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Investigation of Radiation Shielding Properties for Some Soil Samples for Use in Shields against Gamma-Rays from Different Nuclides

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ABSTRACT The variation of radiation shielding parameters like linear and mass attenuation coefficients, half value layer, tenth value layer and mean free path with different soil samples of various chemical compositions and physical properties has been investigated using gamma ray spectrometer NaI(Tl) atthe gamma energies of 360, 662, 1280, 1330 KeV emitted from radioactive isotopes of ^{133}Ba, ^{137}Cs, ^{22}Na and ^{60}Co, respectively. For this work, soil samples were collected from different sites of Aurangabad, India, and then prepared using standard techniques. The study of attenuation coefficients of various materials has been an important part of research in radiation physics, chemistry, agriculture and human health. This study aims to investigate of radiation shielding properties for various soils of various components. For the attenuation coefficients, a significant variation is observed in low and high energy regions whereas there is no notable change in the intermediate region. The results have been discussed on the basis of obtained attenuation coefficients of different partial photon interaction processes. It is observed that the variation of obtained values of all parameters strongly depends on the photon energy; it decreases or increases due to chemical composition and density of the sample. The study has practical importance to know the nature of the soils in the construction and agricultural purposes. Generally, the radiation shielding parameters determined in this study can be used for determination of gamma emitters in any soil samples.

KEYWORDS Gamma ray attenuation, Density, Radiation shielding, NaI (Tl) detector, Half value layer, Soil samples.

INTRODUCTION

With the increasing use of radio-isotopes in many fields such asmedical, industrial and agricultural, etc. it becomes necessary to study the different parameters related to the passage of gamma radiation through a material. Attenuation coefficient is an important parameter for study of interaction of radiation with matter that gives us the fraction of energy scattered or absorbed[1].The study of interaction of nuclear radiations with matter is the important research area for the development of materials which can be used in high radiation environment. These radiation shielding materials have great importance for many scientific, engineering and medical applications. The data based on mass attenuation coefficient and half value layer is very useful for the purpose to identify the various radiation shielding materials. In the environment of high radiation exposure, concrete is used as radiation shielding material because it is cheap and it can be molded easily into any desired design[2].The attenuation coefficient is an important parameter, which is widely used in industry, agriculture, science, and technology, etc. The properties characterizing the penetration and diffusion of gamma rays in composite materials such as soil are very important. Soil has chemical properties as on its compositions like C, N, S, P, Ca, Mg, Na, etc. and has physical properties such as moistness, particle density, appearance density, porosity, water holding capacity and particle size distribution (sand, silt and clay), etc. in variable concentrations. Soil also contains microelements such as Cu, Fe, Mg and Zn. The interaction of gamma-ray depends on the incident photon energy. The linear attenuation coefficient, μ (cm^{-1}) is the most important quantity characterizing the penetration and diffusionof gamma radiation in a medium. The linear attenuation coefficient, also called the narrow beam attenuation coefficient, is a quantity which describes the extent to which the intensity of a beam is reduced as it passes through the material [3,4].The linear attenuation coefficient for photons of a given energy in a given material is due to contributions from the various physical processes (photoelectric effect, Compton scattering and pair production) that can remove photons from the beam. The linear attenuation coefficient of a material depends on its density. The dependence of the linear attenuation coefficient µ on the absorber density (ρ) is overcome by normalizing it with the absorber density. The mass attenuation coefficient (μ_m) is really of more fundamental value than the linear coefficient, because it does not depend on the actual density and physical state of the absorber. Half value layer (HVL) and mean free path (MFP) are also important parameters to ascertain shielding capability of a material. Half value layer (HVL) is the thickness of a shielding material necessary to reduce the intensity of the gamma-ray to half its original; while the average distance a unit radiation can travel in a material without having any kind of interaction is called mean free path (MFP).The present work aims at the estimation of attenuation coefficients of selected soil samples from outskirts of Aurangabad, Maharashtra-India, as this is a historic region with a documented history and having monuments of world heritage for tens of centuries.Aurangabad is an industrial hub with a lot of industrial activity and monitoring of radioactivity and related aspects is one of the concerns. A property of soil like attenuation coefficient is widely used in industry, science, and technology for a variety of applications[5,6].Recently, several research studies relevant to the measurement of linear attenuation coefficient, mass attenuation coefficient, Half value layer, Tenth value layer, and mean free path for different types of materials have been published[7-12].In present work, the shielding parameters of the gamma ray in selected soil samples using radioactive isotopes ^{133}Ba,^{137}Cs, ^{22}Naand^{60}Co at gamma-ray energies of360, 662, 1280 and 1330 KeV have been studied. Furthermore, the chemical compositions and physical properties of soil sampleswere measured using different standard analytical techniques.

EXPERIMENTAL DETAILS

Samples of soil were collected from different selected locations from outskirts of Aurangabad, India, and standard initial preparations of the samples were implemented that includes drying, powdering and sieving. Gamma ray spectrometer with 2"x2" NaI(Tl) detector was used for measuring the intensity of gamma rays and the point sources used were ^{133}Ba , ^{137}Cs, ^{22}Na and ^{60}Co with gamma ray energies of 360, 662, 1280 and 1330 KeV, respectively. It has been procured from the Bhabha Atomic Research Centre (BARC), Mumbai, India. It was well shielded by means of lead bricks. For the narrow beam setup, the gamma ray beam from the source was collimated by using a cylindrical lead block with a central hole of diameter 1cm. The transmitted beam was also collimated using a similar lead cylinder. The absorbers used were lead sheets of dimensions 5 cm× 5 cm and had thickness of 0.9 gm/cm^2. The multichannel analyzer used with the gamma-ray spectrometer had 8 K channels, and the channel numbers were set corresponding to the γ ray photo-peak of 360, 662, 1280 and 1330 KeV radiation from ^{133}Ba, ^{137}Cs, ^{22}Na and ^{60}Co. The detector was placed in a lead castle with proper shielding and arrangement was provided for placing the sample above the detector and at the top of the sample holder source with γ ray source was mounted at a fixed place as shown in Fig.1. The sample cell was a cylindrical container made of plastic and the powdered soil sample after due preparation was placed in the cell and the sample cell was placed in the sample holder provided in the detector housing. Diameter of the sample cell was 4.2 cm, and height was 5.1 cm thus the available volume is 70.62 cm^3. The calibration of gamma ray spectrometry was done in the beginning of work using standard point sources and all details of radio-isotopes used for the experiments are given in Table.1. Spectrum of the gamma ray without attenuation is shown in Fig.2.

Table 1:The information of radioisotopes used for the experiments

Sr. No	Radioisotope	Energy (MeV)	Half-life (Years)	Activity (μCi)
1	Ba–133	0.36	7.5	2.324
2	Na–22	0.511	2.6	1.973
3	Cs–137	0.662	30	2.622
4	Mn–54	0.840	0.83	3.054
5	Co– 60	1.17	5.3	3.622
6	Na–22	1.28	2.6	1.973
7	Co–60	1.33	5.3	3.622

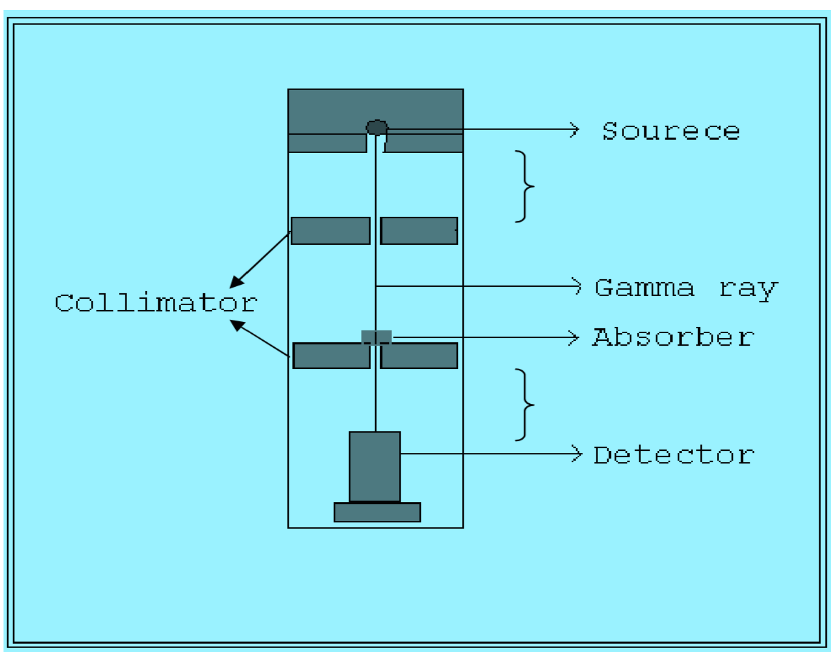

Figure 1: The schematic diagram of experimental setup

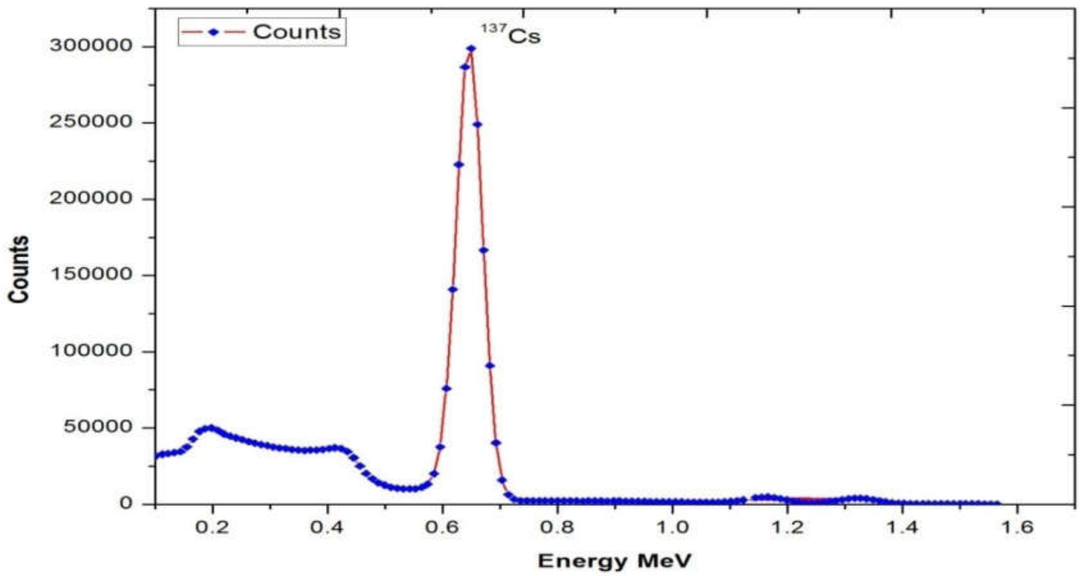

Figure 2: A typical spectrum of gamma-ray without attenuation at 0.662 MeV

Once the gamma ray scintillation counter assembly is ready and set to appropriate channel background count was found taking several readings. The incident gamma ray intensity I_o was determined using the standard point sources keeping the channel number at the photo-peak of the gamma radiation used, and no sample in the sample cell. For determination of gamma intensity I at different sample thickness the sample cell was filled with fixed amount of soil sample (say 1, 2 … cm thick layer.) and kept between the source and detector in the sample holder present in the lead castle. Counting was done for a suitable time interval and several trials were used and the average count was recorded for each sample thickness used. From the count representing the γ ray intensity, background count was subtracted to find I. A graph is plotted using I_o (incident γ-ray intensity) and I (transmitted γ-ray intensity) versus the thickness for each sample as shown in Fig. 3.It is seen that all the points lay well along a straight line, the points plotted represent the actual data i.e. the value of Io/I corresponding to each thickness of the sample and the straight line joining to those points is the leas square fit straight line. The equation shown in the inset of the graphs is the equation to the fitting straight line, and the coefficient of x is the slope (m) and the constant in the equation (c) is the intercept on the y–axis, the values of m and c are used in calculation of the attenuation constant μ and μ_m.

CALCULATION METHODS

Linear and mass attenuation coefficients

When a gamma-ray beam passes through a soil sample of thickness L (cm), the photons are transmitted according to Beer– Lambert's law[13]. This process is expressed by the following equation:

$I = I_0 \; exp \; (-\mu L)$(1)

whereI_0 is the initial intensity of the incident gamma-rays, $I$is intensity of the gamma-rays after attenuation through a soil sample of thickness L and μ (cm^{-1}) is the linear attenuation coefficient of the soil. The linear attenuation coefficient can be given as follows:

$\mu = (\mu/\rho\,)\,\rho$ (2)

whereμ_m = μ/ρ (cm^2/g) is the mass attenuation coefficient and ρ is the density of the soil sample. Equation (1) can be rewritten as follows:

$I = I_0 \; exp \; (-\mu_m \rho L)$(3)

$ln\, I = \; ln\, I_0 \; - \mu_m \rho\, L$(4)

Also, $\mu_m = \mu/\rho = (1/\rho L)\ ln\ (Io/I)$(5)
Where ρ is the density of the sample used. When a graph is plotted taking Io/I on the Y– axis and thickness of the sample on the axis of X, m is the slope of the straight line best fitting to the data and c is the intercept on the Y– axis. The linear graphs are fitted by the least square method. The slopes from the plotted graphs are given the values of the linear absorption coefficients which indicate the equation: μ = m ρ + c.

Half Value Layer (HVL) and Tenth Value Layer (TVL)
The half value thickness or half-value layer is the thickness of the absorbing material that reduces the intensity of the beam to half of its original magnitude. Then the relation between half value thickness and linear attenuation coefficient is given by following equation[14]:

$$HVL = \frac{ln\,2}{\mu} = \frac{0.693}{\mu} \quad (6)$$

Where μ (cm^{-1}) is the linear attenuation coefficient of the material. Similarly, we can define the Tenth value layer (TVL) is the thickness of shielding material required to reduce the radiation intensity to one-tenth of its initial intensity and is calculated by following equation:

$$TVL = \frac{ln\,10}{\mu} = \frac{2.303}{\mu} \quad (7)$$

These two parameters are commonly used in shielding calculation, especially in radiotherapy and medical imaging. The HVL and TVL are expressed in units of distance (cm or mm). Like the attenuation coefficient, the values of HVL and TVL are dependent on the energy of the photon radiation and the type of material. HVL and TVL are inversely proportional to the linear attenuation coefficient.

Mean Free Path (MFP) or (relaxation length λ)
The photon interaction can also be characterized by their mean free path (λ), which is defined as the average distance between two successive interactions is called mean free path or relaxation length. When photon traversing in material which has linear attenuation coefficient μ, the probability of interaction in any short distance dx is μdx. Then the probability that a photon can travel a distance x without any interaction is given by $exp\ (-\mu\ x)$, Thus, the relationship between the mean free path and linear attenuation coefficient determine by the following equation[15]:

$$\lambda = \frac{\int_0^\infty x exp(-\mu x)dx}{\int_0^\infty exp(-\mu x)dx} = \frac{1}{\mu} (8)$$

Where μ is the linear attenuation coefficient and x is the absorber thickness. Therefore, the mean free path is simply the inverse of the linear attenuation coefficient.

RESULTS AND DISCUSSION

The linear and mass attenuation coefficients for different soil samples from selected locations of study area have been determined for gamma radiation from ^{133}Ba, ^{137}Cs, ^{22}Na and ^{60}Co with γ ray energies of 360, 662, 1280 and 1330 KeV using gamma ray spectrometry and results shown in Tables 2 & 3.

It was observed that the experimental values of number of particles of radiation counted without absorber (I_0) per number of particles of radiation counted with absorber (I) were linearly increased with increasing thickness (Fig. 3). Moreover, the linear and mass attenuation coefficient decrease with increasing the energy as shown in Figs. & 5. Also, as the density of soil increases, mass attenuation coefficient decreases exponentially as shown in the Fig. 6.

This confirms the contribution of photoelectric absorption, Compton scattering and pair production to the absorption of gamma rays by the soil samples. It is found that the linear attenuation coefficient is

in the range of 1.0520 to 1.6093, 0.9803 to 1.3746, 0.8359 to 1.1504 and 0.6874 to 1.1184 cm^{-1} and the mass attenuation coefficient is found in the range of 0.7687 to 1.5767, 0.7632 to 1.3467, 0.6546 to 1.1135 and 0.4924 to 1.0776 cm^2/gm for soil samples using ^{133}Ba, ^{137}Cs, ^{22}Na and ^{60}Co with γ ray energies of 360, 662, 1280 and 1330 KeV, respectively.The results of mass attenuation coefficient variation as a function of photon energy of the studied soil samples. The variation of mass attenuations due to chemical composition is energy dependent. In the low-energy region, μ_m has the highest values, where the photoelectric absorption is significant, and its cross section is proportional to $Z^{4–5}$. Due to the dominant photoelectric absorption, the $\mu_m$values show a strong incident photon energy dependence in the low energy range because μ_m is inversely proportional ($1/E^{3.5}$dependence) to the incident energy. In the intermediate energy region, the incoherent scattering (Compton inelastic scattering) is the most effective. Compton (inelastic) scattering starts to dominate over the photoelectric absorption process when the incident photon energy exceeds ~100 KeV, up to ~1 MeV.
In this intermediate energy range, no significant differences in the behavior of the different soils are observed because the composition effects play a less significant role in Compton scattering (linear *Z* dependence) relative to photoelectric absorption thus, there is a linear *Z*-dependence of the incoherent scattering and μ_m is found to be constant.

In the high-energy region, the pair production processes in the nuclear and electric fields come into prominence after certain thresholds above 1 MeV are exceeded. The energy dependence of μ_m thus changes its slope relative to the intermediate energy region so, in the high-energy region, mass attenuation coefficients decrease, where the pair production is significant and mass attenuation is proportional to Z^2[16,17].

The densities of samples are given in Table 2. Inspection of the data in Table 2 shows that there is an approximately linear relationship between the attenuation coefficients and the corresponding density of the samples. The linear attenuation coefficient values of the samples varied with the physical density of the sample, increased with increasing in density for the same gamma ray energy, and decreased with increasing of gamma ray energy for the same sample. Moreover, comparison of the mass attenuation coefficients for all the types of studied samples with respect to the corresponding photon energies supports the validity of the expected exponential absorption law. On examination of the measured photon mass attenuation coefficients for soil samples across the energy range 360–1330 KeV; it is observed that, there are slightly differences between the results. The variation values of mass attenuation coefficients for various soil samples are presented in Fig. 7. It is observed from the data that the linear and mass attenuation coefficients of different soil samples decrease with increasing the energy of gamma rays. The linear and mass attenuation coefficients depend on the strength, chemical composition of samples particularly (ratios of iron, zink, copper), material density and photon energy. The work presented is part of a survey recently conducted with the larger database.

Table 2: The linear attenuation coefficients μ (cm^{-1}) of soils for various energies of the gamma rays

Sample. No	Soil density (ρ) gm/cc	Ba–133 360 KeV	Cs–137 662 KeV	Na–22 1280 KeV	Co–60 1330 KeV
S1	1.3959	1.0730	1.0654	0.9137	0.6874
S2	1.2662	1.0520	0.9803	0.8359	0.8144
S3	1.2322	1.2398	1.1603	1.1504	1.1115
S4	1.1308	1.1381	1.0910	1.0406	1.0336
S5	1.0778	1.3359	1.2847	1.1361	1.1184
S6	1.0492	1.5170	1.3195	1.1383	1.1069
S7	1.0207	1.6093	1.3746	1.1366	1.0999

Table 3: The mass attenuation coefficients μ_m(cm²/gm) of soil samples for various energies of the gamma rays

Sample. No	Soil density (ρ) gm/cc	Ba–133 360 KeV	Cs–137 662 KeV	Na–22 1280 KeV	Co–60 1330 KeV
S1	1.3959	0.7687	0.7632	0.6546	0.4924
S2	1.2662	0.8308	0.7742	0.6602	0.6432
S3	1.2322	1.0062	0.9416	0.9336	0.9020
S4	1.1308	1.0065	0.9648	0.9202	0.9140
S5	1.0778	1.2395	1.1920	1.0541	1.0377
S6	1.0492	1.4459	1.2576	1.0849	1.0550
S7	1.0207	1.5767	1.3467	1.1135	1.0776

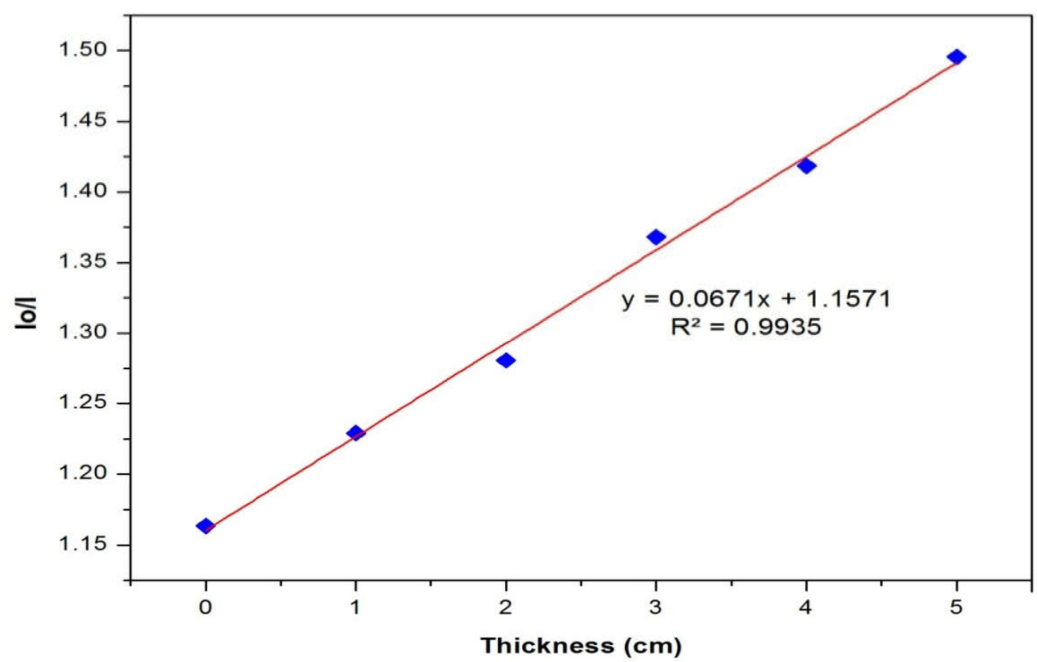

Figure 3: The typical plots of thickness versus *Io/I* at energy 360 KeV for soil sample

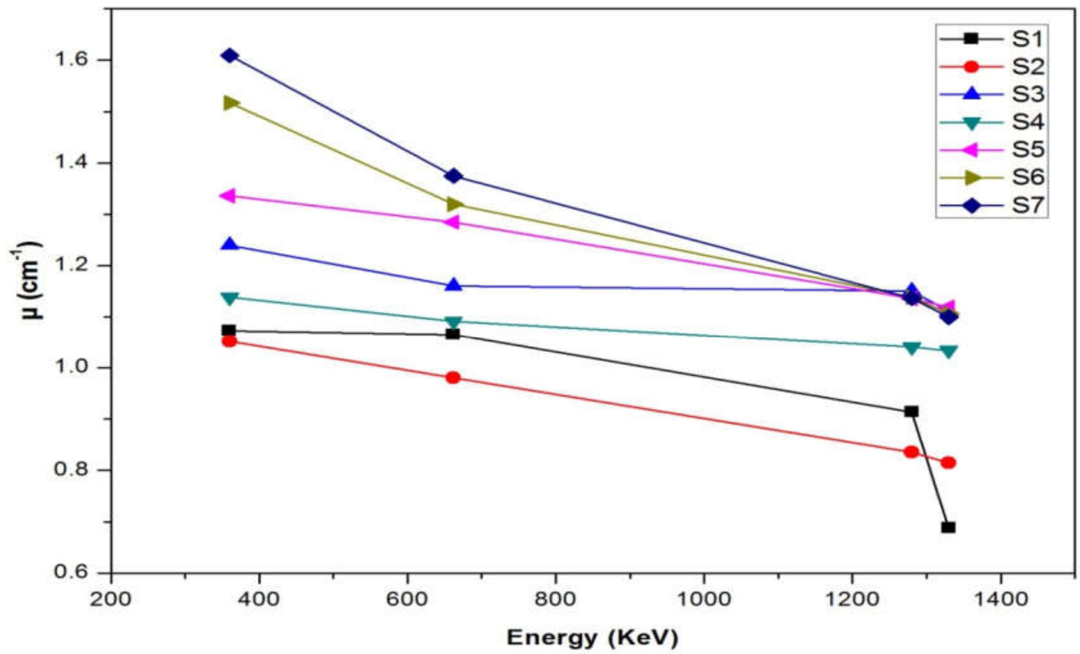

Figure 4: Linear attenuation coefficient versus energy of the investigated soil samples

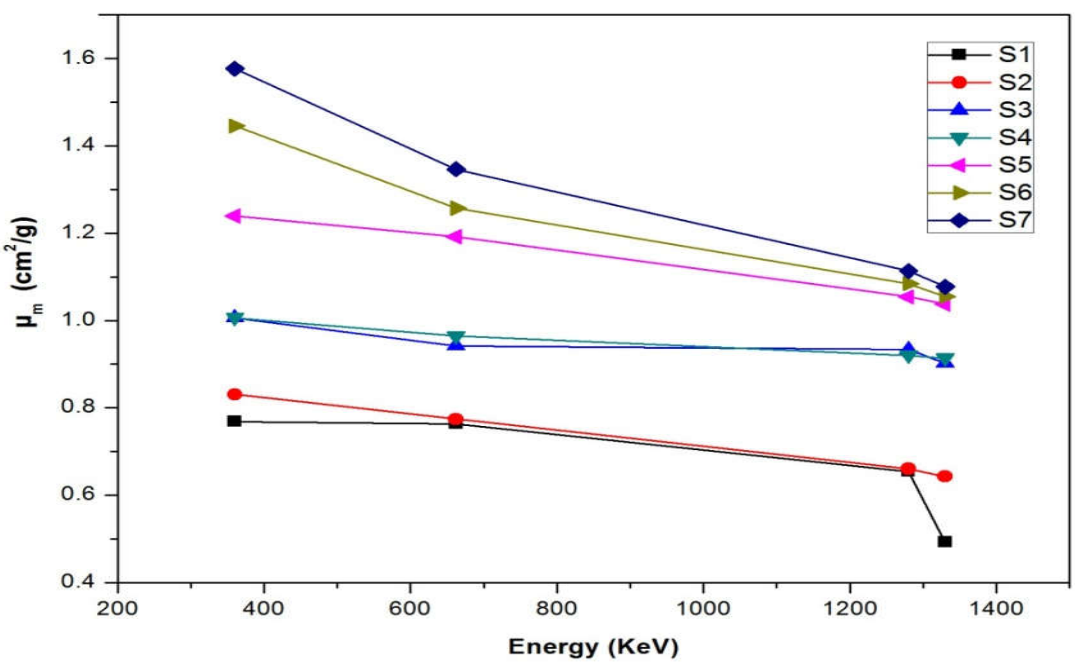

Figure 5: Variation of mass attenuation coefficient of different soil samples with energy

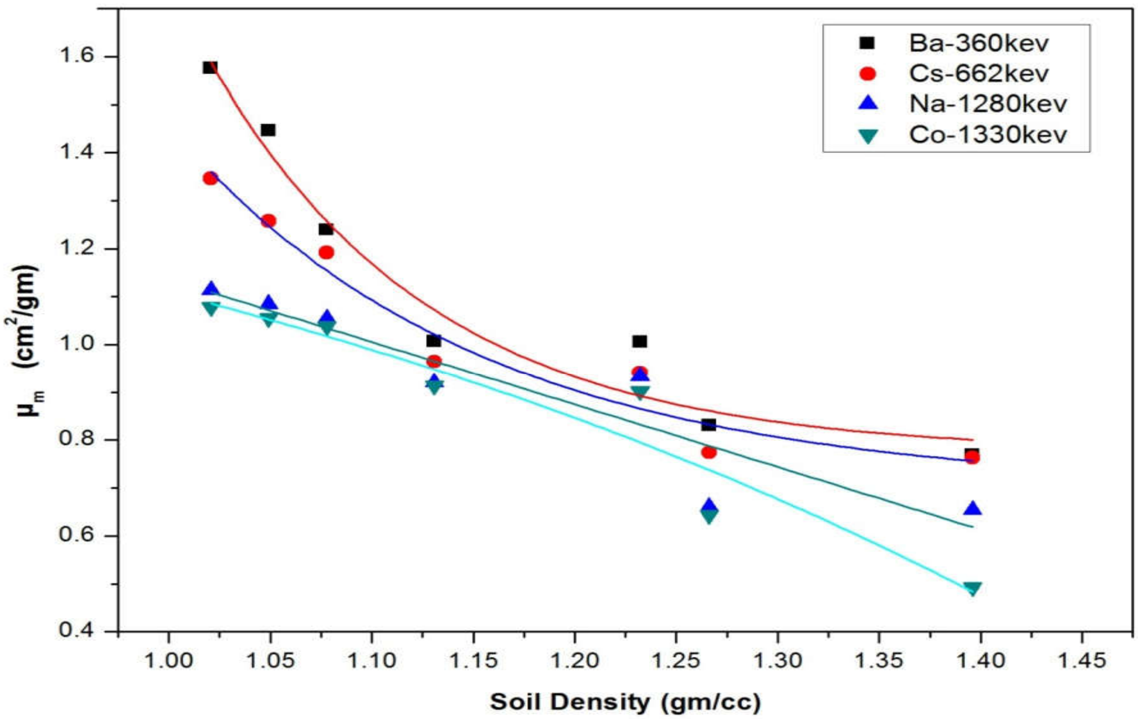

Figure 6: The mass attenuation coefficient versus the soil density at different energies

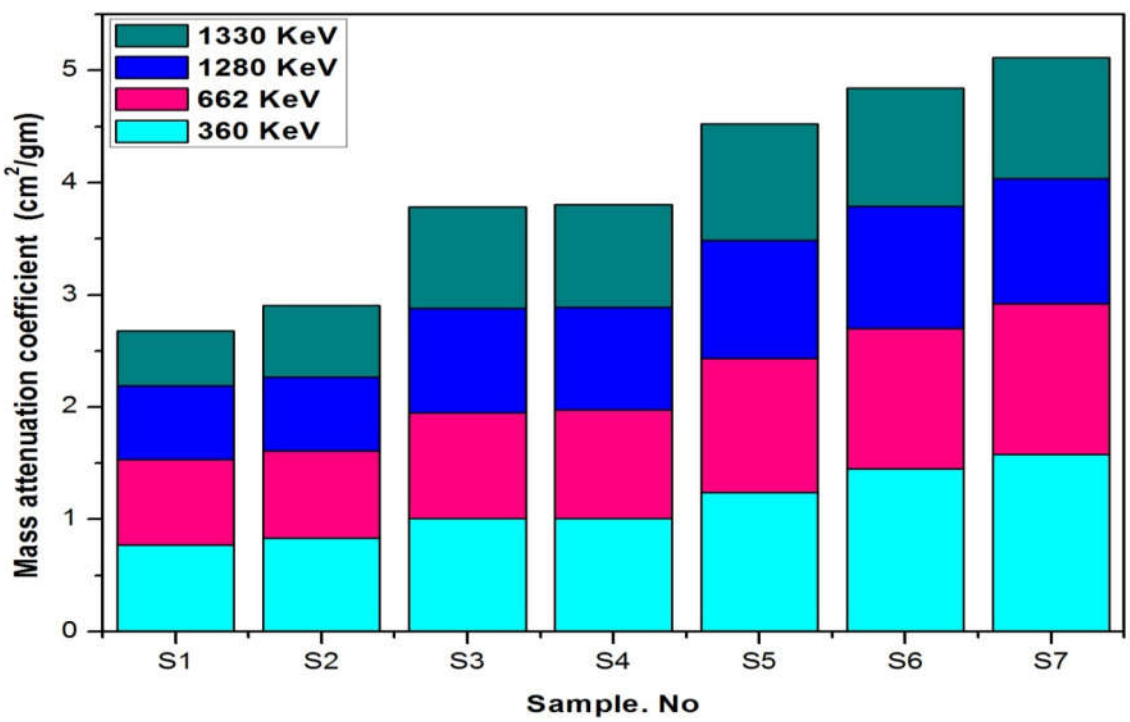

Figure 7: Mass attenuation coefficients of the investigated soil samples at different energies

Table4. shows the variation of half value thickness, tenth value thickness and mean free path as a function of gamma-ray energies. Half value layer (HVL), tenth value layer (TVL) and mean free path (MFP) are important parameters that reflect the fact that energetic photons have the capability to penetrate a sample with the increment of photon energy. Half value layer (HVL) and tenth value layer (TVL) are two important parameters in designing any radiation shielding since half value layer and tenth value layer indicates the required thickness of an absorber to reduce the radiation level to half and one tenth of its initial value respectively. The mean free path or relaxation length (λ) of any particular radiation represents the average distance between two successive interactions, the shielding properties of the present samples can be easily compared by studying this parameter for that particular kind of radiation. The less the relaxation length of a material, the better the shielding properties it possess. Mathematically this parameter (λ) is equivalent to the reciprocal of linear attenuation coefficient (μ). These parameters (HVL, TVL and MFP) were calculated from linear attenuation coefficient values using the equations (6–8) for each sample at at the photon energy range 360–1330 KeV andresults are listed in Table4.

Table 4: The measured values of Half value layer (HVL), Tenth value layer (TVL) and Mean free path (λ) in the energy range (360– 1330 KeV) for investigated soil samples

Sample. No	Energy KeV	HVL (cm)	TVL (cm)	MFP (λ) (cm)
S1	360	0.6459	2.1459	0.9320
	662	0.6505	2.1613	0.9386
	1280	0.7585	2.5201	1.0945
	1330	1.0081	3.3497	1.4548
S2	360	0.6587	2.1888	0.9506
	662	0.7069	2.3489	1.0201
	1280	0.8290	2.7546	1.1963
	1330	0.8509	2.8274	1.2279
S3	360	0.5590	1.8572	0.8066
	662	0.5973	1.9845	0.8618
	1280	0.6024	2.0016	0.8693
	1330	0.6235	2.0716	0.8997
S4	360	0.6089	2.0232	0.8787
	662	0.6352	2.1105	0.9166
	1280	0.6660	2.2128	0.9609
	1330	0.6705	2.2277	0.9675
S5	360	0.5188	1.7236	0.7486
	662	0.5394	1.7923	0.7784
	1280	0.6100	2.0268	0.8802
	1330	0.6196	2.0588	0.8941
S6	360	0.4568	1.5179	0.6592
	662	0.5252	1.7451	0.7579
	1280	0.6088	2.02284	0.8785
	1330	0.6261	2.0802	0.9034
S7	360	0.4306	1.4308	0.6214
	662	0.5041	1.6751	0.7275
	1280	0.6097	2.0259	0.8798
	1330	0.6301	2.0935	0.9092

It can be observed that the values of HVL, TVL and MFP increase with an increase in photon energy such as seen in Fig.8. It has to be noted that at each specified gamma energies, HVL, TVL and MFP values are slightly different for all the samples. Moreover, we conclude that the half value thickness and mean free path are the mainly related to the density and then thickness and atomic number of absorbing medium. The results of μ, HVL, TVL and MFP parameters are related directly to the mass attenuation coefficients. The linear attenuation coefficient μ is inversely proportional to HVL, TVL and MFP. It can be concluded that the low-energy photons can lose its energy in a short distance while high-energy photons need a longer distance to lose their energy. This study can be useful for selecting the appropriate shielding materials for these gamma ray sources.

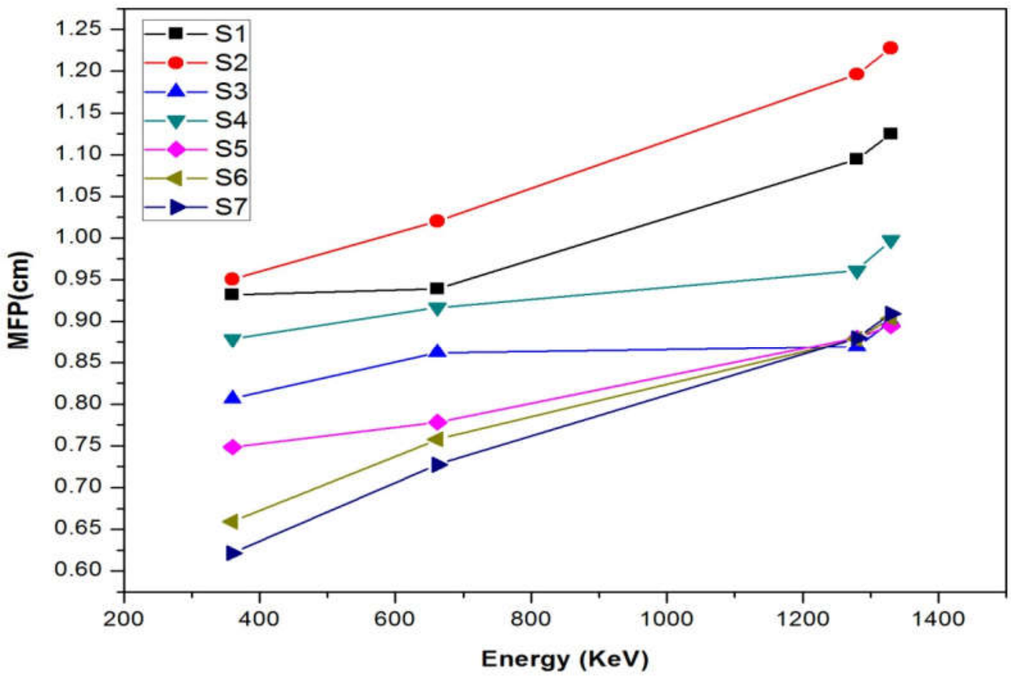

Figure 8: Mean free path versus energy for the investigated soil samples

The chemical compositions and physical properties of soil samples collected from different regions of Aurangabad, Maharashtra-India, have been measured by using various standard analytical techniques and results are given in Tables 5–7. The samples were distinguished as per their exact location. The soil porosity was measured by using evaluation of bulk density and the particle density in soil samples. According to the results of the soil analysis, the soils were primarily medium-textured, had slightly alkaline *pH*, contained different amounts of lime, and primarily had low organic matter content. There was no salinity problem in the soils. The chemical compositions of these soil samples are given in Tables 5 & 6. The studied soil samples have different chemical composition (P, K, N, Ca, Mg, Na, Fe, Mn, Zn, Cu, and $CaCO_3$). Table 7 gives the physical properties (particle density, porosity, organic matter, moisture, water holding capacity and percentage of sand, silt and clay). It is important to have in mind that different proportions of sand, silt and clay will result in different soil textures. Soil texture is an important physical property related to several dynamic phenomena. The particle size analysis was used to measure the percentage of sand, silt and clay in the soil. From Table 7, soil samples were classified as sandy (S), sandy loam (SL) and loam sandy (LS) based on their different proportions of sand, silt, and clay. The texture analysis was carried out based on the feel method. Sandy loam has the larger size of its particles, feels gritty. Whereas silt, being moderate in size, has a smooth or floury texture and clay loam has the smaller size of its particles, feels sticky. Sandy, sandy loam and loam sandy soils demonstrate poor photon energy absorption characteristics (i.e. low μ, μ_m, HVL, TVL and λ) comparison to the clay and clay loam soils which have good photon energy absorption characteristics. These results because variation of the chemical compositional of the different types of the soils and the effects of the soil grain size on the gamma-ray attenuation. Generally as the soil is characterized by a broad distribution of particle sizes, soils with different textures can also attenuate the radiation in a different manner. These results are mainly related to the chemical composition such as Zn, Cu and Fe contents.

Table 5: Some chemical components of various soil samples

Sample. No	Iron (Fe) ppm	Manganese (Mn) ppm	Zink (Zn) ppm	Copper (Cu) ppm	Calcium-Carbonate ($CaCO_3$) %
S1	24.53	10.34	1.19	0.25	1.25
S2	6.80	68.45	2.89	2.34	6.25
S3	3.13	6.87	5.36	0.84	2.63
S4	7.06	15.25	1.56	1.21	2.25
S5	30.32	8.89	1.90	1.86	5.63
S6	5.67	81.14	3.87	1.73	2.50
S7	4.14	12.86	7.53	0.92	1.25

Table 6: Some chemical components of investigated soil samples

Sample. No	Phosphorus (P) Kg/hect	Potassium (K) Kg/hect	Nitrogen (N) Kg/hect	Calcium (Ca) %	Magnesium (Mg) %	Sodium (Na) %
S1	25.16	324.24	425.39	43.04	5.48	79.40
S2	58.06	4509	102.49	26.52	7.05	74.20
S3	15.24	197.50	28.55	33.91	4.31	88.70
S4	12.34	142.58	61.42	30.43	6.66	11.20
S5	6.77	1055	530.49	27.83	7.05	15.50
S6	8.71	67.59	78.55	20.43	6.27	34.35
S7	12.82	1056	123.81	42.17	5.09	64.95

Table 7: The physical properties of investigated soil samples

Sam ple. ID	Particle density (gm/cc)	Porosity (%)	Organic matter (%)	Moisture (%)	Water holding capacity (%)	Particle size distribution %			Texture Classification (USDA)[18]
						Sand	Silt	Clay	
S1	2.54	50.08	0.67	2.61	37.32	87.63	6.49	5.8	Sandy
S2	2.33	45.06	1.45	5.49	31.62	71.68	17.41	10.54	Sandy loam
S3	1.91	43.51	1.12	3.66	38.77	79.21	6.81	13.1	Loam sandy
S4	1.75	48.25	0.98	4.36	47.06	85.19	5.34	9.43	Sandy
S5	2.33	50.78	0.47	4.53	36.28	82.9	9.14	7.16	Loam sandy
S6	2.60	54.83	1.22	4.89	44.82	80.31	10.59	9.03	Loam sandy
S7	1.88	46.72	0.93	10.57	53.90	88.28	10.96	0.08	Sandy

CONCLUSIONS

The radiation shielding parameters for various soil samples collected from different sites of study area, were measured using gamma ray spectrometry NaI(Tl) with ^{133}Ba, ^{137}Cs, ^{22}Na and ^{60}Co at 360, 662, 1280 and 1330 KeV with different origins of various chemical components. The effects of chemical components such as (P, K, N, Ca, Mg, Na, Fe, etc.) as well as physical properties like (particle density, porosity, moistness, percentage of sand, silt and clay, etc.) of soilson attenuation coefficients have been studied at gamma ray energies from 360 to 1330 KeV. It can be concluded from this work as density increases the mass attenuation coefficient of soil samples decreases. This gives the validity of exponential absorption law$I = I_0\, e^{-\mu x}$where, x is thickness of the soil sample. This method is useful for the study of properties the soils in agriculture purposes. The overestimate measured values of attenuation coefficients at some energy reflect the effect of the chemical components percentage, a specific set of chemical components and from narrow beam geometry in the source-detector arrangements. There are differences between the mass attenuation coefficients of soil samples, this clearly due to the different chemical components percentage, especially Fe, Zn, Ca, K and Cu. The results have shown that soils are one of the best building materials to be used in shielding against gamma rays. The mass attenuation coefficient values are useful for quantitative evaluation of interaction of gamma radiations with soil samples. Also, attenuation coefficient is of interest to scientists and research in different areas of present-day technology. Generally,the photon absorption parameters depend on the photon energies, sample density and the chemical composition of the samples. The presented radiation attenuation data of investigated soil samples are very useful in medical applications, fission and fusion reactors, radiation physics, shielding researchers and nuclear applications.

CONFLICT OF INTEREST

Authors declare that they have no conflict of interest.This research has not received any financial funding.

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