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Radiation Shielding Properties of Mortars and Plasters Used in Historical Buildings

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In this study, the radiation absorption properties of mortars and plasters used in historical buildings have been investigated. Studied lime concretes contained such additives as brick dust, fertilizer, wet lime, wool, egg white, bone meal, rice, casein, whey, bone ash and tree leaf juice, in different concentrations. The linear attenuation coefficients of gamma rays in lime concretes have been measured at 662, 1773 and 1332 keV. The gamma rays have been obtained from ^{137}Cs and ^{60}Co sources and the measurements have been performed using a gamma spectrometer, based on a $3'' \times 3''$ NaI(Tl) detector, connected to 16384-channel multi-channel analyser.

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1. Introduction

With the introduction of radiation in many areas of technology, people are facing radiation hazards. Therefore, the development of different shielding materials is important for radiation protection. There are many studies that investigate the radiation shielding properties of different materials [1–9].

There are various materials, which can be used for shielding, such as building materials. In ancient times it was known that organic and inorganic materials help to improve the properties of building materials [10–13]. Therefore, in this study, radiation absorption properties of mortars and plasters, used in historical buildings, were investigated. For this purpose, different types of lime concrete have been developed to test radiation absorption.

2. Methodology of research

In the study, five different types of lime concrete have been manufactured using brick dust, fertilizer, wet lime, wool, egg white, bone meal, rice, casein, whey, bone ash and tree leaf juice. While the amount of wet lime was kept constant in the study, the proportions of additives, such as brick dust, fertilizer, wool, egg whites, bone meal, rice, casein, whey, bone ash and ash leaves, were changed. The content of the studied samples is summarized in Table I.

TABLE I

Content of the studied mortars and plasters.

	N15	N17	N18	N19	N20
Materials	250.1 g wet lime	250.5 g wet lime	250.3 g wet lime	250.3 g wet lime	250 g wet lime
	100 g brick dust	100 g brick dust	100 g brick dust	100 g brick dust	100 g brick dust
	30 g bone ash	5 g bepermo(chemical)	5 g bepermo(chemical)	5 g bepermo (chemical)	5 g casein
	5 g casein	35 g bone meal	35 g bone meal	35 g fertilizer	63.47 g egg white
	65.15 g whey	4.6 g wool	37.5 g whey	66.2 g disbudak tree leaf juice	15 g rice
		44.8 g whey			18.2 g whey

Linear attenuation coefficient is defined as the probability of interaction of radiation with the material, per unit path length [14–19].

The linear attenuation coefficients, μ (cm^{-1}), of gamma rays in lime concrete have been measured at gamma energy of 662, 1773 and 1332 keV. The employed gamma rays have been emitted by ^{137}Cs and ^{60}Co sources, and the measurements have been performed using a gamma spectrometer (Fig. 1) which contains a $3'' \times 3''$ NaI(Tl) detector, connected to 16384-channel multi-channel analyser. Analysis of the resulting spectra was performed using MAESTRO software, version 7.01.

The linear attenuation coefficient is calculated using Beer-Lambert equation

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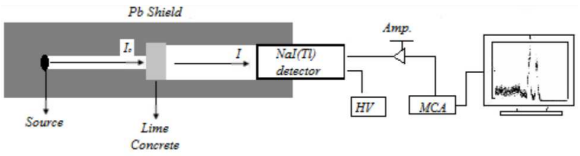

Fig. 1. The schematic view of experimental set-up.

$$\mu = \frac{1}{x} \ln \frac{I_0}{I}, \tag{1}$$

where μ is the linear attenuation coefficient, x is the thickness of the lime concrete, made with a mixture of mortars and plasters, I_0 and I are incident and transmitted intensity.

3. Results

The values of linear attenuation coefficient were calculated for each sample and radiation attenuation characteristics were compared. The obtained linear attenuation coefficients for different energies and for different samples are shown in Table II and Fig. 2.

TABLE II

Linear attenuation coefficients.

N15	N17	N18	N19	N20	Energy
		[cm^{-1}]			[keV]
0.0765	0.0789	0.0850	0.1225	0.0847	662
0.0576	0.0603	0.0750	0.1082	0.0711	1173
0.0576	0.0604	0.0721	0.1036	0.0700	1332

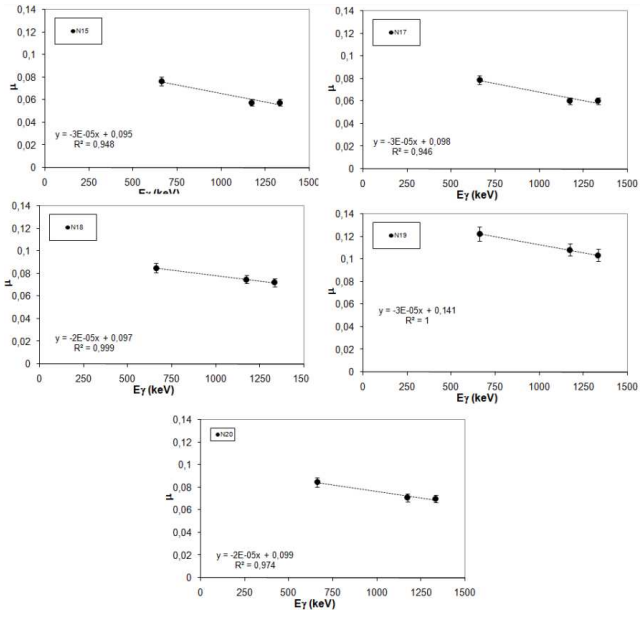

Fig. 2. Measured linear attenuation coefficients for lime concretes and R^2 values.

Linear attenuation coefficients as functions of energy are shown in Fig. 2. It can be seen from this figure that N15 has a low attenuation coefficient at 662 keV and 1173 keV but N19 has a high attenuation coefficient at all energies. It can be concluded from this work that fertilizer and tree leaf juice increase linear attenuation coefficients of lime concrete. The R^2 values of the results are also given in Fig. 2, where it can be seen that the results are quite compatible.

Acknowledgments

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