Gamma ray attenuation studies on concrete reinforced with Coconut Shells

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Introduction

The fact that radiation could be harmful has led to the development of wide variety of shields to protect against it. For nuclear radiation shielding, a larger quantity of shielding material is required and therefore, the study of propagation of radiation flux in shielding materials is an essential requirement for shield design. Concrete has proven[1] to be an excellent and versatile shielding material with well-established linear attenuation for neutrons and gamma rays. Coconut being naturally available, it can be used readily in concrete, still maintaining almost all the qualities of the original form of concrete. Concrete obtained using coconut shell as a coarse aggregate satisfies the requirements of concrete[2]. Coconut shell aggregate possess acceptable strength which is required for structural concrete.

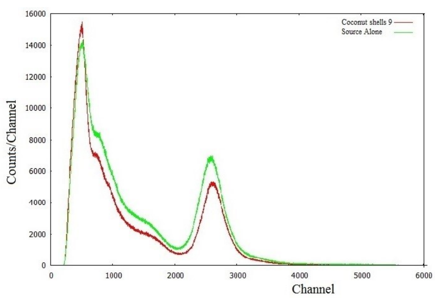

FIG. 1: Spectrum of 662 keV gamma rays obtained awith and without coconut shell as an absorber.

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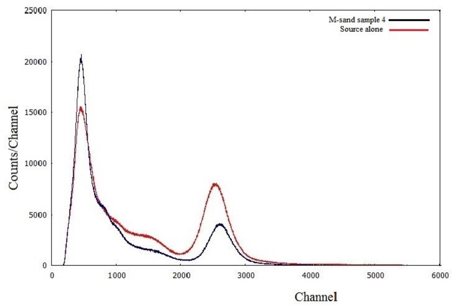

FIG. 2: Spectrum of 662 keV gamma rays obtained from concrete 4(msand sample) reinforced with coconut shell.

Theory

When gamma rays of definite energy pass through matter, their intensity is reduced according to the familiar exponential law,

$$I = I_0 e^{-\mu x} \tag{1}$$

where μ is a constant called linear attenuation coefficient, and I, I_0 are the intensities of radiation with and without on an absorber of thickness x. The mass attenuation coefficient,

$$\frac{\mu}{\rho} = \frac{ln(I_0/I)}{x\rho} \tag{2}$$

By the mixture rule, the mass attenuation coefficient of a compound or mixture of elements is calculated from,

$$\left(\frac{\mu}{\rho}\right)_c = \Sigma_i W_i \left(\frac{\mu}{\rho}\right)_i \tag{3}$$

where the W_i factors represent the weight fraction of element i in the compound or mixture and $\frac{\mu}{\rho}$ is the photon mass attenuation coefficient for the individual elements in the compound.

Experimental details

For this, coconut shells were cut into the size 4cm x 4cm, in a grinding machine. Mean value of coconut shell density is $1.607 gm/cm^3$. The thickness of the shells are varied from 3-6 mm and mass of the shells also varied from 11-14 grams. The coconut shells were irradiated using 662 keV gamma rays emitted from a ^{137}Cs source. In the second part of the study, we have used concrete samples reinforced with coconut shells as gamma absorber material. In this case, five concrete samples containing coconut shell in the ratios of 0, 2, 3, 4, and 6% (by weight) in the cement were used. Two types of sands were used in this study: Common sand (Sand) and Modular/ Manufactured Sand (M-sand). They were mixed homogenously and then by adding water in the standard ratios mortar was prepared.

Results and Discussion

It is seen that as the cumulative thickness of coconut shell increases, the counts decreases marginally, and hence a corresponding decrease in the value of logarithmic relative transmission, $ln(I/I_0)$. So these results indicate that coconut shell absorbers can act as a shielding material. The obtained mass attenuation coefficients were then multiplied by the density of the specimens ($1.607 gm/cm^3$) to obtain the linear attenuation coefficient values. As mentioned earlier the mass attenuation coefficient of the coconut shell is also determined using the mixture rule and its value is found to be 0.0563. The linear attenuation coefficient can be obtained as the negative of the slope of this curve.

The mass attenuation coefficient is the highest for the block marked as concrete 4 prepared using normal sand, which has the highest density due to the additives. Among all forms, the ordinary concrete has the lowest mass attenuation coefficient[4], hence the concretes formed with different additives of different coconut composition provide higher attenuation coefficient. The increase of (μ/ρ) with the increase of the content of the reinforced coconut shell compounds can be attributed to an increase in the photoelectric absorption

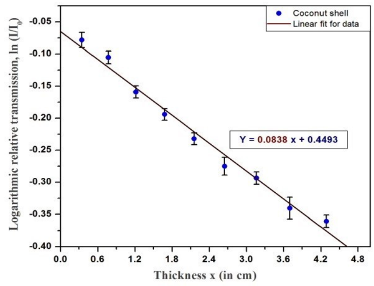

FIG. 3: Logarithmic relative transmission plotted against thickness of coconut samples.

and Compton scattering probabilities[3]. On the other hand, the small particle size of the coconut shell additive allows more interaction probability of the incident -rays due to high values of the target surface/volume ratio. It is clearly seen from the tables that the linear attenuation coefficients increased with increasing percentage of coconut shell in concrete.

References

[1] K. V. Rao, A. H. L. Swaroop, Dr. P. Kodanda Rama Rao and Ch. Naga Bharath, *International journal of civil engineering and technology (IJCIET)*, **6**, 42(2015).

[2] Gaikwad D.K., R.R. Bhosle, S. Obaid, V. Awasarmol, R. Lokande, P. Kore, B. Ladhaf, S. Raut, C. More and P.P. Pawar , *Bionano Frontier*, **8**, 137(2015).

[3] Sukhpal, Singh, Ashok, Kumar, Devinder, Singh, Kulwant, Singh Thind, and Gurmel, S.Mudahar, *Nuclear Instrument Methods B*, **266**, 140(2008).

[4] C.J. Ewansiha, J.E. Ebhoaye, I.O. Asia, L.O. Ekebafe and C. Ehigie, *International Journal of Pure and Applied Sciences and Technology*, **13**, 57(2012).