ENGINEERING PROPERTIES OF CONCRETE MADE WITH CHOLEMANITE, BARITE, CORN STALK, WHEAT STRAW AND SUNFLOWER STALK ASH

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ABSTRACT

In this study, in the mix of concrete 5% and 10% barite and, 0.5% and 1% cholemanite are used instead of sand by reducing. Also 2.5% and 5% wheat straw, sunflower stalk corn stalk ash are used instead of cement by reducing. Reference samples with no additives are produced for making comparisons. A total of 29 series of standard tests were made with the wet and hardened concrete examples. Am 241 gamma-ray source is used for the detection of the radiation permeability of mortars produced from 12x12x2 cm. linear absorption coefficient of the barite and cholemanite added samples were larger than the control sample.

Keywords: Cholemanite, Barite, Corn stalk, Wheat straw and Sunflower stalk ash.

INTRODUCTION

Many researchers have argued that concrete is one of the materials used for radiation protection in facilities. The radiation protection feature of concrete depends on its components. Admixture in concrete plays an important role in affecting the strength and radiation prevention capacity of the concrete. Thus, the linear attenuation coefficient and the adsorbent radioactivity are increased. Because the high radioactive materials particularly increased photoelectric interactions of low energy photons and high radioactive material produces more double reaction in high-energy photons. Because of high radioactive effect, lead and concrete are widely used in x-ray room and concrete plant walls. Minerals such as barite and hematite are added into the concrete to increase the ability of photon shield. Another related issue in the concrete is the amount of hydrogen forming the neutron shield. The importance of hydrogen in the concrete for radiation shields are known. Concrete blocks absorb neutrons due to the amount of hydrogen that they content. Also neutron dose offset values of some new type of concrete containing cholemanite are calculated. [1].

Use of proton accelerator up to 250 MeV in hospitals is increasing worldwide. Hadrons in treatment is more effective because it is heavier than protons. The use of carbon up to 430 MeV is present in a number of health facilities. But the future use of lighter ions should not be overlooked. [2].

Concrete in which water, cement and aggregate, is widely used in nuclear power plants, particle accelerator and hospitals. Concrete components are important for radiation protection. Barite use in buildings will certainly be a very good solution for radiation

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protection, but it is not economical. Because barite reserves are less in the world. Therefore, it is used as an alternative to concrete. The interaction of gamma rays depends on the incoming photon energy and gamma rays are difficult to maintain. It is because they do not have mass and charge. Gamma ray depends on linear attenuation coefficient of the incoming photon energy, the atomic number density of the protective material. Different elements, compounds, mixtures, building materials and few studies have been made to linear attenuation coefficient of the theoretical and experimental calculations for concrete. [3].

According to the unit volume weight concrete can be classified as light, normal and heavy concrete. Special barite aggregates utilized in the production of heavy concrete may generally be natural aggregates as limonite and magnetite iron ore industry or residues that artificial aggregates such as iron and lead particles. The barite aggregates are used in heavy concrete production because of its radiation resistance [4-6].

In this study, using barite, blast furnace slag, cholemanite, and pumice it is intended to produce the radiation-resistant material. When cholemanite ratio increased, linearly absorption coefficient decreased. Linear absorption coefficient of the 5% barite and 10% pumice added samples was found to be close. In this study, radiation transmittance was investigated using barites instead of sand by reducing, blast furnace slag, pumice and cholemanite. In this study am light source 241 is used. [7]

MATERIAL

In this study cholemanite and barite was used instead of decreasing sand used in concrete production. Also reducing corn stalks, wheat straw and sunflower stalks ash from the cement on the sample production were used in different ratios.

Barite

The chemical formula of barite is $BaSO4$, specific gravity is 4.5 g / cm^3 heavy aggregate, and Mohs hardness of 2.5-3.5, crystal structure is orthorhombic. It may be colourless, white, sometimes yellow and grey. Barite is a clean, smooth, naturally unresponsive and inexpensive mineral. Turkey has 2.1% of the total world reserves of barite. These reserves includes good quality barite that are crushed, broken or raw. Barite reserves is located in Konya, Istanbul, Muş, Antalya and Kütahya. Turkey ranks eighth in the world on barite production with 1.7% share and 120 thousand tons [8]. Barite used in this study were obtained from Osmaniye-Bahçe area.

Cholemanite

It is similar to diamond due to its crystalline boron appearance and optical properties, and is almost as hard as diamond. Today, the two countries where most of the world's boron reserves and production are US and Turkey. Shares in the production of the major producing countries, respectively, are Turkey 33%, USA 28%, Russia 23%, and other countries are16%. Cholemanite used in the study was obtained from Balıkesir Bigadiç.

Wheat Straw

Wheat straws abundant in the area and burned by farmers after harvest (stubble) were collected in an appropriate manner. This material was allowed to cool after burning for a suitable medium. The cooled ash was ground in a laboratory with hammer until 1 mm grain size was obtained. The resulting ash is sieved through 1 mm sieve.

Corn-stalk

Yet after cutting corn produced in the second product of a high rate of waste remaining stem aimed to use these materials as cement and concrete since it contains silicon. Ash was obtained after incinerated in vitro to zero moisture of this material, collected appropriately.

Sunflower Stalk

In the northern district of Kahramanmaraş are particularly abundant for sunflower. It is generally preferred as the development is too fast and a type is very suitable for climate. However, perhaps thousands of tons of the dried sunflower stalks in autumn stay in the field or are caused environmental pollution by burning in the open field. With this study it was collected with the appropriate techniques and the ash obtained by burning used as an additive in the cement and concrete. Chemical element contents of wheat straw used in the experiments, corn straw and sunflower stalk ash are given in Table 1. Chemical element contents were made in Adana Cement Factory. The materials used in the experimental work; cholemanite was obtained from Etimaden Inc. Bigadiç Boron Facility, and barite aggregate was obtained from Barite Mining Turkish Inc. Garden plants. Chemical compositions of Barite (B), Cholemanite (K) used are given in Table 2.

Table 1. Chemical Contents of Used Organic Ashes

Organic ash species	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	K_2O	Na_2O	SO_3	Loss on Ignition	Total	Specific Gravity g /cm^3
Wheat straw ash (B)	4.99	1.15	0.95	25.44	4.63	24.72	1.28	6.98	28.97	99.11	3.05
Corn stalk ash (M)	37	2.37	1.19	13	7.35	15	0.25	1.32	22.50	99.98	3.11
Sunflower stem ash (A)	26	2.23	1.19	17	6.65	17.1	0.22	4.63	23.53	98.55	2.91

Table 2. The chemical content of cholemanite and barite

Components (%)	**Barite(BA)**	**Cholemanite (C)**
SiO_2	1.15	4
Al_2O_3	0.33	0.4
Fe_2O_3	0.08	0.08
CaO	0.10	26
MgO	0.17	3
Na_2O+K_2O	0.03	0.35
SrSO	1.26	1.5
$BaSO_4$	94,2	-
MnO	0.18	-
B_2O_3	-	40.00
Loss on Ignition	-	24.60
Grain size	75 micron	75 micron

When analysed in Table 1 it is seen that SiO2 ratio is low, percentage of CaCO3 is very high. The presence of significant amounts of alkaline in ashes requires to be careful in terms of alkali aggregate reaction.

Aggregate

Aggregate used in the production of ready-mixed concrete in the city is same with creek aggregate used in concrete production. The physical properties of the aggregates used in the experiments is given in Table 3.

Table 3. Physical properties of aggregates

Properties	**Fine Aggregate**	**Course Aggregate**
Specific Gravity	2,65	2,70
Congested Unit Weight	1,90	1,79
Loose Unit Weight	1,70	1,65
Water Absorption Capacity %)	2,30	1,32

Cement

Working in CEM I 42.5 cement is used. The chemical and physical properties of cement are given in Table 4.

Table 4. Chemical content and physical properties of cement

Chemical Analysis Results	
Components	%
SiO_2	20,02
Al_2O_3	4,87
Fe_2O_3	3,44
CaO	62,49
MgO	2,81
Na_2O+K_2O	0,91
SO_3	2,86
Free CAD	0,48
Loss on Ignition	2,04
Physical Analysis Results	
Specific Weight (kg/cm^3)	3,16
Specific Surface (cm^2/g)	3763
Finesses	
45 Space on Sieves (%)	03,5
90 Rest on the Sieve (%)	0,1

EXPERIMENTAL STUDIES
Preparation of the mortar mixture

According to TS EN 196-1 29 kinds of mix designs were made including the control samples produced substituted by cholemanite mass at rates of 0.5% and 1 and 5% and 10 percentage barite instead of RILEM - Cembureau standard sand and cement in the mortar mixture. The names of the samples 4x4x16 cm in size, mixing ratio and the materials used are given in Table

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6. The materials used regarding the weight of the mixture was weighed precisely excised. Specimens were stored in pools filled with tap water cure at normal temperature under the same conditions.

Table 6. The names of materials and sample rate for the mortar mixtures

Sample name	**Mortar Components**					**Fresh mortar properties temperature (°C)**
	Water (g)	Cement (g)	Sand (g)	Additive (g)	Ash (cm)	
R	225	450,00	1350			20
BA5	225	450,00	1282,5	67,5	-	20
BA10	225	450,00	1215	135	-	20
BA5M2,5	225	438,75	1282,5	67,5	11,25	19
BA5M5	225	428,06	1282,5	67,5	21,94	19
BA10M2,5	225	438,75	1215	135	11,25	19
BA10M5	225	428,06	1215	135	21,94	19
BA5B2,5	225	438,75	1282,5	67,5	11,25	19
BA5B5	225	428,06	1282,5	67,5	21,94	19
BA10B2,5	225	438,75	1215	135	11,25	19
BA10B5	225	428,06	1215	135	21,94	19
BA5A2,5	225	438,75	1282,5	67,5	11,25	19
BA5A5	225	428,06	1282,5	67,5	21,94	19
BA10A2,5	225	438,75	1215	135	11,25	19
BA10A5	225	428,06	1215	135	21,94	19
K0,5	225	450,00	1343,925	6,075	-	19
K1	225	450,00	1336,5	13,5	-	18
K0,5M2,5	225	438,75	1343,25	6,75	11,25	19
K0,5M5	225	428,06	1343,25	6,75	21,94	19
K1M2,5	225	438,75	1336,5	13,5	11,25	18
K1M5	225	428,06	1336,5	13,5	21,94	18
K0,5B2,5	225	438,75	1343,25	6,75	11,25	19
K0,5B5	225	428,06	1343,25	6,75	21,94	19
K1B2,5	225	438,75	1336,5	13,5	11,25	18
K1K0,5	225	428,06	1336,5	13,5	21,94	18
K0,5A2,5	225	438,75	1343,25	6,75	11,25	19
K0,5A5	225	428,06	1343,25	6,75	21,94	19
K1A2,5	225	438,75	1336,5	13,5	11,25	18
K1A5	225	428,06	1336,5	13,5	21,94	18

Radiation Absorption Coefficient

Mortar specimens 120 x 120 x 20 mm in sizes were produced using the value of the mixing ratio in Table 2. Produced mortar samples were incubated for 28 days at cure pool. After the samples were removed from the curing pool, they were dried at 105°C in an oven until the weight does not change. After cooling to room temperature by placing a suitable container removed from the oven, were weighed 0.1 g precision. Dimensions and thickness of each sample were measured. Radiation absorption coefficient of the mortar was found using the Am 241 (59.60 keV) gamma-ray source (Equation 2) at K.S.U. Department of Physics Radiation Laboratory.

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$$I = I_0 e^{-\mu . t} \quad (2)$$

In the experimental system, the 59.6 keV Canberra brand Si (Li) semiconductor solid-state detectors, Am 241 (59.6 keV) radioisotope source, preamplifier, amplifier, ADC (Analog-Digital Converter), the system 100 PC card, computer and printer were used to print obtained data. Si (Li) semiconductor solid-state detector is a detector supplied with 2 mm thick, 12.5 mm^2 active area and 500 volts reverse bias voltage that the lithium atoms are diffused into in the lattice space of semiconductor silicon crystal of the latter, and is under vacuum. For preventing separation of lithium evaporation increasing the conductivity Volatile at room temperature and electronic noise reduction, was plunged into liquid nitrogen at -196 ° C and thermal equilibrium was provided. Am 241 radioisotope source is a monochromatic stimulant source, and 59.6 keV X-ray is released. Pre-amplifier converts the characteristic X-ray detector from an order of a few millivolts of electrical pulses. Here, electrical pulses reaching the amplifier is raised to the range of 0-10 volts. These electrical pulses, ADC (Analog Digital Converter) is converted to a digital value. These values form peaks regarding channel energy on the display 4096 channel regarding their sizes. Thus different numbers of pulses and energy from the screen gives X-ray spectra characteristic of the analysed samples (Figure 1).

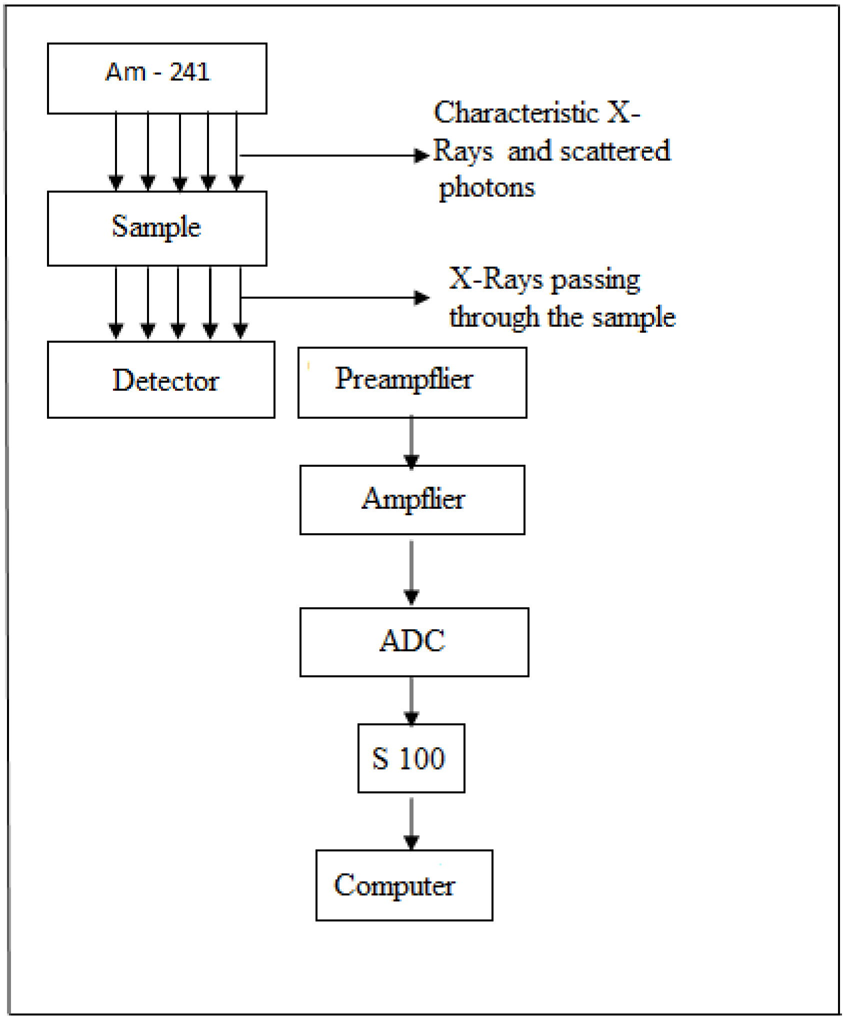

Figure 1. Radiation Absorption Scheme

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RESULTS AND DISCUSSION

Linear absorption coefficients of mortars values presented in Table 1.

Table 7. Linear absorption coefficient values of samples

Samples	I_o	I_x	Linear absorption coefficient
R	141427	37105	0,582
BA5	141427	34708	0,611
BA10	141427	32309	0,642
BA5M2,5	141427	30208	0,617
BA5M5	141427	31236	0,629
BA10M2,5	141427	28185	0,645
BA10M5	141427	29675	0,651
BA5B2,5	141427	34275	0,616
BA5B5	141427	32296	0,612
BA10B2,5	141427	32535	0,639
BA10B5	141427	33047	0,632
BA5A2,5	141427	32625	0,615
BA5A5	141427	33315	0,602
BA10A2,5	141427	30648	0,637
BA10A5	141427	30999	0,632
K0,5	141427	39885	0,575
K1	141427	38775	0,563
K0,5M2,5	141427	37256	0,58
K0,5M5	141427	34602	0,587
K1M2,5	141427	36116	0,569
K1M5	141427	35578	0,575
K0,5B2,5	141427	36819	0,585
K0,5B5	141427	35586	0,575
K1B2,5	141427	37918	0,572
K1B5	141427	36462	0,565
K0,5A2,5	141427	34737	0,585
K0,5A5	141427	35165	0,580
K1A2,5	141427	35901	0,571
K1A5	141427	34596	0,563

Linear absorption coefficient shape of the concrete samples 2, 3, 4, 5, 6, 7 and 8 herein is provided.

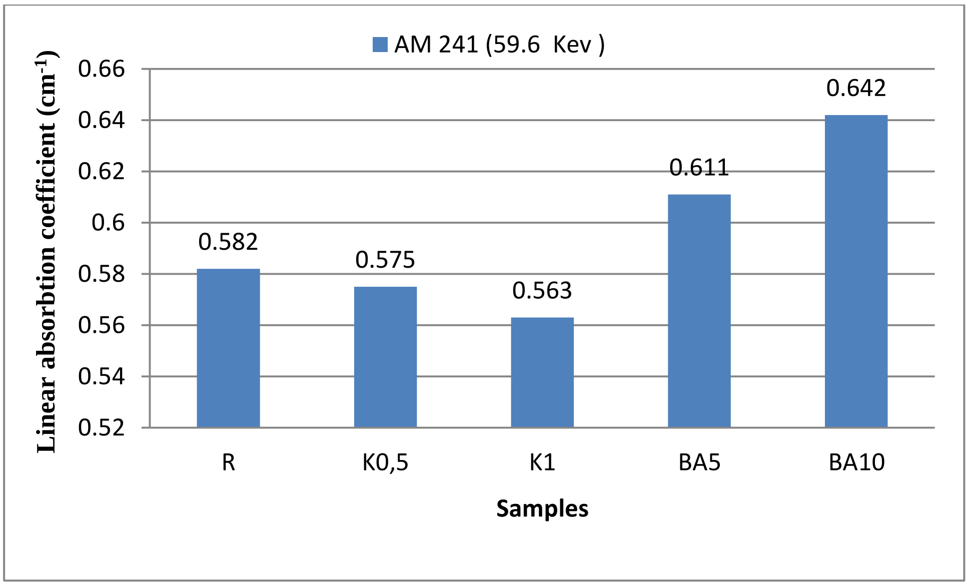

Figure 2. Linear absorption coefficient values of barite and cholemanite doped samples

When the amount of the barite increased the linear absorption coefficient increased in barite doped samples. The high amounts of $BaSO_4$ in chemical structure of barite, heavy aggregate is fading gamma rays. Test results are similar to other studies in the literature [9-10]. In cholemanite added samples amount of cholemanite decreased, linear absorption coefficient decreased. Gamma ray was fading depending on the amount of B2O3 in the chemical structure of cholemanite. Whereas linear absorption coefficient of control samples were low. Test results are similar to studies in the literature [11-12].

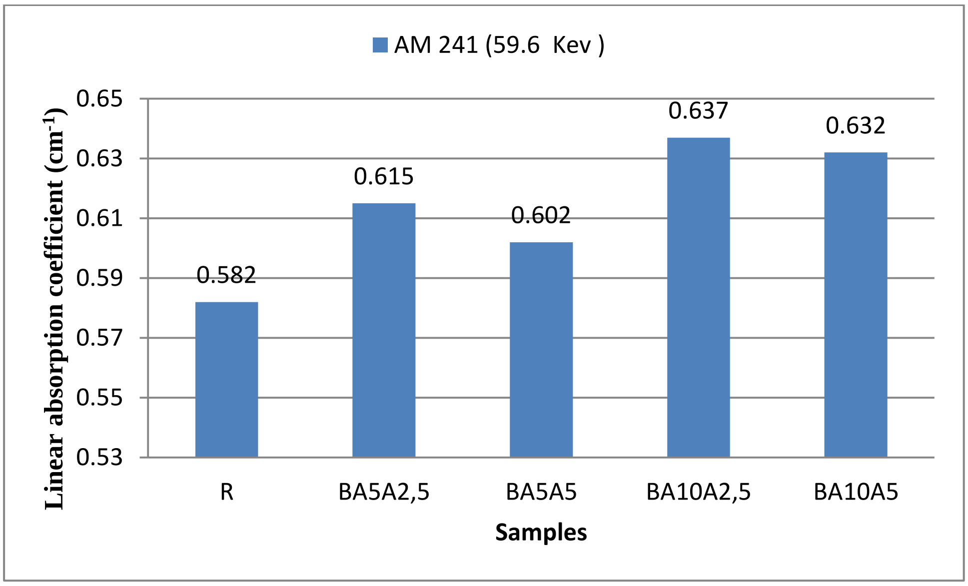

Figure 3. Linear absorption coefficient of barite, cholemanite and sunflower stalk ash doped specimens

The increased rate of the Sunflower stalk ash in the sample decreased the linear absorption coefficient.

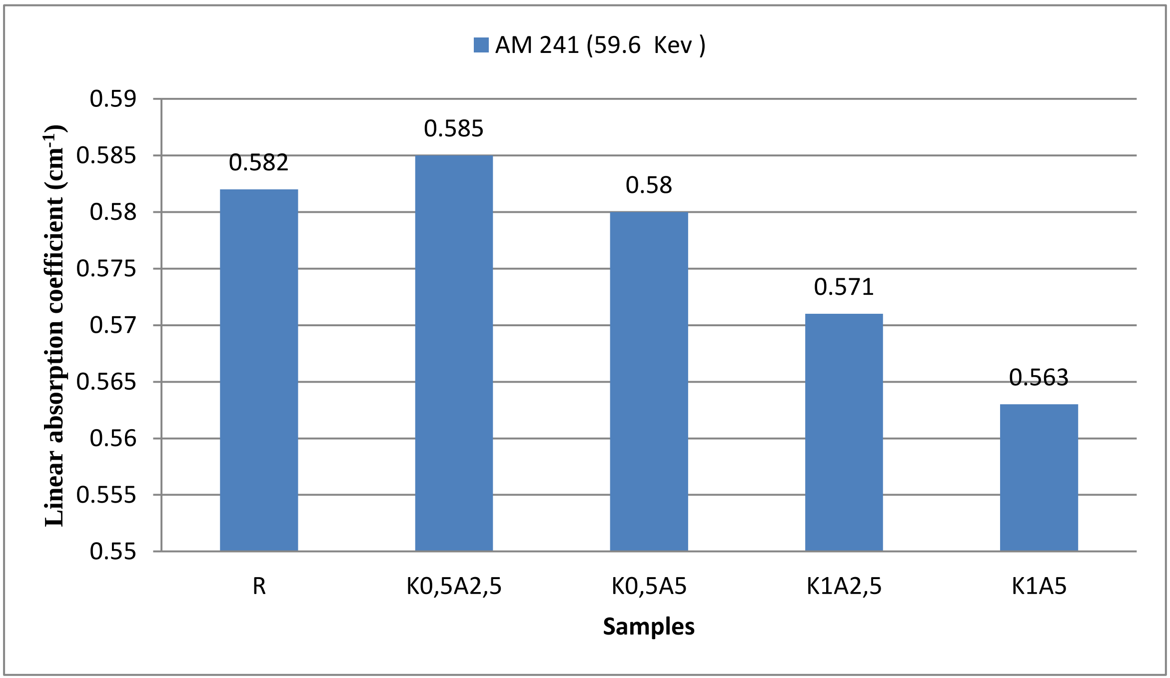

Figure 4. Linear absorption coefficient of barite, cholemanite and sunflower stalk ash doped specimens

In Figures 24 and 25 the linear absorption coefficient of K1A5 sample is the lowest, while BA10A2.5 sample has the highest linear absorption coefficient. While the sunflower stalk contributing 2.5% as a small amount of ash, it has contributed 5% negatively. This case can be explained by the lack of presence of high the atomic number elements of the chemical structure of the sunflower stalk ash.

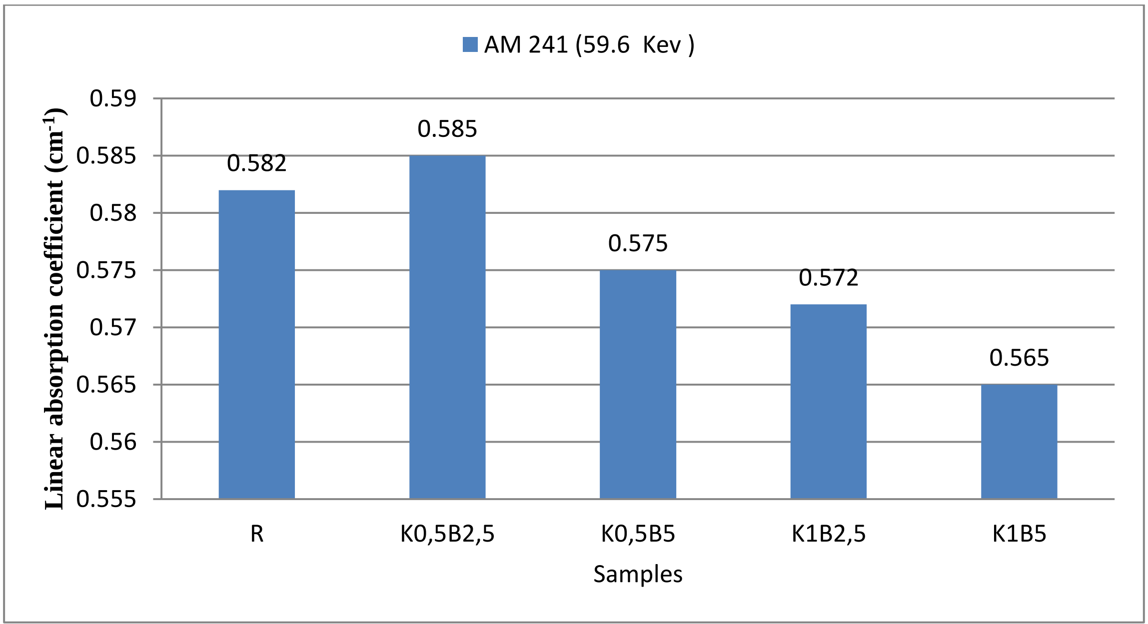

Figure 5. Linear absorption coefficient of barite, cholemanite and wheat stalk ash doped specimens

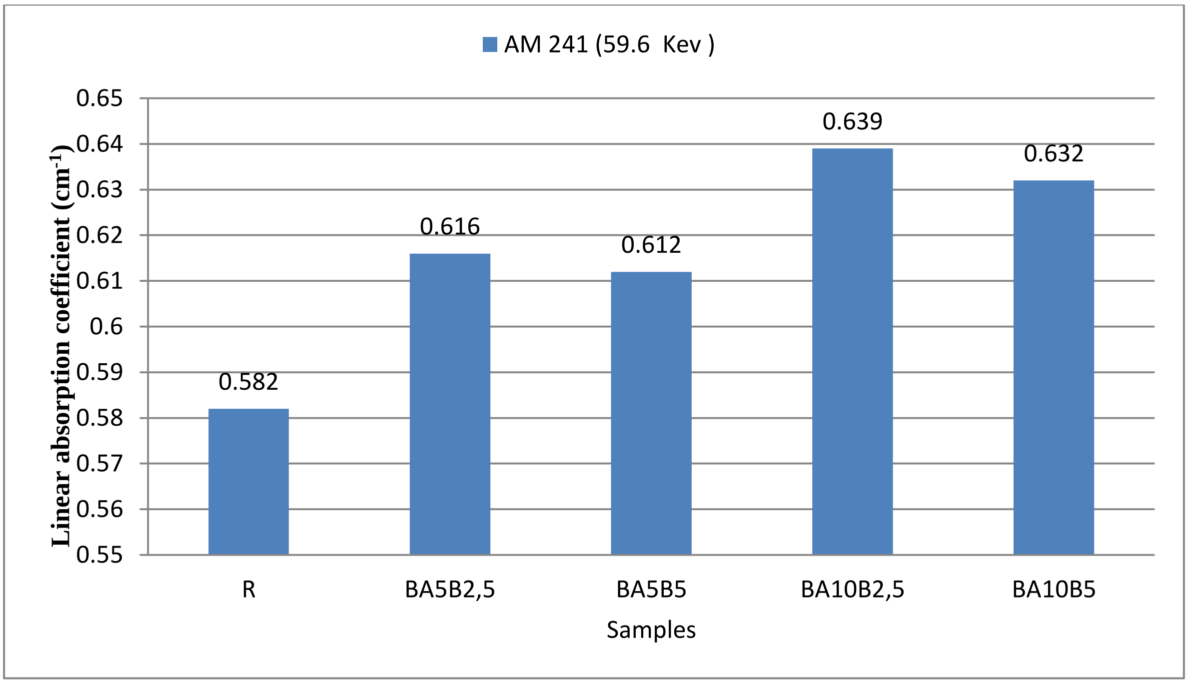

Figure 6. Linear absorption coefficient of barite, cholemanite and wheat stalk doped specimens

In Figures 26 and 27 In Figures 24 and 25 the linear absorption coefficient of K1B5 sample is the lowest, while BA10A5 sample has the highest linear absorption coefficient. While the wheat straw contributing 2.5% as a small amount of ash, it has contributed 5% negatively. This case can be explained by the lack of presence of high the atomic number elements of the chemical structure of the wheat straw ash.

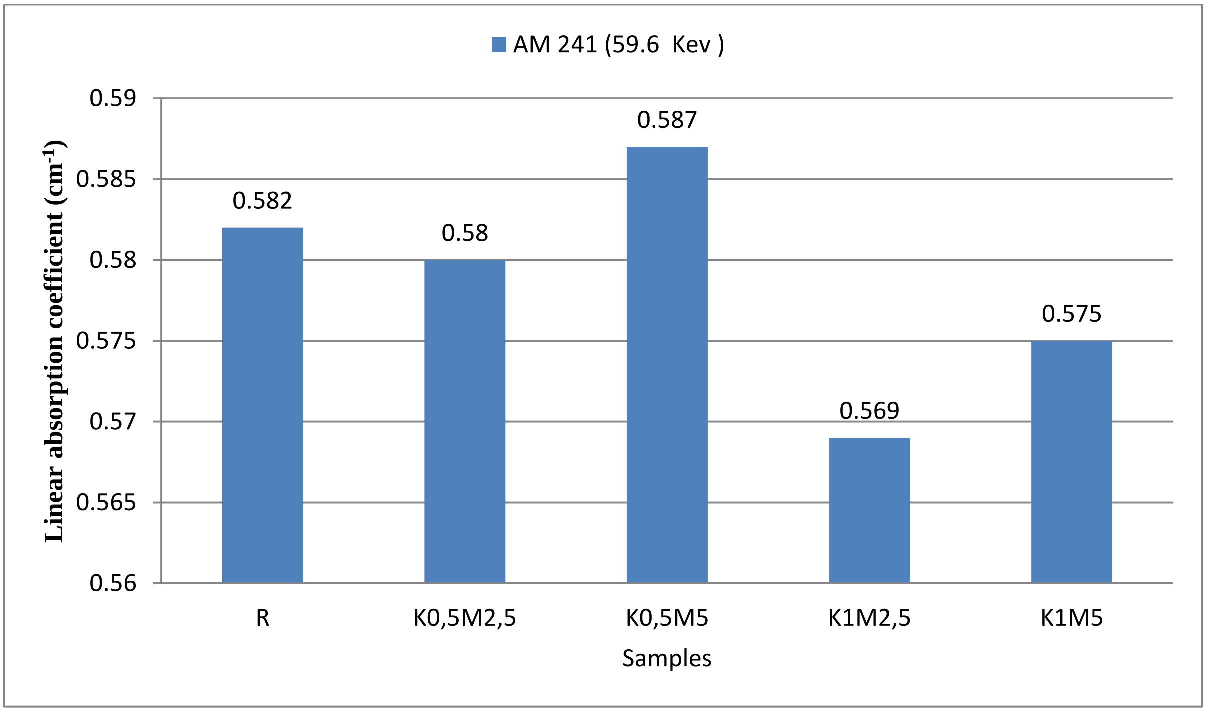

Figure 7. Linear absorption coefficient of barite, cholemanite and corn stalk doped specimens

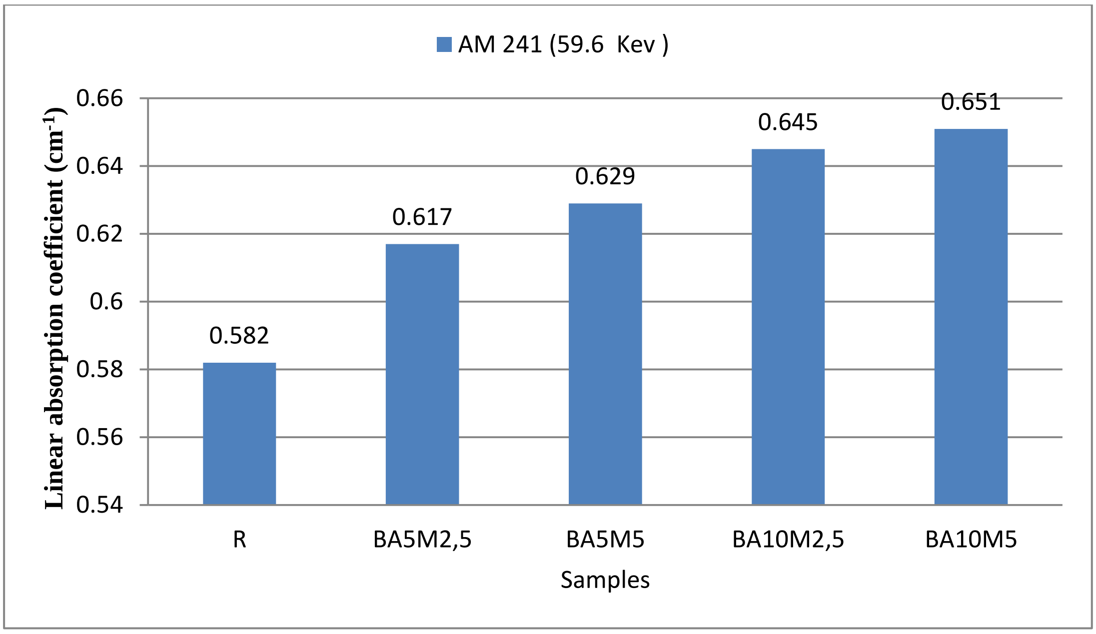

Figure 8. Linear absorption coefficient of barite, cholemanite and corn stalk doped specimens

In Figures 28 and 29, the linear absorption coefficient of K1M2, 5 sample is the lowest, while BA10M5 sample has the highest linear absorption coefficient. While the contribution of the corn stalk increased, linear absorption coefficient increased. This case can be explained by the presence of high the atomic number elements of the chemical structure of the corn stalk ash.

CONCLUTIONS

Under the Am-241 gamma rays of mortar specimens for the radiation absorption the highest linear absorption coefficient for corn 10% barite added instead of aggregates and 5% corn blended BA10M5 replaced with cement, for wheat 10% barite addition instead of aggregates and 2,5% wheat blended BA10B2.5 instead of cement, for sunflower 10% barite added instead of aggregates and 2% 5 sunflower doped BA10A2.5 samples instead of cement, and minimum linear absorption coefficient for corn 1% cholemanite added instead of aggregates and 2.5% corn doped K1M2.5 instead of cement, substituting aggregate wheat 1% cholemanite added and 5% wheat tempered K1B5 instead of cement, for sunflower 10% cholemanite added instead of aggregates and 5% sunflower K1A5 samples instead of cement were added. Finally, while barite increases in barite doped samples, the linear absorption coefficient increases. In addition, when cholemanite decreased in cholemanite doped samples, amount of residual linear absorption coefficient decreased.

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