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DETERMINATION OF ELEMENTAL CONCENTRATION AND GAMMA ATTENUATION COEFFICIENT OF CONCRETE BLOCK

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Abstract

The present work is performed to find out the elemental concentration and gamma attenuation coefficients of Autoclaved Aerated Concrete (AAC) block by using EDXRF method (EDX-720) and gamma spectroscopy method using NaI(Tl) detector for Cs-137 gamma source. The various thicknesses of AAC block samples are used as attenuator for gamma ray intensity in this work. Toxic elements and radioactive nuclides are not detected by EDXRF method. It is highly attenuated to radiation shielding. So, these results will be helpful in the development of radiation shielding technology.

Keywords: Elemental analysis, EDXRF method, AAC concrete block, NaI(Tl) scintillation detector, ^{137}Cs gamma source

Introduction

Autoclaved aerated concrete was invented in the mid-1920s by the Swedish architect and inventor John Axel Eriksson. Autoclaved Aerated Concrete, AAC is an economical, sustainable, lightweight solid block that provides thermal and acoustic insulation and is also fire and termite resistance. AAC is good for heat isolation, fire protection, and seismic resistance especially for high tower buildings. The prominent advantage of aerated concrete is its lightweight. AAC products include blocks, wall panels, floor and roof panels, cladding panels and lintels. The ingredients for manufacturing Autoclaved Aerated Concrete block are fly ash or sand 60~70%, limestone powder 15~20%, cement 8~10%, gypsum 2% and aluminum powder 0.074%. Human beings are continuously exposed to background radiation from the sun and cosmic rays in the atmosphere, naturally occurring radioactive materials within Earth, their bodies, houses and food. So Human safety and structural material that may be compromised from radiation exposure are vital concerns in nuclear technology. As technology is developed day by day, the gamma rays are used in many fields,

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like medicine, food preservation, surgery, industry, research, agriculture etc. it has now become necessary to provide shielding to reduce exposure to gamma radiation. For safety of people, selection of attenuating materials, attenuation coefficient becomes most important. Radiation shielding usually consist of barriers of lead, concrete or water. There are many materials, which can be used for radiation shielding, but there are many situations in radiation protection. Nowadays, autoclaved aerated concrete are used widely. Attenuation coefficient describes the extent to which the radiant of a beam is reduced as it passes through a specific material. The attenuation of gamma radiation can be then described by the following equation.

$$I = I_o.e^{-\mu x}$$

where I is intensity after attenuation, I_o is incident intensity, μ is the linear attenuation coefficient (cm^{-1}), and physical thickness of absorber (cm).

Experimental Procedure

AAC block sample was ground with grinding machine to get powder samples and the samples were at least 5 grams weighed with scientific balance and pressed into pellet with 5 tons of hydraulic press, SPECAC, Cambridge Electric Industries. The diameter of pellet is 2.5cm. After sample preparation, the samples were analyzed by EDXRF (Shimadzu EDX-720) system at Universities' Research Center (URC). And the samples were prepared with square shape of AAC block samples (10 cm × 10 cm) with increasing thicknesses ranging from 1.4cm to 24.1cm. The block diagram of experimental setup is shown in Figure 1. The source to detector distance is 35cm. For energy calibration, the intensities of the standard gamma sources measurement were carried out firstly to reduce the background radiation. After calibration, the incident beam intensity (I_o) of gamma source of cesium (^{137}Cs) was measured firstly and the attenuated beam intensities (I) of each sample were measured one by one with ten different thickness samples. Each sample was placed 7cm from the gamma ray detector. The spectra of gamma ray energies of these samples were counted at a fixed time period of 900 seconds using MCA measure software with gain level 1 and offset 1. The counts under the peak spectrum area were got from the data table and the gamma ray intensities I_o and I of ^{137}Cs source for different attenuators were obtained.

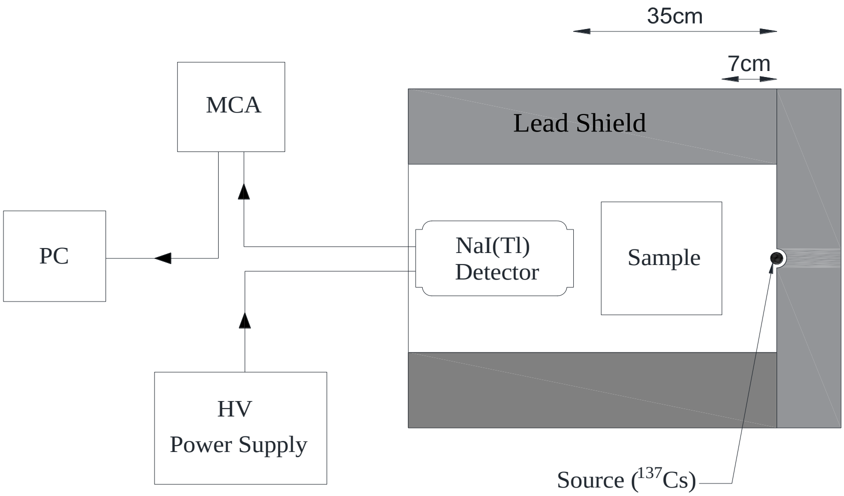

Figure 1: Block diagram of Experimental Set up

Table 1: Elemental Concentration in AAC Block Sample

Element	Wt %
Ca	60.884
Si	25.697
Fe	8.951
K	1.306
Ba	1.021
S	0.856
Ti	0.787
Cr	0.119
Mn	ND
Sr	0.081
Zn	0.186
Cu	0.075
Zr	0.037

ND = non-detected

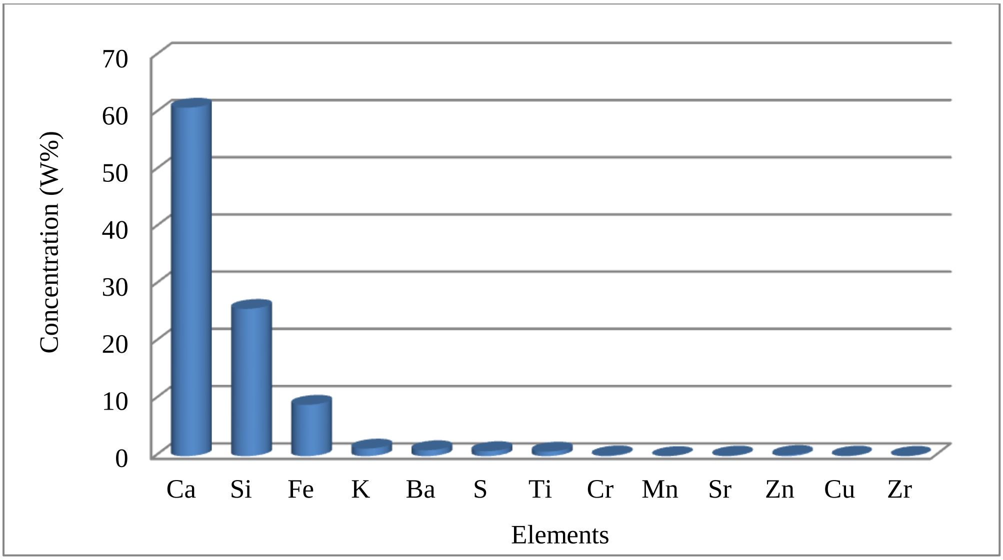

Figure 2: Elemental Concentrations in AAC Block Sample

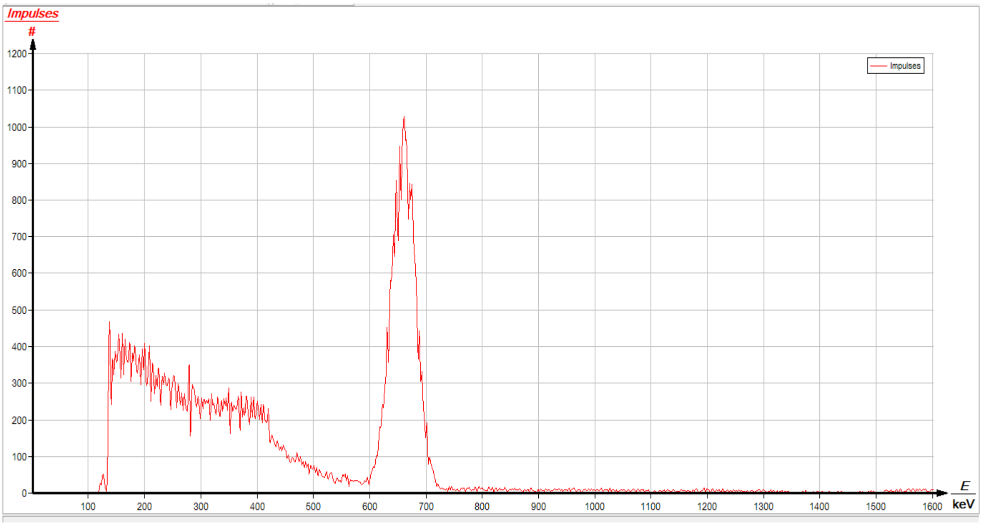

Figure 3: The recorded spectrum of AAC block sample for ^{137}Cs source without absorber

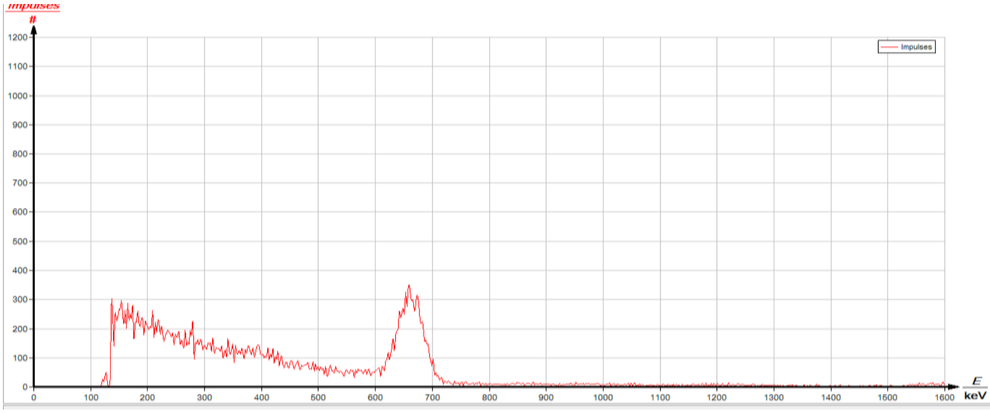

Figure 4: The recorded spectrum of AAC block sample for ^{137}Cs source with absorber thickness 24.1cm

Table 2: Attenuation coefficients of AAC block sample with different thicknesses by using ^{137}Cs source

Thickness		$I_o \pm \sqrt{I_o}$	$I \pm \sqrt{I}$	–ln	μ	μ_m
(cm)	(gcm^{-2})	$(Cmin^{-1})$	$(Cmin^{-1})$	(I/I_o)	(cm^{-1})	(cm^2g^{-1})
1.4	1.21		1448.27±38.06	0.06	0.0427	0.0584
3.8	2.83		1300.67±36.06	0.16	0.0440	0.0592
6.4	4.51		1154.07±33.97	0.29	0.0438	0.0636
8.9	6.93		1054.87±32.48	0.37	0.0423	0.0554
11.4	7.16		994.93±31.54	0.43	0.0382	0.0608
14	10.98	1537.6 ± 39.21	832.53±28.85	0.62	0.0438	0.0549
16.5	12.14		790±28.11	0.67	0.0404	0.0581
19.1	13.51		701.53±26.49	0.78	0.0411	0.0596
21.6	14.5		647.87±25.45	0.87	0.0400	0.0629
24.1	15.85		567.73±23.83	0.99	0.0413	0.0628

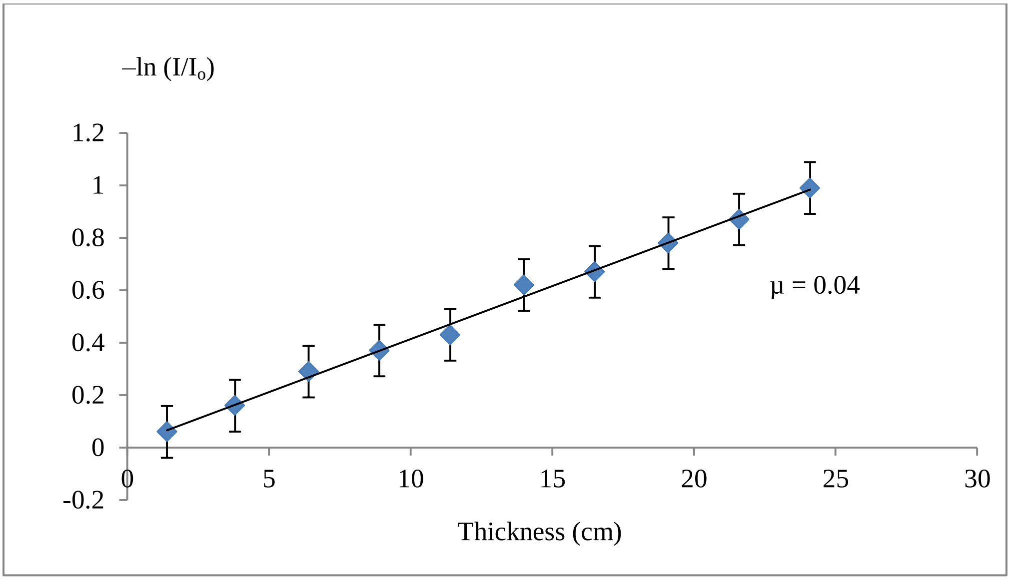

Figure 5: –ln (I/I_o) versus different thicknesses (cm) of AAC block sample of ^{137}Cs source

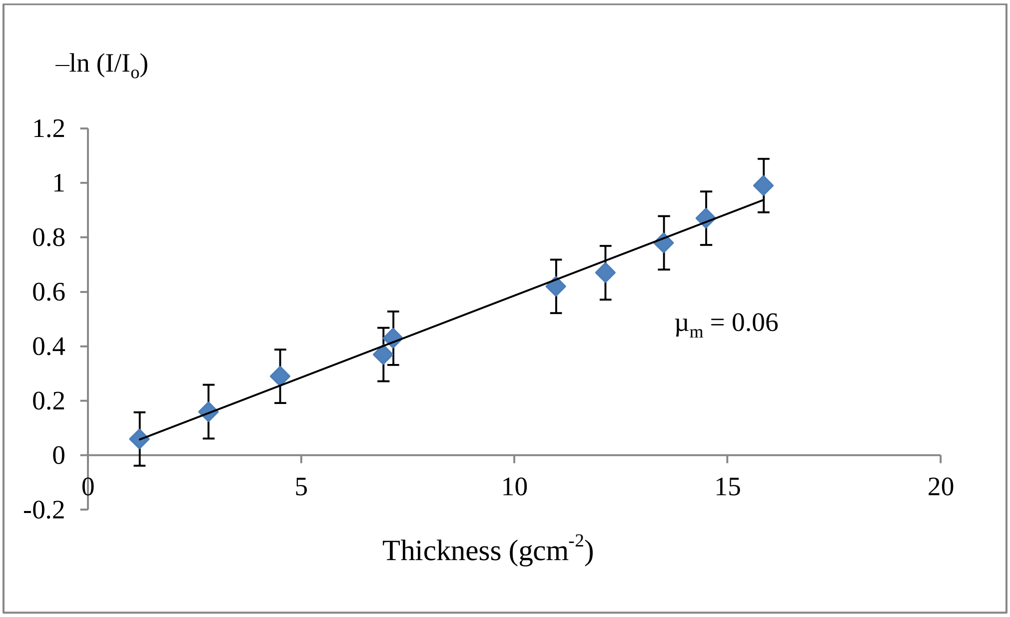

Figure 6: –ln (I/I_o) versus different thicknesses (gcm^{-2}) of AAC block sample of ^{137}Cs source

Results and Discussion

The elemental concentration in AAC block sample was shown in Table 1 and Figure 2 showed the graph of elemental concentration in AAC block sample. According to the measurement data of AAC block sample using EDX-720, calcium was found as major element contained in this sample 60.884 weight%. Silicon was found as second major element with 25.697weight%. Iron was also found as third major element contained in this sample 8.951%. Potassium, barium, sulphur, titanium, chromium, manganese, strontium, zinc, copper and zirconium were found as minor elements. The recorded spectrum of AAC block sample for ^{137}Cs source without absorber was shown in Figure 3 and that of spectrum with absorber thickness 24.1cm was shown in Figure 4. The graph of –ln (I/I_o) versus different thicknesses of AAC block sample of ^{137}Cs source was shown in Figure 5. From the graph, the slope gave the value of linear attenuation coefficient (μ). Figure 6 showed the graph of –ln (I/I_0) versus different thicknesses (gcm^{-2}) of AAC block sample of ^{137}Cs source. The slope of this graph gave the value of mass attenuation coefficient (μ_m).

Conclusion

From the results of elemental analysis in AAC block sample, it was concluded that toxic elements such as fluorine, lead, cadmium, and arsenic were not observed obviously in weight percent level in the present study. And also radioactive nuclides thorium (Th) and uranium (U) were not detected by EDXRF method. Gamma attenuation coefficients of AAC block sample with different thicknesses were measured by gamma detection system. All the values of mass attenuation coefficient are nearly equal for ten sample thickness. Thus, attenuation coefficients do not depend on sample thickness. The attenuation coefficient of AAC is slightly less than aluminium (Al) but there are no toxic elements. So, AAC block can be used as radiation shielding material for both internal and external construction in desirable and these results will be helpful in the development of radiation shielding technology.

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