International Journal of Physical Sciences Vol. 4 (10), pp. 588-591, October 2009
Available online at http://www.academicjournals.org/IJPS
ISSN 1992 - 1950

Full Length Research Paper

Investigation of photon attenuation coefficient for pumice

I. Akkurt[1]*, S.Kılıncarslan[2], C. Basyigit[2], B. Mavi[1] and H. Akyıldırım[1]

[1]Physics Department, Science Faculty, Suleyman Demirel University, Isparta, Turkey.
[2]Structural Education Department, Technical Education Faculty, Suleyman Demirel University, Isparta, Turkey.

Accepted 06 August, 2009

With the rapid development in technology, the radiation protection has become one of the most important part of building construction. As shielding is the basic method for radiation protection, besides the physical and mechanical properties of materials used in building construction, the radiation shielding properties should also be known. In this study, the linear attenuation coefficients of two different types of Golcuk-Isparta pumice which is an alternative building material have been measured and the results were compared with the calculation and some other materials.

Key words: Pumice, γ-ray shielding, attenuation coefficients.

INTRODUCTION

Building materials are important in building construction for both in durability and to carry architectural culture to next generation. For this reason, instead of using single type of building materials, mixture of them is more useful. This can cause a number of problems such as mechanical deformation, thermal and voice conductivity. The pumice formed after volcanic event, is cavity, spongy, porous and light building material. As the inferred reserve of pumice high in Turkey, it becomes important materials in engineering sectors. About 80% of produced pumice is used in construction sector as light block elements and isolation materials (Erkoyun, 2005). Besides being one of the most common building materials it can also be used as an architectural covering stones in many engineering structures. Because of this, it became vital to investigate its response to radiation, heating and cooling, and also it's thermal and voice conductivity properties. Properties like having lower unit weight than normal concrete and also high performance on thermal and voice conductivity make it ideal choice in building construction. Besides using it in natural form, it can be used in compressed form as a decorative wall cladding material (Davraz et al., 1997). The photon attenuation coefficients of such an important material should be determined by testing the should be determined by testing the materials for radiation shielding. It is important in radiation physics and radiation dosimeter as it measures the probability of all possible interactions between photon and atomic medium. The magnitude of linear attenuation coefficient depends on the incident photon energy, the atomic number and the density (ρ) of the shielding materials (Woods, 1982). A number of experimental and theoretical works have been performed on the linear attenuation coefficients for different types of materials such as marble, barite and limra (Akkurt et al., 2004), some kind of rocks (Özkahraman, 2004) and also concrete (Akkurt et al., 2005; Bashter, 1997) which is commonly used materials in building construction.

In this paper, the linear attenuation coefficients of pumice will be presented for two different forms and then will be compared with the calculation and some other materials.

MATERIALS AND METHODS

The pumice used in this study was obtained from Isparta- Gölcük region where its inferred reserve is about 2.5 billion m^3 (Davraz 2005; Gündüz, 1998). Both natural (NatPum) and powder pumice were casted 5 × 5 × 2 cm in sizes. The powder pumice was compressed (CompPum) in a metal mould. The density of powder and natural pumice became 1.69 and 0.787 g cm^{-3} respectively. The linear attenuation coefficients (μ) were obtained via mass attenuation coefficients μ/ρ calculated using the XCOM code at

*Corresponding author. E-mail: iskender@fef.sdu.edu.tr. Tel: +90 246 211 4033. Fax: +90 246 2371106.

Table 1. Chemical composition of pumice (%) (Gündüz et al. 1998).

Chemical	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	Na_2O+K_2O	LOI
Percentage (%)	70	14	2.5	0.9	0.6	9	3

Table 2. The results of linear attenuation coefficient for pumice.

Photon energy (Average)	**Materials**	**Experimental (μ□) cm^{-1}**	**XCOM (μ) cm^{-1}**
1.25 MeV	Natural pumice	0.027	0.031
	Compressed pumice	0.071	0.068

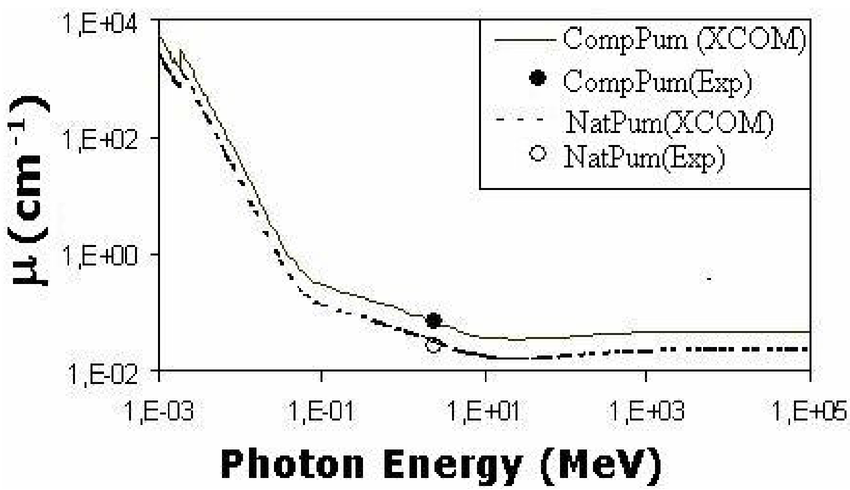

Figure 1. The linear attenuation coefficients of two types of pumice as a function of photon energy.

photon energies of 1 keV - 100 GeV (Berger 1987). The XCOM data base run on a PC and was prepared by combining previously existing data bases for coherent and incoherent scattering, photoelectric absorption, and pair production cross sections. It uses chemical structure of materials as input for materials. The chemical properties (Davraz, 2005) of pumice are tabulated in Table 1. The linear attenuation coefficients (μ) were determined by measuring the transmission of γ-rays through the target of three different thicknesses. The γ-rays of the average 1.25 MeV obtained from ^{60}Co source which emits 1.17 MeV and 1.33 MeV were used in this study as the Geiger-Muller counter does not identify each γ-ray. The linear attenuation coefficients (μ) can be given by the following expression:

$$N = N_o e^{-\mu x} \tag{1}$$

Where N and No transmitted and incident photon recorded by detector respectively and x is the thickness of material.

RESULTS AND DISCUSSION

The photon attenuation coefficients at 1.25 MeV were measured for both natural and compressed pumice and the results were compared with the calculation. These values are given in Table 2 and are shown in Figure 1 and where it can be seen that the agreement between measurement and calculation are good (even only one data point) and the linear attenuation coefficients decrease with the increasing photon energy. It can also be clearly seen from this figure that the linear attenuation coefficients are higher for compressed pumice than for natural pumice. In Figure 2 the linear attenuation coefficients of pumice were compared with the other materials of barite, limra and marble (Akkurt et al., 2004).

It can be seen from this figure that the linear attenuation coefficients are lower for pumice in comparison with the others. This could be resulted from differences in densities as the linear attenuation coefficients are related to materials density. This is plotted in Figure 3 where it can be clearly seen that there is a linear relation between linear attenuation coefficient and the density of materials.

In radiation shielding, it is important to know material's thickness to stop half and tenth rate of radiation. The shielding effect of various materials to radiation is usually expressed in half-value thickness, or tenth-value thickness: in other words, the thickness of material required to reduce the intensity of radiation by one-half or one-tenth. Successive layers of shielding each reduce

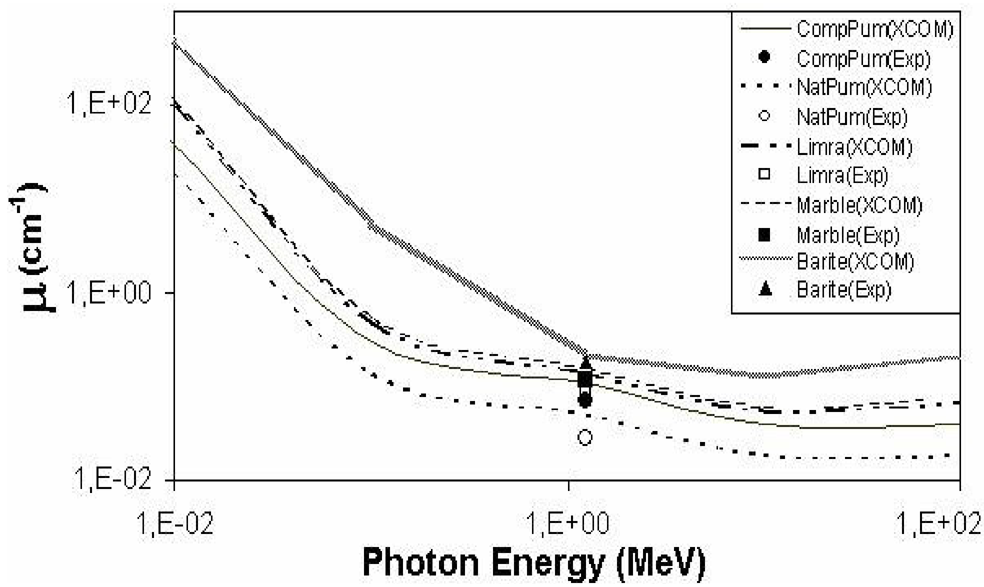

Figure 2. The comparison of linear attenuation coefficients for pumice and other materials (Akkurt et al. 2004).

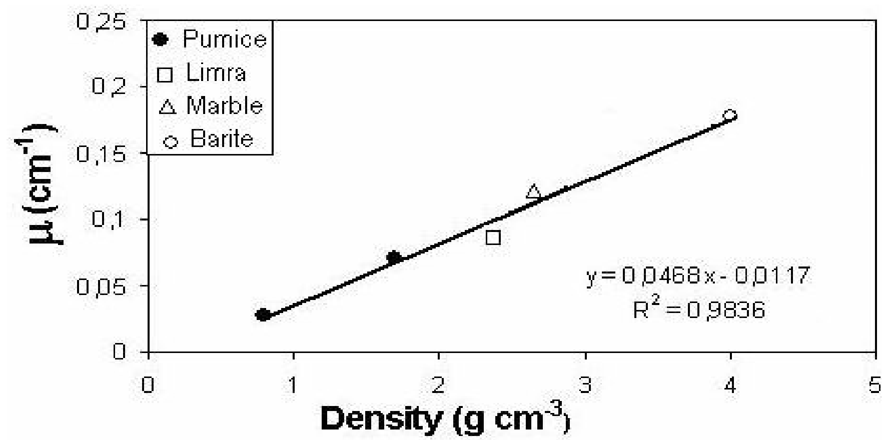

Figure 3. The linear attenuation coefficients as a function of pumice's density.

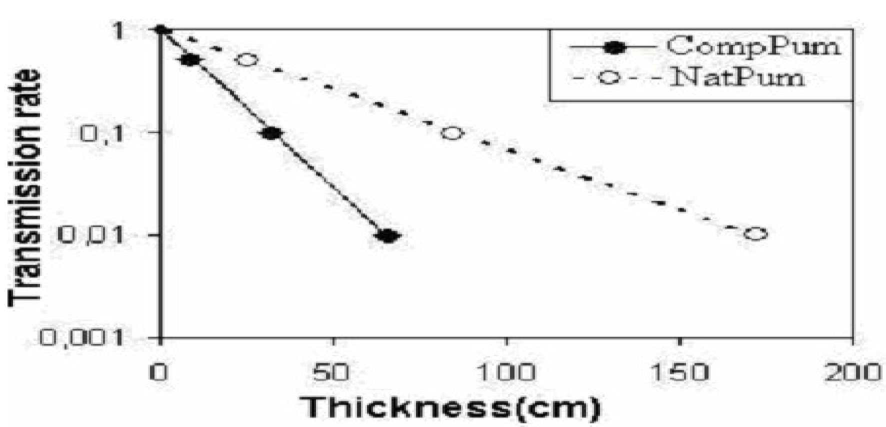

Figure 4. The radiation transmission rate as a function of pumice's thickness.

the intensity by the same proportion, so three tenth-value thicknesses reduce the intensity to one-thousandth. This is obtained for both types of pumice and displayed in Figure 4. It can be seen in this figure that to shield 50% of 1.25 MeV photons, the thickness of 25.67 cm natural pumice and 9.79 cm compressed pumice are required.

ACKNOWLEDGEMENT

This work partly supported by the TUBITAK (Turkiye Bilimsel ve Teknik Araştırma Kurumu) under the project number of 106M127.

REFERENCES

Akkurt I, Basyiğit C, Kilincarslan S (2004). The photon attenuation coefficients of barite, marble and limra , Ann. Nucl. Energy; 31-577.

Akkurt I, Basyiğit C, Kilincarslan S, Mavi B (2005). The Shielding of γ-rays by Concretes Produced with Barite Prog. Nucl. Energy, 46: 1-11.

Bashter II (1997). Calculation of radiation attenuation coefficients for shielding concretes, Ann. Nucl. Energy, 24:1389.

Berger MJ, Hubbell JH (1987). NBSIR 87-3597: Photon Cross Sections on a Personal Computer. National Institute of Standards, Gaithersburg MD 20899 USA. (http://physics.nist.gov/PhysRefData/Xcom/Text/XCOM.html).

Davraz M, Gündüz L (1997). Isparta Yöresi Pomza Taşının Hafif Yapı Elemanı Olarak Değerlendirilmesi Üzerine Bir Analiz. I. Isparta Pomza Sempozyumu. 61-70, Isparta.

Davraz M (2005). "Industrial importance of Pumice in Isparta Gelincik Region" Türkiye Pomza Sempozyumu ve Sergisi, 23-32, Isparta.

Erkoyun H (2005). "The importance and situation of Pumice in Turkey" Türkiye Pomza Sempozyumu ve Sergisi, 1-7, Isparta.

Gündüz L, Sarıışık A, Davraz M, Uğur İ, Çankıran O (1998). PomzaTeknolojisi Cilt-1. SDÜ Yayını, 285s. Isparta.

Özkahraman HT (2004). Kaplama taşı olarak kullanılan andezitler kaynaklanmış tüfler Burdur beji ve limranın fiziksel özellikleri, Madencilik Bülteni, Nisan 2004. Mermer özel sayısı, TMMOB., Ankara.

Woods J (1982). Computational Methods in Reactor Shielding, Pergamon Press., New York.