INVESTIGATIONS AND ANALYSIS OF EARTH MATERIALS TOWARDS THE DEVELOPMENTS IN SOME ADVANCED CHEMICAL AND CATALYTIC USES

SURESH ALUVIHARA[1]*, C.S. KALPAGE[1], P.W.S.K. BANDARANAYAKE[2], W.M.A.T. BANDARA[3], CIPRIAN CHELARU [4]

[1]*University of Peradeniya, Chemical and Process Engineering Department, Peradeniya, Sri Lanka, sureshaluvihare@gmail.com, +94758578194*

[2]*University of Peradeniya, Physics Department, Peradeniya, Sri Lanka*

[3]*University of Peradeniya, Chemistry Department, Peradeniya, Sri Lanka*

[4]*The National Research & Development for Textiles and Leather - Leather and Footwear Research Institute Division, Bucharest, Romania, cchelaru_cciprian@yahoo.com, +40722405053*

Earth materials are some sort of valuable resources with some multiples uses in some of industrial purposes and they are obtaining some economical values based upon the demand and the abundance. According to the most of research and experiments that relevant with the characteristics of solid earth materials, mainly there were obtained and disclosed some various outstanding physic-chemical characteristics of a large number of earth materials including the applications of material processing, nano-materials, composite materials and hard materials. In the existing research there were expected to characterize some selected clay varieties, a dolomite variety and a feldspar variety which are available in Sri Lanka towards the developments especially in some advanced chemical and catalytic applications. The X-ray fluorescence (XRF) spectroscopic analysis and Scanning electron microscopic (SEM) analysis were done for all of selected materials. The X-ray diffraction (XRD) analysis was done for three different selected clays and the Fourier transforms infrared (FT-IR) spectroscopic analysis was done for three different clay types and for a dolomite variety. According to the obtained results for the research, there were found the presence of at least 75% of Fe as the major element in each of clay with some other trace metallic elements such as K, Ti, Ca, Ba and Zr in such clays, kaolinite, montmorillonite and some of Fe minerals namely as muscovite and glauconite in such clays with quartz as a non-clayey mineral. There were found some higher amount of calcite in the selected dolomite with a trace amount of K and also there were found some higher K and Ca amounts presence in the selected feldspar rocks. When comparing the obtained results with past research out comes and modifications of materials, it seems that these materials will be much useful in the industrial applications such as the catalytic activities, waste water treatment applications in the removal of heavy metals due to the adsorption capacity, ion exchanging materials to remove unnecessary ions from waste water and in the removal of hardness from waste water due to the adsorption capacity of dolomite.

Keywords: earth materials, chemical analysis, chemical characteristics, essential applications

INTRODUCTION

Earth materials are natural resources in different phases such as gas, liquid and solid materials. Among all phases of earth materials, the solid earth materials are being considered under different categories such as the rocks, minerals, soil and organic materials. In the consideration of their physic-chemical and mechanical characteristics of such materials, there can be found some variations and applicability in various tasks even in their raw forms or they can be utilized for some advanced industrial applications in alteration. According to the categorizations of solid earth materials, soil types and mineral resources are considered as industrially demanded materials because of the variations in physic-chemical and mechanical characteristics of such earth resources which are focused on a vast range of industrial requirements and to solve a series of industrial problems (Ahmaruzzaman, 2011). When considering the important characteristics of most of solid earth materials, the variations in mineralogy, chemical contents, physical characteristics and mechanical strength of such materials are highlighted. In the short listing of the existing industrial applications of such earth materials, the following important applications and there can be found most of research works are being progressed that

https://doi.org/10.24264/icams-2022.I.3

associated with earth materials and their important characteristics for the sake of industrial applications as mentioned in Table 1 (Al-Anber, 2015).

Table 1. Earth resources/ materials and their applications

Earth Material	Applications/ Utilization
Clay, dolomite, feldspar	Water treatment applications/ adsorbents
Clay, dolomite	Catalytic applications/ catalytic materials
Dolomite, feldspar, charcoal	Recovery materials
Dolomite, clay	Refractory materials

When considering the distribution of some outstanding earth materials throughout the world, mostly there can be found uneven distributions at around some particular locations around the world based upon the geological incidents happened with the time. Sri Lanka is rich in mineral and earth resources as some of them are already being utilized in various industrial purposes such as tile manufacturing, brick manufacturing, composite materials and some of advanced chemical applications. It is an essential concern to discover some unexposed earth materials in the industrial applications based upon the requirements in the solving of environmental issues. In the existing research there were expected to analyze a few of selected earth materials for the sake of introducing a series of new and advanced applications that associated with the outstanding characteristics of such earth resources.

MATERIALS AND METHODOLOGY

According to the availability and expectations of the existing research, there were selected three different types of clay, a selected type of dolomite and a selected type of feldspar available at around different regions in Sri Lanka.

Three different types of clay samples were collected from three particular locations in Sri Lanka as mentioned in the Table 2.

Table 2. A brief description about the selected clays

Clay Type	Location	Current Applications
Anthill Clay	Matale, Sri Lanka	-
Brick Clay	Maduragoda, Sri Lanka	Manufacturing of bricks
Roof Tile Clay	Dankotuwa, Sri Lanka	Manufacturing of roof tiles

A few of representative clay samples are shown in the following figures.

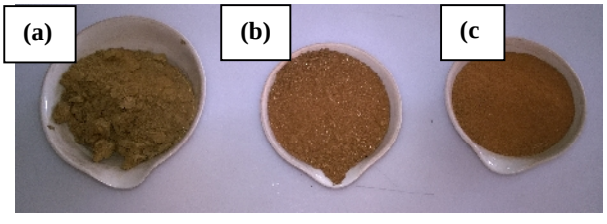

Figure 1. (a) Roof tile clay, (b) brick clay and (c) anthill clay

Apart from the clays, two different types of earth materials were selected. Those are dolomite and feldspar as described in the Table 3.

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Table 3. A brief description about the selected dolomite and feldspar

Earth Material	Location	Current Applications
Dolomite	Matale, Sri Lanka	Lime productions
Feldspar	Owala-Kaikawala, Sri Lanka	Ceramic and porcelain purposes

A few of dolomite and feldspar samples were shown in the following figures.

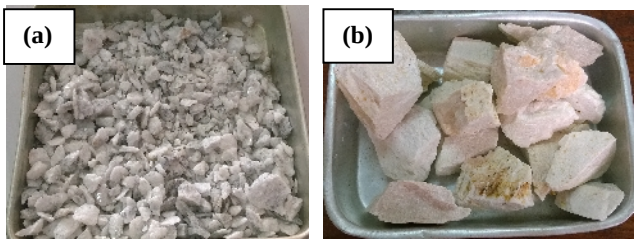

Figure 2. (a) Dolomite and (b) feldspar samples

In the preparation of the final representative samples for the experimentation, the following methodology was followed.

- Drying of each row sample and removal of the moisture content
- Pulverizing or the comminuting of each sample to prepare a powdered samples as <0.075mm of particle size.

Each powdered raw material sample was characterized using X-ray fluorescence (XRF) spectrometer, Scanning electron microscope (SEM), Fourier transform infrared (FT-IR) spectrometer and X-ray diffraction (XRD) spectrometer.

RESULTS AND DISCUSSION

The X-ray fluorescence (XRF) spectroscopic results regarding the selected earth materials are shown in the Table 4.

Table 4. Elemental compositions of earth materials

Element (%)	Fe	Ti	Ba	K	Ca	Zr	Zn
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	-
Dolomite	-	-	-	0.54	99.46	-	-
Feldspar	5.14	-	-	52.98	41.43	-	0.45

According to the elemental chemical compositions of the selected clays there were obtained at least 75% of Fe in each clay type with the trace amounts of Ti, Ba, K, Ca and Zr in some of clays. It was not detected any toxic element even in any of earth material apart from the basic metallic elements. Based upon the non toxicities of clays, it is possible to recommend these clays for the applications of waste water treatments only considering the phenomenon of filtration. However, the adsorption capacities of such clays can be further discussed with the mineralogy of such clays furthermore (Ashutosh *et al*., 2018).

When considering the chemical composition of dolomite, it seems that the content is much closer to the chemical content of calcite rather than the chemical content of dolomite because of the lack of Mg which is an essential element for dolomite and the

https://doi.org/10.24264/icams-2022.I.3

relatively higher content of Ca in such dolomite. Also it was observed some significant percentage of Ca in feldspar and it is possible to recommend both materials for the applications as the strong refractory materials as CaO is a strong refractory agent.

The Fourier transform infrared (FT-IR) spectra and Scanning electron micrographs (SEM) of clays and other earth materials are shown in the following figures.

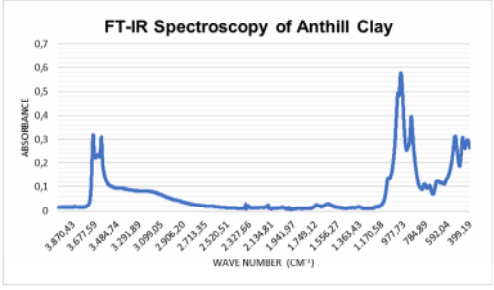

Figure 3. FT-IR spectroscopy of anthill clay

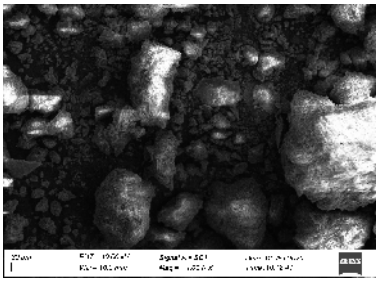

Figure 4. SEM micrographs of anthill clay

The above spectroscopes and micrographs showed the presence of kaolinite which is known as a leading clay mineral and a strong adsorbent for heavy metals, pathogens, particulate matter and some organic matter presence in waste water and polluted air.

In the consideration of FT-IR spectroscopy of this clay type especially there were identified some peaks at the wave numbers of ~3700 cm^{-1}, ~3650 cm^{-1}, ~1100 cm^{-1}, ~900 cm^{-1}, ~700 cm^{-1} and ~550 cm^{-1} that relevant with the compound kaolinite.

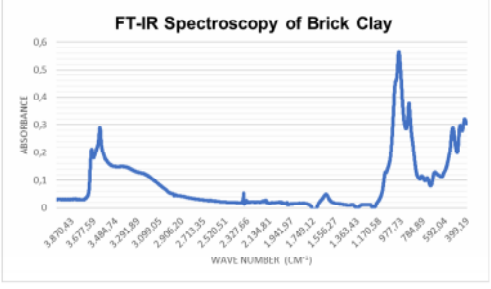

Figure 5. FT-IR spectroscopy of brick clay

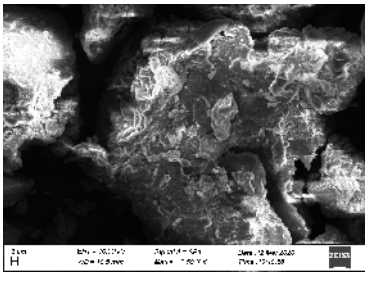

Figure 6. SEM micrographs of brick clay

Apart from the leading clay mineral kaolinite, there can be identified a few of various clay minerals and non clayey minerals with respect to the peaks at ~1100 cm^{-1}, ~800 cm^{-1} and ~450 cm^{-1} for quartz and ~1000 cm^{-1} for muscovite.

Muscovite is known as a clay mineral which is having the property of electrical conductivity. Therefore, it is possible to expect some electrical conductivity from such clay types based upon the content of such mineral (Parker *et al*., 1969).

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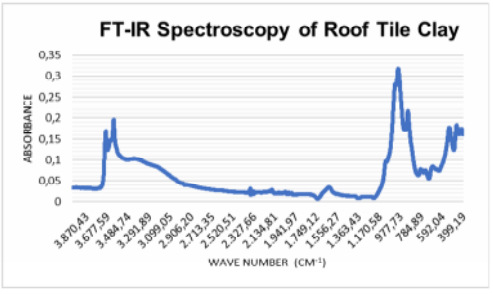

Figure 7. FT-IR spectroscopy of roof tile clay

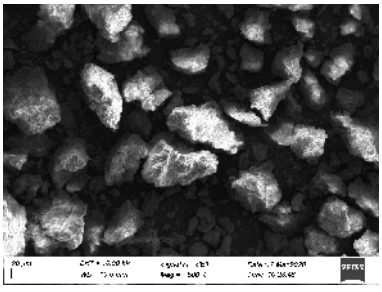

Figure 8. SEM micrographs of roof tile clay

As the overall analysis of the above results, there can be observed the presence of kaolinite in each as every clay type in different contents and it is possible to these clay types for the sake of following applications (Srinivasan, 2011).

- Waste water treatments such as the removals of particulate matter, heavy metals, organic pollutants and pathogens.
- Catalytic applications that associated with the advanced chemical processes

The analytical results of dolomites and feldspar are shown in the following graphs and figures.

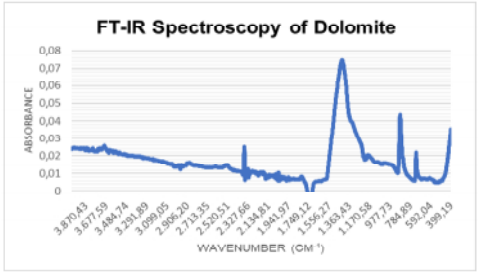

Figure 9. FT-IR spectroscopy of dolomite

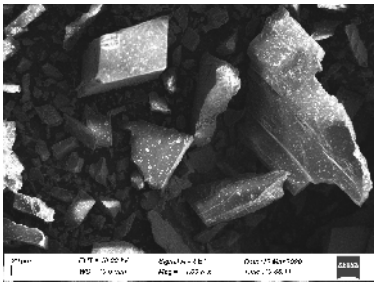

Figure 10. SEM micrographs of dolomite

According to the above results of the dolomites, especially it is bit difficult to distinguish the FT-IR spectroscopy of dolomite from the same spectroscopy of calcite. Therefore, some specific advanced analytical method would be an essential step for the further analysis. The SEM micrographs interpreted the tabular and massive crystals which are much similar with the crystal systems of dolomite.

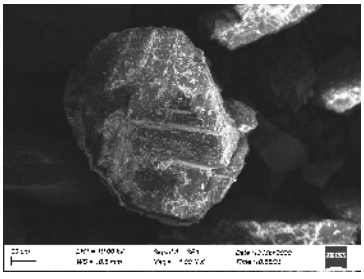

Figure 11. SEM micrographs of feldspar

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The SEM micrograph of feldspar shows the massive crystals with cracked surfaces and some advanced microscopic or elemental chemical compositional analysis will be needed in further analysis.

When considering the obtained results for both feldspar and dolomite and comparing them with the past research outcomes and literature concepts, it is possible to recommend the following industrial applications.

- Water treatment applications such as the removal of hardness from water due to the adsorption capacities;
- Recovery material due to the adsorption;
- Refractory material due to the heat resistant capacity.

CONCLUSION AND FURTHER RECOMMENDATIONS

The characterization results of the earth materials interpret the non toxicity in clays, dolomites and feldspar and there were observed the presence of kaolinite, muscovite and quartz as the minerals, relatively higher content of calcite in the selected dolomite variation and relatively higher amount of Ca in the selected feldspar. Therefore, these earth materials can be further developed towards the applications in waste water treatments based upon the adsorption capacities of them including the clay and dolomite, refractory materials, catalysis applications and some particular advanced chemical applications.

It is possible to recommend the following advanced analysis for the above materials based upon the advanced industrial application purposes of such materials.

- Advanced microscopic analysis, advanced compositional analysis and performing of nano-technological uses.

Acknowledgement

We wish to acknowledge the technical staff at the Department of Chemistry, Department of Physics, Department of Zoology, Department of Chemical and Process Engineering and Department of Civil Engineering, University of Peradeniya, Sri Lanka and voluntary material providers on behalf of their great assistance in our research works.

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