CHARACTERIZATION OF SOIL USED IN POTTERY MAKING OF NWE-NYEIN QUARTER, KYAUK-MYAUNG, SHWEBO DISTRICT, SAGAING REGION

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Abstract

This research is aimed to investigate the physicochemical constituents of soil samples from the well-known glazed pot industry of Nwe-nyein and to characterize these soil samples by advanced spectroscopic techniques. Potters make earthen and glazed pot by mixing too types of soil: yellow soil (sample 1) and red soil (sample 2). They prepare the combined soil (sample 3) by mixing these two types of soil with two: one ratio by weight of yellow and red soil. pH, moisture, colour, electrical conductivity and cations exchange capacity of yellow soil, red soil and combined soil samples were measured by their respective methods to explore their physicochemical properties. Then exchangeable cations analysis informed the cations exchange capacity (CEC), Sodium Adsorption Ratio (SAR), Exchangeable Sodium Percentage (ESP %) and Exchangeable Magnesium Percentage (EMgP %) of tested soil samples and the values of SAR pointed out that all soils were dispersive due to the sodium contents. Textural analysis was done on all soil samples and they were classified as clay. Soluable salt extraction tests were carried out by titration methods to detect the amount of soluble chloride, sulphate, carbonate and bicarbonate but the bicarbonate was not found in all samples. To characterize soil constituents, Energy Dispersive X-ray (EDX) and Scanning Electron Microscopic techniques(SEM) were also applied. According to the EDX results, the highest relative abundance of Si were 42.06 %, 42.55 % and 44.50 % in sample 1, sample 2 and sample 3 respectively and it was followed by the percentages of Fe with 25.92 %, 30.36 % and 28.53 %. Heavy toxic mineral constituents were not found in these soils. SEM examination showed that the crystal like structure of sample 1 and flaky similar soil structures with many porous could be observed in the soil sample 2 and 3. It was concluded that the soil samples used in Nwe-nyein pottery industry were suitable for pottery making and the products of this area were popular in the whole Myanmar.

Keywords: Soil, Cations exchange capacity (CEC), Sodium Adsorption Ratio (SAR), Exchangeable Sodium Percentage (ESP %), Exchangeable Magnesium Percentage (EMgP %)

Introduction

The characteristics common to all clay minerals are derived from their chemical composition, layered structure, and size. There are three definitions of clay: (I) based simply on size, including anything finer than 4 microns be it true clay minerals, quartz, calcite, pyrite or any other substance; this is the "clay" of the grain-size analysis workers, of the sedimentologists and oceanographers; (2) based on composition, defined as one of the hydrous aluminum silicates belonging to the kaolin, montmorillonite or illite groups and also including fine-grained chlorite and vermiculite; (3) the petrographic definition, which includes under the general term "clay", the true clay minerals listed in (21, plus sericite and fine- grained muscovite, biotite and chlorite if finer than about 20 microns, and even the hydrous aluminum oxides "bauxite" and gibbsite (Folk,1974). Grain size distribution of soil classify gravel and sand as coarse grained soil and, silt and clay are categorized as fine grained soil. Soil, particle size < 2 μm is the most determining factor which gives plasticity to

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soil and are called clay particles(Shrestha, 2018). Clay minerals all have a great affinity for water. Some swell easily and may double in thickness when wet. A mixture of a lot of clay and a little water results in a type of mud that can be shaped and dried to form a relatively rigid solid. This property is exploited by potters and the ceramics industry to produce plates, cups, bowls, pipes, and so on. Clay minerals resemble the micas in chemical composition, except the fact that they are fine grained and usually microscopic. Like the micas, clay minerals are shaped like flakes with irregular edges and one smooth side. Glazes are made up of materials that fuse during the firing process making the pot vitreous or impervious to liquids. (Ceramics engineers define vitreous as a pot that has a water absorption rate of less than 0.5%.) Glazes must have three elements: silica, the vitrifying element (converts the raw pottery into a glasslike form)—is found in ground and calcined flint and quartz; flux, which fuses the glaze to the clay; and refractory material, which hardens and stabilizes the glaze. Colour is derived by adding a metallic oxide, including antimony (yellows), copper (green, turquoise, or red), cobalt (black), chrome (greens), iron, nickel, vanadium, and so on. Glazes are generally purchased in dry form by production potters.

Pottery, one of the oldest and most widespread of the decorative arts, consisting of objects made of clay and hardened with heat. The objects made are useful and the importance of pottery production to the local culture and economy facilitates and reinforces common property institutions associated with these goods. The evidence indicates that when rare or scarce "private goods" are integral to a people's livelihoods and culture, common property arrangements can be an effective approach to management (Tucker,201). Nwe-nyein pottery is well known in Myanmar and there is no chemical analysis on the soils from this area. The aim of this research work is to characterize the constituents of soil samples from Nwe-nyein Glazed pottery Industry from Kyauk-Myaung, Shwebo District, Sagaing Region, Myanmar and the location map of the study site is shown in Figure 1.

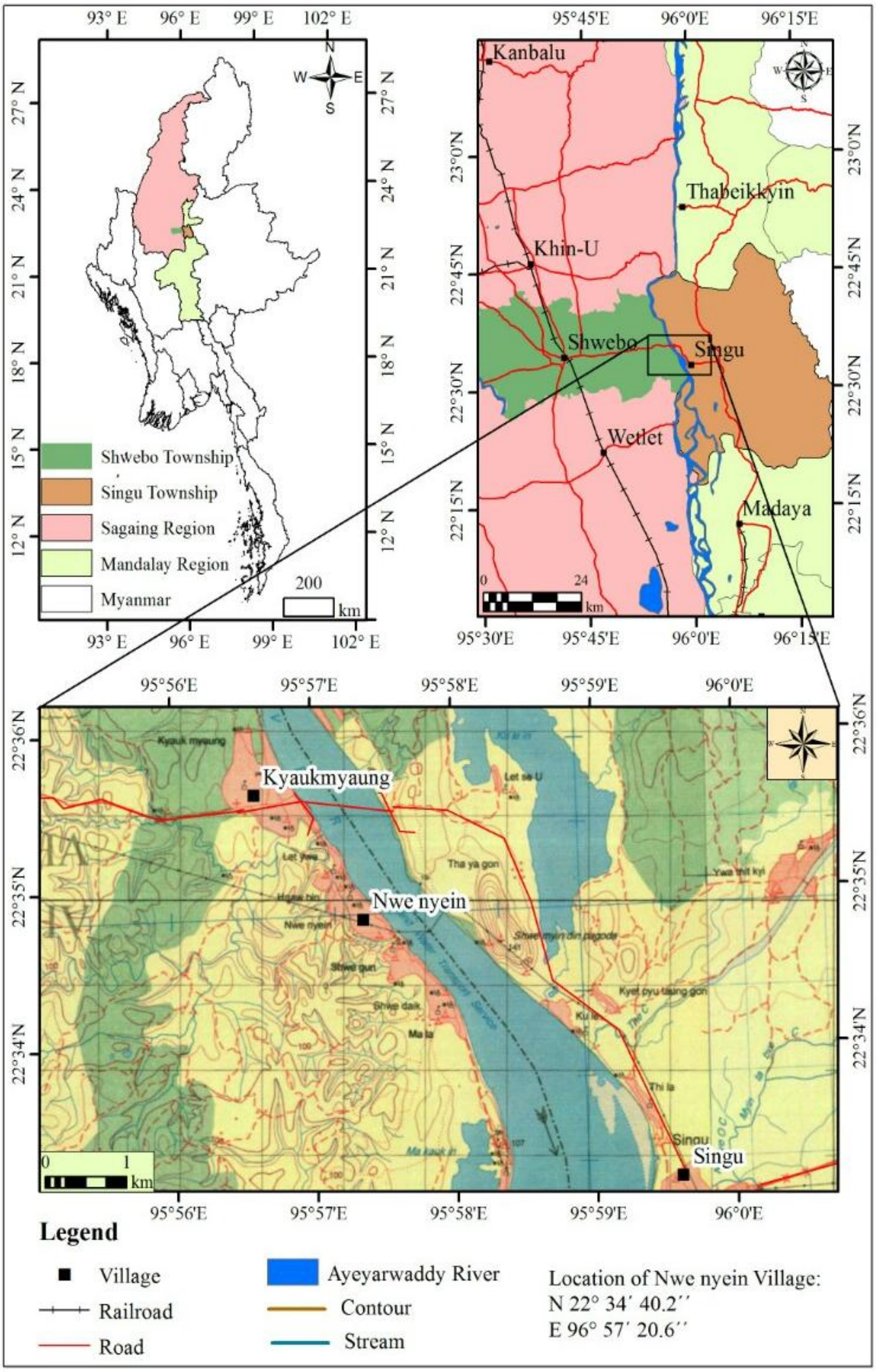

Figure 1 Location map of the study site

Nwe-nyein Pottery

Kyauk-myaung is situated 46 miles north of Mandalay on the west bank of the Ayeyawady River, and 17 miles to the east of Shwebo. It has four large-scale pottery "villages" or complexes and they are Nwe-nyein, Shwe-gon, Shwe-daik, and Malar. Nwe-nyein is the largest pottery village and it is famous for the production of large glazed pots which can be used to store about 200 litres of water. Potters use two kinds of soils for pottery making and they are red soil and yellow soil. Villagers dig red soil from the floor of the Ayeyawady river and bring yellow soil from the soil deposit which is not far from the villages. Potters needed raw soil material to make pots by mixing yellow and red soils according to weight ratio (2 : 1). In this research, determination of physicochemical properties and characterization of yellow soil, red soil and (2 :1) combined soil were investigated to characterize the constituents of soil samples from the glazed pot industry of Nwe-nyein.

Figure 2 Traditional pottery making procedure of Nwe-nyein industry

(a) Pasting and preparing the soil
(b) Bottom part of a big pot on the potter's wheel
(c) After preparing a big pot
(d) Printing on the pot with chalk glaze
(e) Traditional earthen ash tray
(f) After decorating the tray with chalk
(g) Ready to fire the pots in the kilns
(h) The arrangement of pots in the kilns
(i) Before closing the kilns to fire
(j) Glazed pots products to send into the market
(k) Chemicals used for the preparation
(l) A building decorated with glaze of colour of the glaze

Materials And Methods

Sample Collection

Three soil samples were collected from one of the pottery industries from Nwe-nyein quarter, Kyauk-myaung, Shwebo District, Sagaing Region which is well- known for glazed-pot making in Myanmar. As it can be seen in Figure 3, soil sample-1 is yellow soil, sample-2 is red soil and sample-3 is made by mixing yellow soil and red soil with 2 : 1 ratio by weight of soil sample-1 and sample -2.

Sample-1 yellow soil   Sample -2 red soil   Sample-3 combined soil y : r = 2:1)

Figure 3 Collected samples

Collected soil samples were allowed to dry in air at room temperature. Then these air-dried soil samples were broken up by hand and then they were ground by milling with a wooden roller. After grinding, the soil was screened through a 2mm (10 meshes) sieve. For textural analysis, air-dried soil samples were utilised naturally. The sample was allowed to dry in an electric oven at 105-110°C for about 8 hrs. After cooling it in a desiccator, the loss in weight was determined. From the loss in weight, the percentage of moisture of the sample was calculated. The pH of soil solution was measured by pH meter. The pH meter was calibrated with pH 4.0 and pH 10.0 buffer solution before measurement. The electrical conductivity of the soil samples was determined electrometrically with a calibrated, HACH model electrical conductivity meter. Soil texture was determined by pipette method. The amount of exchangeable calcium and magnesium were determined by titration method at Soil Survey Section, Irrigation Department Yangon. The concentration of exchangeable sodium was detected by using the atomic absorption flame emission spectrophotometer at Soil Survey Section, Irrigation Department Yangon. Characterization of soil samples were done by Energy Dispersive X-Ray Analysis (EDX) and Scanning Electron Microscopic method (SEM). The energy dispersive X-ray spectra (EDX) of the three soil samples were recorded on a Perkin Elmer 700, EDX spectrometer. Morphological structures of sample 1, sample 2 and sample 3 was taken at Chemistry Department, West Yangon University by using Scanning Electron Microscope (JOEL-JSM-5610 Japan), Ion Sputter (JFC-1600).

Results and Discussion

Determination of Physicochemical Properties

Some physicochemical properties of three soil samples were examined and the data obtained were shown in Table 1.

Table 1 Physicochemical Properties of Soil Samples

Sample	pH	Moisture Content (%)	EC (μ mhos/cm)	Colour
1	7.80	1.32	743	pale yellow
2	8.70	1.47	222	red
3	8.60	1.94	779	reddish yellow

Soil sample 1 showed slightly alkaline pH 7.80 and the other two sample 2 and 3 had strongly alkaline pH, 8.70 and 8.60 respectively. Low moisture contents 1.32 and 1.47 were belonged soil sample 1 and sample 2 while soil sample 3 had the higher moisture content (1.94 %). Sample 1 and the combined sample 3 had medium electrical conductivity (EC) (743 and 779 μmhos/cm) but the soil sample 2 had low electrical conductivity (EC) (222 μmhos/cm).

Table 2 Textural Properties

Sample	Composition			
	Sand (%)	Silt (%)	Clay (%)	Texture
1	24	27.5	48.5	Clay
2	15	31.5	53.5	Clay
3	25	33	42	Clay

Soil sample 2 showed the highest clay content, 53.5% and sample 3 had the highest amount of sand and silt percentages, 25% and 33% respectively but all soil samples were informed as clay texture in Table 2.

Table 3 Exchangeable Cation Contents

Sample	meq/100 g of soil							SAR	ESP %	EMgP %	Remark
	Na^+	Ca^{2+}	Mg^{2+}	K^+	Al^{3+}	H^+	CEC				
1	7.30	3.28	1.52	1.23	0.25	0.00	13.58	14.90	53.76	11.19	Dispersive
2	4.43	3.29	1.70	1.61	0.30	0.00	11.33	8.88	39.10	15.00	Dispersive
3	7.30	3.36	1.84	1.28	0.21	0.00	13.78	14.31	52.98	13.35	Dispersive

Low cation exchange capacity was found in all soil samples because they were fallen in the low CEC range 5-15 meq/100 g of soil in Table 3. Relatively unsuitable sodium adsorption ratio between 10-18 were found in the yellow clay sample 1 and the combined sample 3 whereas red clay sample 2 was found as suitable classification of SAR between 1-10 meq/100 g. Increased exchangeable sodium percentage is related to decreased exchangeable magnesium percentage and it can be seen in the results of all soil samples. According to the exchangeable cations analysis, all soil samples were regarded as dispersive soil. But this property is no longer significance during pottery making.

Table 4 Extracted Soluble Salts

No	Parameter (meq/L)	Sample 1	Sample 2	Sample 3
1	CL^-	0.67	0.35	0.46
2	SO_4^{2-}	5.53	0.05	6.40
3	CO_3^{2-}	0.00	0.00	0.00
4	HCO_3^-	0.80	1.60	0.80

Water soluble salts were determined and the results were observed as shown in Table 4. Sample 1 contained the highest CL^- salt (0.67). Medium content of sulphate salts was observed in sample 1 (5.53). Sample 2 showed the lowest SO_4^{2-} contents (0.05 meq/L) while sample 3 gave the highest SO_4^{2-} value (6.40 meq/L) of soil solution. Sample 2 possesses the double HCO_3^- content (1.6 meq/L) of the other two samples (0.80 meq/L). Water soluble CO_3^{2-} was not found in all tested soil samples.

Scanning Electron Microscopic Examination

SEM images of soil samples were measured by scanning electron microscopic analysis and the result obtained were informed in Figures 4, 5 and 6.

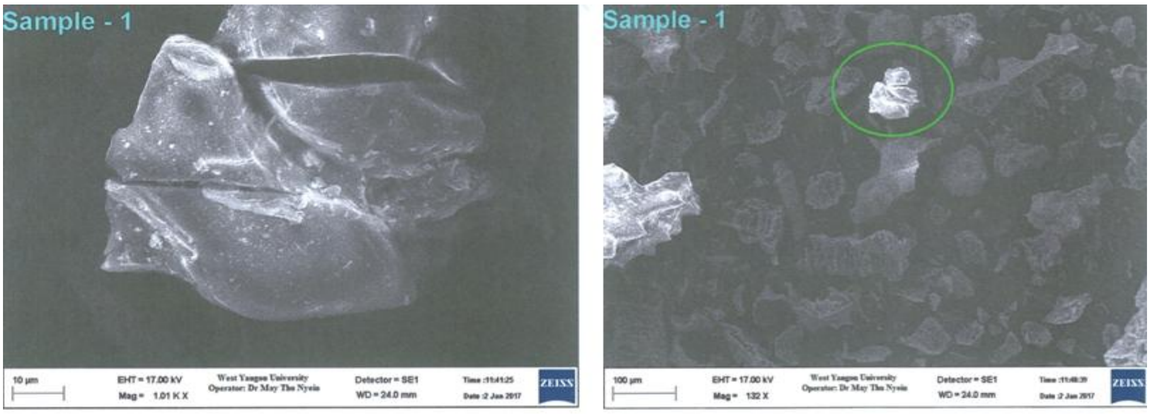

Figure 4 Morphological structure of soil sample 1

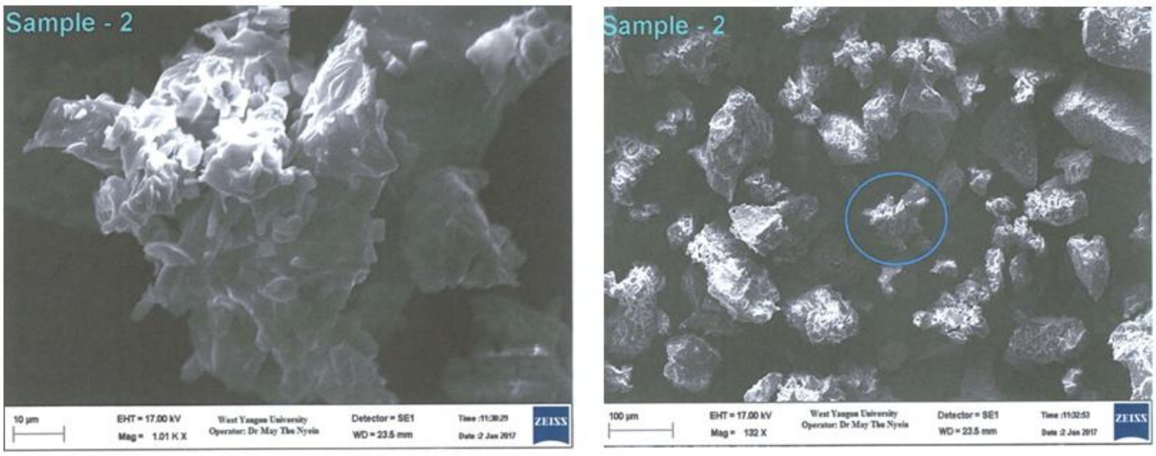

Figure 5 Morphological structure of soil sample 2

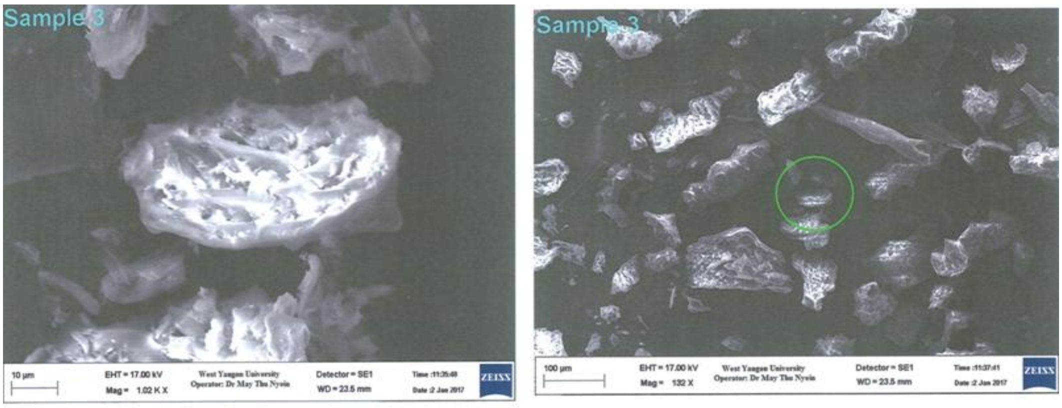

Figure 6 Morphological structure of soil sample 3

In these SEM photograms, soil sample 2 and 3 gave flaky structures with many micropores but sample 1 was found as crystal like structure.

Elemental Composition of Soil Samples

Determination of elemental composition of soil samples was carried out by Energy Dispersive X-ray analysis. The resulting relative abundant compositions in percentage of tested soil samples were displayed in Table 5. The highest Ca contents (9.342 %) was observed among these three soil samples and also the highest Al amount (14.83 %) was determined in soil sample 2. The composition of major elements such as Si, Fe and K of all soil samples do not differ significantly.

Table 5 Elemental Composition of Soil Samples

No	Element	%Composition		
		Sample 1	Sample 2	Sample 3
1	Si	42.064	42.554	44.500
2	Fe	25.922	30.355	28.526
3	Ca	9.342	1.546	2.831
4	Al	7.997	14.826	13.824
5	K	6.794	6.958	6.695
6	S	4.397	0.490	0.431
7	Ti	2.297	2.359	2.240
8	Zr	0.259	-	-
9	Mn	0.232	0.272	0.381
10	Sr	0.201	0.216	0.178
11	Cr	0.107	0.066	0.071
12	Zn	0.086	0.127	0.098
13	V	0.083	0.119	0.121
14	Ni	0.073	-	-
15	Cu	0.055	0.065	0.060
16	Rb	0.050	-	-
17	Y	0.042	0.048	0.045

Conclusion

Ceramics and earthenware created by Nwe-nyein pottery industry are still in common use in many parts of everyday life of Myanmar people. Most are in the form of cooking pots, flower pots, drinking water pots and food and water storage pots. Drinking water pots are earthenwares and it is convenient to use these pots to filter heavy toxic minerals of ground water and other unneeded impurities. Glazed pot or in Myanmar we called San-Oh is being made by applying specific elevated temperature (>1000 °C). Analyzed soil samples from Nwe-nyein complex have not been investigated scientifically before. This study revealed that the determination of pH, moisture, color, electrical conductivity, cations exchange capacity, texture, soil mineralogical constituents and characterization of soil morphology. Particle size distribution was also measured to classify the texture. According to physiochemical properties of pottery soils, they do not contain hazardous toxic metals and all results data support that these soils are suitable to use in pottery making. Another detail research should be carried out on pottery soil by using other additional advanced spectroscopic techniques to do a complete survey and long term assessment. Finally, traditional pottery making of Nwe-nyein area was still needed to maintain this art and encourage with advanced technology and all kinds of supplements for local people as soon as possible.

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References

Folk, R.L. (1974*). Petrology of Sedimentary Rocks*, Austin, Texas, Hemphill Publishing Company, p.89.

Lajunen, L.H. (1997). *Spectrochemical Analysis by Atomic Absorption and Emission*, Cambridge, the Royal Society of Chemistry, British Library.

Lieutenant Kyaw Thu Hein, (2011). *Elemental Analysis of Dolomitic Limestone Samples by Various Methods*, MSc Thesis, Chemistry Department, University of Mandalay (Unpublished)

Zunbul, B. (2005). *AAS, XRD, SEM, EDS and FTIR Studies of the Effect of Calcite and Magnesite on the Uptake of Pb^{2+} Ions by Natural Kaolinite and Clinoptilolite*, MSc Thesis, Graduate School of Engineering and Sciences of İzmir Institute of Technology

Shrestha R., Prajapati R. S. and Maskey P. N. (2018). Basic Properties of Soil of Bhaktapur Pottery, *International Journal of Science and Engineering Investigations*, vol 7, (78), pp.75-78, ISSN:2251-8843

Tucker, C. M. (2010). “Private Goods and Common Property: Pottery Production in a Honduran Lenca Community”, *Human Organization*, Vol.69 (1), pp 43-53