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Variation of the Photon Attenuation Coefficients of Pumice Concrete in Different Chemical Media

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As the radiation has started to be used in a variety of different fields after the development of technology, its shielding became one of the main research in physics. This is because of its hazardous effect on human cell. Different types of material including lead or concrete can be used to shield hazardous radiation. On the other hand the radiation shielding properties of those materials can be deformed by outer effect. The effect of chemical media on the radiation shielding properties of concrete has been investigated. The linear attenuations have been measured at 662, 1773 and 1332 keV for 6 month period. The measurement has been performed using γ-spectrometer contains a NaI(Tl) detector and 16k channel MCA. It was found that the chemical media decreased linear attenuation coefficients of the pumice concrete.

Key Words: Concrete, Linear attenuation coefficients, Chemical effect, Radiation.

INTRODUCTION

The increasing of the radiation using in a variety of different field makes shielding of this radiation important. Thus the radiation protection becomes important subject to be investigated in nuclear science. The γ-ray is a widely used radiation type and as it is uncharged and has no mass, it can easily penetrate into matter. The radiation shielding properties of a material is expressed with the term of linear attenuation coefficients, which is defined as the probability of a radiation interacting with a material per unit path length. The magnitude of linear attenuation coefficients depends on the incident photon energy, the atomic number and the density of the shielding materials[1-3]. The concrete is widely used material in building construction especially for houses.

A large number of experimental and theoretical investigations of radiation attenuation coefficients have been performed due to the importance of radiation hazards on human body. Akkurt *et al*.[4], have measured photon attenuation coefficients of barite, marble and limra in Turkey and also measured linear attenuation coefficients of concrete containing zeolite[5] and pumice[6]. Bashter[7] made a calculation to obtain the attenuation coefficient for different types of shielding concrete. Besides those of works which are related with the determination of radiation shielding properties of the materials, the improvement of these properties has also been studied[8]. On the other hand, the variation of the radiation shielding properties of concrete with the chemical media has not been studied in our knowledge apart from recent work done by same author[9]. Rahimi *et al*.[10], have investigated chemical corrosion on the gamma-ray attenuation properties of Zr and Ti containing lead silicate glasses Therefore it has been found interesting to obtain variation of photon attenuation coefficients with the chemical. In this work the concrete produced with the pumice the variation of the linear attenuation coefficients of pumice concrete has been investigated.

EXPERIMENTAL

The concrete used in this study has been obtained using pumice as an aggregate in concrete. In Table-1 the properties of pumice and cement have been tabulated. The linear attenuation coefficients (μ) were measured at the photon energies of 662, 1173 and 1332 MeV obtained from ^{137}Cs and ^{60}Co γ-ray sources, respectively. The γ-rays are measured with the γ-spectrometer contains NaI(Tl) connected to 16k channels multi-channel-anayser (MCA) with Genie 2000[11] for data acquisition and analysis. If N and N_0 are the measured count rates in detector, respectively with and without the absorber of thickness x (cm), the linear attenuation coefficients (μ) can be extracted by the standard equation:

$$N = N_0 e^{-\mu x}$$

TABLE-1
CHEMICAL COMPOSITION OF THE CEMENT AND PUMICE

Chemical composition	CEM I 42,5 N	Pumice
CaO	61.00	12.12
MgO	3.56	1.06
NaO	–	0.40
K_2O	0.11	3.60
Fe_2O_3	3.81	0.80
SiO_2	22.56	56.00
Al_2O_3	7.11	12.10
SO_2	2.70	–
SiO_2	–	12.70
H_2O	–	9.30

Plotting In(N_0/N) *versus* x would give straight line and m can be obtained from the value of the slope. In Fig. 1 the γ-ray spectrum has been displayed obtained for ^{60}Co source with and without concrete sample.

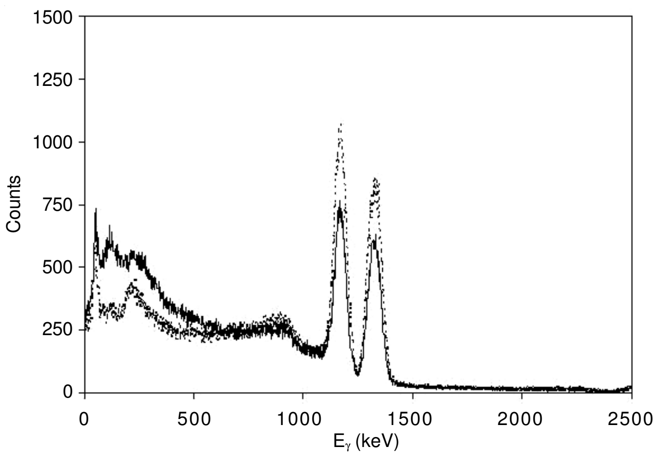

Fig. 1. Photon energy spectrum with and without concrete between detector and ^{60}Co radioactive source

RESULTS AND DISCUSSION

In order to investigate the chemical effect on the linear attenuation coefficients, the concrete contains pumice has been left in two different types of chemical media for 6 month period. The chemical media were NaOH and Na_2SO_4 solutions where the linear attenuation coefficients have been measured in each month for 6 months. The results have been displayed in Fig. 2 for NaOH and in Fig. 3 for Na_2SO_4. It can be seen from these figures that the linear attenuation coefficients have decreased with the increasing leaving time of concrete in the chemical media. This could be the result of deformation in the concrete structure with the chemical effect. In order to see the effect of chemical types the linear attenuation coefficients have been displayed in Fig. 4. It can be seen from this figure that the linear attenuation coefficients have decreased sharper in NaOH medium than Na_2SO_4. The transmission rate for 662, 1173 and 1332 keV as a function of concrete thickness has been placed in Fig. 5 for NaOH and in Fig. 6 for Na_2SO_4. It can also be seen from those figures that the chemical media effects concrete structure and the stopped thickness of the concrete. Comparing 662, 1173 and 1332 keV photon energies (Fig. 5 and Fig. 6) it can be seen that the larger concrete is needed for higher energy photons.

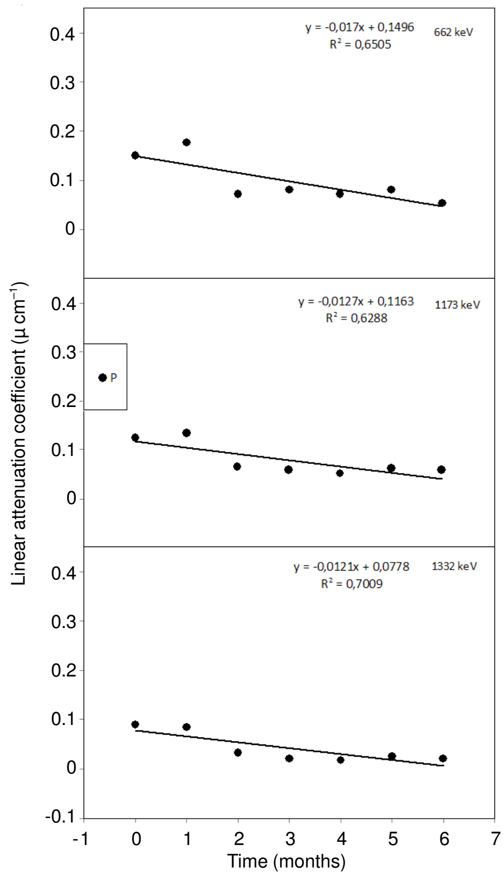

Fig. 2. Variation of the linear attenuation coefficients with the time for 662, 1773 and 1332 keV energy photons in NaOH medium

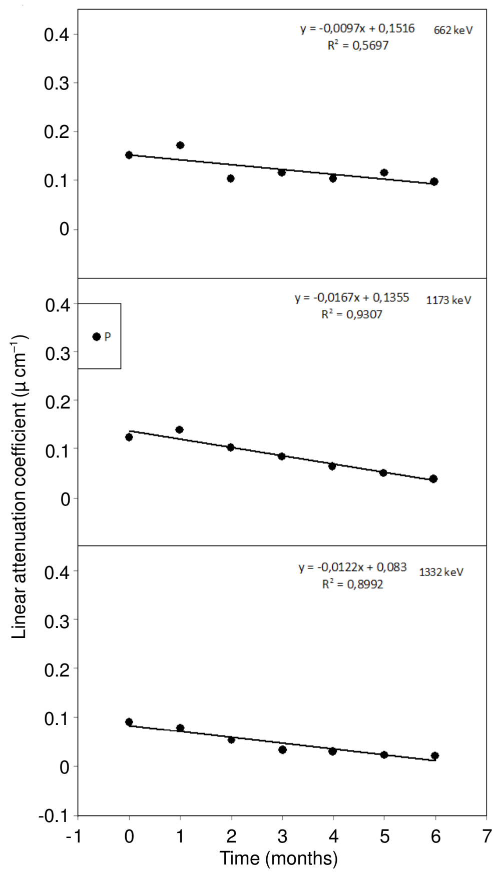

Fig. 3. Variation of the linear attenuation coefficients with the time for 662, 1773 and 1332 keV energy photons in Na_2SO_4 medium

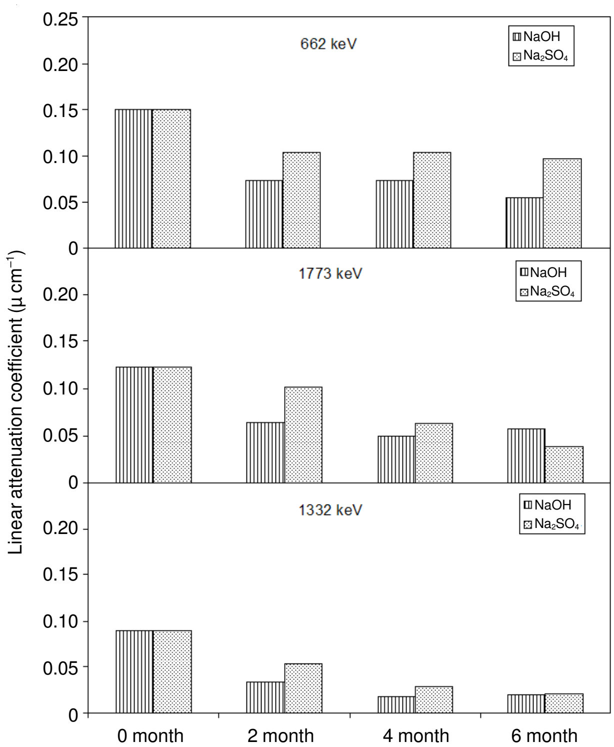

Fig. 4. Variation of the linear attenuation coefficients with the different chemical media obtained at 662, 1773 and 1332 keV energy

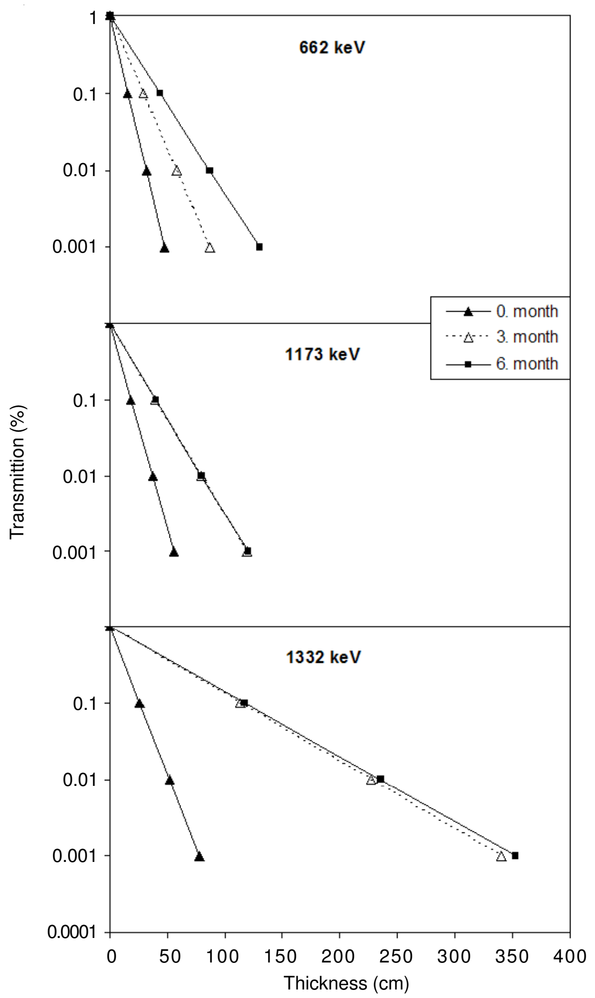

Fig. 5. Transmission rate of γ-rays at different energies for various month chemical effect in NaOH medium

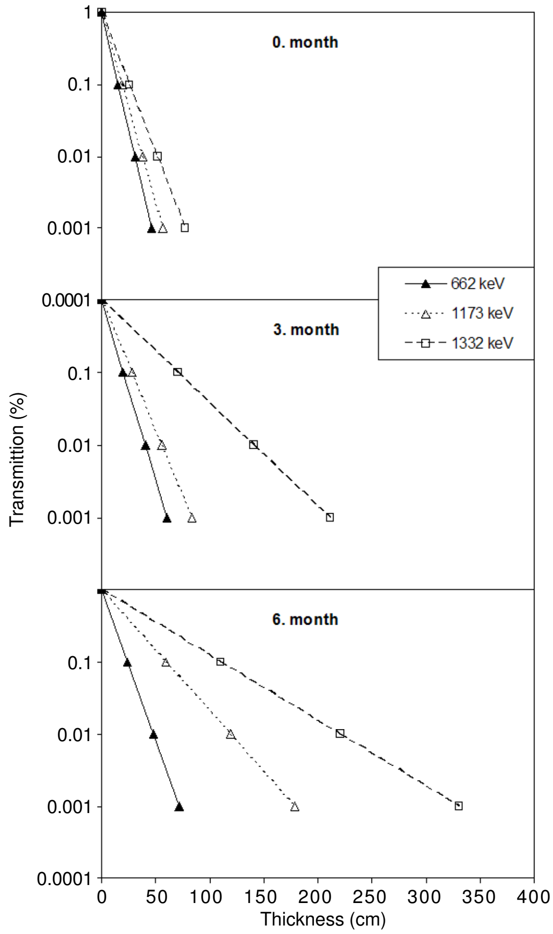

Fig. 6. Tansmission rate of γ-rays at different energies for 662, 1173 and 1332 keV photon energies in Na_2SO_4 medium

It can be concluded from this work that the radiation shielding properties of concrete containing pumice has been effected by the chemical media.

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