60 cm between source and detector as shown in Fig. 4. With further increase in the distance between source and detector (65-70 cm), reversal in the trend is observed *i.e.* intensity of multiple scatter peak decreases with the increase in distance between source and detector as shown in Fig. 5.

It may be due to the reason that for lower thicknesses (upto 55 cm) between source and detector, as the transverse thickness of the soil medium is increased, the photons which may have earlier escaped from the sides, now scattered again and again, and able to reached the detector, which results in increasing the intensity of multiple scatter peak. But for larger thicknesses (65-70 cm) between source and detector, the self-absorption starts dominating; hence the intensity of multiple scatter peak decreases with increase in source-detector distance.

Our present results regarding the variation of multiple scatter peak intensity with the transverse thickness are in good agreement with our previous findings[1,2], in which the source and the detector were kept fixed and only longitudinal and transverse thickness of the soil medium has been varied. Hence it can be concluded that the behaviour of intensity of multiple scattered gamma rays through a given material was independent of the geometrical constraints such as the position of the source but depends strongly on the thickness of the interacting medium between the source and the detector.

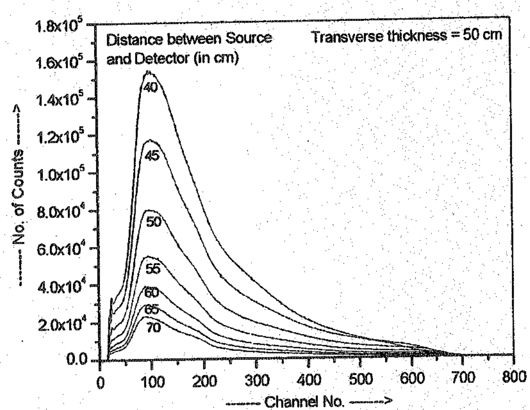

Fig. 2. Plot of no. of counts vs channel no. for transverse thickness of 50 cm and varying distance between source and detector.

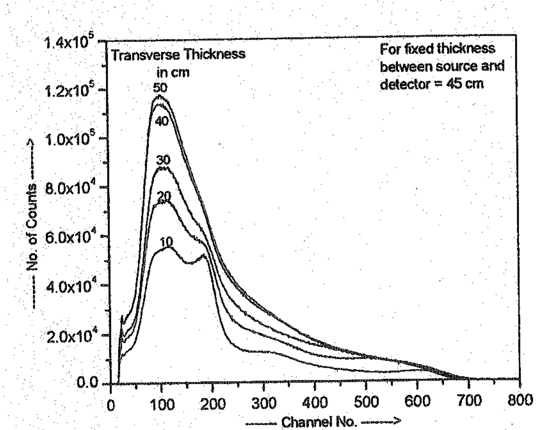

Fig. 3. Plot of no. of counts vs channel no. for 45 cm distance between source and detector and varying transverse thickness.

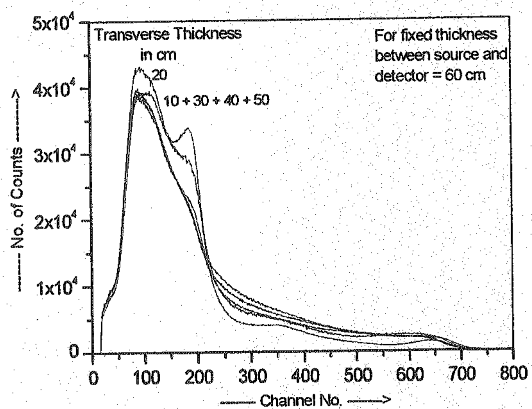

Fig. 4. Plot of no. of counts vs channel no. for 60 cm source - detector distance and varying transverse thickness.

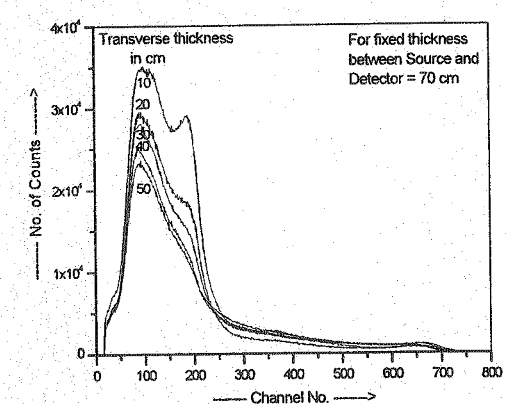

Fig. 5. Plot of no. of counts vs channel no. for source - detector distance of 70 cm and varying transverse thickness.

REFERENCES

1. G.S. Sidhu, K. Singh, P.S. Singh and G.S. Mudahar, *Nucl. Sci. Engng.*, **134**, 201 (2000).
2. C. Singh, G.S. Sidhu, A. Kumar, T. Singh, P.S. Singh and G.S. Mudahar, *Radiat. Measurements.*, **39**, 451 (2005).
3. M. Singh, G.S. Brar and G.S. Mudahar, *Nucl. Sci. Engng.*, **114**, 214 (1993).
4. J. Swarup, *Nucl. Instr. Meth.*, **172**, 559 (1980).
5. J. Swarup and L.H. Peshori, *Int. J. Appl. Radiat. Isot.*, **36**, 531 (1985).
6. J. Swarup and L.H. Peshori, *Appl. Radiat. Isot.*, **37**, 13 (1986).
7. C.V. Smith and N.E. Scofield, *Nucl. Sci. Engng.*, **47**, 1 (1972).