BEST: International Journal of Humanities, Arts,
Medicine and Sciences (BEST: IJHAMS)
ISSN (P): 2348-0521, ISSN (E): 2454-4728
Vol. 5, Issue 07, Jul 2017, 15-20

EXPERIMENAL INVESTIGATION OF GAMMA RAY SHIELDING CHARACTERISTICS OF WOOD MATERIALS AT DIFFERENT ENERGIES

B. SARITHA & A. S. NAGESWARA RAO

Nuclear Radiation Laboratory, Department of Physics, Kakatiya University, Warangal, Telangana, India

ABSTRACT

In the present study different wood materials are collected from various areas in Telangana and Andhra Pradesh states. The experimental linear and mass attenuation coefficients of wood materials have been determined by using NaI (TI) scintillation detector coupled with 8k MCA at gamma ray energies of 59.5kev 81kev and 661.6kev obtained from Am^{241}, Ba^{133} and Cs ^{137} radioactive isotopes respectively. The elemental composition of wood materials finds out by vitro labs Hyderabad. The experimental values of μ/ρ compared with X-Com data base. The highest attenuation coefficient obtained for *Pterocarpus santalum* and lowest value for *sterculia urens* in all energies. It shows that, *Pterocarpus Santalum* a good attenuator because of density and chemical composition presented in these materials.

KEYWORDS: Wood Materials, Different Energies, Scintillation Detector & Attenuation Coefficient

INTRODUCTION

With the increasing use of radioactive isotopes and the study of fundamental interaction of gamma ray with material is an important in several fields of science and technology, industrial, medical, agriculture and commercial importance. It has become a major area of interest in the field of radiation. There arises the need of using them with extreme care, only after having proper shielding. A scientific study of interaction of radiation with matter is proposed for characterization and assessment of penetration and diffusion of gamma rays through external media. The mass attenuation coefficient depends upon the energy of the radiation and nature of the material. The roll of attenuation coefficient is very important for shielding characterization of gamma radiation in any medium. The mass attenuation coefficient is expressed as linear attenuation coefficient per unit mass of material (Kaplan 1989). The values of mass attenuation coefficients are available for a wide range of elements and compounds National institute of standard and technology (NIST) -Xcom data base. The linear attenuation coefficient and mass attenuation coefficient are by (Hubble-1999).

Shielding from gamma radiation requires large amounts of density. The radiation is better absorbed by materials with high atomic number density, although neither effect is important compared to the total mass/area in the path of the gamma ray. For this reason, a lead is more effective to shield gamma radiation than an equal mass of other shielding materials like aluminum, concrete, or soil or same quantity of water. Lead's major advantage, however, is its density. The higher the energy of the gamma rays, the thicker the shielding is required. Materials for shielding gamma rays are typically measured by the thickness required to reduce the intensity of the gamma rays by one half (the half value layer or HVL). Wood materials are suitable for shielding applications because these materials are rich in H-atoms and water content and available in solid state at room temperature, they have low density. Now a day's Wood, as one of the main materials, cheap as compared to lead and other better shields, used in modern building construction, and its method of production in the subject of detailed scrutiny, particularly where the buildings are of critical importance such as a hospital. When compared to conventional shielding materials like polymers, concrete, silicates and building materials (Kulwinder Singh Mann *et al* 2015; Akkut *et al* 2010a, 2010b; Damda *et a*l 2010; Turkmen 2008; Mann and Sidhu 2012; Mann and Korkut 2013; Kurudirek *et al* 2009 Mann *et al* 2012). There is less work on mass attenuation coefficient of wood materials; such data are useful for radiation shielding. For this purpose an attempt is made to study the linear and mass attenuation of different wood materials. The present study on wood samples with different density and thickness are taken at 59.5KeV, 81KeV and 661.6 KeV for comparison with theoretical X-com values.

MATERIALS AND METHODS

Preparation of Samples

The wood materials used in present studies are given in table 1 they are collected from various areas in Telangana and Andra Pradesh states. Before use they are first dried for six months in the open air, mainly for de-moisturirate and later they are cut into different lengths and dimensions. To characterization of the wood samples in the crash form had been done in Vitro labs, Hyderabad for elemental analysis given in table 2. The method adopted is CHN analysis methodology and AAS (atomic absorption Spectroscopy).The attenuation coefficient values were computed with the help of a state-of-the art computer program due to Berger and Hubbell (1988) named XCOM: Photon cross section on a personal computer.

Theory

The mass attenuation coefficient for different wood materials of different energies of radiation is determined by the following equation.

$$I = I_o e^{-\mu_m t} \quad (1)$$

Were I_o denotes the intensity of incident photons with energy E, without attenuator and I is intensity after attenuation. While‘t’ is the thickness of attenuator (sample) i.e., mass per unit area.

$$\mu_m = \frac{\mu}{\rho} \quad (2)$$

μ_m is the mass attenuation coefficient and μ is the linear attenuation coefficient ρ is the density of a given sample. Total attenuation coefficient (μ_m) value for the materials is assume to compose of attenuation coefficient of multi elements i.e, (μ_m)I present in the sample is called mixture rule(Hubbell and Sltezer 1995).

$$\mu_m = \sum_i w_i\,(\mu_m)_i \quad (3)$$

Were w_i is the proportion by weight of each element.

EXPERIMENTAL DETAILS

NaI (Tl) Scintillation detector is used in the present investigation. This scintillation head is consists of a beryllium/ alluminium window over a NaI (Tl) crystal, a photo multiplier of RCA type and a preamplifier built in to a single unit. The NaI (Tl) crystal is mounted on the photo cathode using optically transference silicon grease. The pre amplifier is a common emitter follower with processing network for the input transistor. The intensity of gamma rays is measured using 2″x2″ crystalline scintillation detector. The detector is closed with a lead jacket of 16mm thickness and 20mm diameter collimator. This detector coupled with photomultiplier tube, preamplifier and amplifier with counting system. The amplifier output pulses are coupled with 8000(8K), pc based multi channel analyzer (MCA) for online data acquisition. The detector system is supplied by Nucleonix Pvt. Limited, Hyderabad. A narrow beam geometry set up is designed as shown in figure 1. The gamma spectrum is analyzed by PHAST software was used for Photo peak area (Saritha and Nageshwara Rao 2014).the gamma ray sources Am^{241}, Ba^{133} and Cs^{137} at energies 59.5KeV, 81KeV and 661.6KeV are used.

RESULTS AND DISCUSSIONS

The experimental linear attenuation coefficient (μ) for wood materials at 661.6 keV, 81KeV & 59.5keV gamma ray energies is given in table 3. It can seem that *Pterocapus Santalum (Red sandal)* has the highest attenuation coefficient for all energies. High attenuation coefficient of wood is considered a very good absorber and a good quality material for radiation shielding and construction of building materials. *Sterculia urens (Thabise)* has the lowest attenuation coefficient compared to all other wood materials investigated. Lowest attenuation of wood is considered a very bad observer and low quality material for radiation shielding. The Linear attenuation coefficient values are decreased with increasing energy of gamma rays.

Mass Attenuation Coefficients

The values of the z-exponents for the photo effect of experimental results of mass attenuation coefficient are presented three photo energies summarized in table 4. The experimental measured values of mass attenuation coefficients (μ/ρ) for wood materials are compared with the theoretical values obtained from x-com data base using equation-2. These results are present in table 4, 5, 6 at energies 661.6 keV, 81KeV & 59.5keV respectively. It can be seemed that the measured values of μ/ρ are in good agreement with the calculated values The possible errors in the measurements presented are mainly due to statistical factors and non uniformly of the observer and here it comes around 1.5 percentage.

CONCLUSIONS

A mass attenuation coefficient depends upon the chemical composition and the photon energy of the material. It has been found that the mass attenuation coefficient decreases as photon energy increases. A good agreement can be seemed in between experimental and theoretical values. All wood material which is investigated in this study, high attenuation coefficient wood is considered as good observer and a good quality material for radiation shielding and construction of building materials. This type of study gives on the way about photon interactions measurements in wood materials

ACKNOWLEDGEMENTS

The author is very much thankful to UGC for giving financial support for Minor Research Project on doing work on biologically important wood compounds.

REFERENCES

1. Kaplan, M F.(1989) Concrete Radiation Shielding. Longrnan Scientific and Technology, Longman Group UK Limited. Essex. England..
2. J.H. Hubbell and M. Berger. (1999). XCOM: Photon Cross Sections data base. NIST..
3. Kul Winder Singh Mann, Asha Rani, Manmohan Singh Heer (2015). Shielding behaviors of some polymer and plastic materials of gamma rays106, 247-254.

4. Akkurt İ. Akyildirim H. Mavi B. Kilincarslan S.Basyigit C. (2010a).Ann. Nucl. Energy, 37–7, 910–914.

5. Akkurt İ. Akyildirim H. Mavi B. Kilincarslan S. Basyigit C. (2010b). Prog. Nucl. Energy 52, 620–623.

6. Damla N. Cevik U. Kobya, A. I. Celik A. Celik N. Van Grieken, R. (2010) Turkey. J. Hazard. Mater. 176, 644–649.

7. Turkmen I. Ozdemir Y. Kurudirek M. Demir F. Simsek.O, Demirbog, R. (2008).Ann. Nucl. Energ, 35, 937–1943.

8. Mann K S. Sidhu G S. (2012).Ann.Nucl. Energy, 40, 241–252.

9. Mann K S. Korkut T. (2013).Ann.Nucl .Energ, 51, 81–93.

10. Kurudirek M. Turkmen I, Ozdeymir Y. (2009). Radiat. Phys. Chem, 78,751–759.

11. Mann K S. Kurudirek M. Sidhu G S. (2012). Appl. Radiat. Isot. 70, 681–691.

12. Berger M J. Hubbell J H. Seltzer S M. Chang, J.Coursey, J S. Sukumar R. Zucker D S. Olsen K. (1998). NIST, Standard reference database, 8, 87-3597.

13. Hubbell J H Seltzer S M. (1995). Tables of X-ray mass attenuation coefficients and mass energy absorption Coefficients from 1keV to 20MeV for elements Z=1to 92 and 48 additional substance of dissymmetric interest. Available at ⟨http:// www. nist. Gov/ pml/data/ xraycoef/index.cfm⟩. International Commission on Radiation Units and Measurements, Report 33.7910.

14. Saritha B and Nageshwara Rao A S 2014 Can. Jr. Phys. 91(3)221

APPENDICES

Table 1: Name of Wood Samples

S.NO	Botanical Name	Vernacular Name (Common Name)	Family	Wood Status
1	*Sterculia urens*	Thabsi	Sterculiaceae	Soft wood
2	*Pterocarpus marsupium*	Peddegi	Fabaceae	Hard wood
3	*Chloroxylum swietenia*	Billudu	Flindersiaceae	Hard wood
4	*Terminalia alata*	Nallamaddi	Combretaceae	Hard wood
5	Pterocapus Santalum	Red Sandal	Fabaceae	Hard wood
6	Azadiracta indica	Neem	Meliaceae	Hard wood

Table 2: Chemical Composition of Wood Materials

Element	*Sterculia Urens*	*Pterocarpus Marsupium*	*Chloroxylum Swietenia*	*Terminalia Alata*	Pterocapus Santalum	Azadiracta Indica
C	42.88	43.29	42.83	42.9	46.01	41.5
H	2.92	3.6	4.32	3.86	4.19	3.76
N	1.17	1.77	2.17	1.7	1.5333	2.14
O	45.85	41.11	40.04	40.08	24.77	40.92
S	0.081	0.071	0.089	0.099	0.519	0.0834
P	0.038	0.019	0.025	0.028	0.24	0.01
H2O	5.51	9.67	10.18	10.66	21.78	10.48
Si	0.4129	0.2486	0.0894	0.1963	0.52	0.4043
Fe	0.0019	0.14	0.004	0.096	0.024	0.016
Al	0.0025	0.004	0.0028	0.013	0.0004	0.0032
Ba	0.0044	0.0017	0.0006	0.0022	---	0.0022
B	0.0022	0.0013	0.0011	0.0021	0.103	0.0021

Table 2: Contd.,

Cd	0.0001	0.0001	0.0001	0.0001	0.27	0.0001
Ca	0.98	0.12	0.21	0.27	0.063	0.57
Cu	0.0005	0.0003	0.0001	0.0005	0.004	----
Pb	0.0002	0.0001	0.0001	0.0002	0.0001	0.0101
Mg	0.038	0.038	0.0003	0.028	----	0.0001
Ni	0.0001	0.0001	0.0001	0.0002	0.063	0.38
K	0.77	0.023	0.024	0.042	0.001	0.0074
Na	0.026	0.016	0.012	0.018	0.005	0.058
Zn	0.0052	0.0028	0.0014	0.0044	0.0242	0.0732
Cr	---	---	-----	----	0.123	-----

Table 3: Linear Attenuation Coefficient of Wood Material at Different Energies

Botanical Name	Density	Linear Attenuation Coefficient(μ) cm^{-1}		
		59.5KeV	81KeV	661.6KeV
Sterculia urens	0.4375	0.0914	0.1303	0.035
Pterocarpus marsupium	0.95	0.1824	0.1641	0.076
Chloroxylum swietenia	1.20	0.2316	0.2193	0.097
Terminalia alata	1.4625	0.2837	0.2514	0.1184
Pterocapus Santalum	1.475	0.2935	0.2610	0.1213
Azadiracta indica	1.425	0.2821	0.2503	0.1152

Table 4: Experimental Mass Attenuation Coefficient Values of Wood Materials at 59.5KeV, 81KeV and 661.6KeV

Botanical Name	Density	Experimental Mass Attenuation Coefficient(μ/ρ) cm^{-1}/gm		
		59.5KeV	81KeV	661.6KeV
Sterculia urens	0.4375	0.209	0.298	0.080
Pterocarpus marsupium	0.95	0.192	0.173	0.080
Chloroxylum swietenia	1.20	0.193	0.183	0.081
Terminalia alata	1.4625	0.194	0.172	0.081
Pterocapus Santalum	1.475	0.199	0.177	0.082
Azadiracta indica	1.425	0.198	0.176	0.0809

Table 5: Comparison of Experimental and Theoretical Mass Attenuation Coefficients at 59.5KeV

Botanical Name	Density	Mass Attenuation Coefficient(μ/ρ) cm^{-1}/gm		
		Experimental	Theoretical	Deviation %
Sterculia urens	0.4375	0.208	0.209	-o.478
Pterocarpus marsupium	0.95	0.191	0192	-0.520
Chloroxylum swietenia	1.20	0.192	0,191	0.523
Terminalia alata	1.4625	0.194	0.194	0.000
Pterocapus Santalum	1.475	0.199	0.198	0.50
Azadiracta indica	1.425	0.198	0.199	0.502

Table 6: Comparison of Experimental and Theoretical Mass Attenuation Coefficients at 81KeV

Botanical Name	Density	Mass Attenuation Coefficient(μ/ρ) cm^{-1}/gm		
		Experimental	Theoretical	Deviation %
Sterculia urens	0.4375	0.298	0.210	2.405498
Pterocarpus marsupium	0.95	0.173	0.182	-1.64835
Chloroxylum swietenia	1.20	0.183	0.172	6.395349
Terminalia alata	1.4625	0.172	0.173	-0.57803
Pterocapus Santalum	1.475	0.177	0.175	1.142857
Azadiracta indica	1.425	0.176	0.178	-1.1236

Table 7: Comparison of Experimental and Theoretical Mass Attenuation Coefficients at 661.6KeV

Botanical Name	Density	Mass Attenuation Coefficient(μ/ρ) cm^{-1}/gm		
		Experimental	Theoretical	Deviation %
Sterclia urens	0.4375	0.080	0.081	-1.23457
Pterocarpus marsupium	0.95	0.080	0.080	0
Chloroxylum swietenia	1.20	0.081	0.081	0
Terminalia alata	1.4625	0.081	0.081	0
Pterocapus Santalum	1.475	0.082	0.08	2.5
Azadiracta indica	1.425	0.0809	0.082	-1.34146

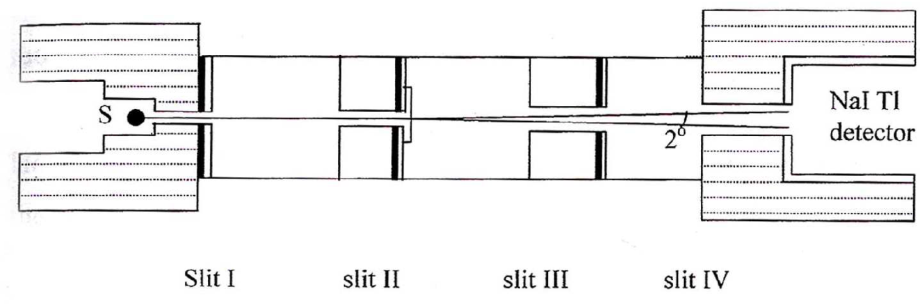

Figure 1: The Maximum Accepted Scattering Angle θ Max in Narrow Beam Geometry Setup