Determination and Comparison of Attenuation Coefficients of Soils from Loikaw, Kayah State and Ohn-chaw, Mandalay Division

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Abstract

Soil samples were collected from the two different places of the agricultural fields in Kayah State and Mandalay Region. In this research, we determined the attenuation coefficients of soils by gamma transmission measurement. The result of attenuation coefficients are $1.1 cm^{-1}$ and $1.155 cm^{-1}$ for ^{137}Cs and $0.63 cm^{-1}$ and $0.67 cm^{-1}$ for ^{60}Co respectively. We also calculated the mass attenuation coefficients, μ_m. Then the result, were compared with the values of Latur and Usmanabad district from Maharashtra, India. The average result of coefficients two soils was nearly the same as that of India soils. So, these soil samples are obeyed the gamma ray attenuation law and technique allows the determination of coefficients of soil with good accuracy.

Key words: Attenuation coefficient, gamma ray energy sources, gamma ray spectrometer, GM Counter.

Introduction

The photon attenuation coefficient is an important parameter characterizing the penetration and diffusion of gamma rays in composite materials soil. The effects of different parameters on the attenuation coefficients of soils were discussed in several studies. Soil has chemical properties as on its compositions like C, N, S, P, Ca, Mg, Na etc. The importance of the study of gamma-ray attenuation properties of materials and its various applications in science, technology, agriculture and human health, we embarked on a study of the attenuation properties of soil sample of various chemical and physical properties containing microelements by using gamma radiation technique.

Interactions of Gamma-Radiation with Matter

In the case of charged particles (e.g., electrons, protons, alpha particles), interaction of photons of gamma radiation with matter is of electromagnetic nature. Photons can be only scattered or absorbed. Photon absorption is an interaction process when the photon disappears and all its energy is transferred to atoms of the material or to secondary particles. Photon scattering is an interaction process when the photon does not disappear, but changes direction of its propagation. In addition, the scattered photon may transfer a part of its energy to an atom or an electron of the material. There are two interaction processes whereby a photon is absorbed and several types of scattering.

Theoretical Background

Gamma rays are much less ionizing than alpha and beta and they are highly penetrating, so that several centimeters of lead are required to absorb gamma rays (almost) completely. The penetrating power of gamma rays in a medium depends on the energy of the gamma rays and on the atomic number of the material. Because of their electromagnetic nature, gamma rays interact principally with the shell electrons and the Coulomb field of the nuclei. Gamma rays lose their energy mainly by the following processes; Photoelectric effect, Compton scattering and Pair production. If a narrow (collimated) beam of gamma rays of intensity I_o is incident on an absorber, their absorption follows the law;

$$I = I_o e^{-\mu x} \qquad (1)$$

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where μ = linear absorption coefficient of the medium for gamma rays of the particular energy, I = intensity of gamma rays transmitted, x = thickness of absorbing material. Hence the absorption coefficient may be determined from values of half thickness or mean free path will obtained from a gamma absorption curve. The knowledge of the absorption properties of gamma rays is important in many fields.

Materials and Methods

In the soil attenuation coefficient determination, the gamma ray attenuation method was developed and it is based on the exponential decay law.

Determination of Attenuation Coefficient for Soil Samples

Using this coefficient the degree of attenuation of a narrow beam of gamma-radiation can be calculated by using the equation (1). The equation relates the intensity of γ-rays at a specified energy after attenuation, I, to that without attenuation at the same energy, I_o. The relationship is only valid under good geometry conditions with a thin absorber and a collimated gamma-ray source. When gamma-rays above the pair production threshold energy are considered there may also be an annihilation gamma-radiation contribution to the dose rate beyond the absorber.

Calculation of Attenuation Coefficient of Soil Samples

The attenuation coefficient of soil samples can be calculated by using exponential decay law,

$$\mu = \frac{\ln 2}{x_{1/2}} \qquad (3)$$

where, μ, $cm^{-1}$is attenuation coefficient, x, cm is thickness of absorption material, soil sample.

Experimental Setup

Sample Collection and Sample Preparation

The first sample was collected from Loikaw Township, Kayah State. The next sample was collected from Ohn-chaw, Patheingyi Township, Mandalay Division. These samples were dug a depth of about ten inches in the fields. Exactly one week was dried (the sun did not tough). The stone mortar was used the samples to make powder then and it made the particle filter about three times. These samples were placed in plastic container. All samples were weighed (about 10g) by using a high sensitive digital weighing balance. Each sample was counted by using ST-360 software with PC.

The linear attenuation coefficient (μ) of soils was determined by the monoenergetic photon that passed through the soil particle container. The relation between I and thickness of soil was shown in figures for all samples. Then, mass attenuation coefficient (μ_m) of these soils was calculated.

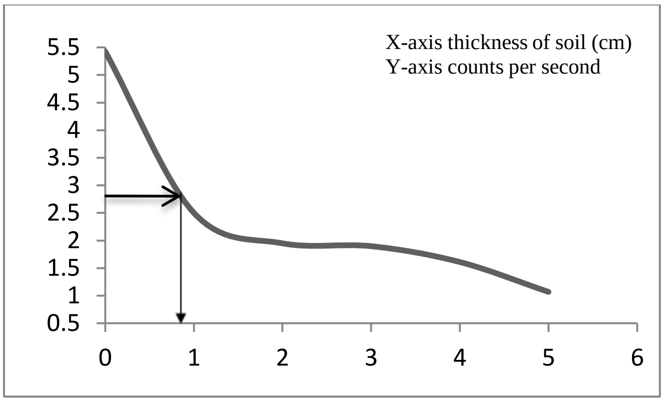

Fig. (1) Attenuation graph for Cs-137 Gamma Source (Loikaw)

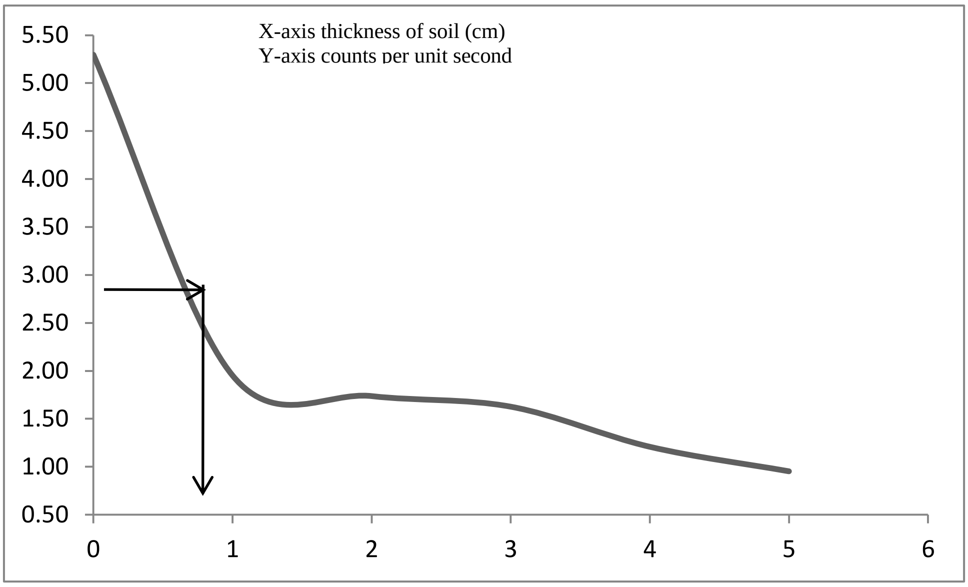

Fig. (2) Attenuation graph for Cs-137 Gamma Source (Ohn-chaw)

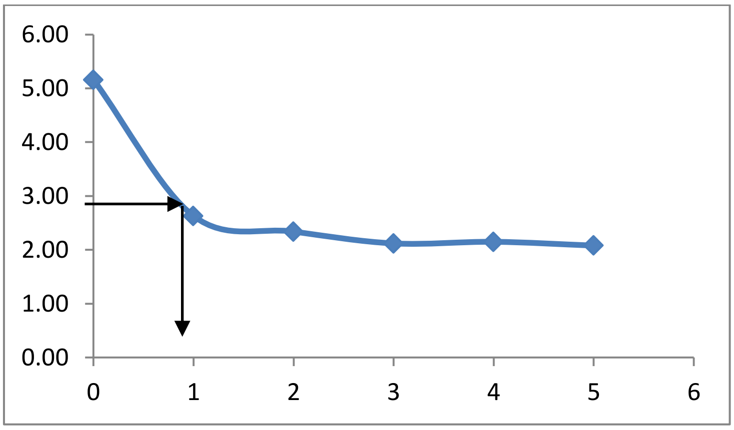

Fig. (3) Attenuation graph for Co-60 Gamma Source (Loikaw)

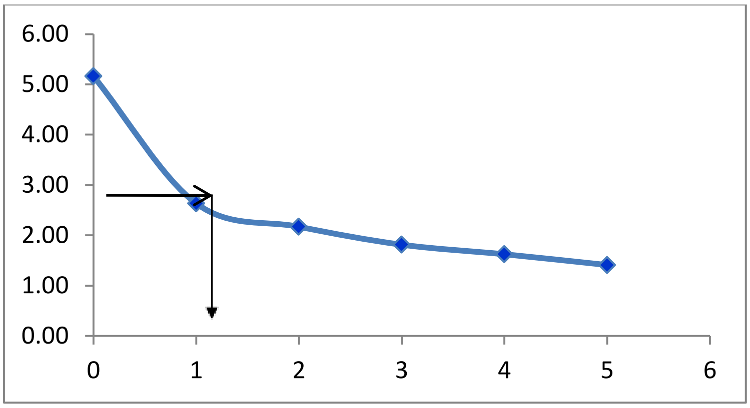

Fig. (4) Attenuation graph for Co-60 Gamma Source (Ohn-chaw)

Experimental Setup for Gamma Transmission Measurement

The photograph for γ-ray spectrometer using GM counter is shown in Fig. (3). The soil attenuation coefficient was determined by using a radioactive gamma ray source of ^{137}Cs having an activity of 5μCi emitting monoenergetic photons of energy 662.6keV. The distance between detector and soil sample container is 6cm, container and source is 0.5cm. By keeping empty container between source and detector firstly, the number of counts I_o of gamma particles for 300 sec was measured the nature of radioactivity. Then by inserting the soil sample in container 1cm, 2cm up to 5cm, the number of counts I of gamma particles for 300 sec was measured for each path length. This measurement repeated for ^{60}Co, 1173keV and 1332keV.

Fig. (3) The Photo of Gamma Ray Detection System

Results and Discussion

The experimental values of absorption coefficient of soil samples from different locations have been studied. Exponential decay observed. As energy increases, the mass attenuation coefficient of various densities and compositions decreases. This gives the validity of exponential absorption law, $I = I_0 e^{-\mu x}$ where, x is thickness of the soil sample. The linear and mass attenuation coefficient depends on material density, sample composition and photon energy.

Table (1) Counting Result for ^{137}Cs Gamma Source (Loikaw)

Sr. No.	Absorber Thickness, cm	Total Counts for 300s	Net Counting Rate, cps
1	0	32575	108.58
2	1	11940	39.80
3	2	10350	34.50
4	3	10070	33.57
5	4	9010	30.03
6	5	8240	27.47

Table (2) Counting Result for ^{137}Cs Gamma Source (Ohn-chaw)

Sr. No.	Absorber Thickness (cm)	Total Counts for 300s	Net Counting Rate (cps)
1	0	1628.7	5.429
2	1	751	2.503
3	2	585	1.950
4	3	569.5	1.898
5	4	483.2	1.611
6	5	321	1.070

Table (3) Experimental Results for Half-value Thickness for ^{137}C

Sr.No.	Source	Energy (keV)	Half-value thickness from graph
1.	Cs-137	662	0.59 cm (Loikaw)
2.	Cs-137	662	0.5 cm (Ohn-chaw)

Table (4) Linear Attenuation Coefficient and Mass Attenuation

Sr. No.	Source	Energy (keV)	Experimental Data	
			Attenuation Coefficient, μ, (cm^{-1})	Mass Attenuation Coefficient, μ_m, (cm^2g^{-1})
1.	Cs-137	662	1.175(Loikaw)	1.698(Loikaw)
2.	Cs-137	662	1.159(Ohn-chaw)	1.664(Ohn-chaw)

Table (5) Counting Result for ^{60}Co (1173keV & 1332keV) (Loikaw)

Sr. No.	Absorber Thickness (cm)	Total Counts for 300s	Net Counting Rate (cps)
1	0	1548	5.16
2	1	790	2.63
3	2	701	2.34
4	3	637	2.12
5	4	644	2.15
6	5	623	2.08

Table (6) Counting Result for ^{60}Co (1173keV & 1332keV) (Ohn-chaw)

Sr. No.	Absorber Thickness (cm)	Total Counts for 300s	Net Counting Rate (cps)
1	0	2909	2659
2	1	2747	2497
3	2	2809	2559
4	3	2799	2549
5	4	2826	2576
6	5	2937	2687

Table (7) Experimental Results for Half-value Thickness for ^{60}Co

No.	Source	Energy (keV)	Half-value thickness from graph
1.	Co-60	1173 & 1332	1.1 cm (Loikaw)
2.	Co-60	1173 & 1332	1.105 cm (Ohn-chaw)

Table (8) Linear Attenuation Coefficient and Mass Attenuation Coefficient

No.	Source	Energy (keV)	Experimental Data	
			Linear Attenuation Coefficient, $\mu(cm^{-1})$	Mass Attenuation Coefficient, $\mu_m(cm^2g^{-1})$
1.	Co-60	1173 & 1332	0.63(Loikaw)	0.9144(Loikaw)
2.	Co-60	1173 & 1332	0.603(Ohn-chaw)	1.481(Ohn-chaw)

Table (9) Comparison Data for Linear & Mass Attenuation Coefficient

Sr	Gamma Sourc	Linear attenuation coefficient		Mass attenuation coefficient	
		Loikaw	Ohn-chaw	Loikaw	Ohn-chaw
1.	^{137}Cs	1.175	1.698	1.159	1.664
2	^{60}Co	0.63	0.603	0.9144	1.481

Results

The experimental results were shown in tables and graphs. This gives the validity of exponential absorption law, $I = I_0 e^{-\mu x}$ where, x is thickness of the soil sample. The linear and mass attenuation coefficient depends on material density, sample composition and photon energy E. The half thickness was determined from the graphs and the linear and mass absorption coefficients are also calculated for the corresponding gamma energies.

Conclusion

In the determination of linear attenuation coefficient of soil samples with gamma transmission measurement, the values obtained from Loikaw and Mandalay soil are good agreement with that of Latur and Usmanabad district from Maharashtra soil. We study the energies value for 1173keV, 1332keV and 662keV. Exponential decay observed. As energy increases, the mass attenuation coefficient of various densities and compositions decreases. This gives the validity of exponential absorption law.

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References

[1] Nuclear Physics Laboratory, Nowrosjee Wadia College, Pune – 411001, MS, INDIA

[2] Department of Physics, Rajarshi Shahu Mahavidyalaya, Latur - 413512, MS, INDIA

[3] www.iaes.org/inis/41097/00 , Internal Journal of Physical Sciences, Voll.6(20) pp.4798-4801, 23 September, 2011, Department of Physics, Faculty of arts and Sciences "Determination of mass attenuation coefficients for natural minerals from different place of Turkey Ibrahim"

[4] William R. Leo (1994)"Techniques for Nuclear and Particle Physics Experiments" UK: Springer-Verlag Barlin Heidelberg