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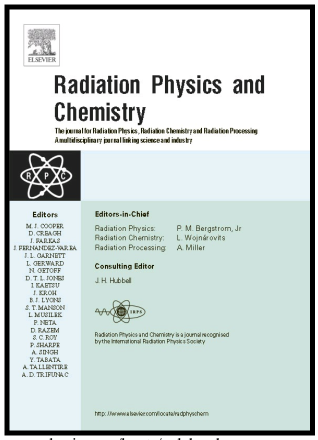

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Attenuation coefficients and exposure buildup factor of some rocks for gamma ray shielding applications

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Abstract

In the present work, the mass attenuation coefficient μ/ρ is investigated experimentally and theoretically for seven rocks (olivine basalt, green marble, jet black granite, telphone black granite, cuddapah limestone, white marble and pink marble).The rock samples were collected from different places of India.The mass attenuation coefficients of the samples were measured experimentally at photon energies of radioisotopes Co^{57} (122 keV), Ba^{133} (356 keV), ^{22}Na (511 and 1275 keV), Cs^{137} (662 keV), Mn^{54} (840 keV), and Co^{60} (1330 keV). Theoretically, the simulation results of μ/ρ using both XCOM and MCNP5 codes were compared with experimental results and a satisfactory agreement was observed. Total atomic cross sections ($\sigma_{t,a}$) electronic cross sections ($\sigma_{t,e}$), effective atomic number (Z_{eff}), electron density (N_e) and half value layer (HVL) were evaluated using the obtained μ/ρ values for investigated rocks. The HVL values for the selected rocks were compared with some common shielding concretes. Moreover, by Geometric Progression method (G-P) exposure buildup factor (EBF) and energy absorption buildup factor (EABF) values were calculated for incident photon energy 0.015–15 MeV up to penetration depths of 40 mean free paths. The results show that among the studied rocks pink marble possesses superior shielding properties for γ-ray. This work was carried out to explore the advantage of utilizing the selected rocks in engineering structures and building construction to shield gamma-rays.

Key Words: rock; MCNP5; shielding; mass attenuation coefficient

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1. Introduction

Human beings are exposed to many types of radiation, some existing in the soil, water and plants; while others are man-made, such as x-ray, medical equipment and factory waste. For this reason, it is important to determine the buildup factors to make corrections for effective energy deposition in different shielding materials. Nowadays, radioactive isotopes are used widely in tomography, medicine gamma-ray fluorescence studies, radiation biophysics, nuclear power plant, agriculture, industry and research, this brings serious shielding problems as X-rays, gamma photons and neutrons are hazardous to human health. Concretes with aggregates of different rocks are used widely in the construction of medical hospitals (X-ray unit and Gamma chamber), nuclear power plant, accelerators, etc. Homogeneous and high density rocks are essential for effective radiation protection; these rocks would be a good choice in building construction to protect against hazardous radiations (Akkurt et al. 2007). Using rocks in building construction is reasonable as plenty of rocks reservoir available worldwide. Some rocks contain a high attenuation coefficient of gamma rays, and the appropriate type of rocks for shielding can be selected in buildings as a protection against various radiations by calculating the buildup factors. The buildup factor is defined as the ratio of the total value of a specified radiation quantity at any point to the contribution to that value from radiation reaching the point without having undergone a collision. Buildup factors exist into two types: (1) the absorbed buildup factor or deposited energy in the interesting materials and detector response function is that of absorption in the interacting medium, (2) the exposure buildup factor (EBF) in which quality of interest is the exposure and a detector response function is that of absorption in the air (Kurudirek and Topcuoglu, 2011; Mann et al., 2012;Sayyed and Elhouichet, 2017; Lakshminarayana et al., 2017; Singh et. al., 2008; Singh and Badiger, 2014;Manjunatha and Rudraswamy, 2012).

High energy photons penetration and diffusion in the medium can be characterized by linear and mass attenuation coefficients. The linear attenuation coefficient is the probability of a radiation interacting with a matter per unit path length, depends on the intensity of the incident photons, atomic number and