International Journal of Multidisciplinary Research and Publications
ISSN (Online): 2581-6187

The Effect of Lead Doped with Sodium Chloride and Iron on the Attenuation of Gamma Ray Radiation Source

Hudhaifah Muhammad Ali Abdo Al-Huraibi[1], Sawsan Ahmed Elhouri Ahmed[2]
[1]M.Sc. Student - Khartoum-Sudan
[2]University of Bahri- College of Applied & Industrial Sciences
Department of Physics - Khartoum -Sudan

Abstract—*In this work a weak radioactive source was used, and different thickness of ordinary concrete clad with lead and concrete containing sodium chloride salts covered with lead in order to study how radiation is attenuated by different materials of different thicknesses. This is important knowledge for those who design radiation shields, to protect the human organism, it should be in controlled situations; where radiation is employed to perform desired tasks, such as medicine, or nuclear power plants, so unwanted exposure must be avoided. It may also be the necessary knowledge to protect human life from nuclear explosions in a situation of warfare.*

I. INTRODUCTION

A gamma ray, also known as gamma radiation (γ), is an electromagnetic radiation that penetrates deeply and is produced when atomic nuclei decay radioactively. It transmits the most photon energy since it is made up of electromagnetic waves with the shortest wavelengths. In 1900, French scientist and physicist Paul Villard made the discovery of gamma radiation while researching the radiation radium released. Ernest Rutherford first identified two less invasive forms of decay radiation (found by Henri Becquerel) in 1900, naming them alpha ray and betraying ascending order of penetrating power. In 1903, he dubbed this radiation gamma rays because to its relatively great penetration of matter[1,2,3,4].

Gamma rays from radioactive decay are in the energy range from a few kilo electron volts (keV) to approximately 8 mega electron volts (~8MeV), corresponding to the typical energy levels in nuclei with reasonably long lifetimes. Gamma ray spectroscopy can be utilized to detect the decaying source by analyzing its energy spectrum. From sources like the CygnusX-3 microquasar, very high energy gamma rays in the 100–1000 treat electron volt (Tev) region have been recorded. The majority of naturally occurring gamma ray sources on Earth are secondary radiation from atmospheric interactions with cosmic ray particles and radioactive decay. However, there are other rare natural sources, such as gamma-ray flashes, which produce gamma rays from electron action upon the nucleus. Notable artificial. Sources of gamma rays include fission, such as that which occurs in nuclear reactors, and high energy physics, such assent pion decay and nuclear fusion [5,6].

According to Astor physics, radiation below 100 Kev is categorized as X rays and is the focus of χ ray astronomy, while gamma rays are traditionally described as having photon energies exceeding 100 (keV). This convention stems from the early man-made χ rays, which had energies only up to 100 Kev, whereas many gamma rays could go to higher energies. A large fraction of astronomical gamma rays is screened by Earth's atmosphere. Because they constitute ionizing radiation, gamma rays are dangerous to biological systems [7, 8].

An atom releases extra energy in the form of electromagnetic radiation, or gamma rays. These are energy bundles, or quanta, that can move through bodily tissue, air, and other materials over great distances (up to several hundred meters). They are devoid of mass and charge. A gamma ray can enter a body and travel through it without striking anything, or it can strike an atom and transfer some or all of its energy to it. This typically ionizes the atom by removing one of its electrons. This electron then uses the energy it receives from the gamma ray to create additional ions by knocking electrons out of other atoms. Because a gamma ray is pure energy, it no longer exists once it loses all its energy. The capability of a gamma ray to do damage is a function of its energy, where the distance between ionizing events is large on the scale of the nucleus of a cell[9,10].

II. MATERIAL & METHOD

Apparatus:

1. Small Pieces Iron the Size the Finger
2. Chloride Sodium (Nacl)
3. Sand And Gravel
4. Cement
5. Lead
6. Iron Molds (Iron Molds to Put Concrete in and Cover it With Lead)
7. Gas Fire to Melt Lead
8. Gamma Radiation Source (Cs-137/Ba-137)
9. Geiger Counter

Sample Preparation:

In this work, there are two types of concrete: the first type is reinforced concrete impregnated with salts, and the second type is reinforced concrete without salts, which will be mentioned in detail as follows:

1. Ordinary reinforced concrete: the molds were designed to obtain the ideal shape of the sample, then cement was mixed with water, small stones, and sand with each other to form the

Hudhaifah Muhammad Ali Abdo Al-Huraibi and Sawsan Ahmed Elhouri Ahmed, "The Effect of Lead Doped with Sodium Chloride and Iron on the Attenuation of Gamma Ray Radiation Source," *International Journal of Multidisciplinary Research and Publications (IJMRAP)*, Volume 6, Issue 9, pp. 104-107, 2024.

appropriate mixture, half of the molds were filled with this mixture, then the iron pieces were geometrically placed on the concrete, and then the mold was stuffed With the concrete mixture, so that a thickness of (3cm) of concrete is obtained, to be covered with (2cm)of raw lead by melting the lead.

2. Reinforced concrete impregnated with salt (sodium chloride): water and sand are mixed with cement and very small stones with (200 grams) of salt, and they mixed together and pieces of iron are placed inside the concrete to obtain the ideal shape of concrete with a thickness of (3 cm). After that, the concrete covered with lead with a thickness of (2 cm).

Figure 1: Concert during preparation

Figure 1.1: Concert After Preparation

Figure 2: The Lead Melting on Reinforce Concrete

After preparing the reinforced concrete, a large mold was designed so that the reinforced concrete would be placed inside and the lead would be melted on the concrete.

Experiment Setup

A gamma radiation source (Cs137/Ba137) was place at a distance of (20 cm) from the radiation detector of a Geiger counter without any protection, and a radiation frequency reading was taken from the Geiger counter 1 min after radiation exposure Next, a sample of reinforced concrete impregnated with salts was placed at zero distance from the radiation detector. The duration of exposure to radiation was one minute, and the thickness of the first sample was (5cm), and the reading was taken from a Geiger counter, then the second sample was placed with the same thickness, so that the thickness of the sample became (10cm) of concrete impregnated with salts, and the radiation exposure time was only one minute, and the radiation frequency was determined on a screen Then a third sample was added with the same thickness, so that the shielding thickness became (15cm). The exposure time for the three samples was one min, and the reading was taken from the display of the Geiger counter. Then the fourth sample was added so that it became (20cm) thick at a distance of (0cm) from the radiation source, and the exposure time was one minute, then readings were taken for this exposure for all these samples. In addition, the same method was use for normal concrete.

Figure 3: The samples setup display

III. Results

The interaction of γ-rays with matter occurs through different physical processes; a physical phenomenon can describe each interaction. The common interaction types are photoelectric effect (PE), Compton scattering (CS) and pair production (PP). The sum of the aforementioned processes yields the total attenuation coefficient, which can be used to evaluate the total interaction of γ-rays.

The total attenuation of γ-rays with a thin target with thickness x follows an exponential behavior which easily described by Beer-Lambert law given by:

$$I = I_0 e^{-\mu x} \quad (1)$$

Where:

I_0 is the intensity of the incident beam (counts per second (cps)).

I is the intensity of the beam after transmission through a thickness (cm) (counts per second (cps)).

μ is the absorption coefficient (cm−1) of the medium.

X is the absorbing material thickness in (cm) [7].

The linear attenuation coefficient (μ), which represents the likelihood of a photon interacting with a material in a specific way per unit path length, is a crucial parameter in radiation shielding. With different thickness to determining the mass

Hudhaifah Muhammad Ali Abdo Al-Huraibi and Sawsan Ahmed Elhouri Ahmed, "The Effect of Lead Doped with Sodium Chloride and Iron on the Attenuation of Gamma Ray Radiation Source," *International Journal of Multidisciplinary Research and Publications (IJMRAP)*, Volume 6, Issue 9, pp. 104-107, 2024.

attenuation coefficients at different energies and from equation (1), we can calculate the linear attenuation coefficient be follows [7]:

$$\mu = \mathrm{Ln}\frac{I_0}{I}/X \quad (2)$$

The mass attenuation coefficient (μ/ρ) is also a useful quantity to evaluate the capability of a medium to shield the photons. For a sample consists of different elements (such Reinforced concrete covered with lead impregnated with sodium chloride salts (NaCl)), the mixture rule is convenient way to determine the μ/ρ at any energy.

$$\mu_{mass} = \frac{\mu}{p} \quad (3)$$

When

P is the density of the material lead = 11.34 g/cm^3 [8].

Since there are two types of concrete models, there will be two tables for the results. The first is for ordinary concrete, which is reinforced concrete covered with lead, and the second is reinforced concrete impregnated with salts (NaCl) and covered with lead.

When: The number of disintegrations per second, as determined by a radiation detector, is expressed in counts per second (cps). This detector will not be perfect. It will not detect all the decays. As a result, there are fewer counts per second than there are disintegrations. The distance between the source and the detector is consonant. The distance in the table is it between source and shield is not consonant.

TABLE 1: Reinforced concrete impregnated with salts (NaCL)and covered with lead.

No	Thickness (cm)	Time (sc)	Distance (cm)	I_0 (cps)	I	$\frac{I_0}{I}$	Ln($\frac{I_0}{I}$)	μ (cm^{-1})	μ (cm^2/gm)
1	No shield	60	20	0.017	0.017	1	0	0	0
2	5	60	15	0.017	0.015	1.13	0.125	0.0250	0.002246
3	10	60	10	0.015	0.007	2.143	0.762	0.076	0.07715
4	15	60	5	0.007	0.005	1.4	0.337	0.0224	0.00198
5	20	60	0	0.005	0.003	1.6	0.5108	0.0256	0.00207

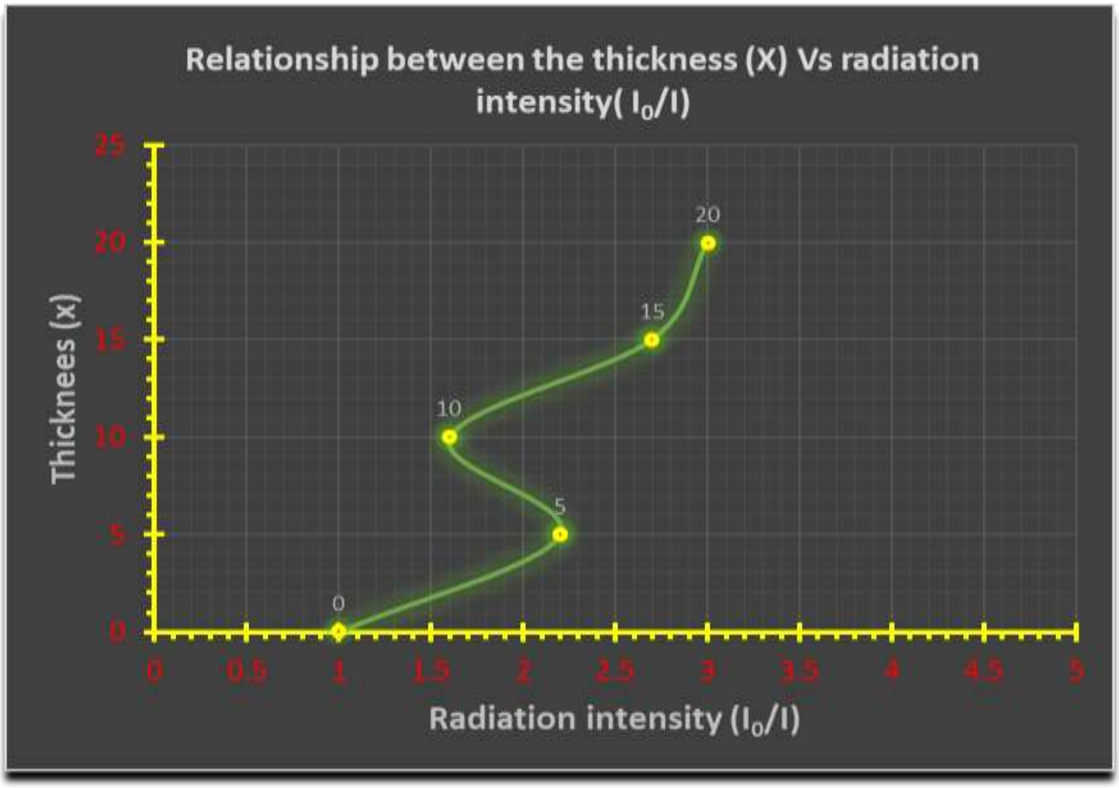

Figure 4: Relationship between the thickness(x) and radiation intensity ($\frac{I_0}{I}$).

TABLE 2: Reinforced concert and free of sodium chloride (NaCl) and covered with lead.

No	Thickness (cm)	Time (sc)	Distance cm	I_0 (CPS)	I (CPS)	$\frac{I_0}{I}$	Ln($\frac{I_0}{I}$)	μ (cm^{-1})	μ (cm^2/gm)
1	No shield	60	20	0.028	0.028	1	0	0	0
2	5	60	15	0.028	0.013	2.2	0.8	0.16	0.01353
3	10	60	10	0.013	0.008	1.6	0.5	0.05	0.00281
4	15	60	5	0.008	0.003	2.7	1	0.07	0.0057
5	20	60	0	0.003	0.001	3	1.1	0.055	0.005

Hudhaifah Muhammad Ali Abdo Al-Huraibi and Sawsan Ahmed Elhouri Ahmed, "The Effect of Lead Doped with Sodium Chloride and Iron on the Attenuation of Gamma Ray Radiation Source," *International Journal of Multidisciplinary Research and Publications (IJMRAP)*, Volume 6, Issue 9, pp. 104-107, 2024.

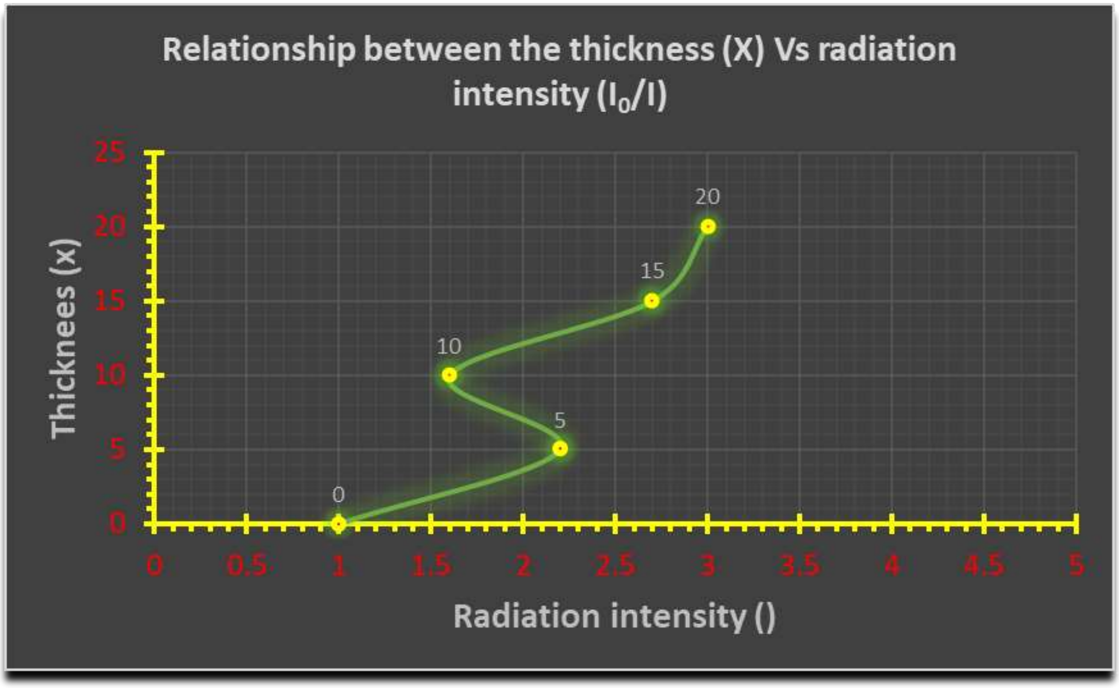

Figure 5: Relationship between the thickness(x) and radiation intensity ($\frac{I_0}{I}$).

IV. Conclusion and Discussion

- In table (1) and (2) show the distance between the radiation source (Cs^{137}/ Ba^{137}) and the shielding material is different with increases the thickness of the material, the distance between the radiation source (Cs^{137}/ Ba^{137}) and the detector is constant (20cm).
- In table (1) and (2) the exposure time to each thickness of the shielding material is (60 second), this meaning when placing reinforce concrete covered with lead that has (5cm) of thickness the exposure time is (60 second), and when add a new thickness it's has same the first thickness be the exposure time for both samples is (60 second), and also with the rest of the samples.
- In table (1) the value of the linear and mass attenuation coefficient is small because this sample contains sodium chloride (NaCl), which absorbs water during the preparation of reinforced concrete and prevents sand from mixing with small stones ideally and forms pores inside the sample that the rays pass through.
- In table (2) it is shown that the value of the linear and mass attenuation coefficient is greater than table (1) because of the ideal shape of the reinforced concrete covered with lead.
- Figure (4) show the relationship between the thickness(x) and radiation intensity ($\frac{I_0}{I}$) to the reinforced concrete impregnated with salts (NaCL) and covered with lead.
- Figure (5) show the relationship between the thickness(x) and radiation intensity ($\frac{I_0}{I}$) to the reinforced concert and free of sodium chloride (NaCl) and covered with lead.

References

1. SONG, Ha-Won; SARASWATHY, Velu. Corrosion monitoring of reinforced concrete structures-A. *Int. J. Electrochem. Sci*, 2020, 2.1: 1-28.
2. AHMAD, Ali. Topological properties of Sodium chloride. *UPB Scientific Bulletin, Series B*, 2022, 82.1: 35-46.
3. BURTON, Christine L. Determining the Effectiveness of Container Lids on Heat Absorption: Measuring Heat of Reaction for NaOH (aq) and HCl (aq). 2022.
4. JAAFAR, Mohd Hilmi. *Determination of Heavy Metal Accumulation in Ipomoea Aquatica Using Wet Destruction Method*. 2020. PhD Thesis. UMP.
5. AENAB, Allaa M.; SINGH, S. K.; LAFTA, Ali Jabir. Critical assessment of air pollution by ANOVA test and human health effects. *Atmospheric Environment*, 2020, 71: 84-91.
6. IKPESU, J. E., et al. Investigation of selected heavy metal and physio-chemical properties of Ekpan River in Delta State, Nigeria. 2020.
7. ARYEE, Aaron Albert. *Levels of Polycyclic Aromatic Hydrocarbons and Heavy Metals in Surface Soil at Auto-Mechanic Workshops within the Accra Metropolis, Ghana*. 2021. PhD Thesis. University of Ghana.
8. PRAVEEN, B. N., et al. Radiation in dental practice: awareness, protection and recommendations. *The journal of contemporary dental practice*, 2020, 14.1: 143.
9. MOHAMMED, Ammar Adam. *Investigating the Attenuation Coefficient for Different Material using X-Ray and Gamma Ray*. 2017. PhD Thesis. Sudan University of Science and Technology.
10. NELSON, G.; REILLY, Doug. Gamma-ray interactions with matter. *Passive nondestructive analysis of nuclear materials*, 2020, 2: 27-42.
11. NORCINI, D., et al. Precision measurement of Compton scattering in silicon with a skipper CCD for dark matter detection. *Physical Review D*, 2022, 106.9: 092001.
12. MCALISTER, Daniel R. Gamma ray attenuation properties of common shielding materials. *University Lane Lisle, USA*, 2020.

Hudhaifah Muhammad Ali Abdo Al-Huraibi and Sawsan Ahmed Elhouri Ahmed, "The Effect of Lead Doped with Sodium Chloride and Iron on the Attenuation of Gamma Ray Radiation Source," *International Journal of Multidisciplinary Research and Publications (IJMRAP)*, Volume 6, Issue 9, pp. 104-107, 2024.