Vol. 03, Iss. 4 (2025) 418-429, DOI: 10.61552/JME.2025.04.006

JME

Journal of Materials and Engineering

www.jme.aspur.rs

Research article

Characterizations of Some Selected Clay Types for Cost Effective Wastewater Treatments

Suresh Aluvihara[a,*], C.S. Kalpage[a], Bhupendra Singh Chauhan[b]

[a]*Department of Chemical and Process Engineering, Faculty of Engineering, University of Peradeniya, Peradeniya, 20400, Sri Lanka,*
[b]*Department of Mechanical Engineering, GLA University, Mathura, Uttar Pradesh, 281406, India.*

Keywords:

Water pollution
Water treatment
Clay
Adsorption
Absorption
Filtration

* Corresponding author:

Suresh Aluvihara
E-mail: sureshaluvihare24@gmail.com

Received: 14 September 2024
Revised: 17 October 2024
Accepted: 26 November 2024

A B S T R A C T

Water pollution is a significant issue affecting water consumption, including drinking. Factors contributing to water pollution include industrial waste, improper garbage disposal, waste accumulation, and natural phenomena. Water treatment is essential for managing water and maintaining environmental standards. Physical, chemical, and biological methods are used, but chemical reagents and complex systems are common. Recent research has focused on cost-effective earth materials, offering advantages such as affordability, ease of use, health benefits, and abundance. This study analyzed the characteristics of selected natural materials for wastewater treatment, specifically through processes like adsorption, absorption, and filtration. Several earth materials abundant in Sri Lanka, including three different types of clays were chosen for evaluation. The research revealed that all clays contain over 75% iron as major clay minerals, with some exhibiting finer particles for increased porosity and permeability. These raw materials can be used to manufacture wastewater treatment systems for the removal of suspended and dissolved solids, heavy metals, pathogens, oils, and toxic compounds. Their unique chemical compositions make them suitable for catalytic and advanced chemical purposes.

1. INTRODUCTION

Environmental pollution has been acknowledged as a controversial consequence of human activities and certain natural events. When analyzing pollution in various regions, water pollution has surfaced as a primary concern among other forms of pollution due to the crucial role water plays in the existence of humans, animals, plants, and the overall equilibrium of ecosystems. Water contamination often precedes water pollution. Pollution is deemed to occur when contamination reaches excessive levels. The release of harmful or toxic substances into the environment is known as pollution.

Safeguarding water quality and addressing water pollution should be considered a crucial issue, particularly given that water is globally recognized as a finite resource, especially when considering the portion suitable for consumption. Numerous regulations and frameworks have been implemented worldwide to regulate water quality, taking into consideration specific conditions and risks.

Hence, the preservation and treatment of water have become crucial in various sectors such as industries, households, and for individuals. Chemical and biological treatment methods come with some drawbacks, including potential adverse health effects from improper use of chemicals and sludge generation in biological processes. Physical and biological treatment methods may incur higher costs for installation and operation, as well as the requirement of technical expertise, hence primarily being suitable for industrial or large-scale wastewater treatment [1-6]. The major setback of these methods is the challenge of adapting them for small-scale or domestic use. Modern scientific and technological research has explored diverse solutions for treating contaminated water, incorporating advanced techniques on a smaller scale utilizing various materials.

The utilization of earth materials and natural resources in wastewater treatment has gained prominence in the water treatment industry due to multiple benefits, especially when used in a small-scale setting by different operators. The objective of a recent study was to develop a wastewater treatment system using natural substances such as clays. A scientific examination of chemical and physical processes will emphasize the phenomenon of adsorption, which occurs on the surfaces of certain solid materials when molecules adhere from liquid or gaseous compounds [2,7-12].

The adsorption process involves two key components: the adsorbate and the adsorbent. Adsorption can occur through physical or chemical means due to specific electrostatic and Van der Waal's forces between the adsorbent and adsorbates. Filtration involves the removal of suspended substances from a liquid using a filter medium under specific conditions. Gravity can serve as a driving force in vertically installed systems [13-21]. Filtration efficiency depends on the conditions and objectives, making it a suitable method for eliminating suspended particles. Absorption introduces a component or substance into another substance, either chemically or physically. Clay, soil type containing hydrated aluminum silicates and other compounds, has shown effectiveness as an adsorbent for heavy metals due to its properties.

2. MATERIALS AND METHODOLOGY

The selection of earth materials for the proposed wastewater treatment system was based on consideration of the scope and limitations of prior research. Preference was given to using locally sourced materials for this purpose.

- Three different clay types

The first phase of the ongoing inquiry entails the collection of materials from the ground. Precise measures were implemented to ensure the reliability and accuracy of the test results during the acquisition of essential materials from specific locations.

- Using of well cleaned plastic tools
- Using of well cleaned/ new polythene bags in the storing of samples
- Preventions of the exposing to the sunlight or some hazardous environments

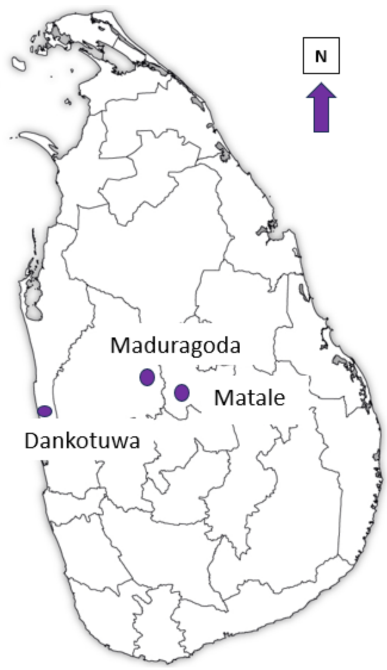

Fig.1. Clay sample collected locations in Sri Lanka.

Table 1. A brief description of the selected clayvarieties

Clay Type	Clay 1	Clay 2	Clay 3
Name	Anthill clay	Brick clay	Roof tile clay
Location	Matale region, Sri Lanka	Maduragodaregion, Sri Lanka	Dankotuwaregion, Sri Lanka
GPS Coordinates of the Location	7.506588/80.613704	7.5715481/ 80.5527214	Procured by a Factory
Current Application	--	Brick production	Roof tile manufacturing

In generally the following characteristics of three different clays were analyzed [2,5-9,12- 14,18,21].

Table 2. A brief summary of the characterizations of clay materials.

Parameter	Methodology	Analytical Instruments/ Apparatus
Moisture Content	Difference between the dry weight and wetted weight of a clay mass	Oven, Analytical Balance
Dry Sive Analysis	Separation of a dry clay mass into their particle sizes	Sieve Shaker, Set of Sieves (from 2mm to 0.075mm), Analytical Balance
Bulk Density	Dry weight of a known volume of clay	Mould of10cm*6cm*1.5cm), Oven, Analytical Balance
Apparent Porosity	Water absorption by a known volume of clay/ fired clay	Mouldof (10cm*6cm*1.5cm), Oven, Analytical Balance, Muffle Furnace
Mineralogical Analysis	Analysis of dry powdered clay samples (< 0.075mm)	X-ray Diffraction (XRD) Spectrophotometer
Functional Groups and Chemical Structure	Analysis of dry powdered clay samples (< 0.075mm)	Fourier Transforms Infrared (FT-IR) Spectrophotometer
Elemental Chemical Composition	Analysis of dry powdered clay samples (< 0.075mm)	X-ray Fluorescence (XRD) Spectrophotometer
Surface Characteristics	Analysis of dry powdered clay samples (< 0.075mm)	Optical Microscope
Advanced Surface Characteristics	Analysis of dry powdered clay samples (< 0.075mm)	Scanning Electron Microscope (SEM)

In these trials, the coning and quartering technique was used to choose a sample that accurately represents the data when moving the instruments.

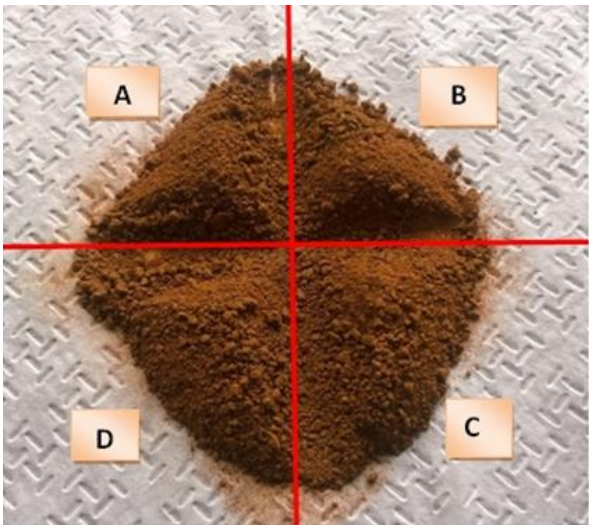

Fig. 2. Coning and quartering method

The coning and quartering method requires the representative sample to be made up of either quarter A and quarter C, or quarter B and quarter D, as per the given definitions and limitations.

3. RESULTS AND DISCUSSION

3.1 Dry Sieve Analysis of Clays

Dry sieve analysis is a recommended method for determining particle size in different soil types, especially those with larger particles like sand and gravel. Even though it is commonly used for soils with coarse particles, the dry sieve analysis technique was tested on three types of clay as well. Along with dry sieve analysis, which is suited for coarse particle soils, the wet sieve analysis method, generally used for finer materials, was also used simultaneously for the clays.

The particle size distribution curve, also referred to as the gradation curve, is a graphical representation illustrating the distribution of varying particle sizes within a specific soil type. This curve is constructed using a logarithmic scale for particle diameter on the x-axis and an arithmetic scale for the corresponding percentage finer on the y-axis.

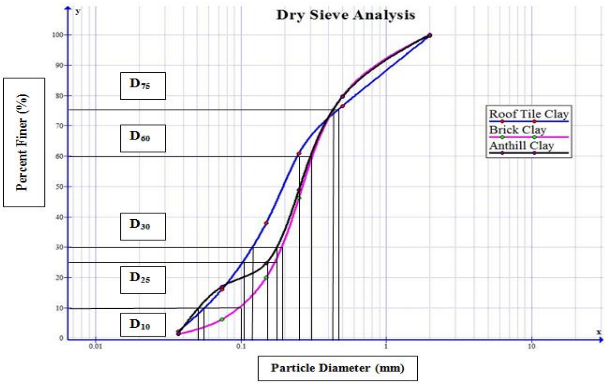

Fig. 3. Particle size distribution curves of clays.

The particle size distribution curve, also referred to as the gradation curve, is a graphical representation illustrating the distribution of varying particle sizes within a specific soil type. This curve is constructed using a logarithmic scale for particle diameter on the x-axis and an arithmetic scale for the corresponding percentage finer on the y-axis.

Upon scrutiny of the shape of the particle size distribution curve, one can often infer the gradation and particle arrangement of the soil. Furthermore, significant numerical data can be extracted from the curve. Advanced coefficients can also be computed based on these data, enabling a comprehensive analysis of the soil's engineering properties such as porosity, permeability, and hardness. The distinct concave curve of the particle size distribution curve for roof tile clay indicates a well-graded mass of clay [7,11,17].

This particular type of roof tile clay displays specific characteristics, including the presence of particles of all sizes within the measured size ranges, lower porosity, lower permeability, and a relatively higher proportion of finer particles. Upon examination of the particle size distribution chart of anthill clay, a discontinuity in the middle of the curve was observed.

This abnormal finding indicates a gap-graded arrangement of particles in the clay or soil. The presence of specific size ranges with an absence of particles is a unique trait of this soil type.

Table 3. Important readings recorded from the particle size distribution curves of clays

Type of Clay	D_{10}(mm)	D_{25} (mm)	D_{30} (mm)	D_{60}(mm)	D_{75} (mm)
Anthill Clay	0.051	0.146	0.175	0.295	0.425
Brick Clay	0.096	0.170	0.192	0.310	0.433
Roof Tile Clay	0.055	0.103	0.119	0.245	0.470

Table 4. Important coefficients regarding the particle sizes of clays

Type of Clay	Effective Size/ D_{10} (mm)	Uniformity Coefficient /C_u	Coefficient of Gradation/C_c	Sorting Coefficient/ S_0	Skewness/ S_K
Anthill Clay	0.051	5.78	2.04	1.71	0.248
Brick Clay	0.096	3.23	1.24	1.60	0.273
Roof Tile Clay	0.055	4.45	1.05	2.12	0.255

Based on the findings mentioned above, it is possible to make significant inferences about the composition and unique physical and chemical properties of these clays. The effective size (D_{10}) plays a crucial role in determining a soil type's physical characteristics like permeability and hydraulic conductivity [7,11].

Typically, there exists a correlation between the effective size (D_{10}) and a soil's permeability. When comparing the effective sizes (D_{10}) of three distinct clay types, it was observed that brick clay had the highest value, while anthill clay had the lowest value. Accordingly, the hydraulic conductivity/permeability of brick clay is expected to be higher than that of other types of clay [17]. Nevertheless, the hydraulic conductivity/permeability of a particular soil/clay is not solely determined by its effective size (D_{10}).

Concerning the uniformity coefficients of three types of clay, it was discovered that brick clay exhibits poor grading as its uniformity coefficient is less than 4 (C_u<4), when compared to the C_u values of other clays. Any clay or soil with a C_u value significantly deviating from 4 would be considered even more poorly graded [6,7,17].

The well-graded roof tile clay showed a closer approximation to a coefficient of gradation (C_c) value of 1, indicating a more balanced distribution of particle sizes. Conversely, the coefficient of gradation (C_c) of anthill clay deviated unexpectedly from 1, as it did not exhibit a well-balanced distribution of particle sizes like the moderately proximate poorly graded brick clay.

When examining the clay used for roof tiles, a higher sorting coefficient (S_0) was noted, whereas the brick clay showed a lower sorting coefficient (S_0). These findings reinforce the notion that the roof tile clay is well graded, while the brick clay is poorly or uniformly graded. This measurement is of great importance when assessing the sorting and grading of soils for geological and engineering purposes. Average grain size is an optional measurement with respect to the particle size distribution of some soil/ clay even through it can be used as a representative value when comparing the particle size distribution of a series of clays/ soils with each other because it is similar to the mean value of the sizes of different particles of some particulate clay/soil. According to the existing analysis, the brick clay particles are relatively larger than the particles of other clay types [6,7,11].

All of the clay types in question are classified as fine skewed clays or soils, based on their skewness values, which fall within the range of 0.30-0.10 and have a positive sign. When comparing the deviation of skewness values from 0.00, it was determined that the anthill clay exhibited a more symmetrical particle size distribution.

In terms of the overall outlook for three distinct types of clays, it can be deduced that the grains from roof tile clays demonstrate good grading and sorting, whereas the particles from brick clays exhibit poor grading. Additionally, anthill clay displays irregular fluctuations in its important parameters. Based on the grain sizes and sorting, brick clay appears to be more suitable for water treatment purposes due to its lower permeability and hydraulic conductivity [3,6,7,11,17].

The apparent porosities and bulk densities of bricks prepared from three different clay types are interpreted in the Table 5.

Table 5. Apparent porosities and bulk densities of bricks.

Clay Type of the Brick	Apparent Porosity (%)	Bulk Density (g/cm^3)
Anthill Clay	65.28	2.62
Brick Clay	62.70	3.15
Roof Tile Clay	34.59	2.00

Based on the aforementioned findings, bricks made with anthill clay exhibited the highest apparent porosity, while roof tile clay bricks had the lowest value. The porosity reflects the empty spaces between the clay particles, and a higher porosity is beneficial for wastewater treatment applications as it provides a larger surface area for better adsorption capacity and higher water absorption capacity. Consequently, the anthill clay type is the most suitable for wastewater treatment applications in terms of apparentporosity. Additionally, higher porosity implies weaker structural strength [3,4,8, 5,16].

Bulk density is a trait that measures the specific gravities of the particles making up a clay or material. The results indicate that brick clay has the highest bulk density, while roof tile clay has the lowest bulk density. Further examination of these findings suggests that brick clay contains a larger quantity of highly dense particles, whereas roof tile clay contains a significant amount of less dense particles.

3.2 Mineralogical Analysis of Clays

According to the X-ray diffraction (XRD) characterizations of three different clay types the XRD spectrums of three different types of clays were represented in the following graphs.

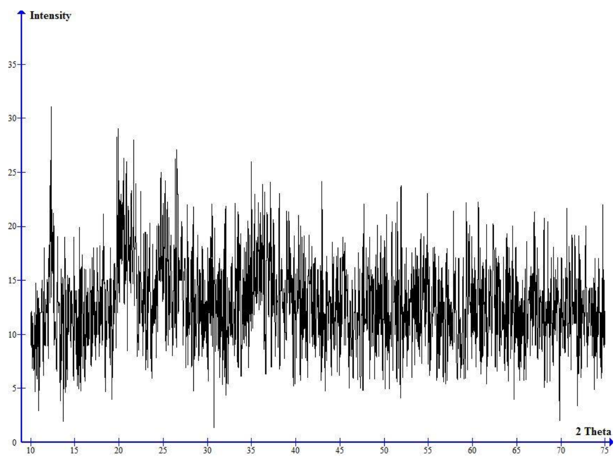

Fig. 4. XRD micrographs of anthill clay

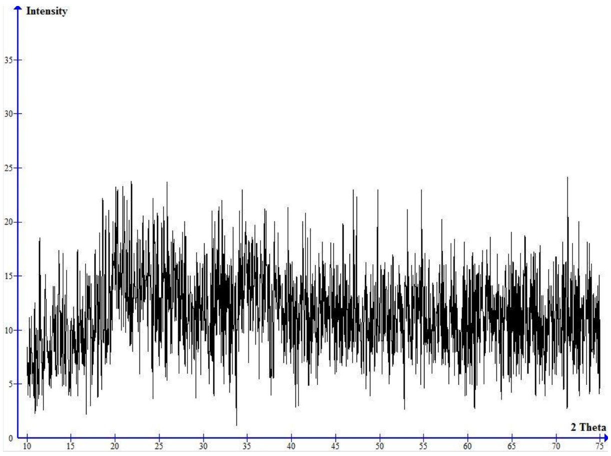

Fig. 5. XRD micrographs of brick clay

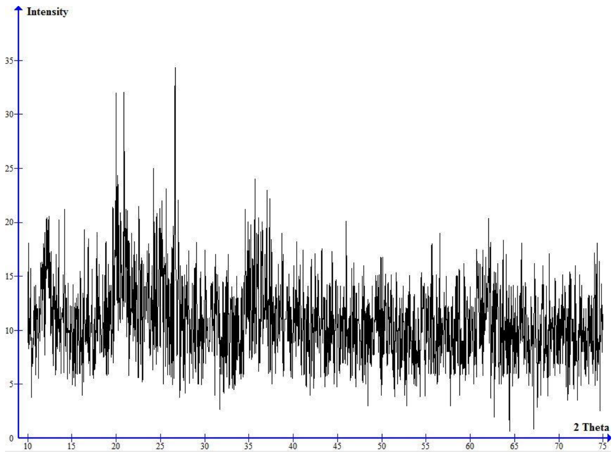

Fig. 6. XRD micrographs of roof tile clay

Table 6. Discussion on the X-ray diffraction (XRD) spectrum of anthill clay

Mineral	Chemical Formula	Observations for 2ϴ	Reference Values for 2ϴ
Kaolinite	$Al_2 (Si_2O_5) (OH)_4$	14^0, 20^0, 26^0, 45^0, 65^0	12^0, 25^0, 37^0
Muscovite	$KAl_2(Si_3Al)O_{10}(OH)_2$	20^0, 35^0, 55^0	9^0, 18^0, 27^0, 46^0
Quartz	SiO_2	21^0, 23^0, 32^0	21^0, 27^0, 36^0,39^0, 43^0, 50^0

Table 6 presents the findings and key insights drawn from the analysis of the X-ray diffraction spectra of three distinct types of clay [2,4,8,15-17].

The presence of kaolinite as a mineral in a smaller quantity was indicated by the lower intensity of the major peaks at 14^0, 20^0, 26^0, 45^0, and 65^0 observed in 2ϴ. Despite not being detected in the elemental chemical composition experiment, the significant element in the chemical formula of kaolinite, $Al_2(Si_2O_5)(OH)_4$, is aluminum (Al). Therefore, it is highly likely that the content of kaolinite in these three clay types would be comparatively lower due to the decreased intensity of the peaks.

In addition to kaolinite being a common clay mineral in three types of clay, muscovite is the second largest clay mineral found primarily in roof tile clay and anthill clay. However, muscovite could not be identified in brick clay based on the peaks for 2ϴ at 20^0, 35^0, and 55^0.

The presence of quartz (SiO_2) in trace amounts was indicated by small peaks observed at around 21^0, 23^0, and 32^0 in the spectrum pattern of other peaks. This suggests that these clay samples contain quartz as the intensities of the peaks are lower.

Therefore, these three clay types are valuable for wastewater treatment applications due to the presence of kaolinite, which has been recognized as a strong adsorbent for most pollutants found in wastewater. The literature review on kaolinite highlights its higher specific surface area, monolayer structure, and ion exchanging capacity as key characteristics related to its adsorption capacity. Additionally, the adsorption capacities of clays vary depending on the content of kaolinite and other clay minerals such as glauconite and montmorillonite, which are also recognized as prominent adsorbents.

3.3 Elemental Chemical Characterizations of Clays

According to the X-ray fluorescence (XRF) analysis of earth materials, the obtained results have been listed in the Table 7.

Table 7. Elemental chemical compositions of earth materials.

Earth Material	Fe (%)	Ti (%)	Ba (%)	K (%)	Zr (%)	Ca (%)
Anthill Clay	82.08	4.84	0.79	12.28	-	-
Brick Clay	84.38	5.92	2.14	-	-	7.56
Roof Tile Clay	75.72	2.95	5.30	12.67	3.36	-

Based on the aforementioned findings, the predominant element in the anthill clay was Fe, accompanied by small amounts of trace metallic elements such as Ti, Ba, and K. In contrast to other known types of clay, the significant metallic component Al was absent in anthill clay. In addition, upon careful examination, no toxic elements such as heavy metals or radioactive substances were detected in the anthill clay. Fe is not considered toxic or hazardous, and Fe minerals have been found to effectively absorb other metals, particularly heavy metals, in research on water treatment. Therefore, the mineralogy of Fe in clay is an important factor in understanding its industrial applications, including water treatment and materials recovery. K is an alkaline element that plays a crucial role in regulating the alkalinity of clay [15-17].

Although Ba^{2+} is known to be toxic in aqueous solutions, Ba itself is not considered toxic. It is important to study the behaviour of Ba/Ba^{2+} ions in aqueous solutions during relevant application processes. In most solid earth materials, metallic elements are commonly found in the form of oxides due to their reaction with water or moisture [2,4,5,11,12,15,16].

The results above indicated that most of the brick clay contains a significant amount of iron, along with small quantities of titanium, calcium, and barium. The conditions and explanations concerning the presence of iron and barium would be comparable to those of anthill clay.

Ca was identified as a distinct element in the samples of brick clay. Extensive research has confirmed that the compound CaO is an effective refractory material, capable of withstanding high heat. Consequently, the brick clay has potential as a refractory material for various heat transfer processes, either as is or with further refinement.

In addition to this, Ca^{2+} serves as a frequently exchanged cation for certain other unwanted cations, making it valuable in the ion exchange process. Ion exchange is a crucial chemical method for treating wastewater by eliminating unwanted ions and substituting them with preferred ions. Hence, brick clay can potentially be suggested as a material for ion exchange [2,5, 15-17].

Based on the elemental make-up of clays used for roof tiles, Fe was found to be the primary metal present, along with small amounts of Ti, Ba, Zr, and K. This suggests that the clay used for roof tiles could be useful in advanced water treatment methods that rely on Fe minerals. No toxic elements such as heavy metals or radioactive elements were found in any of the three different types of clay tested.

3.4 Chemical Structural Analysis of Clays

According to the Fourier transforms infrared spectroscopic (FT-IR) analysis of clays, the FT-IR spectrums of three different types of clays are shown in the following figures/ graphs.

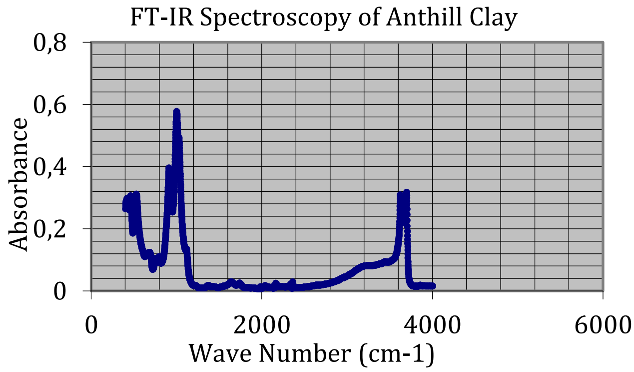

Fig. 2. FT-IR spectroscopy of anthill clay

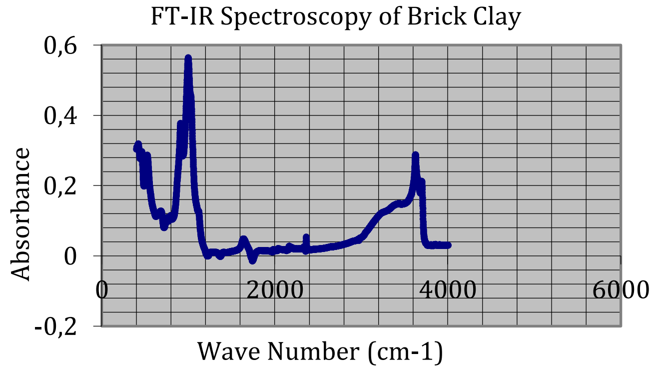

Fig. 8. FT-IR spectroscopy of brick clay

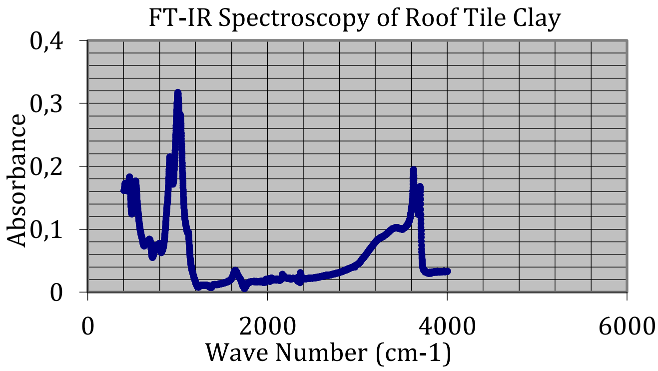

Fig. 3. FT-IR spectroscopy of roof tile clay.

According to three FT-IR spectrums, the general observations and conclusions have been given in the Table 8 [4,15-19].

Table 8. Observations and conclusions of the FT- IR analysis.

Wave number (cm^{-1})/Reference	Wave number (cm^{-1}) / Obtained	Functional groups/ Minerals
3698	~3700	O-H stretching
3698, 3652,1095, 908, 689, 528	~3700, ~3650, ~1100, ~900, ~700, ~550	Kaolinite $Al_2(Si_2O_5)(OH)_4$
1075, 790, 452	~1100, ~800, ~450	Quartz SiO_2
1001	~1000	Muscovite $KAl_2(AlSi_3O_{10})(OH)_2$
1006	~1000	Glauconite $(K,Na)(Mg,Fe)(Fe,Al)(Si,Al)_4O_{10}(OH)_2$
407, 396	~ 400	Marcasite FeS_2

After analyzing the FT-IR analysis of clay used for roof tiles, it is evident that both quartz and kaolinite are present. In addition to these findings, it is also plausible that minerals such as glauconite, muscovite, and marcasite are present, either individually or as composite materials. As a result, these particular clays are suitable for various industrial purposes.

- Sorption material – glauconite and marcasite.
- Adsorber in waste water treatments– kaolinite is a strong adsorber for metals including heavy metals.
- Electrical applications – muscovite (mica)
- The raw material for ceramic industry – kaolinite.

In addition, a detailed examination was conducted on the types of quartz found in the clay used for making roof tiles, as these quartz formations might contain other minerals like tridymite and cristobalite. Depending on the specific structure of the quartz, its potential industrial uses can vary[4,15-18].

3.5 Optical Microscopic Analysis of Clays

According to the obtained results for the optical microscopic analysis of three different types of clays, mainly the following specific summary can be concluded.

- A significant portion of finer soil/ clay particles were found from both anthill clay and roof tile clay
- Less amount of impurities were found from three different clay samples
- Different particle shapes were identified from the clays including regular shaped particles, irregular shaped particles and some specific crystal shapes such as hexagonal crystals
- The overall color of those clay particles was identified in the range of brown to reddish brown which are known as the typical colors for clayey minerals
- Trace amounts of other non-clayey minerals were identified because of the transparent and translucent surfaces which are typical characteristics for either quartz or calcite

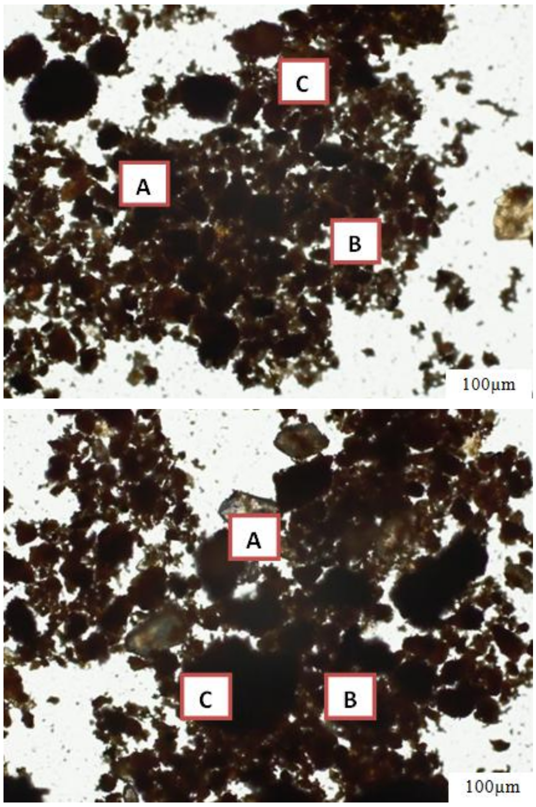

Fig. 10. Optical micrographs of anthill clay

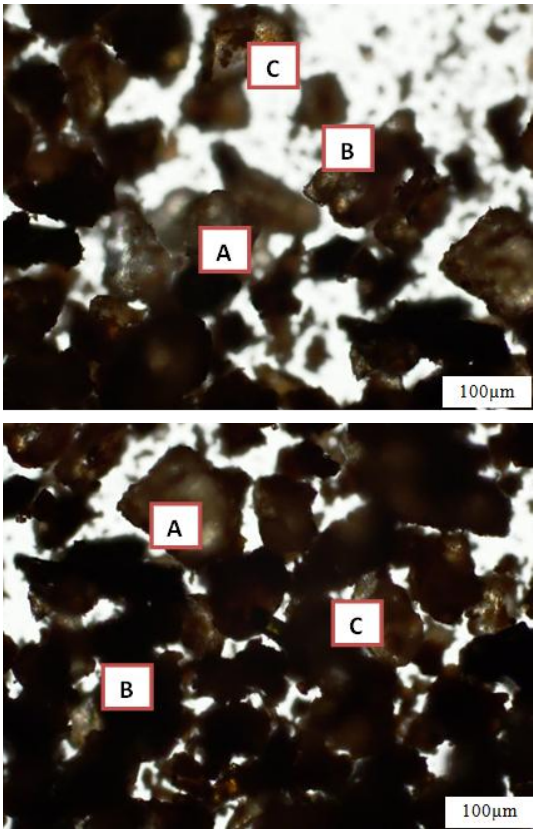

Fig. 11. Optical micrographs of brick clay

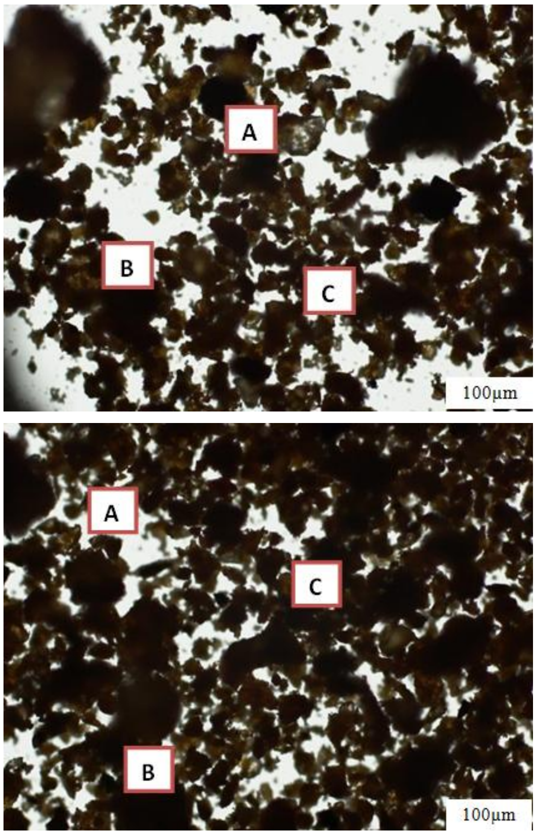

Fig. 12. Optical micrographs of roof tile clay

Table 9. The observations of optical micrographs of roof tile clay and description (Ralph, et al., 1952)

Letter/ Mark	Mineral/ Compound	Description
A	Quartz/ Sand	Transparent and translucent surfaces, white color and colorless particles in large and small sizes
B	Clay Minerals	Opaque surfaces, brownish white to reddish brown color particles
C	Clay Minerals	Relatively higher amount of finer particles such as clay, silt and ultrafine clay

Based on the microscopic analysis of three different types of clays, it is concluded that there is the presence of various clay minerals such as kaolinite, montmorillonite (smectite), and mica (muscovite) based on the observations under the microscope. Therefore, these clay types can be utilized as raw materials for manufacturing ceramics, catalysts, pigments, and as adsorption materials for pollutants in water. Kaolinite, in particular, is effective in water treatment applications as it can remove heavy metals, dissolved particles, organic pollutants, and pathogens from wastewater [1,8,9,13,19,20, 21]. The efficiency of water treatment is greatly influenced by the filtration and absorption capacities of these clays. Hence, all three clay varieties can be beneficial in treating different types of wastewaters due to the presence of kaolinite (an adsorbent), variations in grain/particle size, particle morphology, and fewer impurities [3,4,17].

3.6 Scanning ElectronMicroscopic (SEM) Analysis of Clays

The SEM analysis of the anthill clay surfaces identified predominantly pseudo-hexagonal platelets and flaky platelets of kaolin, along with some other non-clay minerals like quartz with minimal impurities. Further examination of the anthill clay surfaces revealed irregularly shaped pore spaces that were relatively larger in size [2,4,12,13,17]. Based on the available literature, kaolinite is known to have strong adsorbent properties, which has been corroborated by numerous studies focused on wastewater treatment and air pollution control applications.

The SEM images of the clay used in bricks showed distinctive features of pseudo-hexagonal platelets and flaky platelets of kaolinite, as well as some non-clay minerals like quartz. The presence of kaolinite was found to be significant in this type of clay used in bricks. The presence of quartz and other minerals was also detected in these clay types. The analysis focused on the optical and surface characteristics of the clay, specifically mineralogy, which was identified as a qualitative examination. Previous and recent research has demonstrated the efficacy of clay, particularly kaolinite, in wastewater [2,8,11-13,17] treatment. The adsorption capacity of kaolinite and other clay minerals, as well as the filtration ability of clay particles, have shown positive results in removing heavy metals, ions, pathogens, particulate matter, and organic pollutants from wastewater.

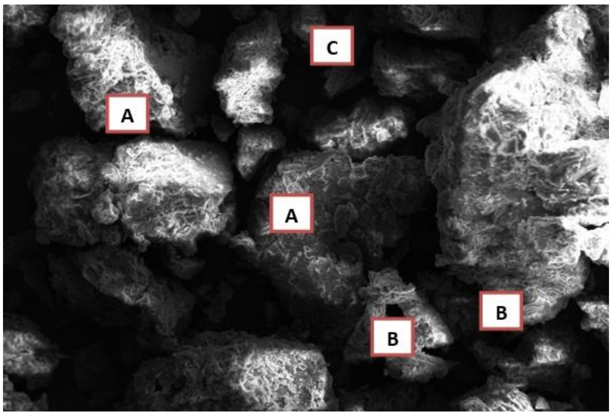

Fig. 14. SEM micrographs of brick clay

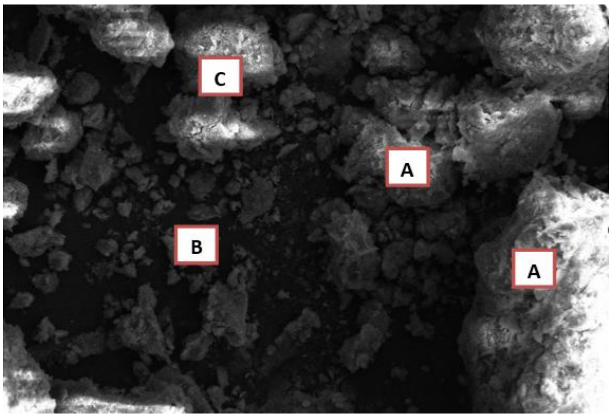

Fig. 13. SEM Micrographs of anthill clay

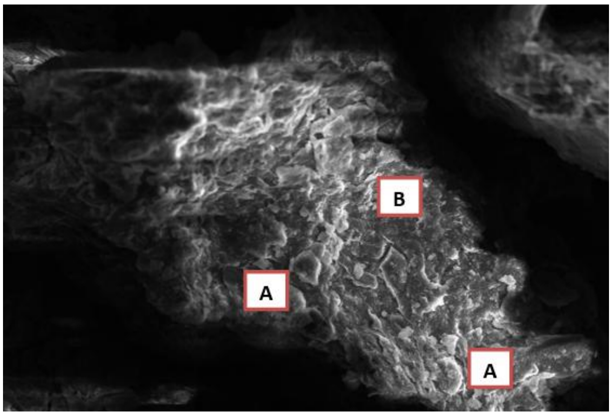

Fig. 15. SEM micrographs of roof tile clay

Table 10. The observations of SEM micrographs of clays and description (Ralph, et al., 1952)

Letter/ Mark	Mineral/ Compound	Description
A	Clay Minerals	Pseudo- hexagonal platelets of kaolinite
B	Clay Minerals	Flaky platelets of kaolinite
C	Other accessory minerals	Pores/ impurities/ quartz

Upon analyzing the clay mineralogy of the roof tile clay using SEM analysis, it was observed that there were higher amounts of clayey minerals present in smaller particle sizes compared to the SEM micrographs of other clay types. Further examination of the clay mineralogy revealed that kaolinite was the primary clayey mineral found in the roof tile clay, accompanied by some non-clayey minerals like quartz. The smaller grain sizes of the roof tile clay can be viewed as beneficial for applications related to adsorption, as the surface area plays a crucial role in determining the efficiency of adsorption capacity [12,15-17]. Moreover, the smaller particle sizes of these clays can serve as a sign of reduced porosity and enhanced structural integrity compared to other types of clays. In total, the combination of favorable clay mineralogy and lower impurity levels make these three types of clays beneficial for various wastewater treatment applications, specifically in adsorption, absorption, and filtration processes [17,19-21].

4. CONCLUSION

The current study revealed distinct properties of different earth materials such as various types of clays. It was discovered that anthill clay and roof tile clay both contain fine clay particles, making them suitable for filtration and absorption purposes with certain liquids. In addition, specific clay types like kaolinite, muscovite, and montmorillonite possess a combination of clayey and non-clayey mineralogy, enabling them to effectively adsorb heavy metals, pathogens, and organic matter present in solvents. For future research, it is recommended to further investigate the potential applications of these clay variations in adsorption, absorption, and filtration processes, including the creation of nanoparticles and composite materials. Furthermore, exploring the utilization of these earth materials in wastewater treatment for various types of wastewaters should be prioritized.

Acknowledgement

My sincere thank goes to the voluntary material providers, laboratory technical staff and the fellows those who supported for this research work both direct ways and indirect ways.

REFERENCES

[1] C. C. Nnaji, B. C. Afangideh, and C. Ezeh, "Performance evaluation of clay-sawdust composite filter for point-of-use water treatment," *Nigerian Journal of Technology*, vol. 35, no. 4, p. 949, 2016. doi: 10.4314/njt.v35i4.33.

[2] C. I. R. de Oliveira, M. C. G. Rocha, A. L. N. da Silva, and L. C. Bertolino, "Characterization of bentonite clays from Cubati, Paraíba (Northeast of Brazil)," *Ceramica*, vol. 62, no. 363, pp. 272–277, 2016. doi: 10.1590/036669132016623631970.

[3] C. Umoru, A. Shuaibu, A. Mahi, and M. U. Umar, "Geotechnical assessment of gully erosion at Ankpa Area, North Central Nigeria," *Journal of Applied Chemistry (IOSR-JAC)*, vol. 8, no. 12, pp. 36–48, 2015. doi: 10.9790/5736-081213648.

[4] D. O. Folorunso, P. Olubambi, and J. O. Borode, "Characterization and qualitative analysis of some Nigerian clay deposits for refractory applications," *IOSR Journal of Applied Chemistry*, vol. 7, no. 9, pp. 40–47, 2014.

[5] E. S. Nweke and E. I. Ugwu, "Analysis and characterization of clay soil in Abakaliki, Nigeria," *The Pacific Journal of Science and Technology*, vol. 8, no. 2, pp. 190–193, 2007.

[6] G. D. Manoj Pradhan, "Effect of fragment size, uniformity coefficient, and moisture content on compaction and shear strength behavior of coal mine overburden dump material," *European Journal of Advances in Engineering and Technology*, vol. 2, no. 12, pp. 1–10, 2015.

[7] H. E. Fadel et al., "Purification performance of filtration process for leachate in Morocco by marine sands, clays, and fly ash," *Journal of Biotechnology Letters*, vol. 4, no. 1, pp. 51–59, 2013.

[8] H. M. Abdel-Ghafar and B. E. El Anadouli, "Iron removal from groundwater using Egyptian cost-effective clay minerals," *Applied Chemical Engineering*, vol. 2, 2019. doi: 10.24294/ace.v2i1.470.

[9] I. Abdullahi Moyosore and S. Bello, "Purification of polluted water from Jibiadam, Nigeria using powdered Moringa oleifera seeds," *MAYFEB Journal of Chemistry and Chemical Engineering*, vol. 2, pp. 1–4, 2018.

[10] K. Murali, K. Sambath, and S. Mohammed Hashir, "A review on clay and its engineering significance," *International Journal of Scientific and Research Publications*, vol. 8, no. 2, pp. 8–11, 2018.

[11] J. Kipsanai, S. S. Namango, and A. M. Muumbo, "A study of selected Kenyan anthill clays for production of refractory materials," *International Journal of Scientific and Research Publications*, vol. 7, no. 9, pp. 169–179, 2017.

[12] O. Akaninyene and J. O. Akankpo, "Investigation of the physical properties of Uruan clay soil used for manufacturing of burnt bricks," *Advances in Physics Theories and Applications*, vol. 53, pp. 18–22, 2016.

[13] R. Svinka, V. Svinka, I. Pudze, and M. Damberga, "Clay ceramic pellets for water treatment," *Material Science and Applied Chemistry*, vol. 32, no. 1, 2015. doi: 10.1515/msac-2015-0007.

[14] R. E. Grim, "Petrographic study of clay materials," *Clays and Clay Technology Bulletin*, vol. 169, pp. 101–104, 1953.

[15] S. Aluvihara, C. S. Kalpage, and K. L. Lemle, "Elementary chemical analysis of different clay types," *Journal of Physics*, vol. 1781, 2021. doi: 10.1088/1742-6596/1781/1/012007.

[16] S. Aluvihara and C. S. Kalpage, "Characterization of Sri Lankan brick clays for more advanced industrial uses," *International Scientific Journal: Machines. Technologies. Materials*, vol. 14, no. 4, pp. 181–185, 2020.

[17] S. Aluvihara and C. S. Kalpage, "Particle size analysis of different clay types," *International Conference of Advance Research and Innovation (ICARI-2020)*, 2020, pp. 44–49.

[18] T. W. Parker, "A classification of kaolinites by infrared spectroscopy," *Clay Minerals*, vol. 8, no. 2, pp. 135–141, 1969. doi: 10.1180/claymin.1969.008.2.02.

[19] X. Shiqing Gu, L. Kang, E. Wang, and C. Lichtfouse, "Clay mineral adsorbents for heavy metal removal from wastewater: A review," *Environmental Chemistry Letters*, vol. 17, no. 2, pp. 629–654, 2019.

[20] Y. Chunguang and X. Han, "Adsorbent material used in water treatment: A review," *International Workshop on Materials Engineering and Computer Sciences*, pp. 290–293, 2015.

[21] Y. John, V. E. David, and D. Mmereki, "A comparative study on removal of hazardous anions from water by adsorption: A review," *International Journal of Chemical Engineering*, vol. 2018, pp. 1–21, 2019. doi: 10.1155/2018/3975948.