Available online www.jocpr.com

Journal of Chemical and Pharmaceutical Research, 2012, 4(8):4032-4037

Research Article

ISSN : 0975-7384
CODEN(USA) : JCPRC5

Measurements of mass and linear attenuation coefficients of γ- rays of photons for Ni in the energy range 360-1330 keV

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ABSTRACT

Mass attenuation coefficient and linear attenuation coefficient of gamma rays of photons for Ni in the energy range 360- 1330 keV have been determined experimentally through photon–transmission measurement performed under narrow collimated beam counting geometry with scintillation spectrometer as a photon detector. The Mass attenuation coefficient and linear attenuation coefficient values reported in this work are found to be in good agreement with the values computed theoretically. These values represent a subject of considerable interest and importance, since it is required in solving various problems in a radiation physic and radiation dosimetry and of interest for industrial, biological, agriculture and medial studies.

Keywords: Mass attenuation coefficients, linear attenuation coefficients, gamma rays, Nickel (Ni)

INTRODUCTION

The photon attenuation coefficients are an important parameter for characterizing the penetration and attenuation properties of x-ray and gamma rays in materials. Accurate data on photon attenuation coefficients are required in a verity of applications in nuclear science, technology and medicine [1]. Mass attenuation coefficients and linear attenuation coefficients are two quantities widely used in the study of interaction of γ-rays with matter. the photoelectric effect ,Compton scattering and pair production processes are the predominant interactions between the photons and atoms apart from other types over a wide range of energies by irradiating the material with gamma rays ionization of the material takes place and stored energy of the material increases .[2] Accurate values of photo electric cross section from photon radiation in several materials are needed in solving various problem in radiation physics and radiation dosimetry it is important to note that much of the data is related on theoretical work and only few experimental results are available for comparison. It is necessary to ensure that the theoretically predicated values do indeed agree with experimental results.[3] Extensive studies have been carried out to determination gamma ray attenuation coefficients for various elements and photon energy [4-5,7-10].

Interaction of radiation with matter:
Nuclear radiations (α, β, γ-rays) have been used for a long time and serious accidents leading to confirmed and suspected deaths of persons arising from direct and indirect effects of radiations have occurred. In different applications of radiations it is observed that, over-exposure is harmful and under-exposure is ineffective. Gamma

rays and ultraviolet radiations, for instance, produce electrons through the well-known mechanism of photoelectric, Compton and pair production.

Photoelectric (PE): Absorption of x-rays occurs when the x-ray photon is absorbed, resulting in the ejection of electrons from the outer shell of the atom, and hence the ionization of the atom. Subsequently, the ionized atom returns to the neutral state with the emission of an x-ray characteristic of the atom. This subsequent emission of lower energy photons is generally absorbed and does not contribute to (or hinder) the image making process. Photoelectron absorption is the dominant process for x-ray absorption up to energies of about 500 KeV. Photoelectron absorption is also dominant for atoms of high atomic numbers.

Compton Scattering (C): When the incident gamma-ray photon is deflected from its original path by an interaction with an electron. The electron gains energy and is ejected from its orbital position. The x-ray photon loses energy due to the interaction but continues to travel through the material along an altered path. Since the scattered x-ray photon has less energy, it therefore has a longer wavelength than the incident photon. The event is also known as incoherent scattering because the photon energy change resulting from an interaction is not always orderly and consistent. The energy shift depends on the angle of scattering and not on the nature of the scattering medium.

Pair Production (PP): Pair production occurs when an electron and positron are created with the annihilation of the x-ray photon. Positrons are very short lived and disappear (positron annihilation) with the formation of two photons of 0.51 MeV energy pair production is of particular importance when high-energy photons pass through materials of a high atomic number.

The gamma rays are highly penetrating and can therefore, reach easily the internal organs of the body. Therapy of deep-sited tumors is, therefore amenable to gamma rays. Gamma rays have different penetration depths in different materials. Lead is the most efficient absorber of gamma rays. Gamma ray shielding is usually described in terms of a parameter known as the half value layer (HVL) of the absorber. HVL is the absorber thickness that reduces the original gamma ray intensity I0 to half, the transmitted intensity. It of the gamma ray beam from a material containing (n), HVL is given by [2].

Theory:
The mass absorption coefficient is used alternatively with linear attenuation coefficient in calculation it is defined as,

$$I = I_0\rho - \mu t$$

$$I = I_0\rho - \mu/\rho\ (\rho t) \quad ---- \quad (1)$$

as $$\mu = \frac{1}{t} \ln\left(\frac{I_0}{I}\right) \quad ----- \quad (2)$$

and $$\mu/\rho = \frac{1}{\rho t} \ln\left(\frac{I_0}{I}\right) \quad ----- \quad (3)$$

Where I and I_0 are intensities of gamma radiation of energy E transferred through the container respectively with and without absorber of thickness t then the linear (μ) and mass (μ/ρ) attenuation coefficient are given from the above experimental law.

EXPERIMENTAL SECTION

For the present study a good resolution NaI(Tl) detector is used for measurements. The present experimental arrangement can be identified as being of narrow beam attenuation geometry which avoids the scattered and the secondary radiations reaching from the detector. The gamma ray spectrometer will be calibrated using standard multi energy gamma sources.

All the samples of elemental solids are thin uniform circular shaped of diameter 3cm for each irradiated samples material and for a given gamma ray energy. We measure the number of gamma ray photons detected when place the sample to be irradiated in the path of gamma rays, for different atomic number foils.

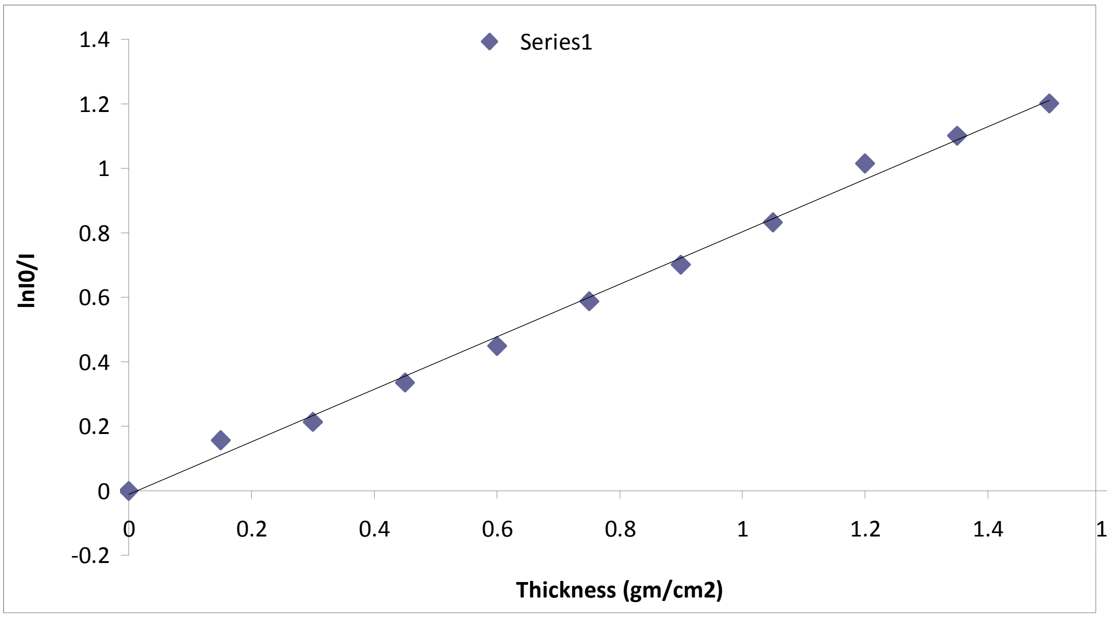

Fig.1 Thickness in gm/cm2 vs.ln I_0/I for nickel at 0.360 MeV

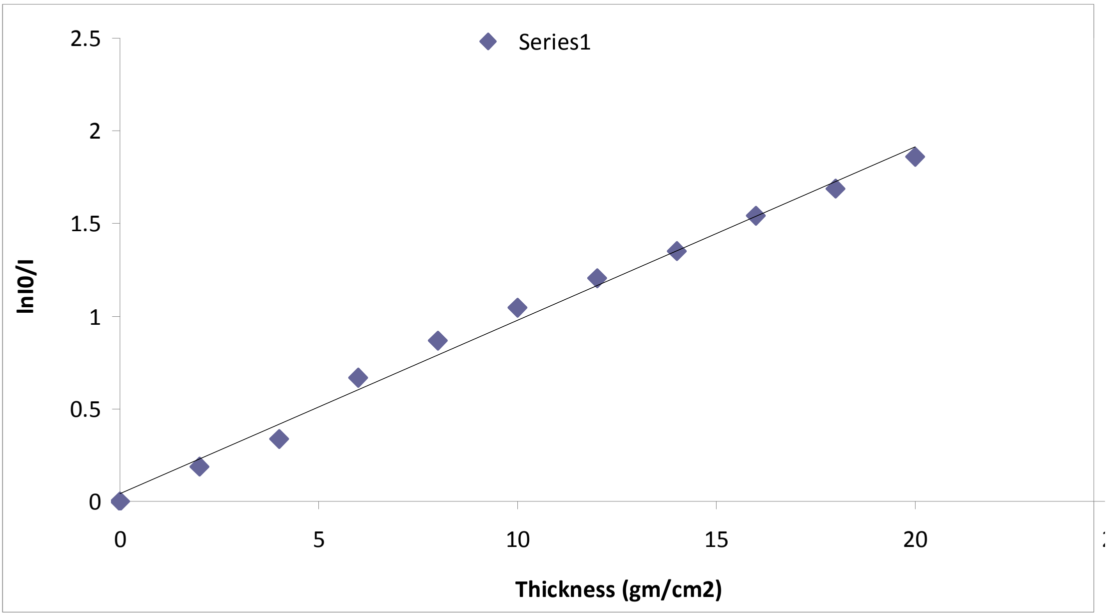

Fig.2 Thickness in gm/cm2 vs.ln I_0/I for nickel at 0.511 MeV

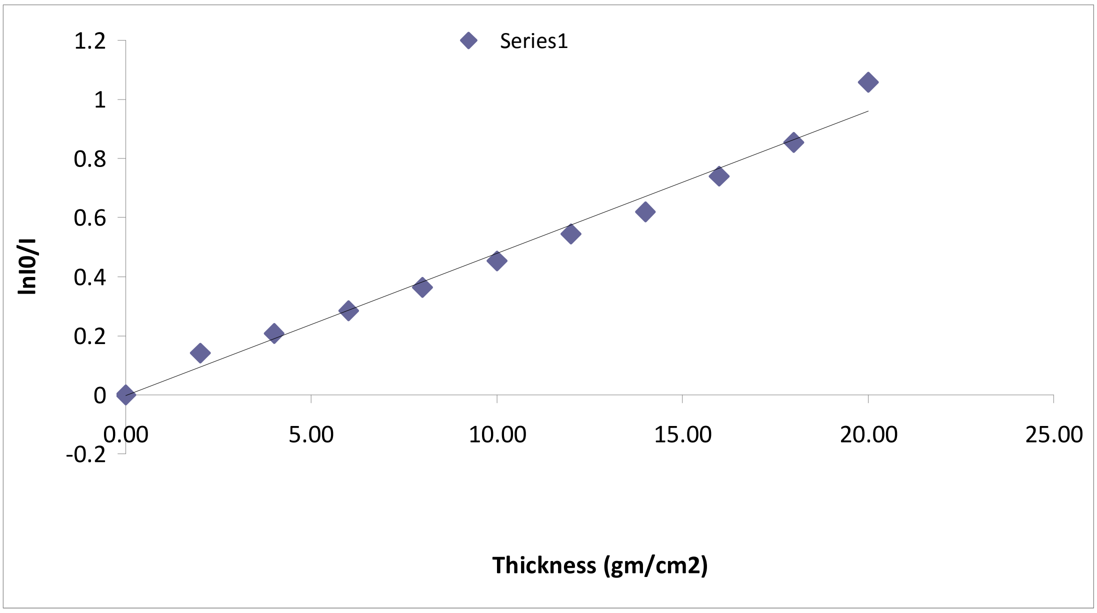

Fig.3 Thickness in gm/cm2 vs.ln I_0/I for nickelat 0.662 MeV

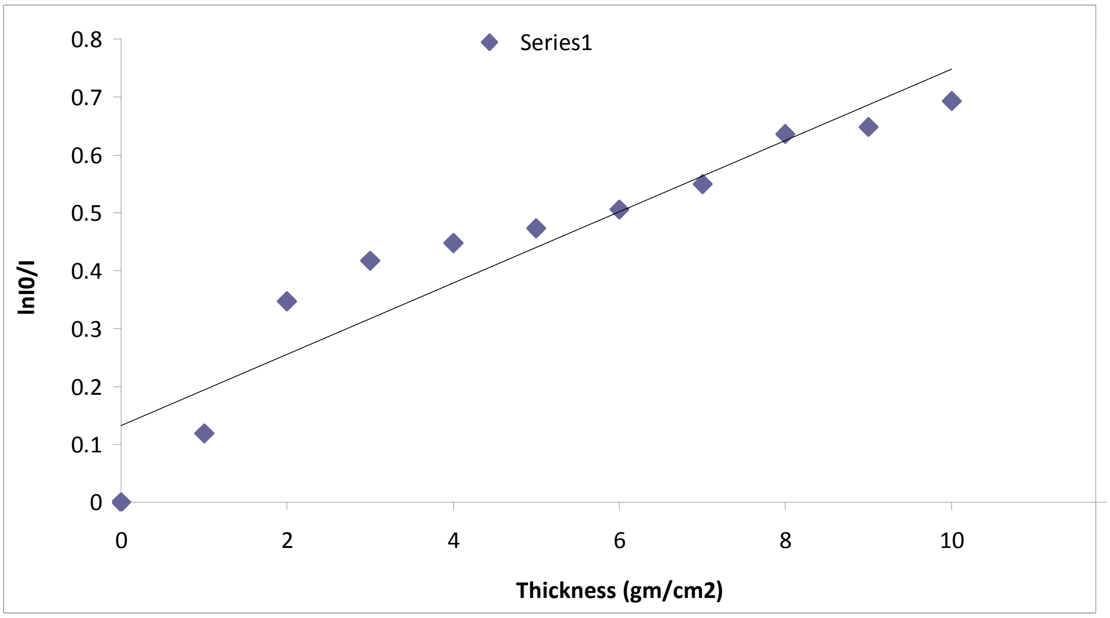

Fig.4Thickness in gm/cm2 vs.ln I_0/I for nickel at 1.170 MeV

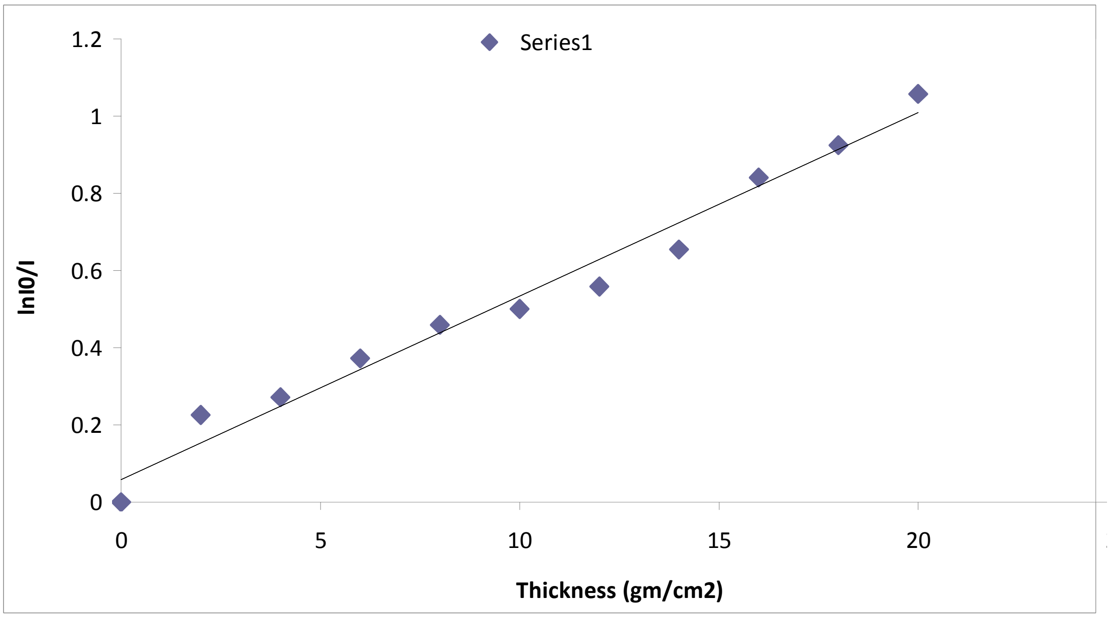

Fig.5Thickness in gm/cm2 vs.ln I_0/I for nickel at 1.1280 MeV

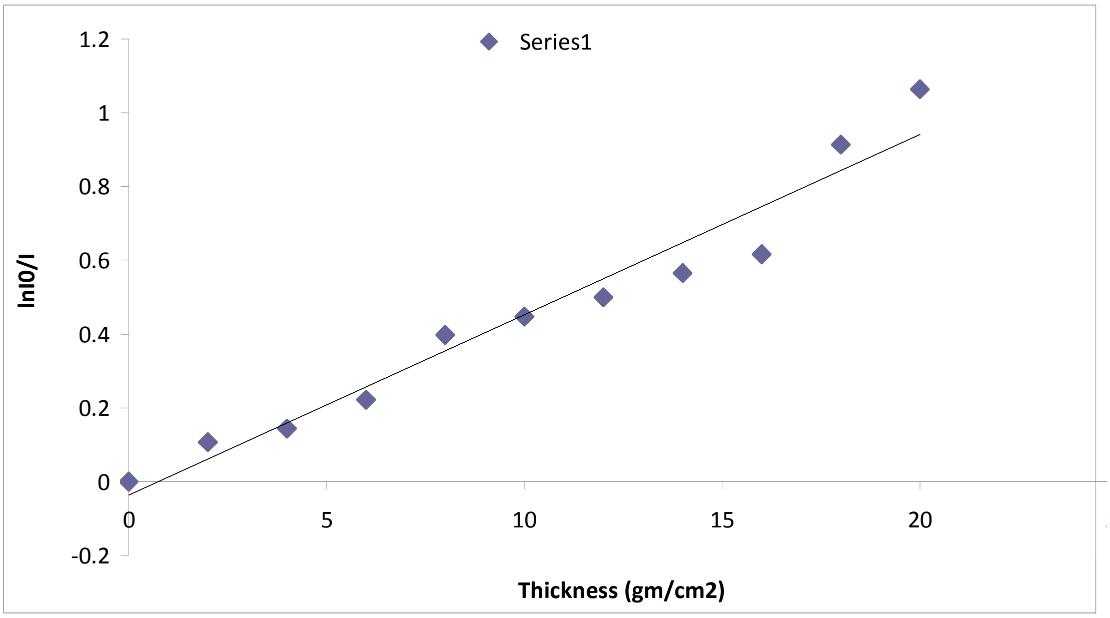

Fig.6Thickness in gm/cm2 vs.ln I_0/I for nickel at 1.330 MeV

Table 1: Linear attenuation coefficient μ (cm^{-1}) and mass attenuation coefficient μ/ρ (cm^2/gm) of Ni absorber in the energy range 360-1330keV.

Sr. No.	Energy KeV	μ(cm^{-1})	μ/ρ(gm/cm2)
1	360	0.89	0.81
2	511	0.76	0.08
3	662	0.67	0.07
4	1170	0.54	0.06
5	1280	0.46	0.04
6	1330	0.48	0.05

RESULTS AND DISCUSSION

Mass attenuation coefficient of elemental solids (Ni) absorber for multi gamma ray energies (Ba^{133},Na^{22}, Cs^{137}, Co^{60},) has been studied.

Various parameters such as linear attenuation coefficient (μ), mass attenuation coefficient (μ/ρ), photo-electric cross-section, total photon interaction cross section (σ_{tot}) have been obtained for elemental solids.

The comparison of their measurement with the theoretical values [6] is done by calculating the percentage deviation as,

$$\text{Percentage deviation} = \frac{\frac{\mu}{\rho}\text{ (theor) - }\frac{\mu}{\rho}\text{ (expt)}}{\frac{\mu}{\rho}\text{ (Theor)}} \text{ x } 100$$

These are also presented in the Table 1 and the author found that the deviation mostly below 2% indicating these by excellent agreement of the authors measurements with theory. The linear attenuation coefficient is obtained by multiplying the mass attenuation coefficient of the element by its density. Fig. 1 to 6 shows plot of ln I_0/I v/s thickness (t) for Ni at 360, 511, 662, 1170, 1280 and 1330 keV using this graphs, slope can be calculated and this slope is nothing but the μ/ρ mass attenuation coefficient of element at that particular energy.

CONCLUSION

The theoretical values of mass attenuation coefficient for element are available from [6] and the author so measured values with experiments confirms the contributions of various process such as photo electric effect, Compton scattering and the pair production. The measured mass and linear attenuation coefficient of elements are useful for dosimetry and radiation shielding purpose. It is found that there is a good agreement with theoretical and experimental measured values.

Acknowledgement
The author is very much thankful to R. Nathu Ram for his fruitful discussion.

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