



# DETERMINATION OF ABSORPTION COEFFICIENTS OF DIFFERENT MATERIAL.

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**Abstract:** Linear and mass absorption coefficients and its related data for various soils have been determined using simple G.M. tube experiment. Strontium 90 continuous beta source is used for measurement of counts. Values are measured for aluminum absorber and then for soil samples. Among all soils, it is observed that Red soil absorbed maximum beta radiation.

**Key words:** Absorption coefficient, soil, absorbance.

## 1. INTRODUCTION

Beta rays are negatively charged particles with very little mass. These particles travel a few meters in air. However they can be stopped in a thickness of about 0.2 cm of Aluminum due to absorption in the medium.

Understanding absorption coefficient of beta rays is of great interest in various applications such as material thickness measurements, medical treatments etc. Lots of studies carried out for determination of absorption coefficient of many different materials [1-5]. Even in nuclear reactors, thick aluminum sheets, steel and concrete walls are used to absorb radiations of nuclear particles. In the present study linear absorption coefficient and mass absorption coefficient and other parameters of some soil samples such as loamy soil, red soil, clayey soil, cow dung and their mixtures were determined along with sample of aluminum and cement absorber.

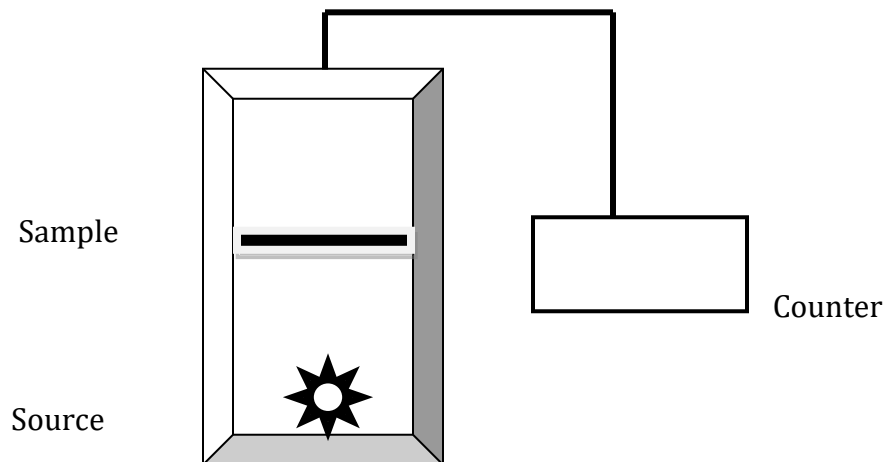
## 2. EXPERIMENTAL

All the soil samples were collected from Rahuri area of Ahmednagar district. All samples were filtered to fine powder before use. After adding water to fine powder the samples are prepared with help of die of 6.5 cm diameter and thickness of 0.31 cm to match with the thickness of standard aluminum absorber which is used in G.M. Tube experiment. The samples are kept open to dry naturally. Fig.1 shows the photographs of the samples used for the measurements in the order of from left to right as Cement sample, Red soil sample, Loamy soil sample and clayey soil sample.



**Fig.1. Absorber sample from Right to left: Cement-Red soil-Loamy soil-clayey soil**

A Strontium 90 has been used as continuous beta radiation source with intensity maximum at about 0.546 MeV and maximum electron energy of 2.2 MeV. The Geiger Miller counter tube instrument used for the measurement was supplied by the Nucleonix systems Pvt. Ltd., Hyderabad [6]. An experimental arrangement is sketched in Figure 2.



**Fig.2. Experimental arrangement of G.M.Counter**

The absorber sample was kept at the middle of the chamber. The initial Intensity  $I_0$ , without absorber between source and counter were recorded for five times for each sample for more accuracy as per standard procedure. Then similar counts were recorded with the absorber in between the source and counter. The mean values of  $I_0$  and  $I$  are listed in Table 1 along with values of particle density of each sample. During the measurements the operating Voltage of the G.M. tube was kept at 550 V.

### 3. RESULTS AND DISCUSSION

When beta particles penetrate through an absorbing sample, some of the particles get absorbed. Amount of absorption depends upon the energy of the particles and the thickness of the material used as absorber. The equation below gives the relationship between the intensity of the beta particles and the thickness of the material. The values of absorption coefficient were determined from the following relation [7]

$$I = I_0 \exp(-\mu x) \quad (1)$$

Where  $I_0$  is the original intensity of beta rays without absorber sample,  $I$  is the number of counts through absorber of thickness  $x$  cm and  $\mu$  is the linear absorption coefficient. The average values of  $I$  and  $I_0$  along with thickness,  $x$  of the absorber for various samples with values of densities are listed in Table 1.

**Table 1: The values of densities and measures counts for various sample.**

Sample	Density, $d$ g/cm <sup>3</sup>	I	$I_0$	X in cm
Aluminum	2.7	6.0	101	0.32
Cement sample	3.15 [8]	5.2	103	0.33
Red soil	2.73 [9,10]	5.6	101	0.30
Loamy soil	2.65 [9,10]	11.0	104	0.32
Clayey soil	2.65 [9,10]	11.0	104	0.36
Cow dung cake	2.31 [11]	22.0	102	0.36
Red soil + loamy soil	nd	5.6	102	0.34

Using equation (1) the values of linear and mass absorption coefficient are determined and tabulated in table 2 below.

**Table 2: Experimentally calculated values of linear and mass absorption coefficient for different samples.**

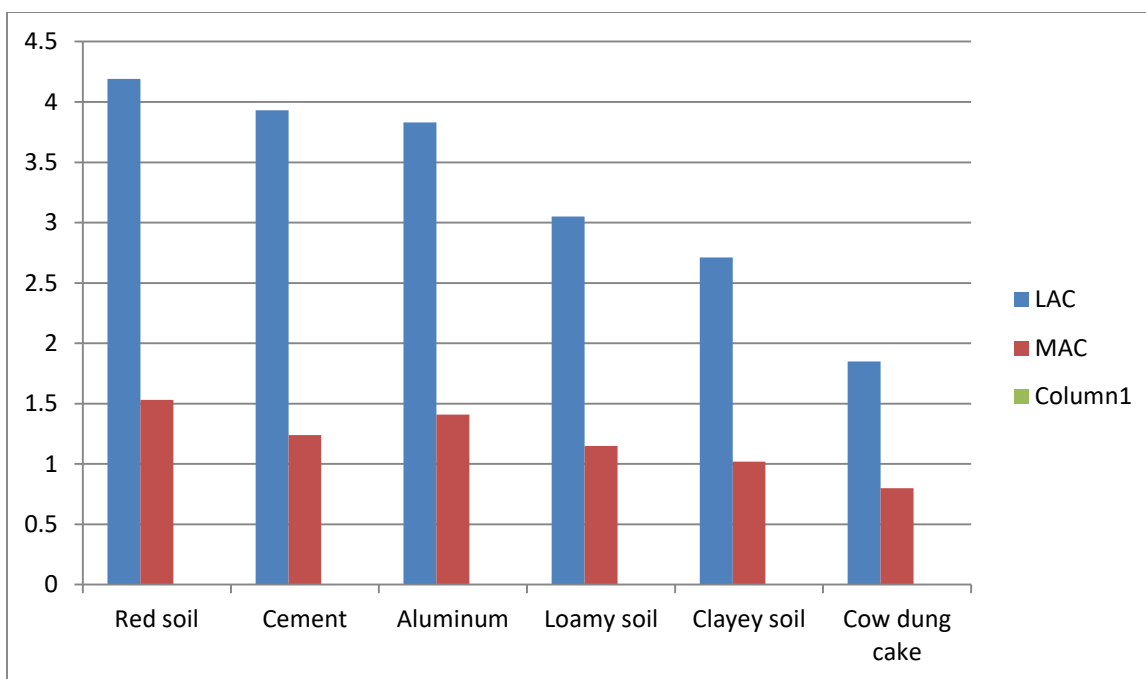
sample	Linear absorption coefficient, $\mu = \frac{1}{x} \left[ \log \frac{I_0}{I} \right] \text{ cm}^{-1}$	Mass absorption coefficient, $\mu_m = \frac{\mu}{d} \text{ cm}^2/\text{g}$
Red soil	4.19	1.53
Aluminum	3.83	1.41
Cement sample	3.93	1.24
Loamy soil	3.05	1.15
clayey soil	2.71	1.02
Cow dung cake	1.85	0.80
Red soil+ loamy soil	3.71	Nd

The mass attenuation coefficient is the ratio of linear attenuation coefficient to the density of the material [7]. For determination of mass absorption coefficient, particle densities of samples are considered because the samples were prepared as per shape and size of diameter of standard aluminum absorber provided with G.M. counter experimental setup. For the determination of mass absorption coefficient,  $\mu_m$ , particle densities of the samples are considered since particle densities associated with porosity which further leads to transmission coefficient of radiation.

It can be seen that linear and mass absorption coefficient values of red soil are largest which suggest that the red soil may be strong absorber of beta radiations. The values for red soil are comparable with standard aluminum absorber. Since the values of linear absorption coefficient,  $3.83 \text{ cm}^{-1}$ , for aluminum are in agreement, under experimental error, with the literature value of 3.50 as given in reference [1] and in [12], we may conclude that values of other samples may be assumed to be accurate.

The values of linear absorption coefficient for the mixture of red and loamy soil are found to be very close to that of aluminum and cement. On the other hand the values of Linear and mass absorption coefficient of dry cow dung cake suggests that it is least absorber of the beta particles. This means the penetration of beta rays through cow dung cake is more than that of red soil and other samples.

The above values are depicted graphically in the Fig. 3 below.



**Fig.3 Graphical Representation of Absorption Coefficients.**

An attempt has been made to determine the values of absorbance which is a measure of the amount of energy that a given material prevents from passing through it using following equation. Absorbance does not give the amount of energy that the material absorbs; absorbance is a just a number without units of measure. Absorbance is based on the ratio of two intensity measurements, so the resulting value has no units.

The value of absorbance were determined by the following relation,

$$A = \log_{10} \left( \frac{I_0}{I} \right) \quad (2)$$

The values of specific absorption coefficient were determined by the following relation,

Specific absorption

$$As = \left[ \frac{(I_0 - I)}{I_0} \right] \times 100 \quad (3)$$

Where, I and I<sub>0</sub> have their usual meaning.

The values of transmittance were determined from the following equation,

$$T = \left( \frac{I}{I_0} \right) \times 100 \quad (4)$$

The half value layer (HVL) of the absorbing material is defined as that thickness X<sub>1/2</sub> which will decrease the initial intensity by half.

$$\text{Half value layer, HVL} = 0.693/\mu \quad (5)$$

And the thickness of the absorber samples were determined by the following equations,

$$\text{Thickness of absorber sample, } x = \frac{1}{2.303} \left( 2.303 \times \frac{A}{\mu} \right) \quad (6)$$

All these values are listed in Table 3 below.

**Table 3: The calculated values of different parameters for absorber sample.**

Sample	Absorbance $A = \log_{10} \left( \frac{I_0}{I} \right)$	Specific absorption, % $As = \left[ \frac{(I_0 - I)}{I_0} \right] \times 100$	Transmittance, % $T = \left( \frac{I}{I_0} \right) \times 100$	Half value layer $HVL = \frac{0.693}{\mu}$ In cm	Thickness of absorber sample, $x = \frac{1}{2.303} \left( 2.303 \times \frac{A}{\mu} \right)$ In cm.
Red soil	1.26	94.45	5.54	0.165	0.30
Aluminum	1.23	94.05	5.94	0.180	0.32
Cement sample	1.30	94.95	5.05	0.176	0.33
Loamy soil	0.98	89.42	10.58	0.227	0.32
Clayey soil	0.98	89.42	10.58	0.255	0.36
Cow dung cake	0.67	78.43	21.57	0.374	0.36
Red soil+ Loamy soil	1.26	94.50	5.49	0.186	0.34

Note from the Table 3 that, Absorbance can range from 0 to infinity such that an absorbance of 0 means the material does not absorb any radiation, an absorbance of 1 means the material absorbs 90 percent of the radiation, and absorbance of 2 means the material absorbs 99 percent of the energy and so on.

The absorbance can also be calculated from the percentage transmittance using the following equation. Note that 100% transmittance, means 0 absorption, 10% means absorption 1, 5% means absorption is 1.31 etc. [13].

$$\text{Absorbance} = 2 - \text{Log} (\%T) \quad (7)$$

Note that this equation also produces similar results.

Higher the value of Absorbance lowers the transmittance. This confirms that Red soil absorbs more beta radiation since value is close to that of aluminum and cement.

The value of specific absorption suggest amount of absorption in the material in the percentage. Note that these values are more than 90% in Al, cement and red soil while it is least in the cow dung sample. This confirms that cow dung absorbs less and transmits more radiation. The higher value of transmittance for the cow dung confirms this observation. As compared to other samples in the measurements, cow dung sample seems to be more porous since the value of transmittance is more. Interestingly addition of specific absorption and transmittance gives us 100%. The transmittance is always written in % transmittance.

The values of half value layer (HVL) indicate the thickness of the material at which half of the incident radiation gets absorbed. The HVL is written in mm or in cm. It is seen that HVL in Red soil is roughly half the value of the thickness  $x$ , used for the experiment. While in case of cow dung still more thickness is needed to absorbed the radiation by 50%.

The values of thickness of absorber sample as determined from the equation (6) matches with the actual values of the thickness of the sample used for the measurements.

#### 4. CONCLUSION

An attempt have been made to determine linear and mass absorption coefficients of some soil sample as an absorber along with aluminum and cement samples. In the present study values of various other parameters such as absorbance, specific absorbance and transmittance and half value layer also determined. From the measurement it may be conclusion that some soils such as Red soil and mixture of equal proportion of Red soil and loamy soil gives similar results as that of aluminum and cement. It is seen from the present study that Red soil is most effective shielding material. This may be due to presence of higher percentage of iron contents which also gives red color to the soil.

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