Mass attenuation coefficient measurements in turmeric samples

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Mass attenuation coefficient of turmeric has been measured at 662 keV gamma energy using NaI(Tl) scintillation detector coupled with Multichannel Analyzer (MCA). The elemental composition of turmeric was analyzed using SEM – EDS technique. Potassium and magnesium were found to be present in good amount. The study showed the dependency of mass attenuation coefficient on the energy of radiation and nature of the absorber. The results validated the gamma absorption law. The study performed would add knowledge and information towards interaction of gamma radiation with matter.

Keywords: Turmeric, SEM-EDS, Scintillation detector, Multichannel analyzer, Mass attenuation coefficient

1 Introduction

Gamma radiation nowadays is being used in many of the areas such as medicine, agriculture, industry, etc. Also an interest in the study of gamma radiation with various materials of industrial and biological importance has increased. And researchers all over the world have come out with results of interaction parameters such as linear and mass attenuation coefficients. The mass attenuation coefficient usually depends upon the energy of radiation, nature of absorbing materials and composition of the absorber.

Work has been performed worldwide in determining the mass attenuation coefficients of various metal absorbers, compounds and mixtures of dosimetric interest. Researchers have calculated the coefficients for both ionizing and non-ionizing radiation such as β-rays, X-rays, γ-rays.1,2 Researches also have employed the gamma ray attenuation method for determining the water content of natural and dried leaves, soil, wood samples, medicinal plants, etc.3,4 The photon interaction study plays an important role in radiation shielding and radiation protection.

Many herbs of ayurvedic importance are used to alter or change a long standing condition by eliminating the metabolic, toxin also known as “bloodcleaners”. Certain herbs improve the immunity of the person, thereby reducing conditions such as fever, cold, cough, etc. Turmeric is a popular ayurvedic root and is commonly used for its high antiseptic and medicinal value.

In the present study, the elemental composition of turmeric has been identified using scanning electron microscopy coupled with energy dispersive spectrometry technique. The SEM-EDS technique is a non-destructive method and has been successfully used for the morphological studies of nanomaterials, polymers, thin films and various other materials. Also researchers have found its application in analyzing the elemental composition in various natural materials such as leaves, seeds, roots, etc.5,6 Not only the morphological, elemental composition information SEM-EDS also provides information about the particle density and gives us a better insight about the origin of the particles that whether from anthropogenic or the natural processes.7

Also the measured mass attenuation coefficient at 662 keV gamma energy for turmeric have been presented in this paper. NaI(Tl) detector coupled with Multichannel analyzer has been adopted in the present work. The results obtained in the present study would add information to the present information and lead to different application of turmeric and other ayurvedic roots. Also the utility of NaI scintillation detector for determination of mass attenuation coefficient in natural materials is highlighted.

2 Materials and Method

Mass attenuation coefficient for various elements, compounds and mixture have been calculated using the famous Beer Lamberts law.8 The attenuation of gamma rays can be expressed as:

\[ I = I_0 e^{-\mu t} \]  \hspace{1cm} \ldots (1)

Where \( I_0 \) is the intensity of incident radiation on an absorber of thickness \( t \), \( \mu \) is referred to as the linear attenuation coefficient of the absorber.
attenuation coefficient. The ratio of the linear attenuation coefficient to the density \((\mu/\rho)\) is called the mass attenuation coefficient and has the dimensions of area per unit mass \((\text{cm}^2/\text{g})\). In terms of mass attenuation co-efficient, the attenuation law for gamma rays takes the form:

\[
I = I_0 e^{-(\mu/\rho)\rho t}
\]  

… (2)

Turmeric roots were collected from the market. The root samples were washed twice using distilled water to remove the dust and then air dried for 48 h. The dried samples were grinded using mixer grinder and sieved using a fine holed sieve to get a fine powder of the sample. The powdered sample was kept in hot air oven to remove its moisture. A measured quantity of powder together with PVA binder is used to prepare pellets of certain thickness using KBr Pellet machine. Similar pellets were prepared of varying thickness for mass attenuation studies. Few milligrams of sample powder were used for elemental analysis using SEM-EDS.

The mass attenuation coefficient of turmeric samples were measured using a 2″×2″ NaI(Tl) scintillation detector. The detector is equipped with 1 K multichannel analyzer. A horizontal alignment of the detector, sample and source was adopted for the purpose. Each prepared pellet of certain mass thickness was counted for a period of 300s using the \(^{137}\text{Cs}\) gamma source at energy 0.662 MeV. The backscattered peak, Compton region and photopeak are acquired using the ORTEC made 1K MCA. The area under the photopeak was used to calculate the net counts for the sample.

3 Results and Discussion

The elemental content of turmeric was analyzed using SEM-EDS technique. The spectrum acquired for turmeric sample using SEM-EDS is shown in Fig. 1. The presence of various elements such as O, Mg, Si, P, K, C etc in turmeric was observed through analysis. The EDS spectra of turmeric showed an \(\text{O}>\text{C}>\text{K}>\text{Mg}>\text{P}=\text{Si}\) trend in elemental content. The composition also has been determined for turmeric and potassium was observed to be high in content. The trace elements identified in the ayurvedic root samples are well known for their important roles in herbal drugs\(^9\). The moderate value of potassium content in turmeric makes it a very good medicine for menstrual problems and is used as a popular home remedy for many diseases. Phosphorous and silicon content was also identified in turmeric in small amounts.

The turmeric pellets were subjected to NaI(Tl) detector coupled with MCA to study the attenuation properties in turmeric. The recorded counts for turmeric samples of varying thickness using NaI detector is presented in Table 1. It is observed that the transmitted counts decreased for increasing mass thickness of the sample. This behavior verifies the absorption law for gamma radiation in turmeric as observed in literature for gamma interactions\(^8\). Figure 2 shows the plot of transmitted counts against the mass thickness which reveals the exponential behavior obeying the radiation absorption law. ln \(I_0/I\) was plotted against mass thickness \((\rho t)\) using least square fitting and a straight line was obtained as revealed in Fig. 3. The slope of the plot is a measure of the mass attenuation coefficient which was measured to be 2.0195 cm\(^2\)/mg for turmeric.

![Fig. 1 — SEM-EDS spectrum of turmeric sample.](image)

<table>
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<th>Sample code</th>
<th>(\rho t) (mg/cm(^2))</th>
<th>(I_0)</th>
<th>(I/\rho t)</th>
<th>ln (I_0/I)</th>
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photoelectric absorption, Compton scattering and pair production to the absorption of gamma rays by root samples\(^2\). Turmeric is a widely used ayurvedic medicine and has been processed in various forms such as anticeptic creams, cosmetic products, food products etc. These processed products sometimes contain adulterated materials with them. Hence this work provides an easy, quick, non-destructive method of adulteration check and quality control of products\(^10\). The study presented in this paper throws light on the utility and advantages of NaI (Tl) detector with MCA. The study also acts as a good laboratory practical for the students towards the illustration of interaction of gamma rays with different materials.

#### 4 Conclusions
Famous and commonly used ayurvedic root turmeric was analyzed for chemical content and gamma absorption studies. SEM-EDS technique was adopted to identify and measure the elemental composition of turmeric which showed a presence of good amount of potassium which makes it a good antiseptic and possesses ayurvedic qualities of curing diseases. The study focused on the application of NaI(Tl) detector coupled with MCA for gamma absorption studies in natural materials. The present study provides a base knowledge of analytical and nuclear techniques for the students.

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#### References