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Assessment of indegenious knowledge and practices on the use of clay among rural communities in Meru, Kenya

Felicity Kaari Mwiandi *, Ochieng Ombaka

Department of physical sciences, Chuka University, P.O Box 109-60400, Chuka, Kenya

Abstract

A survey was conducted to ascertain the clay applications and its health effects on humans among the rural communities. Household survey, focus group discussion and direct observation were employed. A structured questionnaire with reliability coefficient of 0.82 was used to collect data. Majority of respondents were male (51.2%) aged 21 to 40 years, had primary education (32.2 %), monthly income below Ksh.5,000 (69.0 %) mainly from farming (47.1 %) and brickmaking (31.6 %); and less than 10 years (38.5 %) in clay production. Traditional applications of clay were pottery (81.0 %), brick making (55.7 %), cooking jikos (94.9 %) and plastering walls / floors (70.1 %). Food cooked from clay pots was perceived to taste different from those prepared using conventional utensils (91.3%). Most respondents (79.8%) ascertained that, they experienced skin irritation during clay production processes. The study findings give an insight of existing traditional clay applications. Furthermore it forms the basis on which the probable clay minerals in the study area can be explored for modern applications.

Keywords: Indigenous Knowledge; Clay; Rural Communities; Traditional Practices; Modern Applications

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* Corresponding author. *E-mail address:* ombakaochieng@gmail.com

1. Introduction

Indigenous knowledge is unique knowledge rooted in a particular community, which facilitate communication and decision making, in solving problems and other numerous activities in a particular ecosystem. It can be reproduced, discovered, lost, learnt through repetition and transferred orally from one generation to another in hereditary form (Esmael and Fatemah, 2011). It tackles several areas which include: natural phenomena, animals, plants, development, health, agriculture, architecture, cottage industry, education, soil sciences and use of appropriate technologies in resources utilization. The practical example is the indigenous soil classification system which is based on the texture, colour, structure and depth (John, 2005). The indigenous farmers among Suba people in Kenya uses the colour and the ratio of clay, sand or decayed matter in determining the soil fertility. The red soil with high percentage of sand containing some decayed matter is taken as moderately fertile, black soil with high percentage of decayed organic matter is regarded as having high fertility while white soil with low decayed content is infertile. Apart from soil degradation, this is in agreement with scientific measures of soil fertility. This observation can be used as a baseline data for comparison of pre- and post- development soil samples and thereafter, appropriate monitoring and soil rehabilitation procedures can be implemented to reverse the damage in case there has been degradation in soil quality (G'Nece, 2012).

The development activities which take into account the indigenous knowledge at the time of designing and implementing stages of various processes will have a positive impact to the people in rural communities and will have taken care of their needs, problems and circumstances hence owning the entire process. The identification, studying, documenting, and utilization of the indigenous knowledge systems will greatly improve the quality of the peoples life due to the fact that, the techniques which are likely to be used will be simple, cheap, and easy to implement by the rural community; for example, utilizing clay material and other locally available materials in making water filter to provide clean water leads to reduction of waterborne diseases among people in rural community. This implies that, if traditional techniques are integrated with modern developments towards sustainable management of various problems in the community, improved livelihood can be achieved.

Documenting and applying indigenous knowledge in various development activities in the community can enhance food security, revitalize agriculture, improve health and promote a sense of cultural pride within the community (Kudzayi, et al., 2013). The scientists and pharmaceutical companies searching for new drug sources due to growth of drug resistance which have rendered several antibiotics and other lifesaving drugs useless are increasingly turning their eyes to traditional medicine. This will involve the use of indigenous knowledge to pinpoint promising plants for new medicines and screening plants as efficient strategy (Adeel et al., 2013). The best example of the major triumphs which have stoked interest in traditional medicine is the use of artemisinin to treat malaria.

Different colours of clays (red, white, yellow) and their corresponding shades with other natural substances like plants and animal extracts were employed by different indigenous communities like Maasais' in Kenya in preparation of cosmetic to meet their needs. This was mainly for protecting the skin against ultraviolet radiation, skin cleansing, skin lightening, hiding skin imperfections and emphasizing the beauty of

specific parts of the body (Matike, et al., 2010). The indigenous knowledge on cosmetic clays is thus instrumental and sheds light on new techniques which incorporates tradition and modern methods to develop improved cosmetics. The rural Luo people in Kenya store untreated drinking water in locally molded wide mouth clay pots which have evaporative cooling effect on the water. This water can lead to numerous diseases depending on the contamination source and leaching of impurities like heavy metals which could have been present in clay materials used to make pots. A technology which relies on the community indigenous knowledge can be developed for designing and making of the modified clay pots which include the treatment stages using locally available materials before being stored and accessed (Karim and Jun, 2002).

The production of bricks, pots and other ceramic products are amongst the range of indigenous arts and crafts the rural Meru people in Kenya have engaged in since ancient time. The designated factories and sites does not exist and individual homes are used to practice these arts and crafts hence there is no regular business given to a store, restaurant or public services by person or groups. The literature reviews shows that, there is very little if any documented literature pertaining indigenous knowledge on clay. It's of paramount importance to establish the indigenous knowledge on application and consolidate the traditional knowledge that exist regarding various aspects of clay with objective of incorporating them in future during development activities. The aspect of great concern are: current applications of clay in the study area, sources of information about clay applications, ceramic production challenges and possible solutions, economic benefits and possibility of health effects of clay materials from the study area. These findings will pave way for intensive study on clay and its potential applications that will enhance optimal mining and utilization of clay resource in Meru County. This study is therefore aimed at investigating the indigenous knowledge that local communities in Meru County have on above mentioned issues, which will offer a platform for further research.

2. Materials and methods

2.1. Study area

Informal survey was conducted between September and December 2015 covering three administrative Sub locations in three sub counties (Kianjogu in Imenti South, Igane in Imenti Central and Kunati in Imenti North) of Meru County, Kenya. The study area was chosen because of the presence of clay deposits which were known to have historical use by local communities. The study sites GPS locations are as follows: Kianjogu (S 00° 09.150' E 037° 40.131'; 1255 m), Igane (S 00° 07.230' E 037° 35.171'; 1126 m) and Kunati (N 00° 05.177' E 037° 55.071'; 898 m). The area has a population of 13,840 persons (KNBS, 2009). The region has a bimodal rainfall distribution pattern with the long rains falling between March and May and the short rains between October and December. The average rainfall ranges between 500 and 2600 mm per year. The ambient temperatures range between 14°C and 33°C, with the lowest temperatures being in July and the highest in February. Geologically, the County can be separated into volcanic and basement system rock soils. Volcanic soils are derived from volcanic parent material from Mt. Kenya, and consists mainly of well drained, very deep, red and friable clays (nitisols, andosols, and acrisols). Soil developed on basement system rocks are somewhat

excessively drained, shallow to deep, red, friable to firm loamy sand and clay (luvisols, cambisols and lithosols. In the bottom lands, moderately well drained to imperfectly drained soils occur (vertisols and gleysols), (Macharia, 1989). People living on the western side (nearer Mt Kenya) grow tea and coffee due to higher rainfall and suitable soil conditions. On the eastern side (where most clay sites are found) people tend to grow food crops such as millet, sorghum, cassavas, maize and beans, that can withstand low rainfall and high temperatures common in the area. Among these crops, sorghum and millet do better than other crops. They also grow tobacco as the only cash crop on small scale and rear livestock. The vegetation of eastern region where the clay sites are found is adapted to the prevailing arid conditions by having thorns, spongy piths, deciduous trees and shrubs.

2.2. Sampling design

The study adopted a descriptive research design since the intent was gaining broader understanding of the contest of the research and processes being enacted. According to Kombo and Tromp (2006) the purpose of descriptive research is to describe the state of affairs as it exists. Three complementary methods were employed in collection of primary data; household survey, focus group discussions and direct observations (Nderi et al., 2014). Household survey was conducted using simple random sampling method to obtain representative primary data. For group discussion participation, purposive selection was done on respondents in the same age bracket, since their experiences and exposure periods on clay were similar. Selection of these groups was based on information provided by the community leaders. More information was obtained by the interviewer through direct observations and documented as field notes.

2.3. Data collection and analysis

A total of 174 structured questionnaires were randomly administered to capture the primary data. Data collected included gender, age, education, household size, monthly income and their sources, sources of information related to clay, organization membership and training, uses of clay, health effects and challenges encountered during clay applications. The questionnaire was designed based on review of related literature and objectives of the study. Face validation was carried out by administering the questionnaire to a small section of the respondent in the county. This group did not participate in the actual study. The questionnaire had reliability coefficient of 0.82. All the data collected were analyzed using Statistical Package for Social Sciences (SPSS) version 17.0 for percentages, standard deviation and analysis of variance (ANOVA) test for significance of association between local communities' demographic characteristics and their clay applications.

3. Results and discussion

3.1. Socio-demographic characteristics of the respondents

Table 1 summarizes the distribution of socio-demographic characteristics of the respondents based on gender, age, education, and household size.

Table 1. Distribution of respondents gender, age, level of education and household size (n =174)

Study site	Kianjogu (%)	Igane (%)	Kunati (%)	Total (%)
Gender				
Male	46.2	57.4	50.6	51.2
Female	53.8	42.6	48.4	48.8
Age (years)				
<20	6.2	6.4	1.6	4.6
21 – 40	27.7	27.6	27.4	27.6
41 – 50	18.5	23.4	29.0	23.6
51 – 60	23.0	14.9	25.8	21.8
>60	24.6	27.7	16.2	22.4
Education				
None	4.6	0.0	4.8	3.4
Primary	24.6	38.5	35.5	32.2
secondary	30.8	31.7	24.2	28.7
A-level	15.4	12.8	11.3	13.3
College	21.6	17	24.2	21.3
University	3.1	0.0	0.0	1.1
Household size				
<3	7.7	38.3	17.7	21.3
4 – 6	78.5	42.6	38.7	53.1
7 – 10	0.0	0.0	6.5	2.2
>10	0.0	0.0	0.0	0.0
No response	13.8	19.1	37.1	23.4

In total, one hundred and seventy four questionnaires were returned, of which 51.1% were male and 48.8% female. The mode age of participants was 37 years with highest percentage of respondents 27.6% (male 33.7%, female 21.2%) being in the age group of 21-40 years. This was followed by the group aged between 41-50 years with percentage of 23.6% (male 22.5%, female 24.7%). The lowest percentage 4.6% (male 4.5%, female 4.7%) were from age group of less than 20 years. The highest percentage of female respondents (53.8%) were from Kianjogu, with 28.6% aged >60 years, while majority of male (57.4%) were from Igane, of which 37.0% aged 21-40 years. The female aged < 20 years from Kunati did not participate in the interview. Of the participants who responded to the education level question, 32.3% (28.1% male, 36.5% female) had not received any formal education, 21.2% (23.6% male, 18.8% female) had primary education, 28.7% (29.2% male, 28.2% female) reached secondary level, 3.4% (2.2% male, 4.7% female) had completed A-level

education,13.2% (14.6% male, 11.8% female) had attained college education and 2% (2.2% male, 0% female) were educated up to university. Out of the 174 respondents, 31.0% (male 32.6%, female 29.4%) had a small family of less than 3 while 0.6% (male 1.1%, female 0.0%) had family size of over 10 members. 37.6% (male 27.0%, female 48.2%) of the total participants did not respond to the question of household size, with higher proportion of male (31.3%) and female (55%) being from Kunati and Igane respectively. The highest percentage (40%) of male respondents were from Kianjogu with family size of less than 3 while 40% of female respondents were from Igane and Kunati with family size of <3 and 4-6 respectively.

3.2. Socio-economic characteristics of respondents

Table 2 shows the socio-economic characteristics of respondents in terms of the major sources of income, monthly income and duration of pottery/ brick making.

Table 2. Distribution of respondents according to monthly income, major source of income and duration of pottery and brick making (n = 174).

Study site	Kianjogu (%)	Igane (%)	Kunati (%)	Total (%)
Major source of income				
Pottery	7.7	36.2	9.7	16.1
Brick making	0.0	19.1	74.2	31.6
Employment	0.0	0.0	0.0	0.0
Business	13.8	0.0	0.0	5.2
Farming	78.5	44.7	16.1	47.1
None of above	0.0	0.0	0.0	0.0
Monthly income in Ksh				
≤ 5,000	73.8	87.2	50.0	69.0
5,001 – 10,000	24.7	12.8	50	30.5
10,001 –20,000	1.5	0.0	0.0	0.5
20,001-50,000	0.0	0.0	0.0	0.0
>50,000	0.0	0.0	0.0	0.0
Duration of pottery and brick making (year)				
≤ 5	4.6	19.1	38.7	20.7
6-10	3.1	19.1	32.3	17.8
>10	0.0	17.0	14.5	9.8
Not applicable	92.3	44.7	14.5	51.7

The results from this table revealed that, majority 47.1% (40.4% male, 54.1% female) of the respondents relies on farming as a major source of income, while 31.6% (40.4% male, 22.4% female) engages on brick making for survival. The percentage of the respondents obtaining their income through pottery and business was found as 16.1% (12.4% male, 20.0% female) and 5.2% (6.7% male, 9.0% female) respectively. In terms of

sex, the percentage of male was higher in brick making and in business, while that of female was higher in pottery and farming in overall. Comparing the three regions, the major occupation of respondents in Kianjogu, Igane, and Kunati was farming, pottery and brick making respectively. 69% (61.8% male, 76.5% female) of the respondents belonged to households with monthly income of ≤ Ksh 5,000, 30.5% (37.1% male, 23.5% female) of the households had an income of ksh 5,001-10,000, and 0.6% (1.1% male, 0% female) had an income of ksh 20,001-50,000. Higher proportion of female respondents in comparison to males from Kianjogu, Igane, and Kunati belongs to households with monthly income of ≤ ksh 5000 while more males comes from the households with monthly income of ksh 5001- 10000. These results revealed that the general income is below the Kenya national average of Ksh 31,381 (KNBS, 2016). The result of survey showed that 20.7% (21.3% male, 20.0% female), 17.8% (23.6% male, 11.8% female) and 9.8% (7.9% male, 11.8% female) of the respondents had ≤ 5, 6-10 and >10 years of pottery/ brick making experience respectively. Male respondents from Kunati with ≤10 years' experience in pottery/ brickmaking were dominant over the females including males from the other two regions.

Age of the respondents is associated with aspects of self-development and the degree of maturity in solving problems hence it becomes essential when analyzing the responses. A large number of respondents were young people falling in the age group of 21-40 years which demonstrated that, they were ready to take health risks associated with clay in learning how to prepare various clay products for their entrepreneurship (Selvaraj, 2016). The percentage of aged people above 60 years who were more knowledgeable and experienced in clay were relatively lower and were responsible for passing traditional knowledge related to clay to young ones as demanded by traditional culture. The respondents' attitudes, visualization, and understanding of any particular social phenomena is related to education level of respondents. The majority of respondents were young and had no formal education which implies that, they were likely to have difficulties in decision making and adopting to new technology in relation to clay products when anticipating lifespan within which to invest in modern clay technology with hope of making maximum profit out of it (Ugwaja et al., 2011). They will continue with the old traditional way which will result to low quality products of clay and in return low profit income. The size of the family is an issue of concern to the nation as a whole for it can contribute to poverty and health problems (Jones, 2005). Large number of respondents had a smaller family size of ≤ 3 which shows awareness of the problems associated with large families. This could be attributed to Birth control campaign, increase of marriage age of couples and grown up children separating from their parents hence reducing household size.

The analysis reveals the dominance of female gender over the male in farming and pottery occupation in the study area. This trend on farming had been reported earlier by Adu et al. 2003 concluding that, majority of labour force in agriculture production is contributed by women. It is therefore appropriate to provide women with modern method of farming to boost their production in agriculture hence improving their standard of living. The higher value of respondents in the farming supports the fact that farming serves as source of livelihood enhancement and is used to supplement family income for a number of families in the study area. The number of women were more than that of males in pottery making. This findings is in line with that of Edem (2016) in which the practice of pottery is done by the women folk and they are responsible for formulating the business of trading with products of pottery. The number of male respondents involving

themselves in brickmaking was much higher than that of their counterpart. This implies that men engages in more risky activities than do women. The dust from bricks can contribute to a serious health threat and also emission of huge quantity of toxic elements from brick kilns is also a threat to human life (Love et al, 1999). This clearly shows why women were not given this role traditionally. This study is consistent with the findings of Will (2000). The majority of respondents have been engaged in clay related activities for not more than 10 years. This is an indication of them not having much experience in clay work which can translate to using trial and error methods when applying indigenous knowledge to prepare clay products hence inconsistency in their products which can lead to rejection by customers.

The economic conditions of an individual is determined by the income the person gets and it has a bearing effect on the responses about an issue posed to that individual. This study revealed that majority of respondents earn a monthly income below or equal to Ksh. 5,000. This indicates that their standards of living are not good and the possibility of taking risks in the large enterprises is very low. It further indicates that the work of clay attracts mainly low earning individuals and itself also does not pay off good money which might also reflects that the clay products from the region is not of high quality. This can affect county government policy in a number of issues such as taxes.

3.3. Organization membership and training results

The survey sought to establish the existence of clay organizations and membership by clay miners training facilities in those organizations and other avenues. Responses were as shown in Table 3.

Table 3. Respondents response on organization membership and training (n=174)

Variable	Yes	No
Are you a member of any ceramics organization?	8.6	91.4
If yes does the organization offer you training?	0.0	100.0
Have you ever received training on manufacture of clay products anywhere?	40.2	59.8

Close look of this table reveals that 8.6%, 0.0% and 40.2% of the respondents were members of ceramics organization, not trained by the organization and trained from fellow local people or tourist who visits these sites respectively.

Table 4. Uses of clay products made after receiving training (n = 174)

Variable	%
Commercial	39.08
Personal use	0.57
Decoration	6.9
Not applicable	53.45

The survey also pursued to find out whether the knowledge acquired through training had a positive impact to the trainees. The results obtained are summarized in Table 4. 39.08%, 0.57% and 6.9% of the respondents use the knowledge obtained from clay for making clay products for commercial purposes, personal use and decoration respectively. 53.45% did not put the training into practice.

Clay organization can assist to develop innovative strategies, training and creativity that result in systemic change and help people become economically secure through the improved quality of various clay products. This can narrow the gap in terms of wealth between the rich and the poor provided it's designed according to the needs of the community (Raja et al., 2011). The success of this will depend on the organization culture, it's ability and also how it's leaders cope up with the change and how they encourages innovation. Further training people who have most interest and confident of their abilities will make them to become change agents enthusiastically promoting new innovations learnt to the rest of people (Fahri, 2007).

The ceramics organization in the study area only facilitate the marketing of the products and do not conduct any innovative training pertaining to ceramic products which could translate to creativity among community members. This could have contributed to low percentage of members from the community joining the organization. Another reason could be that, the community do not see the benefits of being members, since there are several avenues of marketing regardless of the prices. Despite the fact that a commendable respondents had received training from fellow people from community and tourist, the clay industry has not taken roots in the study area and this can be associated with the absence of forum for follow up and feedback. Additionally, some of the people involved in training might not have incorporated indigenous knowledge with the modern one making the trainees not to have interest hence inability to act as a change agents in promoting new technologies learnt.

Sizeable number of respondents which are almost comparable with the number of respondents who received training are involved in commercial production of ceramic products after training in order to reduce poverty and increase the security of livelihoods (Kathleen and Chris 2009). The diverse challenges of the rural people in the study area includes making ceramic products free of toxic substances, lack of innovative and creativity, inability of incorporating indigenous knowledge in modern technology, lack of proper methods of marketing products, making products which can compete with other similar products. These challenges can be overcomed by rural people continuing to receive training for improving their skills and being provided with necessary facilities. These sizeable numbers of respondents participating in making ceramic products for commercial is therefore associated with little training they received.

The low percentage of the respondents who uses clay products for personal use and for decoration could be associated with continuing penetration of the products manufactured using modern technology in rural areas.

3.4. Sources of information about clay and clay manufactured products

The study used a 5-point rating scale, 1 (Strongly disagree), 2 (Disagree), 3 (Neither agree nor disagree), 4 (Agree) and 5 (Strongly agree) to establish the degree of agreement or disagreement on sources of information about clay and clay related products in the area. The percentages and standard deviations were generated from

SPSS and are illustrated in Table 5. From study findings majority of respondents agreed that they obtained information from relatives and friends (50.0 %) while 51.7 % got it from other miners. Few respondents (0.6 %) said they obtained information from extension officers. All respondents did not get information from radio, television, newspapers, posters and internet.

Table 5. Distribution of respondents according to degree of agreement or disagreement on sources of information about clay and clay products (n=174)

Information source	Strongly disagree (%)	Disagree (%)	Neutral (%)	Agree (%)	Strongly agree (%)	Standard deviation
Radio	100	0.0	0.0	0.0	0.0	0.0
Newspaper	100	0.0	0.0	0.0	0.0	0.0
Television	100	0.0	0.0	0.0	0.0	0.0
Posters	100	0.0	0.0	0.0	0.0	0.0
Extension officer.	76.4	22.4	0.6	0.6	0.0	0.44
Relative/ friends	0.6	47.7	1.7	50.0	0.0	0.546
Internet	100	0.0	0.0	0.0	0.0	0.0
Clay miners	1.7	41.4	5.2	51.7	0.0	0.616

This implies that traditional knowledge is the main source of information among clay workers in Meru County. This could be attributed to the fact that clay industry in the region has not been well explored and documented; thus, it's not in public domain to be disseminated by other forms of media. A lot of information is available in the internet but none of the respondents was aware an indication of low exposure to modern technology and high level of ignorance. The standard deviation varies from 0 to 0.616 indicating that the responses did not vary to great extent.

3.5. Clay applications in Meru County

The study used a 5-point likert scale, 1 (Strongly disagree), 2 (Disagree), 3 (Neither agree nor disagree), 4 (Agree) and 5 (Strongly agree) to establish the respondents degree of agreement or disagreement on various clay applications in the area. The percentages and standard deviations were generated from SPSS and are illustrated in Table 6. Results revealed that majority of respondents use clay for brickmaking (55.7 %), plastering walls and floors (70.1 %), pottery (81.0 %) and making cooking jikos (94.9 %). All respondents did not use clay for making detergents, pesticides, cosmetics, water purification, oil drilling, making tooth pastes, oil and sugar refining, making animal feed additive, sealing water reservoirs, agrochemical making, fillers in textile and paper industry and catalyst in petroleum production. Figure 1, 2, and 3 demonstrate some of the major applications revealed in the survey.

Table 6. Distribution of respondent according to degree of agreement or disagreement on clay applications in the region (n =174)

Variables Clay application	Strongly disagree (%)	Disagree (%)	Neutral (%)	Agree (%)	Strongly agree (%)	Standard deviation (%)
Medicine	91.4	8.6	0.0	0.0	0.0	0.281
Brickmaking	27.6	10.9	5.7	33.9	21.8	1.351
Plastering floors and walls	0.0	14.9	14.9	38.5	31.6	0.923
Decoration	36.8	23.0	1.7	12.6	25.9	1.121
Pottery	0.0	19.0	0.0	58.6	22.4	0.644
Refrigeration of drinking water	12.1	41.4	44.3	2.3	0.0	0.721
Storage of cereals	81.0	17.8	0.6	0.6	0.0	0.46
Cooking jikos	0.0	5.2	0.0	48.3	46.6	0.529
Manufacture of pesticides	100.0	0.0	0.0	0.0	0.0	0.0
Making detergents	100.0	0.0	0.0	0.0	0.0	0.0
Making cosmetics	100.0	0.0	0.0	0.0	0.0	0.0
Water purification	100.0	0.0	0.0	0.0	0.0	0.0
Oil drilling	100.0	0.0	0.0	0.0	0.0	0.0
Making toothpaste	100.0	0.0	0.0	0.0	0.0	0.0
Sugar and oil refining	100.0	0.0	0.0	0.0	0.0	0.0
Animal feed additive	100.0	0.0	0.0	0.0	0.0	0.0
Sealing water reservoir	100.0	0.0	0.0	0.0	0.0	0.0
Agrochemical	100.0	0.0	0.0	0.0	0.0	0.0
Fillers for textile	100.0	0.0	0.0	0.0	0.0	0.0
Paper industry	100.0	0.0	0.0	0.0	0.0	0.0
Catalyst in petroleum industry	100.0	0.0	0.0	0.0	0.0	0.0

Figure 1. Pot making at Igane site in Igane sub location, Meru County, Eastern Kenya

Figure 2. Brickmaking at Kunati site in Kunati sub location, Meru County, Eastern Kenya

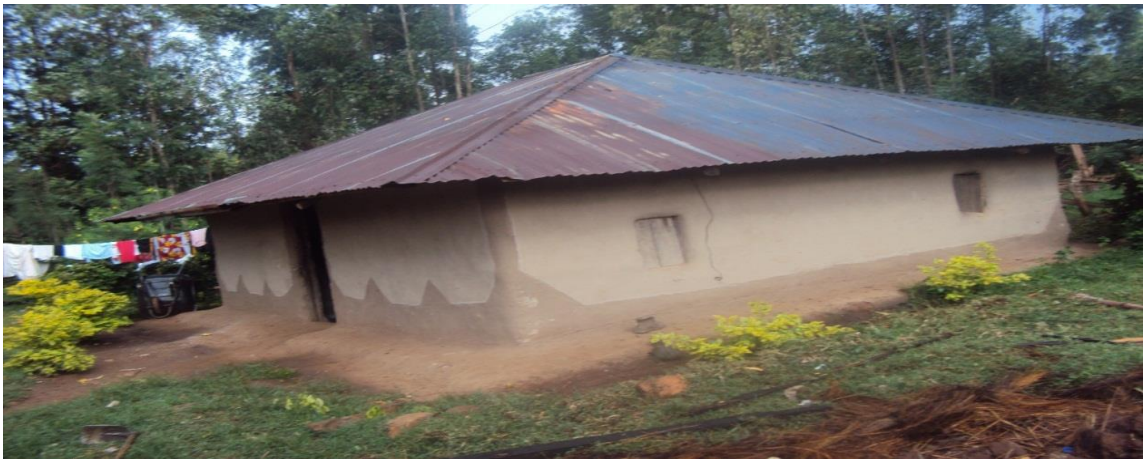

Figure 3. Wall plastered with clay near Kianjogu site at Kianjogu sub location, Meru County, Eastern Kenya

This is an indication that traditional applications have taken roots and residents are ignorant of other advanced technological applications. These applications might also suggest that the clay mineral present in the study area is kaolinite. The standard deviation ranging from 0 to 1.351 demonstrated that resident's view on extent of various clay application did not vary so much hence their responses were similar.

The other possible applications not captured in the questionnaire that the respondents gave were as shown in Table 7.

Table: 7. Distribution of respondent's views on other uses of clay in the region (n = 174)

Variables	%
Farming	43.3
Fishpond liners	48.6
Modelling	8.1
No other application	0.0

The survey revealed that 48.6 % uses the clay for lining fish ponds. This ensures retention of water to the expected levels for longer periods because clay prevents water seepage by creating impermeable layer which do not allow water to pass through. Many respondents (43.3%) used clay soils for farming by spreading it in their vegetable gardens to boost their growth. This indicates that, the clay materials in the study area have nutrients required for plant growth. The clay could be containing macro nutrients like phosphorous, potassium or Illite mineral that is rich in potassium. Meru County is not an isolated case in clay applications. Several other parts of the country also embrace traditional as well as modern applications. For instance, clay in Nyanza is traditionally used for pottery; however the NGO care Kenya has trained pottery groups to make modified version of traditional wide mouthed clay vessel, that is, making clay pots with small mouth and a tap at the bottom for storage of drinking water. The modified version prevents dipping of containers into the water, thus, minimizing stored water contamination routes (Michael, 2005). Also, clay found in mukurwe-ini, Nyeri County, is used for ceramic production (Wachira and Andala, 2015).

3.6. Relationship between gender, education level and clay applications

The study sought to establish the relationship between gender and clay applications. Analysis of variance was performed with null hypothesis that, there is no significant relationship between gender and pottery / brickmaking at $p \geq 0.05$. Pottery and brickmaking were chosen randomly amongst major clay applications. Results in Table 8 on one way ANOVA between gender showed that, there is no statistically significant difference in applications between men and women on brickmaking $F(1,172) = 2.326$, $p > 0.058$ and pottery $F(1,172) = 0.843$, $p > 0.5$. Therefore, we retain the null hypothesis and conclude gender has no influence on pottery and brick making.

Table 8. Analysis of variance on gender and clay applications

		Sum of Squares	df	Mean Square	F	Sig.
brickmaking	Between Groups	3.526	1	3.526	2.326	0.058
	Within Groups	312.112	172	1.815		
	Total	315.638	173			
pottery	Between Groups	0.670	1	0.670	0.843	0.500
	Within Groups	71.123	172	0.414		
	Total	71.793	173			

Similarly one way ANOVA between different levels of education with null hypothesis that, there is no significant difference between education level and pottery / brickmaking at $p \geq 0.05$ was sought. Results (Table 9) showed that there was no statistically significant difference in application between educated and uneducated respondents on brickmaking, $F(5,168) = 1.341$, $p > 0.249$ and pottery, $F(5,168) = 0.346$, $p > 0.885$. Therefore, we retain the null hypothesis and conclude that education level has no influence on clay application.

Table 9. Analysis of variance on education level

		Sum of Squares	df	Mean Square	F	Sig.
brickmaking	Between Groups	12.117	5	2.423	1.341	0.249
	Within Groups	303.521	168	1.807		
	Total	315.638	173			
pottery	Between Groups	0.731	5	0.146	0.346	0.885
	Within Groups	71.062	168	0.423		
	Total	71.793	173			

3.7. Health effects of clay

The study strived to establish whether the respondent health was affected by the interactions with clay. As shown in Table 10, majority (79.8 %) said they experience skin irritations upon prolonged exposure to clay during the kneading / wedging process since they do it manually, while 20.2 % complained of irritation and coughing upon inhalation of clay dust. About 91.3 % reported that food cooked from clay pots tasted differently from food prepared using utensils made from other materials. However very few (11.6 %) reported of stomach upset on taking food from clay pots.

These could be brought about by the constituent of clay material used in pottery. The hypersensitivity of the skin may result when working on the clay that has been aged in dump places till molds develop. Also, hand contact with wet clay can result in abrasion and dryness of fingertips and hands which may results to irritation.

Table 10. Effects of interactions with clay on human health (n = 174)

Variable	Yes	No
Do you experience any effect on the skin when interacting with clay?	79.8	20.2
Does the clay dust affect you in any way after inhalation?	20.2	79.8
Is food prepared from pots made of clay taste different from food prepared from other kind of utensils?	91.3	8.7
Are there people who complain about stomach upsets when they take food prepared from clay pots?	11.6	88.4

Clay is composed of hydrated aluminum silicates, often containing large amounts of crystalline silica and other metal oxides. The crystalline silica can cause scarring of lungs (silicosis) and is carcinogenic. Its main symptoms includes shortness of breath, dry cough and high susceptibility to lung infections like tuberculosis. Therefore, the irritation and coughing among clay workers could be contributed by presence of silica in clay dust. Silicosis is an incurable occupational lung disease caused by breathing dust containing crystalline silica. One can develop chronic silicosis if exposure is low but frequent. This may show symptoms after 10 years. When exposure levels are increased an individual acquires accelerated silicosis whose symptoms appears within 5-10 years. For those exposed to crystalline silica dust of extremely high levels acute silicosis affects them within a few weeks. However, only a chest x-ray, lung function test, sputum analysis and lung biopsies can determine whether one has silicosis (OSHA, 2002). A report of Meru county-health policy project (2015) revealed that, out of 100,000 people, 117 were confirmed of having lung infections. There is a possibility that clay dust among other factors could be the predisposing factor. This can be prevented by eliminating inhalation of clay dust that is rich in silica, that is, silica levels greater than 0.1mg/ $m^3$of air averaged over an 8 hour period (Thygerson et al,. 2016).

The variation in taste of food cooked from clay pots could be brought about by constituents' clay elements leaching into food from the pots, for example, presence of iron and manganese in high concentration causes metallic tastes, changes in colour and flavor of food. Thus, probable presence of such elements could have led to changes in organoleptic characteristic of food made from clay pots from the study area. Leaching of contaminants or heavy metals to food from cooking pots, which exceed the recommended dietary allowance (average daily level of intake), causes health problems. Some may cause symptomatic stomach upsets, example, excess zinc, others may not cause stomach upsets yet causes a lot of poisoning, example, lead. Research have shown that locally made clay utensils can be a potential source of heavy metal poisoning. For instance, in Nigeria, a study on locally made utensils as potential source of heavy metals contamination of water destined for cooking purposes, indicated presence of leached heavy metals in water after boiling in these pots (Lar et al., 2014). The sources of these heavy metals are linked to composition of rocks from which clay raw material are derived (Alper-Baba et al., 2008; Lar et al., 2014). Craft potters do not have a way of quality control and therefore poisoning of heavy metals could be the cause of stomach upsets (Ojekale et al., 2013)

3.8. Challenges and solutions in the local ceramic production

All respondents experiences breakages of ceramics at various stages of their production (Table 11). Majority (75.7 %) did not have a precise way of minimizing these breakages. However, 24.3% had traditional ways of minimizing them. This could have been reached through trial and error experiences by great grandfathers. Most of the respondents (65.9%) had specific clay site they did not prefer for ceramic making. This might have been contributed by the quality of the products they once obtained and drew a general conclusion that the site were not good for their local ceramic production.

Table 11. Challenges in ceramic making (n = 174)

Variable	Yes	No
Do you experience breakages of pots during manufacturing process?	100.0	0.0
Do you have a way of minimizing these breakages?	24.3	75.7
Are there sites in the area not preferred for pottery and brick making?	65.9	34.1

As shown on Table 12, majority of the respondents (75.7 %) reported that they experience breakages during firing, 20.2 % before firing and 4.0 % after firing. However, 6.8 % of respondent reported that strong firing (maintaining high temperatures for a long period by ensuring constant supply of firewood) gave them durable products and 17.5 % said that slow drying under shade reduced breakages before firing.

Table 12. Challenges and possible solutions of ceramic production (n =174)

Variable	%
When is the breakages of clay products experienced	
Before firing	20.2
During firing	75.7
After firing	4.0
How do you minimize these breakages?	
Not applicable	75.7
Strong firing	6.8
Drying under a shade	17.5
Why are some sites not preferred for pottery and brick making?	
Not applicable	34.1
Products easily break	11.6
Very sandy	35.3
Lots of pebbles	19.1

This concurs with the scientific findings that, most breakages before firing are caused by poor handling and drastic drying process like exposure to intensive sunlight. During firing, quartz inversion and drastic changes in temperature may have led to breakages. Quartz inversion involve changes in volume of quartz at a temperature of about 570^{o}C, that is, increase in volume during rise in temperature and reverse during cooling (Anna, 1956; Sedat et al., 2006). After firing, calcareous inclusion or lime blowing and dunting may be the major cause of products disintegration. Dunting involve cracking of clay products when cooled drastically. Lime

blowing is a post firing defect taking the form of small spalls pushed out of the walls of vessels containing calcareous inclusions. When fired above 750°C, $CaCO_3$ is converted into CaO which when cooled absorbs atmospheric water to form $Ca(OH)_2$ leading to increase in volume that forces flakes out of the surface of fired clay hence breakages (Gibson and Woods, 1997). This can be reduced by firing at low temperature (below 750°C) or by adding common salt (Gibson and Woods, 1997).

The respondents who did not prefer clay from specified sites claimed that the sites are either too sandy (35.55%) or had lots of pebbles (19.1%) resulting to difficult manufacturing process or weak products. Presence of sand and pebbles reduces the quality of clay which leads to poor quality ceramic products (Michael, 2005).

4. Conclusions

The survey revealed that, major clay applications in the study area are pottery (81.0 %), brick making (55.7 %), plastering walls and floors (70.1 %) and making of cooking jikos (94.9%). Most respondents have a monthly income of less than Ksh.5000, whose source is mainly farming (47.1 %), brickmaking (31.6 %) and pottery (16.1 %). People rely on traditional practices of getting information about clay and clay products, that is, from relatives / friends (50.0%) and other clay miners (51.7%). Majority of the clay miners are not members of any clay organization. The few organizations that are in place do not offer training facilities to their members. However, many embrace training from other avenues but rarely put knowledge acquired into practice. Clay and clay products in the region have some human health effects. Miners complain of skin irritation upon excessive kneading and wedging exposure, irritation upon inhaling clay dust, changes in organoleptic characteristics of food cooked in clay pot and stomach upsets upon taking these foods. The local ceramic production faces enormous challenges of breakages before firing, during firing and after firing; with majority of miners having no control measures. Use of clay is embraced by many and statistically there is no influence of gender or level of education on its applications.

5. Recommendations

Further indigenous knowledge on ceramic production techniques needs to be sought to ensure comprehensive information is acquired and establish its relationship with challenges encountered by potters. There is need for organized groups to be upheld since group peer pressure enforced by this approach is also an effective instrument for progressive development of the entire group.

Further research on other potential applications of the local clay and dissemination of knowledge to people involved needs to be employed to ensure adequate utilization of the resource that will benefit the locals to a greater extent.

The essential plant nutrients present in these clays that boost crop production needs to be established through further research. Once established the clay can be utilized as an alternative fertilizer to supply specific nutrients which will reduce the cost of crop production in the region.

Analysis of mineralogical, chemical and physical properties of clay soils in these sites needs to be done to establish causes of breakages, explain why some sites give poor quality products and changes in organoleptic characteristics of food.

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