

## Assessing the Radiation Shield Capacity of Mud and Clay Block from Biu Blended with Rice Husk Ash

### Abstract

The assessment of radiation shielding capacity of mud and clay block blended with rice husk ash from Biu was carried out in this work. The soil sample was obtained by digging 3ft below the surface soil within Nigerian Army University and the rice husk ash was prepared and mixed proportionally in a designated ratio with the mass and density of the RHA blended soil sample obtained and molded to form block of which two of them A0 and D0 stand for mud block samples while that of the A1 and D1 stand for clay block samples respectively, After, they were all taken for analysis in order to assess their elemental composition, morphological, and their radiation shielding capacities as presented in the result and discussion session.

### Introduction

Many researchers have tried to look at the impact of radiation on human health and have envisaged on how various ways through which human being use to absorb could be minimized especially the ionizing type that poses health risks to living organisms due to its ability to ionize atoms and molecules [1]. Since man needs shelter such building where every human being finds shelter, it has become necessary that in selecting the materials used in construction of such shelter, their mechanical strength and ability to shield /absorb some of the ionizing has to considered and preference given to them in order to minimize radiation absorption by the occupants of the shelter [2]. This why, there has been a growing interest in identifying cost-effective and sustainable materials with acceptable radiation attenuation properties. [3,4] Traditional shielding materials include lead, steel and concrete are found to be often effective in performance of the function, they are not environmentally friendly coupled with the fact that they are expensive, an alternative is being sought to minimize radiation effect.

Radiation shielding refers to the process of using a material to block or reduce the intensity of radiation therefore there is quest to identify and explore

### Research Article

**Emmanuel Ifeanyi Ugwu<sup>1\*</sup>, Sunday Ikpughul Iyua<sup>1</sup>, Barnaba Abel Adeiza<sup>2</sup>, Celestine Nweke Ukwu<sup>4</sup>, Hyacinth Kevin Idu<sup>5</sup>**

<sup>1</sup>Department of Physics, Nigerian Army University Biu, Borno State

<sup>2</sup>Department of Mechanical Engineering Nigerian Army University Biu

<sup>3</sup>Federal University Ndufu -Alike, Ikwo

<sup>4</sup>Department of Physics Federal University Udufu-Alike Ikwo

<sup>5</sup>Department of Physics, Taraba State University, Jalingo

**\*Correspondence:** Emmanuel Ifeanyi Ugwu, Department of Physics, Nigerian Army University Biu, Borno State, Nigeria,

Email: [Emmanuel.ifeanyi@naub.edu.ng](mailto:Emmanuel.ifeanyi@naub.edu.ng), [ugwuei2@gmail.com](mailto:ugwuei2@gmail.com)

**Received:** 19 May, 2026; **Accepted:** 12 June, 2026;

**Published:** 19 June, 2026

**Copyright:** © 2026 Emmanuel Ifeanyi Ugwu. This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

sustainable and eco-friendly building materials commonly used by many rural dwellers in low-income regions due to their availability, affordability for use as building materials such mud and clay block. They possess good thermal insulation properties and are biodegradable coupled with fact that their mechanical strength and resistance to environmental and radiological hazards are relatively low, can be improved upon through the use of additives [5]. Therefore, many material scientists have worked on using other materials, particularly rice husk/rice husk ash as additive to improve on mechanical strength of some these building materials [6,7]. Also some have tried at the same time to estimate the effectiveness of blending block with rice husk ash in radiation shielding [8] analyzed the gamma radiation shielding capacity of fly ash bricks using Co-60 and Cs-137 gamma sources. Their results showed that bricks

with higher silica and density had increased mass attenuation coefficients, improving their ability to block or absorb gamma radiation. It had been found that the review of agro-waste materials such as rice husk ash and it has been found that these materials exhibited effective radiation shielding properties [9] of which RHA is found to improve the density and silica content of blocks, thereby enhancing their gamma attenuation, this is because it has been found that there is presence of high-silica content which increases the density and compactness of any material it is blended with making them to be a better absorber or scatterer of ionizing radiation, thereby enhancing the radiation shielding ability of such materials [10-12]. Therefore the aim is to assess the effectiveness of radiation shielding capacity of mud and clay block from Biu blended with rice husk ash.

### Materials and Methodology

Clay soil obtained where we dug about 3ft below the surface soil within Nigeria Army University Biu, Borno state to obtain the sample soil for this work and molded with plumbing pipe of 2 diameter after it was thoroughly mixed with rice husk ash proportionally in a designed ratio as outlined below;

- 20g of rice husk ash was mix with 100g of soil
- 100g of rice husk ash was mix with 100g of soil

After mixing, we now molded it and taking one of 20g (RHA), and 100g (RHA) after which two of the sample were molded as mud block directly while the other two were heated at the temperature of 10000C in order to turn it to clay. After the preparation, the mass and density of the samples were obtained respectively and they were taken for analysis in order to assess their elemental composition, morplogical, and the radiation shielding capacities.

### Results and Discussion

S/N	Rice Husk (g)	Loamy Soil (g)	Total Mass(g)	Density(ρ)
1	20	100	120	3.43
2	100	100	200	3.03

**Table 1:** The mass and density of the samples with their mixed Proportion before heating

S/N	Rice Husk (g)	Loamy Soil (g)	Mass(g)
A1	20	100	63.3
D1	100	100	61.20

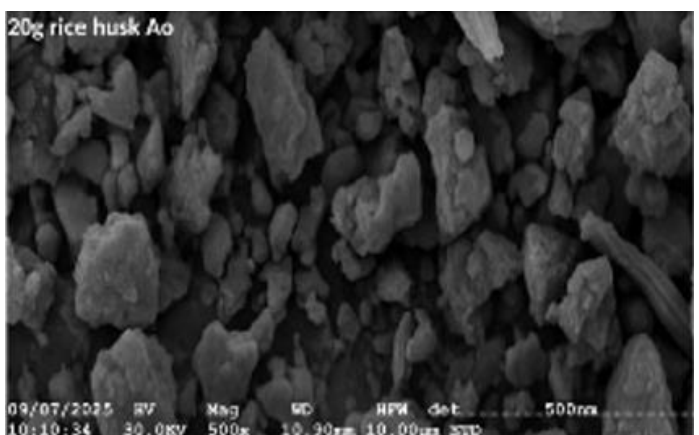
**Table 2:** Mass (g) heated samples

S/N	Rice Husk (g)	Loamy Soil (g)	Density(ρ)
A0	20	100	1.81
D0	100	100	1.36

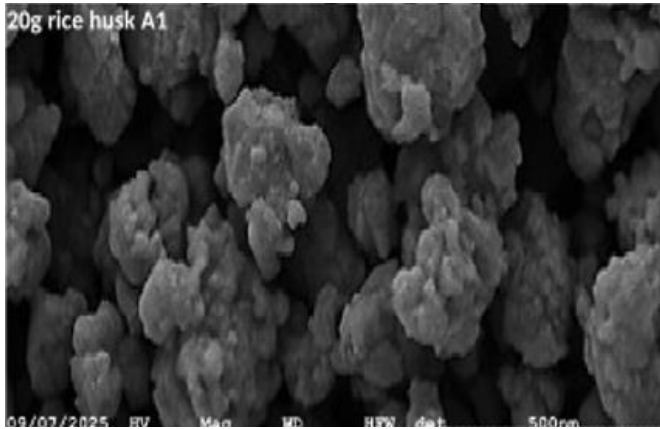
**Table 3:** mass and density of the heated samples

Table 1 is the mixing proportion, the sample mass in (g) and the density as prepared before heating while table 2 and table3 depict the mass in (g) and the density after the samples had been heated which are presented as A1 and D1 for unheated while the heated ones i.e. the clay are denoted with A0 and D0 respectively as depicted in fig.3 and fig.4 In subsequent discussion all the information based on the mud and clay samples would be presented as coded. The elements present in the composition percent of A0 and D0 were as shown in table4 and table 5 respectively, where it is seen from the analysis that there is a high amount of oxygen in both samples above having 45. 14% and 45.32% respectively. This result indicated that there are air molecules present in the composition. We also have other elements present in the composition such as silicon, Carbon, Aluminium, Iron, Calcium, Potassium, Magnesium, Sodium, and Titanium having relative difference from each composition.

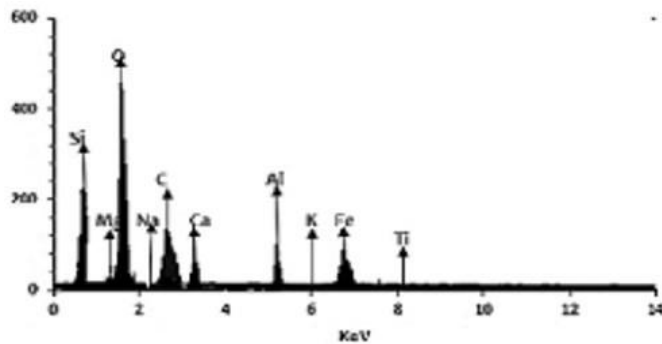
Fig.1 and fig 2 showed the morphological structure of the mud and clay blended with rice husk as carried out here in this work. While fig 5 and fig 6 depict that of clay block.



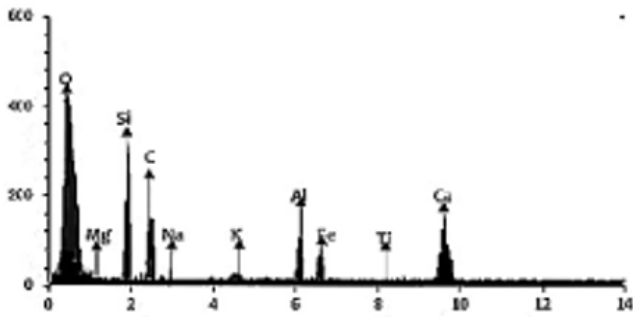
**Figure 1:** The Morphology mud block, A0 mixed with 20g of Rice Husk Ash (RHA) in the Sample



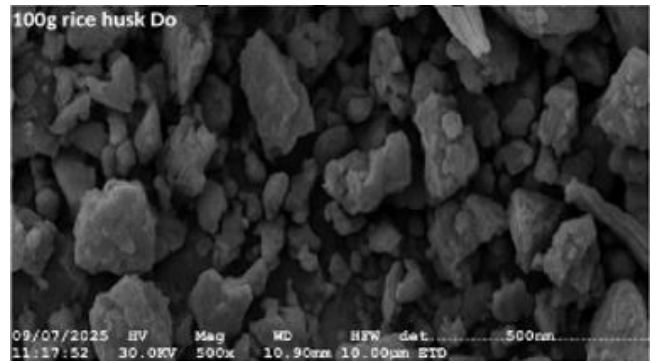
**Figure 2:** The Morphology of clay block, A1 mixed with 20% rice husk ash



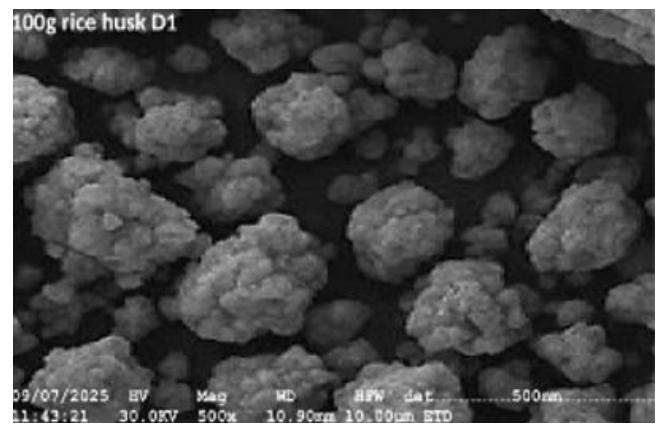
**Figure 3:** The Chat of Elements in the mud block mixed with 20g of Rice Husk Ash (RHA) as in Sample A0



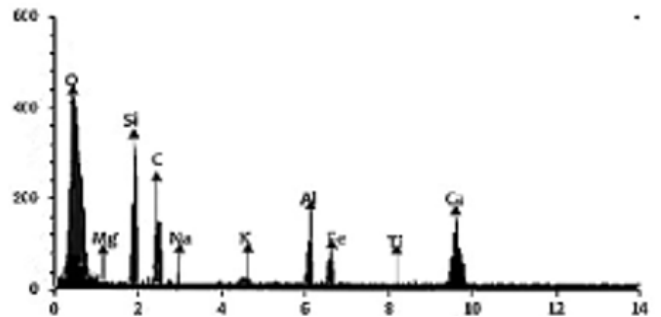
**Figure 4:** The Chat of Elements in the mud block mixed with 20g of Rice Husk Ash (RHA) as in Sample A1



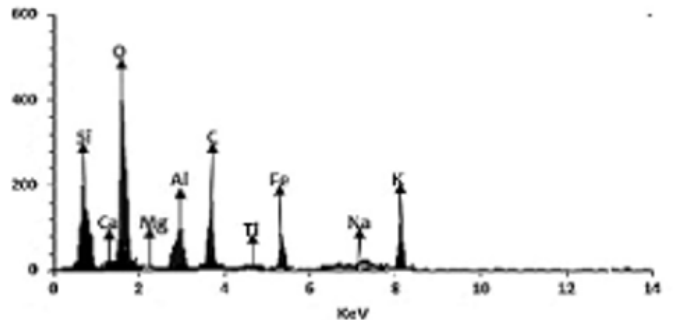
**Figure 5:** The morphology of mud Block mixed with 100g of rice husk ash (sample D0)



**Figure 6:** The Morphology of Clay block mixed with 100g of Rice Husk Ash D1



**Figure 7:** The Chat of Elemental Composition in the 100g of Rice Husk Ash (RHA) in the Sample D0 of the Mud block



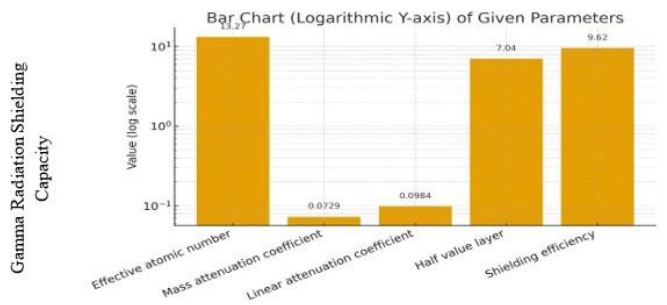
**Figure 8:** The chat of Elements in the 20g of Rice Husk Ash (RHA) in the Sample D1 of the Clay block

Element	Composition A0 (%)	Composition D0 (%)
Oxygen (O)	45.14	45.32
Silicon (Si)	31.06	29.84
Carbon (C)	8.85	12.56
Aluminium (Al)	5.16	4.13
Iron (Fe)	3.23	3.34
Calcium (Ca)	2.15	2.01
Potassium (K)	1.37	1.22
Magnesium (Mg)	1.16	0.74
Sodium (Na)	1.21	0.56
Titanium (Ti)	0.67	0.28

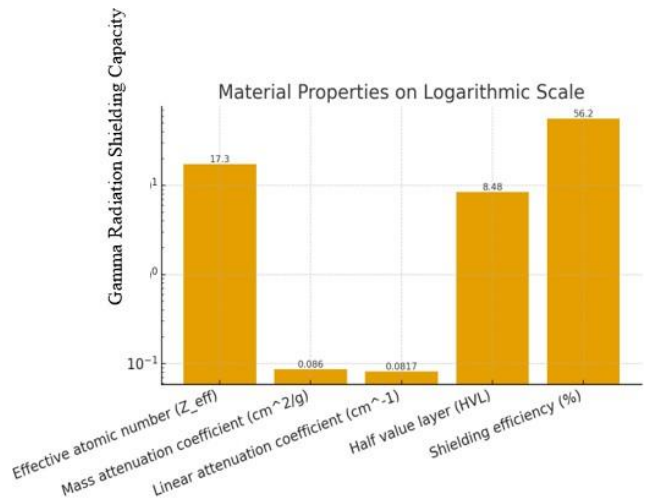
**Table 4:** The Elemental composition of Mud Block mixed with 20g and 100g of Rice Husk ash [A0 and D0 respectively]

Element	Composition A1 (%)	Composition D1 (%)
Oxygen (O)	44.30	43.33
Silicon (Si)	27.51	26.21
Carbon (C)	8.42	11.84
Aluminium (Al)	7.64	6.52
Iron (Fe)	4.47	4.23
Potassium (K)	2.32	2.75
Calcium (Ca)	2.05	2.37
Magnesium (Mg)	1.58	1.34
Sodium (Na)	1.23	1.16
Titanium (Ti)	0.48	0.25

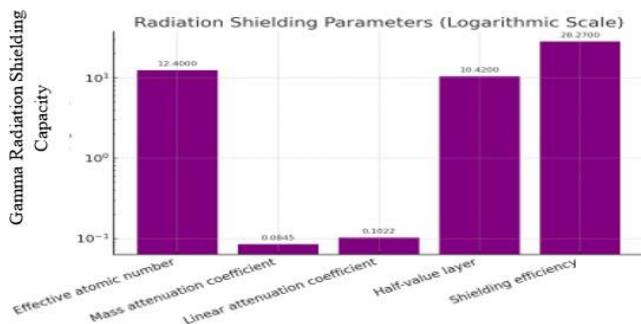
**Table 5:** The Elemental composition of Clay Block mixed with 20g and 100g of Rice Husk ash [A1 and D1 respectively]



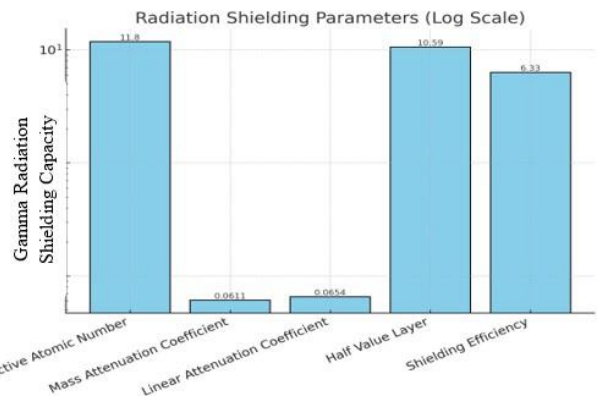
**Figure 10:** Bar Chart representation of Radiation Shielding capacity of Mud Block mixed with 100g of rice husk D0



**Figure 11:** Bar Chart representation of Radiation Shielding capacity Clay Block mixed with 100g of rice husk A1



**Figure 9:** Bar chart representation of mud Block mixed with 20g of rice husk ash A0



**Figure 12:** Bar Chart representation of Radiation Shielding capacity Clay Block mixed with 100g of rice husk D1

Above lies a detailed result of elements situated in the composition of sample A1(20g) and D1(100g) Clay blocks (i.e. after burning or heating). An elements Oxygen bearing a higher percentage of 44.30% and 43.33 % respectively. This indicating that the higher the increase in grams of RHA in the Clay blocks the

lesser the air molecules present thereby giving us a stronger and more durable blocks to build with good shielding capacity. Furthermore, we have Carbon which is also present in the compositions having 8.42% and 11.84% respectively. Considering the differences between both composites, it appears to be that there is a high increase in carbon when there is an increase in gram of RHA present in the clay blocks which also is of advantage to strengthening the bonds of elements and giving us a durable block for use. Other elements such as Aluminium, Iron, Potassium, Calcium, Magnesium, Sodium and Titanium are all present having different percentages in the composition.

Additionally, below contains a well-structured diagram and a graphical representation of sample.

The bar chart illustrates the variation of key radiation shielding parameters, including the effective atomic number, mass attenuation coefficient, linear attenuation coefficient, half-value layer, and shielding efficiency. Among these, shielding efficiency exhibits the highest value (28.27), signifying the strong capacity of the material to reduce radiation intensity. The effective atomic number (12.4) and half-value layer (10.42) are of comparable magnitude, reflecting the influence of atomic composition and material thickness on radiation absorption. In contrast, the mass attenuation coefficient (0.0845) and linear attenuation coefficient (0.1022) are relatively small, indicating that the probability of photon interaction per unit mass or thickness is low. However, when integrated across the bulk material, these microscopic properties contribute significantly to the macroscopic shielding performance. The logarithmic scale representation makes it clear that while the attenuation coefficients are small in magnitude, they remain critical in determining the overall shielding efficiency. Thus, the chart emphasizes that effective atomic composition and material thickness work together with attenuation coefficients to produce high shielding efficiency [11].

These graphical representations of the shielding parameters which shown on a logarithmic scale provides a clearer understanding of the variations in magnitude between the different properties. The parameters that influences shielding that were considered includes the Effective Atomic Number ( $Z_{\text{eff}}$ ), Mass Attenuation Coefficient (MAC), Linear Attenuation Coefficient (LAC), Half-Value Layer (HVL), and Shielding Efficiency (SE). The effective atomic number (11.8) is relatively high compared to most polymeric or biological materials, suggesting

that the studied material possesses enhanced photon interaction potential. This is significant because higher  $Z_{\text{eff}}$  values generally correspond to stronger photon absorption, particularly for photoelectric-dominated interactions at lower photon energies. The mass attenuation coefficient (0.0611  $\text{cm}^2/\text{g}$ ) and the linear attenuation coefficient (0.0654  $\text{cm}$ ) are comparatively smaller values, but their importance lies in quantifying the material's ability to attenuate photons per unit density and per unit thickness, respectively. When viewed on a logarithmic scale, these coefficients appear significantly lower than  $Z_{\text{eff}}$ , reflecting their different physical dimensions and dependence on photon-material interactions. The half-value layer (10.59  $\text{cm}$ ), which represents the thickness required to reduce the incident photon intensity by 50%, is relatively high compared to dense shielding materials such as lead. This indicates that while the material does exhibit shielding capacity, its effectiveness is limited and would require larger thicknesses for practical radiation protection application. The shielding efficiency (6.33%) is not moderate for effective shielding suggesting that the material can only provide partial attenuation against incoming radiation. On the logarithmic scale, it is positioned between the LAC/MAC and the higher  $Z_{\text{eff}}$  and HVL values, highlighting the intermediate performance of the material in radiation mitigation. Overall, the logarithmic representation emphasizes on the wide range of magnitudes across the different parameters such as the effective atomic number is considered to connote strong potential interaction, with a relatively high half-value layer and modest shielding efficiency. This therefore demonstrates that the material may be considered highly effective for radiation shielding in isolation, and considered good for use appropriately in composite or hybrid shielding systems where other materials can compensate for its low effectiveness.

## Summary

Considering, all necessary details presented thus far from the chapter one to four and having carried out all necessary procedures towards achieving the research project, some key information was observed that led to the summary of the research Elements: Elements found in the composition where Oxygen (O), Silicon (Si), Carbon (C), Aluminium (Al), Iron (Fe), Calcium (Ca), Potassium (K), Magnesium (Mg), Sodium (Na) and Titanium (Ti). Composition Percentage: elements had relative percentage to each sample with some having high difference in composition percentage tore each other thereby affecting the samples positively and negatively based on their elemental characteristics.

Durability/strength due to the high presence of carbon that is present in RHA in the samples contribute to the strength of the blocks thereby making it more efficient for usage in radiation shielding [14,15].

In all, the study investigated the radiation shielding capacity of mud blocks blended with rice husk ash (RHA) revealed that the addition of RHA to mud blocks enhanced its radiation shielding capacity, making it a potential alternative to traditional building materials since it exhibits radiation shielding characteristics [16]. Therefore, it observed that based on the unique elemental composition of RHA-blended mud blocks, which is found have contain elements which include

the lightweight elements like oxygen and carbon, all contributing to the radiation shielding properties of the material [17]. The use of RHA mud and clay and clay block blended with rice husk ash provide a solution for radiation shielding enhancement in various applications, including medical facilities, nuclear power plants and industrial settings if applied therefore the overall observation in this study demonstrates the potential of RHA-blended with mud and clay blocks as a novel radiation shielding material which can be further enhanced thereby there is an indication of significant implications for development of sustainable building material with good radiation shielding capacity.

## References

1. Pornnumpa, C., S. Tokonami, A. Sorimachi, and C. Kranrod. "Characteristics of indoor radon and its progeny in a Japanese dwelling while using air appliances." *Radiation protection dosimetry* 167, no. 1-3 (2015): 87-91.
2. Barnabas, AA; Nathan, C; Emmanuel, IU; Rufai, AM; Zuberu, M; Sadiu, A; Ibrahim, U (2025). "The Effect of Rice- Husk Ash and Pulverized Broken Bottle on Composite Material Developed from Gula Clay." *Greener Journal of Science, Engineering and Technological Research*, 14(1): 18-27, <https://doi.org/10.15580/gjsetr.2025.1.091625136>.
3. Bashter, I. I. "Calculation of radiation attenuation coefficients for shielding concretes." *Annals of nuclear Energy* 24, no. 17 (1997): 1389-1401.
4. Basha, E. A., Roslan Hashim, H. B. Mahmud, and A. S. Muntohar. "Stabilization of residual soil with rice husk ash and cement." *Construction and building materials* 19, no. 6 (2005): 448-453.
5. Onyango, J., Mutuku, S., & Mwangi, J. (2017). Performance improvement of mud blocks using natural additives. *International Journal of Civil Engineering and Technology*, 8(12), 24252.
6. Nweke, E. S., and E. I. Ugwu. "Analysis and characterization of clay soil in Abakaliki, Nigeria." *The Pacific Journal of Science and Technology* 8, no. 2 (2007): 190-193.
7. Minke, Gernot. "Building with Earth: Design and Technology of a Sustainable." (2006).
8. Nasly, M. A., & Yassin, A. M. (2009). Earth architecture: Sustainability and durability of mud brick construction. *WIT Transactions on the Built Environment*, 112, 9–18.
9. Akhtar, M., & Basha, S. M. (2017). Agro-waste materials as sustainable radiation shielding materials: A review. *Construction and Building Materials*, 150, 581–595. <https://doi.org/10.1016/j.conbuildmat.2017.05.190>
10. Sasidharan, S., & Thomas, P. (2018). Study on mechanical and durability properties of rice husk ash concrete. *International Journal of Civil Engineering and Technology*, 9(10), 1686–1694.
11. Olutoge, Festus A., Habeeb A. Quadri, and Oladipupo S. Olafusi. "Investigation of the strength properties of palm kernel shell ash concrete." *Engineering, Technology & Applied Science Research* 2, no. 6 (2012): 315-319.
12. Mbah, M., Okafor, V., & Chukwu, C. (2022). Agricultural waste-based construction materials for radiation shielding. *Journal of Sustainable Construction Materials*.
13. Sharma, A., Singh, R., & Gupta, P. (2020). Radiation attenuation properties of soil bricks mixed with rice husk ash. *Construction and Building Materials*, 238, 117726.
14. Akinyele, J. O., & Olawuyi, B. J. (2016). Stabilization of lateritic soil with rice husk ash. *International Journal of Scientific & Engineering Research*, 7(5), 1520–1526.
15. Kumar, A., Singh, N., & Shukla, A. (2015). Effect of rice husk ash on the properties of burnt clay bricks. *International Journal of Engineering Research and Applications*, 5(1), 84–87.
16. Yahaya, M. S., et al. (2017). Mechanical and physical changes in materials under ionizing radiation. *Journal of Materials Science*, 52(4), 2155–2165.
17. Sharma, A., Singh, R., & Gupta, P. (2020). Radiation attenuation properties of soil bricks mixed with rice husk ash. *Construction and Building Materials*, 238, 117726.

**Citation:** Emmanuel Ifeanyi Ugwu, Sunday II, Barnaba AA and Celestine NU et al. "Assessing the Radiation Shield Capacity of Mud and Clay Block from Biu Blended with Rice Husk Ash." *J. Nanotechnol. Nanobiotechno* (2026): 104. DOI: [10.59462/3071-1983.2.1.104](https://doi.org/10.59462/3071-1983.2.1.104).