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Experimental Measurements of the Radiation Shield Properties of some Produced Compounds

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Abstract

The number of hospitals in Iraq has increased during the recent period due to the many wars that Iraq entered, which led to the poor health status of many regions, many of the advanced devices depend on ionizing radiation for diagnosis and treatment, on the other hand, the use of radiation has been increased day by day according to the development of technology. Linear attenuation coefficients were calculated in two methods (practically and compared with Xcom online calculation methods), depending on these results, adding Magnetite Aggregate Concretes will have a positive effect on the density of the final compound, which leads to better absorption and better attenuator values for gamma emitter, it can be concluded that Magnetite Aggregate Concretes attenuators considered a good shielding for both low and very high photon energies where photoelectric and pair production effects are dominant, respectively.

1. INTRODUCTION

Radioactivity and sources of radiation became very widely used in our modern life, they are used in medicine, industry, research, and agriculture, as well as for electricity generation, and make an important contribution to economic development and people's well-being, there is a new application to promote the security situation in the world like ionization inspection systems (García-Toraño *et al*. 2017, Akkurt *et al.* 2006).

The number of hospitals in Iraq has increased during the recent period due to the many wars that Iraq entered, which led to the poor health status of many regions, many of the advanced devices depend on ionizing radiation for diagnosis and treatment, on the other hand, the use of radiation has been increased day by day according to the development of technology (Waheed, F. Q. and Dawood, Q. A. 2021, Akkurt, I. and Tekin, H. O. 2020).

Al-Tuwaitha Nuclear Research Center (ATNRC) was established in about 1960, it is shown in Figure 1.1. It lies in Baghdad province, the capital of Iraq at 33o 12.57 north and 44o 31.822 east. It covers an area of about 1.3 km^2. It is located approximately 1 km east of the Tigris River 20 km south of Baghdad, this site was the previous Iraqi Atomic Energy Commission (IAEC), and it is surrounded by earthen berms with 30m height around the facilities. This site currently undergoing the decommissioning project for the nuclear-destroyed facilities by the Ministry of Science and Technology of Iraq. Al-Tuwaitha comprised 90 buildings, the radiochemistry laboratories one of them (Rasheed *et al.* 2016).

Figure 1.1 The building in Al-Tuwaitha site, Radiochemistry laboratories RCL building

1.1 Aim of Study

The purpose of this work is to develop special materials and to measure their radiation shielding properties and it's attenuation, the frequently used shielding material for gamma rays are dense materials or big thicknesses or lead. In spite of its effectiveness and high mass attenuation coefficient, lower-weight gamma shielding materials are required.

The theoretical calculation will be performed by using the Xcom online program and all the experimental investigations including production and radiation measurement and comparison processing in this work will be done by using the Gamma Spectroscopy Laboratory in Iraq.

3. MATERIALS AND METHODS

3.1 Materials

3.1.1 Magnetite aggregate concretes samples

Aggregates are generally durable and hard materials such as sand, gravel, and crushed stone, which are used together with cement and water in concrete/ mortar production. The Aggregates were used in concrete in many ratios, most probably it was used from 60% to 75% of concrete volume, and thus enhancing its mechanical properties, for more hardness in the building, bridges, and other construction, Table 3.1 shows some details of Magnetite aggregate concretes (Akkurt *et al.* 2010).

Table 3.1 Some information about Magnetite aggregate concrete samples

		% 0 Magnetite	**% 25 Magnetite**	**% 50 Magnetite**	**% 75 Magnetite**	**% 100 Magnetite**
1	CaO	0.115624383	0.153550419	0.188609629	0.2207	0.250183037
2	MgO	0.392115401	0.28608994	0.189926987	0.101907	0.021039005
3	Na_2O	0.008100004	0.006543786	0.005612078	0.004759	0.003975758
4	K_20	0.012698806	0.009398212	0.006876379	0.004568	0.002447373
5	Fe_2O_3	0.009717797	0.090505873	0.164636922	0.23249	0.294830981
6	P_2O_5	0	0.001655266	0.002555528	0.00338	0.00413664

7	CO_2	0.084041834	0.061861181	0.042128812	0.024067	0.00747348
8	SiO_2	0.250642519	0.259771599	0.268580309	0.276643	0.284050783
9	H_2O	0.07997819	0.076242514	0.073324071	0.070653	0.068198512
10	Al_2O_3	0.041135076	0.035569527	0.030983023	0.026785	0.0229279
11	SO_2	0.00594594	0.005433915	0.005454062	0.005473	0.005489456
12	TiO_2	0	0.001220138	0.001723759	0.002185	0.002608255
13	BaO	0	0.001174338	0.0016362	0.002059	0.002447373
14	Cr_2O_3	0	0.001316328	0.001907624	0.002449	0.002946109
15	MnO	0	0.003533164	0.006145266	0.008536	0.010732829
16	SO_3	0	0.001678167	0.002599305	0.003442	0.004217082
17	V_2O_5	0	0.001142278	0.001574916	0.001971	0.002334755
18	ZnO	0	0.003313312	0.005725004	0.007932	0.009960592

3.1.2 Samples and Preparation

To arrive at the goal of the current investigation "develop special materials and to measure their radiation shielding properties and it's linear attenuation coefficient" a different type of materials in different thickness were made for this purpose, some related important parameters were calculated such as; the weight, thickness, others as shown in Figure 3.1. The preparation of samples for the current study were made according to recorded information which are given in Table 3.1.

The selected samples were prepared for testing against gamma-rays, for determination the results; gamma spectrometer was used in Baghdad University Physics Department. The linear attenuation coefficient (μ cm^{-1}) of the selected samples were exposed for gamma rays of three different energies (0.511, 0.834, and 1.275 MeV).

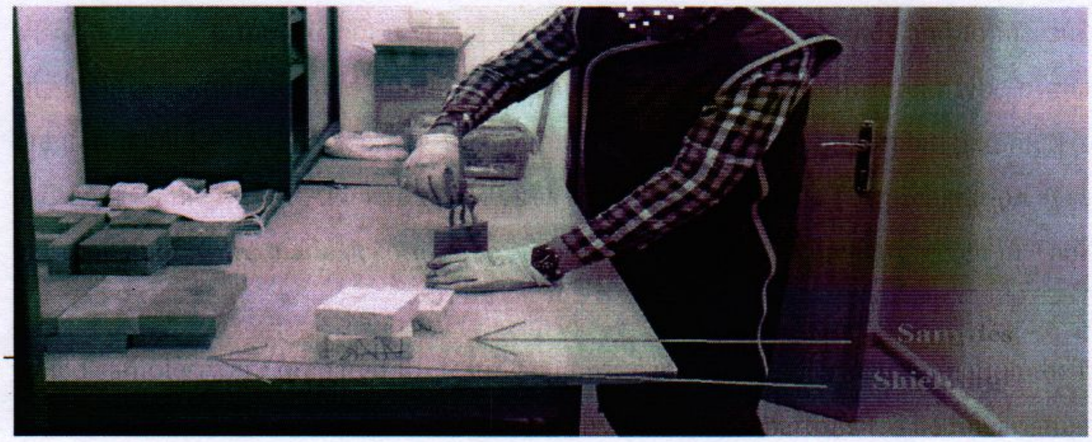

Figure 3.1 Calculation of weight and thickness for studied samples

4.1.1 Magnetite aggregate concrete density

Figure 4.3 shows the density of magnetite aggregate concrete with different ranges (Different ratios), the density of 0% magnetite aggregate concrete is 2.434 g/cm^3, while the density of adding 100% of magnetite aggregate concrete is 2.893 g/cm^3. It is clearly shown depending on Figure 4.1 that adding magnetite aggregate will positive effect on the density of the final compound, more density leads to more attenuation against gamma-ray emitters.

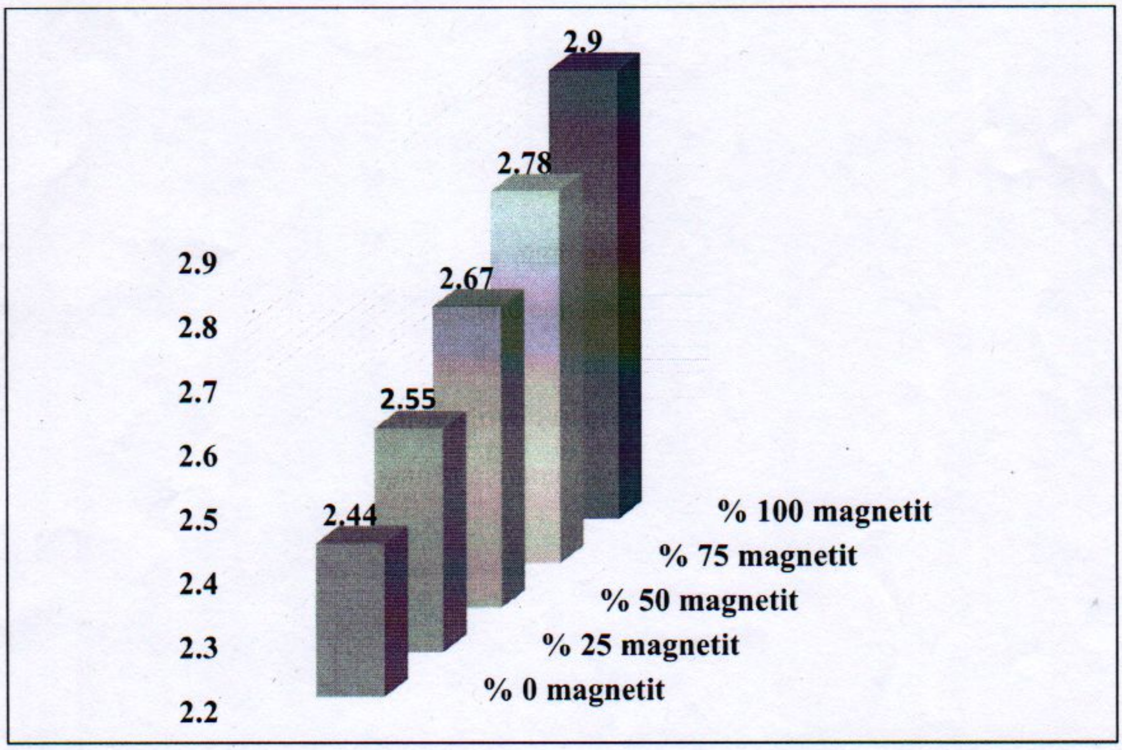

Figure 4.1 The density of magnetite aggregate concrete with different ranges (Different ratio)

4.2 Linear Attenuatuion Coefficient (μ cm-1) for Magnetite Aggregate Concerete

4.2.1 Linear attenuatuion coefficient (μ cm^{-1}) for magnetite aggregate concerete ratio (0%)

Figure 4.4 shows the linear attenuation coefficient (μ cm^{-1}) as a function of the three Gamma-ray energies (0.511, 0.834, and 1.275 MeV) for the practical results and its comparison with Xcom calculation, the ratio of magnetite aggregate concrete, in this case, is (0%), it clearly seems from this diagram that μ in low energy (0.511 MeV) is in high level while in high energy (1.275 MeV) it decreased. In addition, the values of μ in both methods (Experimental results and Xcom Calculation) are in good agreement.

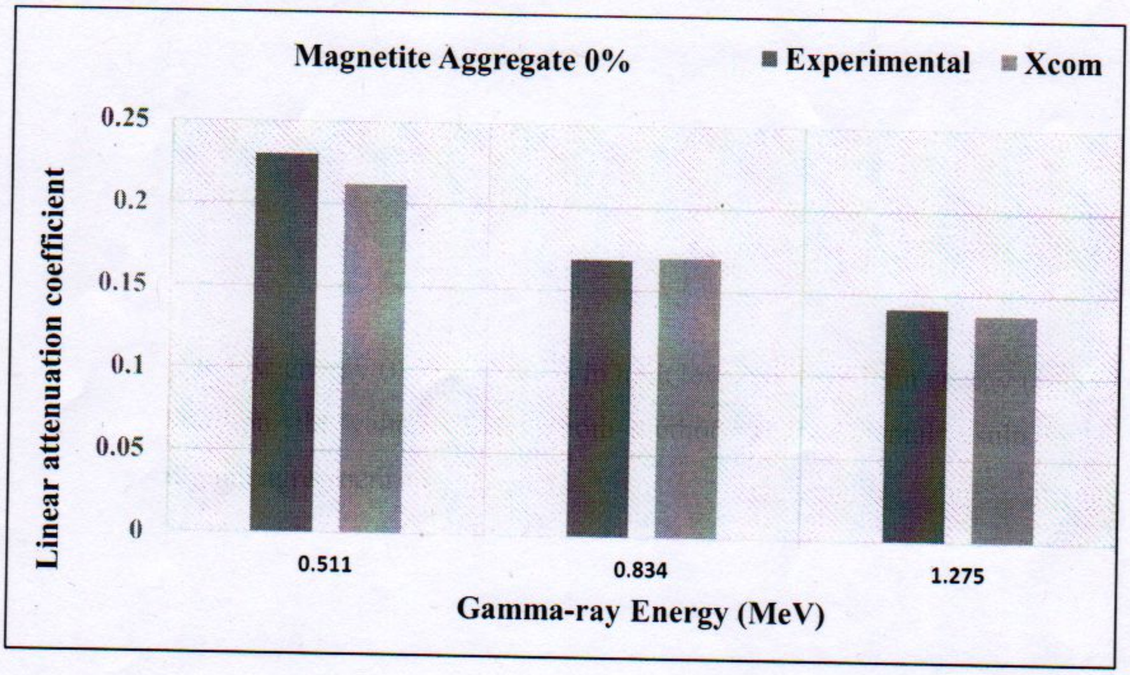

Figure 4.2 Linear attenuation coefficient (μ cm-1) as a function to the three energy (MeV), the ratio of magnetite aggregate concrete is (0 %)

4.2.2 Linear attenuatuion coefficient (μ cm-1) for magnetite aggregate concerete ratio (25%)

Figure 4.5 shows the linear attenuation coefficient ($\mu\ cm^{-1}$) as a function of the three Gamma-ray energies (0.511, 0.834, 1.275 MeV) for the practical results and its comparison with Xcom calculation, the ratio of magnetite aggregate concrete, in this case, is (25 %), it clearly seems from this diagram that μ in low energy (0.511 MeV) is in high level while in high energy (1.275 MeV) it decreased. In addition, the values of μ in both methods (Experimental results and Xcom Calculation) are in good agreement.

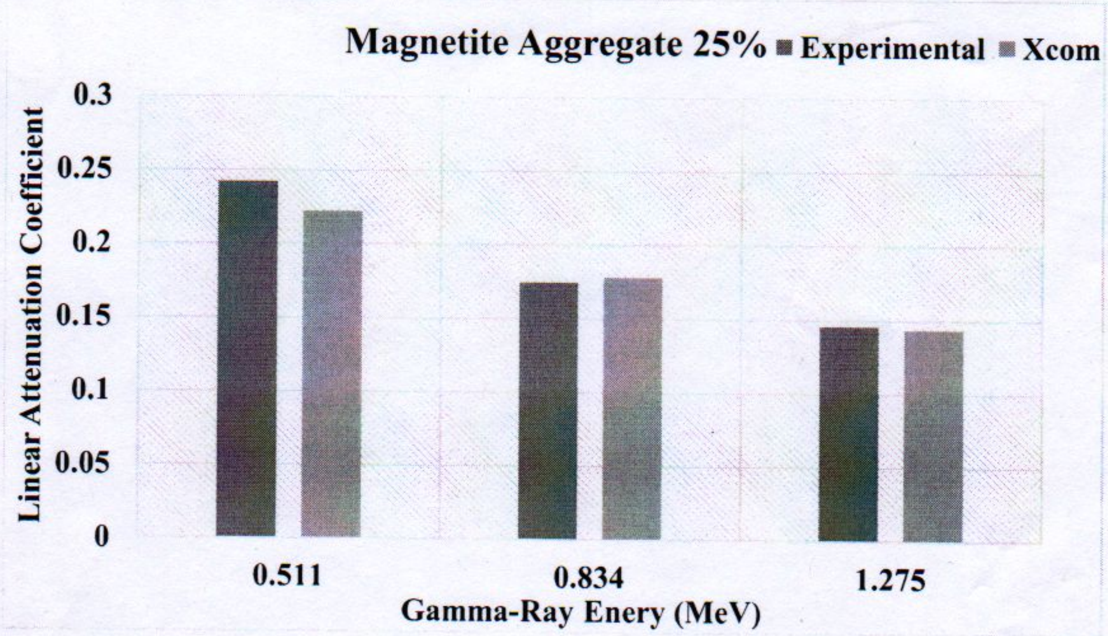

Figure 4.3 Linear attenuation coefficient (μ cm-1) as a function to the three energy (MeV), the ratio of magnetite aggregate concrete is (25 %)

4. CONCLUSION

Linear attenuation coefficients were calculated in two methods (practically and compared with Xcom online calculation methods), depending on these results, adding Magnetite Aggregate Concretes will have a positive effect on the density of the final compound, which leads to better absorption and better attenuator values for gamma emitter, it can be concluded that Magnetite Aggregate Concretes attenuators considered a good shielding for both low and very high photon energies where photoelectric and pair production effects are dominant, respectively.

The content of elements with high atomic masses contributes to the attenuation capability of concrete. This concretes compounds in a positive way. From this point of view, it can be stated that the chemical property of a Magnetite Aggregate Concretes strongly affects radiation shielding properties. Xcom is a powerful tool to be used in such radiation shielding studies.

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