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GAMMA RADIATION DETERMINATION OF TRANSVERSE ABSORPTION COEFFICIENTS OF WOOD

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ABSTRACT

Absorption coefficients of different types of wood were measured using gamma radiation from ^{60}Co (5μci) source. Results show that Cam wood (*Pterocarpus*) has the highest absorption coefficient of 0.086 per cm, while Oxystima (*Oxystima spp*) has the least absorption coefficient of 0.042 per cm. Densities of wood were also measured. Mass absorption coefficient was determined for each wood sample. Results show that hard wood has a mass absorption coefficient of 0.127 ± 0.005 cm^2g^{-1} and, soft wood has mass absorption coefficient of 0.117 ± 0.003 cm^2g^{-1}.

KEY WORDS: Gamma radiation, absorption coefficients.

INTRODUCTION

Woods are of two main classes; soft and hard. Wood of coniferous trees is generally softer than that of other sorts of trees (Barry, 1975). The wood from all conifers (thin-needle-like leaves) is classified as soft wood, while the wood from all other trees which have broad leaves is termed hard wood. Woods have a variety of uses some of which include construction of lockers/boards, walls of buildings, packaging of materials. They can also be used to shield radiations from nuclear sources etc.

Gamma radiations are now being used for some industrial processing such as vulcanization of rubber, hardening of organic protective coatings, processing of various foods (Hawley, 1981). Such nuclear processes, in addition to nuclear waste from nuclear power plants, nuclear bomb testings, volcanic eruptions may increase the source of gamma radiation in our environment. Recent studies show that our environment has been contaminated by some radioactive fall-outs (Essien 1991, 1994). Gamma rays are extremely penetrating and are best absorbed by dense materials. Exposure to gamma radiation may be harmful. Thus complete protection is often recommended (Friedlander et al, 1981). Very dense materials such as lead are very expensive.

Therefore, there is the need to source for local materials, that may be able to absorb or extinct some of these radiations, for use as protective shields and coatings.

The absorption depends on the density of the material of the sample as well as on other properties (Friedlander et al, 1981).

Recently, gamma rays from cobalt-60 have been used in the determination of densities of various materials (Bhimasankaram, 1980 and Uwah et al, 1992). In this investigation, the same gamma radiation from cobalt-60 has been used in determining the absorption coefficient of different types of wood that are cheap and locally available. This radiation has further been used to estimate the mass absorption coefficient of different types of wood, thereby forming the basis for classifying wood.

THEORY

Absorption of a radiation may result from the effect of all the energy exchange mechanisms due to the interaction between radiation and the particles contained in the material. Thus, when a radiation is incident on a material, there is a reduction in the transmitted intensity. The transmitted intensity depends on the density, length of the absorbing layer and size of the particles of the material as well as on other factors (Jekins et al 1976 and Lovell et al, 1977). The radiation which is not transmitted is said to be absorbed. Absorption of radiation here refers to both true absorption and scattering of the radiation (Ekpe et al 1998).

The transmitted intensity, I is given by

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

where I_o = intensity of incident radiation

x = thickness of absorbing material, and

α = absorption coefficient

Equation (1) may be expressed as

$$\ln(I_o/I) = \alpha x \qquad (2)$$

By plotting $\ln(I_o/I)$ against x, the absorption coefficient for each wood sample can be determined. The mass absorption coefficient, μ can also be determined by plotting the absorption coefficient against density of each sample.

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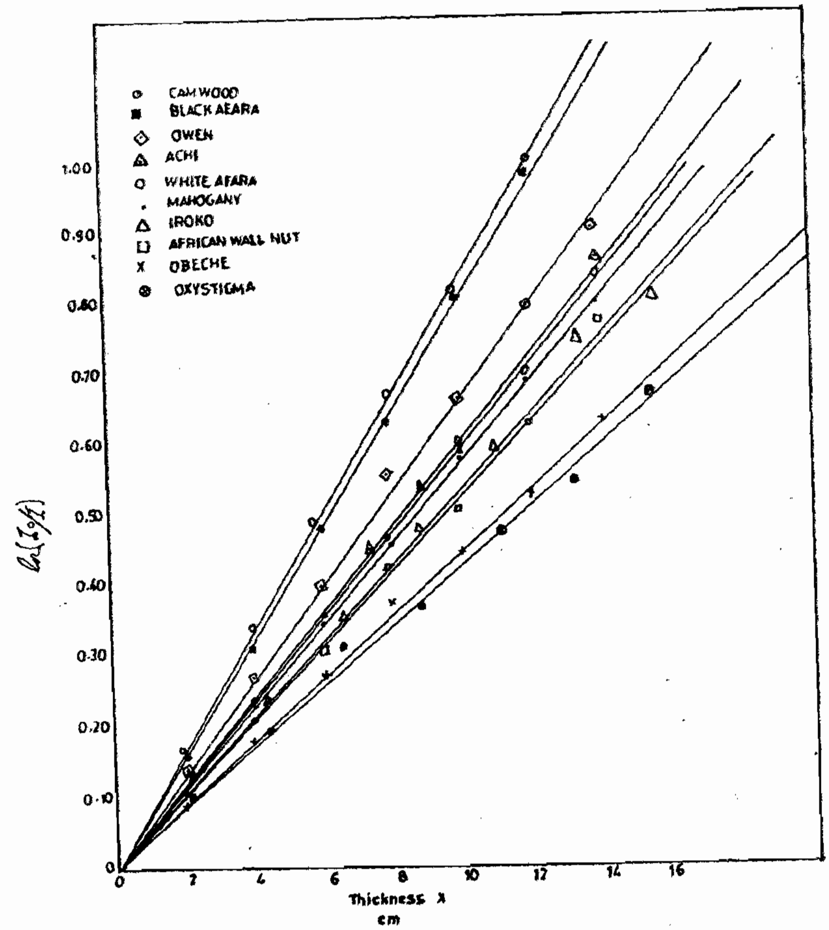

Fig:1 A plot of $ln(I_o/I)$ against thickness of the wood samples

MATERIALS AND EXPERIMENTAL METHOD

Materials

Ten different wood samples were collected from the Timber market in Uyo. The ten wood samples were camwood (*Pterocarpus spp*), Black afara (*Terminalia iverensis*), Owen (*Mitragyna ciliata*), Achi (*Brachystegia eurycoma*), White afara, Mahogany (*Khaya spp*), Iroko (*Milicia excelsa*), African Wallnut (*Lovoa trichilioides*), Obeche (*Triplochiton scleroxyton*), Oxystigma (*Oxystigma spp*). Each wood sample was carefully cut into seven rectangular blocks with thickness varying between 1,4 and 14.0cm. Cobalt-60 (^{60}Co, 5μci) gamma source model P66340/8, Geiger Muller (GM) tube detector, and scalar counter/Timer model P67520/4 were used in measuring the absorption coefficients of the wood samples.

Experimental method

The scalar counter/timer was calibrated and maintained at a voltage of 430V. The source, sample and detector were arranged vertically and axially. The intensity of incident radiation I_o was counted for one hour by placing the detector directly above and on the source. Thereafter, the sample was placed transversely between the source and the detector.

The number of counts for the intensity of transmitted radiation, I for each sample (of varying thickness) was taken for the same time duration of one hour. The experiment was repeated for all the different wood samples.

At each instance, the count rate without sample was measured before each sample was introduced.

The bulk densities were determined by measuring mass and volume of the samples.

RESULTS AND DISCUSSION

Table 1 shows the experimental results for the density ρ, transverse absorption coefficient, α and mass absorption coefficient, μ for the different wood samples. Fig. 1 shows the plot of $In(I_o/I)$ versus thickness for the various wood samples from which their respective absorption coefficients were determined. The mass absorption coefficients for these examples were also determined (Fig. 2). The lines were approximated by using the least square method. The slope gave the mass absorption coefficient of 0.127 cm ^{2}g^{-1} for hard woods and 0.117 cm ^{2}g^{-1} for soft woods.

The result shows that the absorption coefficient increases linearly with increase in density of wood (Fig. 2). This confirms the assertion that denser materials absorb more radiation than less dense materials (Jerkins et al 1976, Lovell et al 1977, and Friedlander et al. 1981). It was noticed that Camwood (*Pterocarpus spp*) has the highest absorption

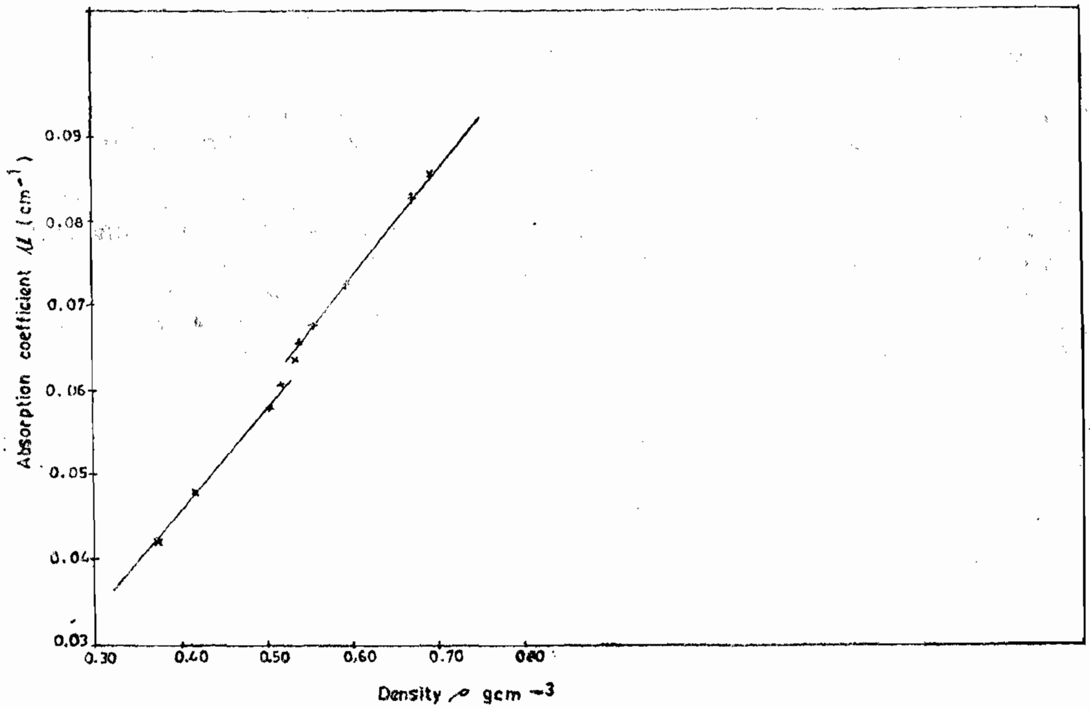

Fig: 2 Variation in absorption coefficient with density of wood samples

coefficient of 0.086 per cm, while *Oxystigma* has the least absorption coefficient of 0.042 per cm. Thus hard woods absorb more radiation than soft woods. This may be attributed to the fact that in hard woods, particles are more closely packed and therefore denser than in soft woods. Soft woods are characterised by long fibres (Barry, 1975), implying large pore spaces.

CONCLUSION

From the experimental results, we conclude that hard wood *Pterocarpus* has the highest absorption coefficient of 0.086 per cm and would therefore make the best choice of wood material for use as a radiation protective shield. And, for wood, the absorption coefficient increases linearly with density.

Further, it was found that hard wood had a mass absorption coefficient of 0.127 ± 0.005 cm ^{2}g^{-1} and soft wood has a mass absorption coefficient of 0.117 ± 0.003 cm ^{2}g^{-1}. This suggests that hardwoods can also be used as protective shield and coatings.

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TABLE 1: Experimental results for the density, transverse absorption coefficient and mass absorption coefficient of the wood samples.

COMMON NAME	BOTANICAL NAME	DENSITY (ρ)gcm^{-3}	ABSORPTION COEFFICIENT (α) cm^{-1}	MASS ABSORPTION (μ) cm ^{2}g^{-1}
Camwood	*Pterocarpus spp*	0.694	0.086	0.1239
Black afara	*Terminalia iverensis*	0.674	0.083	0.1231
Owen	*Mitragyna ciliata*	0.595	0.073	0.1227
Achi	*Brachystegia eurycoma*	0.556	0.068	0.1223
White afara		0.541	0.066	0.1219
Mahogany	*Khaya spp*	0.535	0.064	0.1196
Iroko	*Milicia excelsa*	0.520	0.061	0.01173
African Wallnut	*Lovea trichilioides*	0.500	0.058	0.1160
Obechi	*Triplochiton scleroxyton*	0.416	0.048	0.1157
Oxystigma	*Oxystigma spp*	0.370	0.042	0.1135

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