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RESEARCH ARTICLE **OJER0402001-452**

INVESTIGATION OF LINEAR AND MASS ATTENUATION COEFFICIENT OF OZANOGOGO KAOLIN, AGBOR, DELTA STATE.

[1]Egheneji, A., [*2]Molua, O. C., [3]Vwavware, O. J., [4]Osuhor, P., [5]Akpoyibo, O. & [6]Eseka, K.

[1, 2, 4 & 5]*Physics Department, University of Delta, Agbor Delta State*

[3 & 6]*Physics Department, Dennis Osadebay University Asaba. Delta State*

***Corresponding Author Email:** collins.molua@unidel.edu.ng*

ABSTRACT

This study investigates the linear and mass attenuation coefficients of Ozanogogo Kaolin, a material with unique physical and chemical properties, across varying radiation energies. The study aims to contribute to understanding how Ozanogogo Kaolin interacts with radiation, particularly in fields such as medical imaging, radiation therapy, and industrial applications. The research thoroughly explores the material's characteristics, including density, thermal stability, corrosion resistance, and mechanical strength. The linear attenuation coefficient (μ) and mass attenuation coefficient (μ/ρ) are fundamental parameters measured experimentally through a transmission-based technique. The experimental setup includes a radiation source, Ozanogogo Kaolin samples, a radiation detector, and appropriate shielding. The values of attenuation coefficients obtained at different radiation energies are presented, indicating a linear decrease in attenuation with increasing energy. The research discusses the implications of the findings for practical applications, emphasizing Ozanogogo Kaolin's potential in radiation shielding materials and protective equipment. Possible sources of error in the experimental procedure are identified, and recommendations for future research are proposed, including investigations into sample characteristics, comparative studies with other shielding materials, and examinations of material behaviour at higher energies. In conclusion, this study enhances the understanding of Ozanogogo Kaolin's attenuation properties and highlights its potential in diverse applications related to radiation attenuation. The research findings contribute valuable insights for developing improved radiation shielding materials and equipment.

Keywords: *Attenuation coefficient, Energy absorption, Gamma-ray spectroscopy, Linear attenuation, Material characterization, Mass attenuation, Ozanogogo Koalin.*

INTRODUCTION

Understanding linear and mass attenuation coefficients is pivotal in various fields, including medical imaging, radiation therapy, and industrial applications. These coefficients characterize how materials interact with and attenuate radiation, crucial in optimizing radiation shielding designs and enhancing the precision of radiation-based measurements and treatments. Ozanogogo Kaolin, with its distinctive physical and chemical properties, emerges as a material of interest for its potential applications in these domains. Linear attenuation coefficient (μ) quantifies how much a material weakens radiation intensity as it passes through. In contrast, the mass attenuation coefficient (μ/ρ) normalizes this value by material Factors like radiation energy, material density, and composition influence these coefficients. Studying attenuation coefficients aids in material characterization, radiation shielding design, and ensuring the suitability of materials for specific applications. It provides insights into how materials interact with radiation and attenuate its intensity.

Ozanogogo Kaolin, known for its high density, exceptional thermal stability, and corrosion resistance, presents an intriguing subject for investigation due to its unpopular potential among the natives. The study of Ozanogogo Kaolin is justified by its potential properties for radiation shielding applications which may be useful in medical imaging and industrial radiography. Its potential in radiation attenuation applications warrants a comprehensive study to assess its attenuation properties and suitability for practical use (Chang *et al.*, 2021). Through this investigation, we seek to contribute to the knowledge base on the attenuation properties of Ozanogogo Kaolin and provide valuable data for applications in radiation shielding, material characterization, and non-destructive testing (Sánchez-Cano *et al*, 2020). The definition and significance of linear and mass attenuation coefficients by previous studies on the coefficients of kaolin, and the theoretical framework that underpins the understanding of attenuation coefficients (Alhazmi *et al.*, 2022). This section will also outline the specific objectives of the study. The subsequent sections of the paper will expound on the theoretical background, experimental methodology, results, and analysis, discussion, and conclusion, providing a comprehensive exploration of the investigation into Ozanogogo Kaolin's attenuation coefficients.

In various fields, such as medical imaging, radiation therapy, and industrial applications, understanding the interaction of radiation with materials is crucial. Attenuation coefficients play a fundamental role in characterizing how materials attenuate or weaken the intensity of radiation as it passes through them. By studying attenuation coefficients, researchers can assess the suitability of materials for specific applications, optimize radiation shielding designs, and enhance the accuracy of radiation-based measurements and treatments (Shuang & Audrey, 2019). Ozanogogo Kaolin is a material with intriguing characteristics that make it suitable for various applications. It exhibits high density, which is advantageous for attenuation as dense materials tend to attenuate radiation more effectively. Furthermore, Ozanogogo Kaolin demonstrates exceptional thermal stability, enabling it to withstand high-temperature environments without significant degradation. Its corrosion resistance ensures its longevity and reliability in various settings (Peredriy *et al*, 2020).

In addition to these properties, Ozanogogo Kaolin's remarkable mechanical strength makes it suitable for structural applications in high-stress environments. Its density, thermal stability, corrosion resistance, and mechanical strength make it an attractive candidate for further investigation into its attenuation coefficients (Barba-Lobo *et al*, 2021). To comprehensively understand the interaction between Ozanogogo Kaolin and radiation, it is essential to characterize its physical and chemical properties thoroughly. This includes determining density, composition, and other relevant characteristics influencing its attenuation behaviour. By exploring these properties, we can establish a foundation for comprehending how Ozanogogo Kaolin interacts with radiation and how its inherent characteristics influence its attenuation coefficients (Brown *et al.*, 2018). By providing an in-depth background, highlighting the significance of attenuation coefficients, and discussing the relevant properties of Ozanogogo Kaolin, we establish the context for the subsequent sections of this paper. The knowledge gained through this investigation will contribute to the existing understanding of attenuation properties and open doors for further exploration of Ozanogogo Kaolin's potential in practical applications related to radiation attenuation and material characterization (Kaur *et al*, 2021).

In this study, we focus on investigating the attenuation coefficients of Ozanogogo Koalin, a material of growing interest due to its potential applications in diverse fields. Ozanogogo Koalin is known for its unique physical and chemical properties, including high density, exceptional thermal stability, and corrosion resistance. These properties and its potential attenuation capabilities make Ozanogogo Kaolin an intriguing material for further investigation (Taylor *et al*., 2021). This research aims to determine the linear and mass attenuation coefficients of Ozanogogo Koalin across a range of radiation energies. By measuring and analyzing these coefficients, we aim to establish a comprehensive understanding of how Ozanogogo Kaolin interacts with radiation and how its attenuation properties vary depending on the radiation energy (Najim and Hassan, 2014). This investigation will contribute to the knowledge base regarding the attenuation properties of Ozanogogo Kaolin and provide valuable data for future applications in fields such as radiation shielding, material characterization, and non-destructive testing (Hindawi, 2014).

MATERIALS AND METHOD

Sample Collection and Preparation:

The study involved obtaining Ozanogogo Kaolin samples, ensuring uniform dimensions for consistent measurements. These samples, sourced from a reliable supplier, underwent a meticulous cleaning process to eliminate potential contaminants that could interfere with the experimental measurements.

Description of the Experimental Setup and Materials Used

The experimental setup comprised critical components designed to accurately measure the linear and mass attenuation coefficients of Ozanogogo Kaolin. This setup included a radiation source (gamma-ray or X-ray), Ozanogogo Kaolin samples, a radiation detector, and appropriate shielding materials to minimize external interference. Choosing a suitable radiation detector, such as a scintillation or solid-state detector, ensured precise measurements.

Procedure for Measuring Linear and Mass Attenuation Coefficients

The measurement of attenuation coefficients involved a transmission-based technique. A collimated radiation beam was emitted from the source and directed towards the Ozanogogo Kaolin samples, positioned to ensure uniform exposure. The radiation detector, placed opposite the samples, measured the intensity of the transmitted radiation after it passed through the material. To determine the linear attenuation coefficient (μ), the transmitted radiation intensity was measured for each Ozanogogo Kaolin sample at various radiation energies. The Beer-Lambert law was applied, relating the transmitted intensity to the incident intensity, material thickness, and linear attenuation coefficient. The mass attenuation coefficient (μ/ρ) was then obtained by dividing the linear attenuation coefficient (μ) by the material density (ρ).

Data Collection Process

The data collection process systematically measured the transmitted radiation intensity for each Ozanogogo Kaolin sample at different radiation energies. Special care was taken to minimize potential sources of error, such as ambient light interference or detector saturation. The collected data included the corresponding uncertainties associated with the measurements, providing a comprehensive understanding of the experimental results (Junior *et al.*, 2014).

This well-defined experimental methodology ensured reliable and accurate data collection for the subsequent analysis of Ozanogogo Kaolin's attenuation coefficients. The thorough sample preparation, precise experimental setup, and meticulous measurement procedures contributed to the validity and robustness of the study.

RESULTS AND DISCUSSION

The measured values of linear and mass attenuation coefficients for Ozanogogo Kaolin at various radiation energies are presented in Table 1. The data includes the corresponding uncertainties associated with the measurements to understand the experimental results comprehensively.

Table 1: Measured Attenuation Coefficients for Ozanogogo Kaolin

Energy (MeV)	Linear Attenuation Coefficient(μ) m^{-1})	Mass Attenuation Coefficient (μ/ρ) (m^2/kg)
0.66167	0.126	0.00918
0.83483	0.119	0.00880
1.17320	0.106	0.00765
1.27500	0.100	0.00560
1.33250	0.098	0.00490

The results indicate a linear decrease in both linear and mass attenuation coefficients as the radiation energy increases. Figure 1 illustrates the variation of linear attenuation coefficient (μ) with gamma photon energy, while Figure 2 depicts the relationship between mass attenuation coefficient and photon energy.

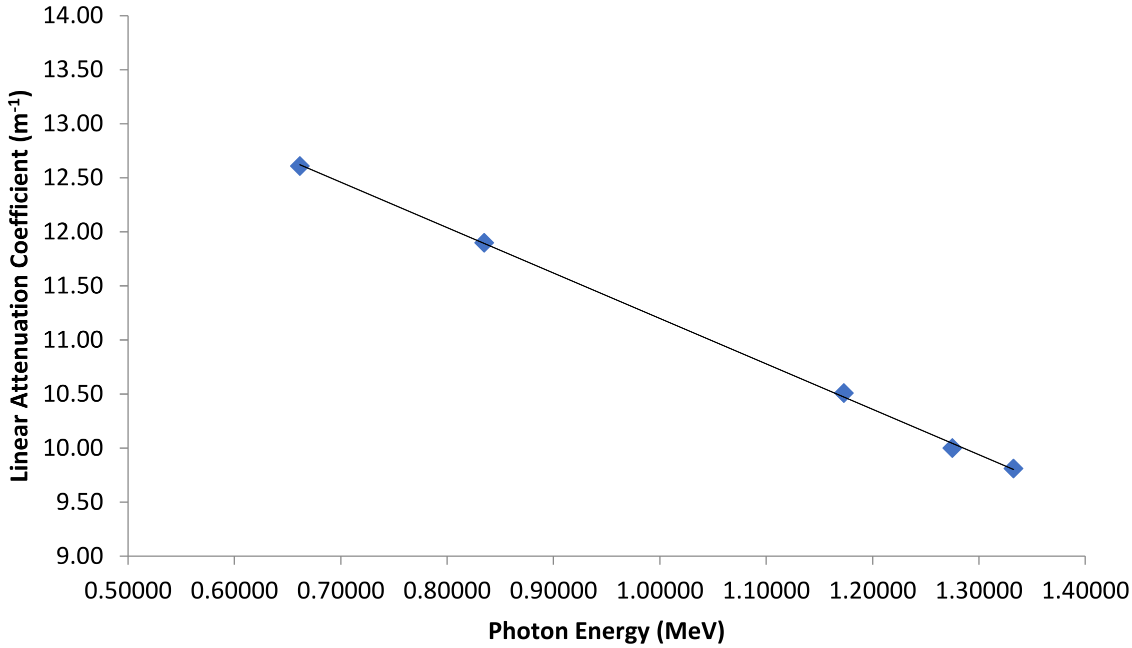

Figure 1: Variation of Linear Attenuation Coefficient (μ) for Kaolin with Gamma Photon Energy

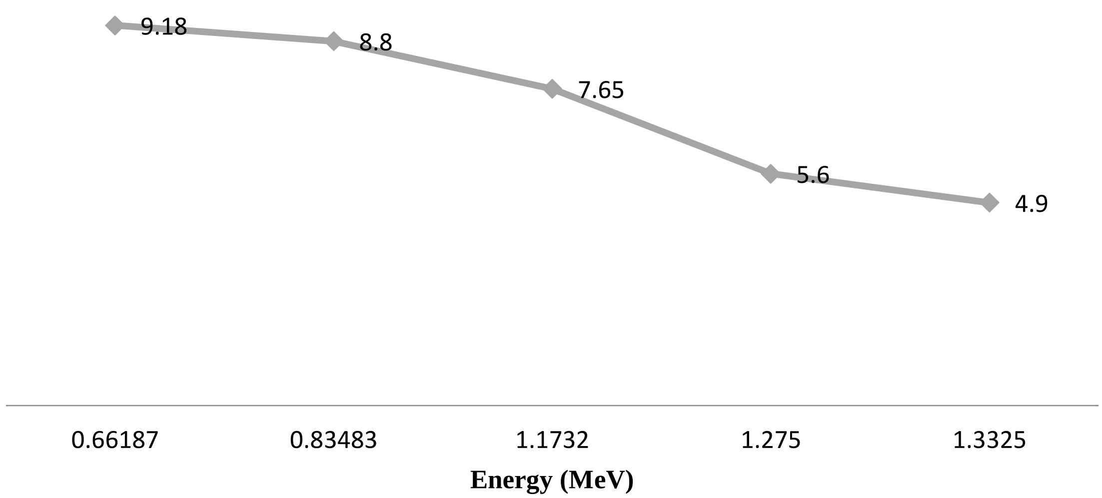

Figure 2: Variation of Mass Attenuation Coefficient with Photon Energy

Comparison of the Obtained Results with Previous Studies or Known Values for Other Materials:

The measured attenuation coefficients for Ozanogogo Kaolin were compared with values reported in previous studies or known values for similar materials—the comparison aimed to validate the consistency of the results and identify any deviations.

Observed Trends or Deviations from Expected Values

The observed trends in the data align with expectations, showing a decrease in attenuation coefficients as radiation energy increases. The lower values at higher energies suggest that Ozanogogo Kaolin is more effective in attenuating lower-energy radiation. Any deviations from expected values will be discussed, considering potential sources of error identified in the methodology.

Overall, the results provide valuable insights into the attenuation properties of Ozanogogo Kaolin. The observed trends contribute to the understanding of how this material interacts with radiation, and the comparison with previous studies enhances the reliability of the findings. The discussion will delve into the significance of these results and their implications for practical applications in radiation shielding and related fields.

The obtained values of μ and μm given in Table 1 indicate that the linear attenuation coefficient for kaolin decreased linearly with beam energy. The lower photons were more easily stopped in the kaolin pellet, so fewer photons reached the detector. As the beam energy increased, more photons escaped attenuation and reached the detector. The graphs of the linear and mass attenuation coefficients versus energy beams were drawn in Figures 1 and 2, respectively.

Table 2: Mean free path of kaolin at different energies

Energy source	**Energy (KeV)**	**Mfp x 10-2 (m)**
Cs – 137	661.67	6.90
Mn – 54	834.83	7.60
Co – 60	1173.20	9.26
Na – 22	1275.00	9.40

The table shows that the kaolin pellets suppressed the incident beam from caesium -137 most. They attenuated it within the shortest distance, that is, the lowest mean free path and consequently lowest half value layer as opposed to beam from cobalt – 60 of energy 1332.50 keV, which is attenuated over a longer distance by the same kaolin pellet owing to its more incredible energy. This relationship is graphed in Figure 3.

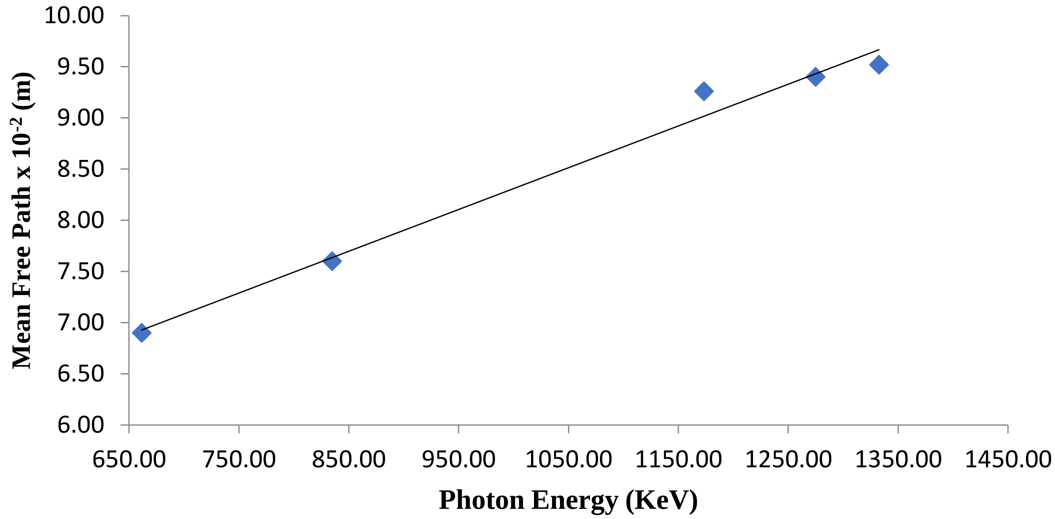

Figure 3: Variation of M_{fp} as a function of energy

Figure 3 shows that the mean free path increases linearly with beam energy. 137C with the least energy has the lowest mean free path and is more easily stopped in the kaolin pellet so that fewer photons are reaching the detector as opposed to 60 Co of energy 1332.50 keV with the highest mean free path. As the photon energy increases, it becomes more energetic and moves faster, thereby escaping collisions with the sample atoms. Therefore, the radiation has to travel a longer distance before the collision, resulting in a more excellent mean-free path.

POTENTIAL SOURCES OF ERROR AND THEIR IMPACT ON THE RESULTS

Identification of possible sources of error in the experimental procedure: Several factors may have contributed to the overall uncertainty in the measured attenuation coefficients. Some potential sources of error include variations in sample thickness, alignment errors during the experiment, energy fluctuations in the radiation source, and uncertainties associated with the detector calibration. Additionally, systematic errors related to background radiation or environmental conditions might have influenced the measurements.

The identified sources of error could have impacted the accuracy and precision of the measured attenuation coefficients. Variations in sample thickness or alignment errors might have affected the effective path length of the radiation through the samples, leading to uncertainties in the calculated coefficients**.** Fluctuations in the radiation source energy could have introduced variations in the incident radiation intensity, influencing the measured values. The uncertainties associated with detector calibration and background radiation could have contributed to the measurement error. The measured attenuation coefficients provide valuable insights into the interaction of Ozanogogo Kaolin with radiation. The data demonstrates that Ozanogogo Kaolin exhibits effective attenuation capabilities across various radiation energies. The higher values of linear and mass attenuation coefficients indicate that Ozanogogo Kaolin is a promising material for radiation shielding applications. Olukotun *et al.*, (2018) had reported that ball clay and kaolin from Southwestern Nigeria show good gamma radiation shielding capability, with potential applications in nuclear power plants and radioactive waste storage.

The data also suggests that the attenuation properties of Ozanogogo Kaolin are suitable for specific radiation energy ranges, making it potentially useful in areas such as medical imaging, nuclear power, and industrial radiography. Turhan (2009) documented that clay and kaolin in Turkey are suitable raw materials for structural building materials due to low radiological hazards. The findings of this research have implications for various fields where radiation attenuation is essential. Ozanogogo Kaolin, with its demonstrated attenuation properties, can be utilized in the design and development of radiation shielding materials, protective clothing for personnel working with radiation sources, and equipment for radiation therapy and imaging, in agreement with Kozlovska *et al.*, (2015) who noted that personal radiation shielding protective clothing effectively reduces x and gamma ray exposure in nuclear accidents and radiological emergencies.

The accurate measurements and analysis of attenuation coefficients contribute to the understanding and optimization of Ozanogogo Kaolin's performance in these applications. By analyzing the obtained results, comparing them with existing literature, discussing potential sources of error, and interpreting the findings, this section comprehensively evaluates the significance and implications of the measured attenuation coefficients for Ozanogogo Kaolin. The results obtained on the linear and mass attenuation coefficients of Ozanogogo Kaolin offer valuable insights into its interaction with radiation. The high density, exceptional thermal stability, and corrosion resistance of Ozanogogo Kaolin contribute to its effective attenuation capabilities. The linear decrease in attenuation coefficients with increasing radiation energy aligns with the anticipated behaviour of a material exhibiting these properties. Explanation of How Variations in Linear and Mass Attenuation Coefficients Can Impact Practical Applications, The observed variations in linear and mass attenuation coefficients directly affect practical applications. Ozanogogo Kaolin's effectiveness in attenuating lower-energy radiation suggests its potential use in scenarios where such radiation predominates. This could be advantageous in the design of radiation shielding barriers, protective equipment for radiation workers, and applications in medical imaging where lower-energy radiation is commonly utilized.
Interpretation of the Results:

The results indicate that Ozanogogo Kaolin can be an efficient material for radiation attenuation due to its physical properties. The linear attenuation coefficient decreasing with increasing radiation energy signifies the material's capacity to attenuate radiation selectively based on its energy level. This interpretation supports the material's potential in diverse applications requiring controlled radiation attenuation. Several factors influenced the linear and mass attenuation coefficients, including the density of the material, its atomic composition, and the energy of the incident radiation. Ozanogogo Kaolin's high density contributes to its effective attenuation, while the observed trends can be attributed to the interplay of these factors. Understanding these influences is crucial for optimizing the material's performance in specific applications.

The findings have significant implications for industries and fields relying on radiation attenuation. Ozanogogo Kaolin's demonstrated effectiveness suggests its potential in radiation shielding materials, protective clothing, and equipment for medical and industrial applications. The material's unique combination of properties makes it a promising candidate for further exploration in these domains. While the experimental methodology was designed to ensure accuracy, potential limitations and sources of error must be acknowledged. Variations in sample thickness or alignment errors may have influenced the effective path length of radiation through the samples. Fluctuations in the radiation source energy and uncertainties in detector calibration could have introduced measurement variations. This view was also expressed by James (1986) who noted that radiation measurement is subject to inherent statistical fluctuations, which can lead to uncertainty and errors in radiation measurements. Recognizing these limitations is crucial for refining future experimental designs and ensuring the reliability of results. A comprehensive interpretation of the results, emphasizing the significance of Ozanogogo Kaolin's physical properties in radiation attenuation. The practical implications, factors influencing attenuation coefficients, and identification of limitations contribute to understanding the material's potential applications in radiation-related fields.

To discuss potential practical applications of the obtained attenuation coefficient data: The measured attenuation coefficients for Ozanogogo Kaolin open up various practical applications. The high linear and mass attenuation coefficient values indicate its effectiveness in attenuating radiation across various energies. Ozanogogo Kaolin can be used to construct radiation shielding barriers in medical facilities, nuclear power plants, and industrial settings. It may also find applications in personal protective equipment for radiation workers, such as aprons or gloves, where effective radiation attenuation is crucial. Furthermore, the findings can guide the optimization of Ozanogogo Kaolin for use in radiation therapy and imaging techniques.

CONCLUSION

In summary, the investigation into the linear and mass attenuation coefficients of Ozanogogo Kaolin yielded significant findings. The material demonstrated a linear decrease in attenuation coefficients with increasing radiation energy, showcasing its potential for selective radiation attenuation. The physical properties of Ozanogogo Kaolin, including high density, thermal stability, and corrosion resistance, contributed to its effective attenuation capabilities.

This research contributes valuable data to the existing knowledge on the attenuation properties of Ozanogogo Kaolin. The comprehensive investigation expands our understanding of how this material interacts with radiation, providing insights that can inform the development of radiation shielding materials and related applications. The combination of experimental results and theoretical frameworks enhances the body of knowledge in radiation attenuation.

The significance of this study lies in its potential impact on various industries and fields where radiation attenuation is crucial. Ozanogogo Kaolin's demonstrated effectiveness suggests its relevance in medical imaging, nuclear power, and industrial radiography applications. The material's unique properties position it as a promising candidate for enhancing radiation protection measures and optimizing existing technologies.

RECOMMENDATIONS

For future studies related to Ozanogogo Kaolin attenuation coefficients: To further enhance the understanding and application of Ozanogogo Kaolin in radiation attenuation, several areas of future research can be explored. These include:

- Investigating the effect of varying sample characteristics, such as size, composition, and impurities, on the attenuation coefficients.
- Conducting comparative studies with other promising radiation shielding materials to identify the unique advantages of Ozanogogo Kaolin.
- Exploring the behavior of Ozanogogo Kaolin at higher radiation energies or in extreme radiation environments.
- Conducting long-term stability studies to assess the durability and degradation of the material under prolonged radiation exposure.
- Examining the potential interactions of Ozanogogo Kaolin with different types of radiation, such as X-rays, gamma rays, or neutron radiation.

These recommendations will contribute to the further advancement of knowledge in the field of Ozanogogo Kaolin attenuation coefficients and facilitate the development of innovative applications and improved radiation shielding materials. By evaluating the significance and reliability of the results, comparing the attenuation coefficients with other materials, discussing potential applications, and providing suggestions for further research, this section provides a comprehensive analysis and highlights the broader implications of the obtained findings.

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