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Quality Assessment of Clay Raw Materials Utilized for Pottery Products in Eastern Tigray, Northern Ethiopia

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Abstract: Geological works in Ethiopia indicate the presence of clay deposits in the country and many occurrences in the Tigray National Regional State. The important characteristics relating to the applications of clay raw materials for pottery and other industrial applications were assessed in this study. The potential sources for clay raw materials currently utilized by local potters have been identified and samples were analyzed for their physical and chemical characteristics such as mineralogical composition, particle size, mixing proportion, firing temperature and loss on ignition. The chemical composition study revealed that SiO_2 content is in the range of 41.4 to 51.3 %, Al_2O_3 content is in the range of 15.8 to 22.1 %, CaO content is in the range 1.14 to 2.23 % and Na_2O content is in the range of 0.36 to 0.68%. Moreover, the LOI results for the analyzed local clay raw materials ranged from 10.88 to 15.32%. Most samples were found to have the desirable physical and chemical characteristics to be used as raw materials in pottery and other ceramic industries. However, the LOI of one sample (S_6) and CaO content of all samples were found to higher than the recommended level.

Keywords : Assessment, Clay, Quality, Pottery, Eastern Tigray

Introduction:

Clay is defined as an earthy material which becomes plastic when moistened with water, can be molded to any shape which is retained when dried [1] . It is also applied both to materials having a particle size of less than 2 microns and to the family of minerals that has similar chemical compositions and common crystal structural characteristics [2].

Clays are used as raw materials in many industrial fields (ceramics, paper, paints, and petroleum products, among others). Their applications depend on their structure, composition and physical attributes and knowledge of these characteristics can help to determine the best way to utilize any particular clay and may often lead to new areas of applications [3]. Two types of clays are generally used-kaolin and ball clays. Kaolin is one of the most useful industrial minerals with a wide range of applications; kaolinite ($Al_2Si_2O_5(OH)_4$) is the main mineral in both clay types and this is composed of alternate octahedral gibbsite and tetrahedral silica layers to give a plate-like structure . In kaolin, minor quantities of quartz and transition elements such as iron, titanium and manganese are generally present as additional minerals [4].

Ball clays are finer than kaolin and are often referred to as plastic clays as they provide a greater plasticity in the ceramic body [5]. The characteristics and quality of the clay are important for the best technical performance of the local products. Moreover, a specific deposit may have separate layers each associated with different clay. This provides opportunities to mix different clays in order to adjust the properties of both the unfired ceramic body and the corresponding final product [6].

Geological works in Ethiopia indicated the presence of clay deposits in the country and many occurrences in the Tigray National Regional State. A preliminary characterization and evaluation clay and associated diatomaceous earth deposits was carried out based on the chemical and mineralogical composition by Kurkura and co-workers [7] and they identified three types of clay and associated sediments. The important characteristics relating to the applications of clay minerals are particle size and shape, surface chemistry, surface area, surface charge, and other properties specific to particular applications, including viscosity, color, plasticity, dry and fired strength, absorption and adsorption, abrasion and pH. In all applications, the clay minerals perform a function and are not just inert components of the [8].

The art of pottery and pottery products have been utilized since ancient civilization of human being all over the world. Archeological evidences in Tigray reveal that pottery products have been commonly utilized as household utensils since the era of Aksumite kingdom. Despite the long history of pottery making practices, the sector still depends on traditional ways of making low quality products. These traditional potters are among the low income people due to production of low quality materials and they are facing severe competition from industrial products like imported ceramics, plastic and aluminum goods.

The chemical composition of clay raw materials, mixing proportion of raw materials, particle size, glaz

ing materials and production technology attributes the overall quality of pottery. This project, therefore, aims to investigate the right quality and mixing proportion of local clay raw materials for pottery making and other industrial applications.

Description of Study Area:

The Eastern Administrative zone of Tigray National Regional State shares a border with Eritrea to the North, Afar National regional State to the east, South eastern zone to the South and Central zone to the west direction. It consists of seven rural weredas viz. Gantafeshum, Gulomekeda, Irob, and Saesie-tsaedaemba, Hawzien, Kiliteawlaelo and Atsbi Wemberta. It has mild to high temperature range typical of its midland elevation with average rainfall of 300 to 400mm per year.

Methodology:

This research project work mainly focused on the following three parts:

1. Identifying possible resource areas for clay raw materials in Eastern Tigray Zone through surveying method
2. Characterization of the identified clay resources for their quality to be utilized for pottery making and other industrial applications.
3. Improving the quality of local pottery products by using appropriate processing techniques and right proportion of additives

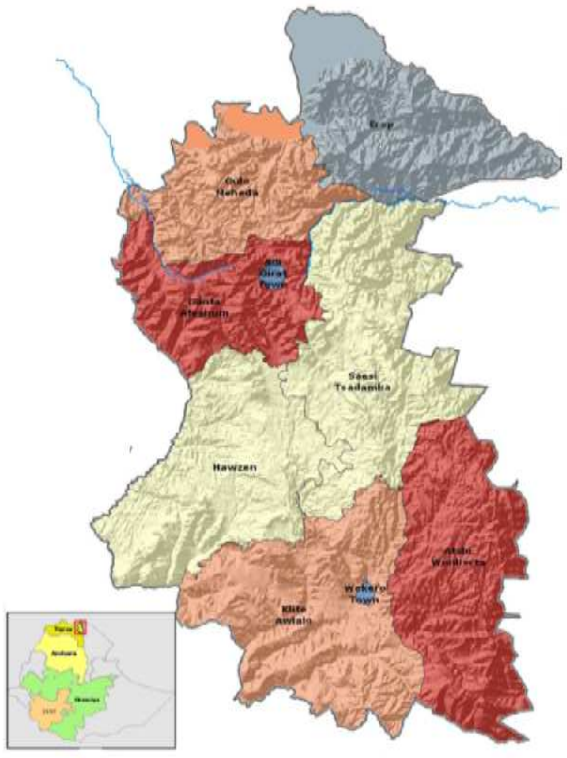

Fig. Map of Eastern Tigray Zone

Sources of Clay Samples*:*

Initially, the potential areas for clay raw materials were identified in consultation with local potters within the study area and the current source of raw materials under utilization was located. Representative samples were collected from identified potential areas of clay resources. In this regard quarry sites currently utilized by potters and additional possible resources were sampled as per the recommended soil sampling techniques.

This study was mainly intended to study the possibility of using the local clay materials in ceramic and other industries besides to the earth-ware pottery fabrication. In this regard, the traditional method of producing pots and other household utensils was assessed for suitability. The appropriate formulation of clay and other raw material for better quality products was suggested based on preliminary experiments for each type of clay raw materials under investigation. Different quality parameters such as particle size, firing temperature, application of glazing materials, amount of water needed for paste making and temperature was optimized.

Results and Discussion:

The potential areas for clay and other raw materials utilized by local potters were identified. There are many sources for clay soils which the local potters currently use them as raw materials in the traditional pot making process. The analysis results for each sample from different sites after treating with acids of different concentrations are presented in

Table 1.

Chemical Analysis:

The collected clay samples were analyzed for their chemical composition and loss on ignition (LOI) due to the loss of associated water and organic matter in the sample. The results of the current study as depicted on table 1 show that the clay raw materials utilized by local potters revealed that silica (SiO_2) is in the range of 41.4 to 51.3 %, alumina (Al_2O_3) is in the range of 15.8 to 22.1 %, lime (CaO) is in the range 1.14 to 2.23 % and sodium carbonate (Na_2O) is in the range of 0.36 to 0.68%. The loss on ignition (LOI) is related to the presence of substantial volatiles in the clay mineral, decomposition of carbonate, organic matter oxidation, and sulfides and hydroxides, among others [6]. The LOI results for the analyzed local clay raw materials ranged from 10.88 to 15.32%.

In comparison to the Thailand clay raw materials represented as R^* in table 1 [9] the collected samples from different areas of Eastern Tigray Zone have desired level silica content, alumina content, Na_2O content except for higher result of LOI for clay samples collected from S_6. Whereas, all the local clay samples were found to have relatively high lime (CaO) content compared to Thailand clay samples.

Particle Size:

The results of particle size distribution of clay samples were studied in different ways as this parameter is responsible for the plasticity of materials made of clay products.The effect of grading on Loss on Ignition (LOI) and total carbon of the clay samples investigated in this study is

shown in Table 2.The clay particles with sizes 30 μm were higher in LOI and total Carbon than the larger particle size (35-60 μm). As indicated in table 2, the clay samples with 50 μm particle size were found to have lower values of LOI and total carbon content. Moreover, the 50 μ m particle size has shown no cracking after firing for 5 hrs at 800oC (other particle sizes have shown considerable cracking at the same condition).

Table 1: Analysis results for Chemical compositionand LOI of clay samples

Sample	SiO_2	Al_2O_3	Na_2O	CaO	LOI
S_1	41.7±1.2	22.1±1.1	0.59±0.12	1.32±0.06	11.6±0.49
S_2^*	43.1±1.5	19.7±0.98	0.68±0.11	1.51±0.05	14.2±0.77
S_3	45.9±1.2	16.2±0.66	0.48±0.08	1.71±0.04	10.88±0.65
S_4^*	44.2±1.6	20.7±0.91	0.44±0.10	1.98±0.08	14.25±0.81
S_5	49.3±1.9	15.8±0.78	0.36±0.22	2.13±0.12	13.23±0.57
S_5	48.2±1.3	18.9±0.62	0.43±0.23	1.14±0.32	12.25±0.25
S_6	51.3±1.8	17.2±1.0	0.50±0.12	2.23±0.17	15.32±0.46
S_7^*	41.4±1.6	20.3±0.45	0.46±0.08	2.12±0.15	12.22±0.56
R	**[47-63]**	**[20-37]**	**[0.04-0.71]**	**[0.01-0.58]**	**[7.5-14.2]**

- * *represents samples collected from local potters*
- *all results are mean values of three determinations.*
- *R= shows Literature values for comparison purpose [9].*

Table 2: Effect of grading on LOI and total carbon of clay samples

size (μm)	LOI (%)	Total C (%)
30	6.71	1.98
35	6.45	1.92
40	6.58	1.85
45	5.32	1.71
50	4.88	1.37
55	4.91	1.45
60	5.01	1.48

Improving Quality of Pottery Products:

Some of the local potters use animal dung additives but these practices were found to reduce the strength and impart unpleasant odor for the pottery products. In order to improve the quality of clay, different additives such as metallic oxides, organic materials and sands were assessed based on trial and error method with different formulations. In this regard, soil types that are rich in CaF_2 and Fe_2O_3 contents were found to enhance the shiny surface of products. Moreover, wood ash is currently utilized by potters as glazing material and this was found to be effective when fired at optimum temperature of 800-850 ^oC for about five hours.

Conclusion:

Most of the clay samples from identified sources of currently under utilization by traditional potters and new ones were found to be suitable for production of good quality ceramic materials. The results of chemical analysis showed that the existence of essential components such as Al_2O_3 and SiO_2 in the desirable level contributes to the necessary refractoriness and strength of the final Product.

Despite the long time history of utilizing pottery products at household level, the local potters engaged in producing these utensils are still among the lower income community due to lack of scientific knowledge & skill to improve the quality of their products. This study, therefore, recommends the Small and Micro scale Enterprise offices and other stakeholders on the sector to provide appropriate training on knowledge and skill about pottery, organize the local potters in cooperatives and encourage them to introduce modern technologies, improve quality of products and create market opportunities through promotion. Moreover, the following research gaps are recommended for further study to utilize the local clay resources appropriately for other industrial purposes.

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References:

1. Hamilton, W.N. and Pauline, H.B.. Alberta Clays and Shales: Summary of Ceramic Properties.Alberta Research, Edmonton, Alberta. 1975.
2. Velde B..Composition and Mineralogy of clay minerals.New York, *Springer-Verlag. 8-42,* 1995.
3. Baccour, H., Medhioub, M., Jamoussic, F., Mhiri , T. and Daoud, A. Materials Characterization 1613-6222, 59: 2008.

4. S.HandrasekharandS.Ramaswamy *Applied Clay Science*, 37, 32-46, 2007.
5. Das, S. K., Sundararajan, T., Pradeep, T., and Patel, H. E. Phys. Rev. Lett. 95, 019402 – Published 27 June 2005 , *Physical Review Letters.*
6. Vieira,C.M.F., Sanchez S. N. *Constr Build Mater 22:781–787.*
7. Kurkura, K.,.Aynalem, Z., Bheema, K., Kinfe, A., Solomon, G., and Kassa, A., *Momona Ethiopian Journal of Science*; 4(2):111-129, 2012.
8. Murray, H. 1997. Applied Clay Mineralogy Today and Tomorrow.Indiana University, Bloomington, IN 47405, USA.
9. Bordeepong, S., Bhongsuwan, D., Pungrassami, T. and Bhongsuwan, T. *Kasetsart J. Nat. Sci. 485 – 500, 46 :* 2012.