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Indigenous knowledge and applications of clay among rural communities in western Kenya

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Abstract

A survey was conducted in Western Kenya involving 281 respondents to ascertain the clay applications and its health effects on human beings. Household survey, focus group discussions and direct observation were employed. A structured questionnaire with reliability coefficient of 0.88 was used to collect data and analyzed using SPSS. Majority of respondents were females (50.2%) aged 21 to 40 years, had secondary education (60.5%), monthly income was below Ksh.5,000 (63.3%), earned income mainly from brickmaking (59.4%), farming (21.0 %) and experience of 6-10 years in making clay products to earn a living (41.6%). Residents acquired information on clay from relatives/friends (31.7 %) and other farmers (34.2 %). They utilized clay mainly for brickmaking (54.8 %), plastering floors and walls (48.1%) and pottery (24.5%). Food cooked from clay pots tastes different compared to conventional utensils (70.0%). 43.3 % of respondents complained of skin irritation after prolonged exposure to clay material during clay handling. The study findings are significant as they unearth the indigenous knowledge of clay in the study area which will facilitate the researchers on understanding the basics of these clays as they explore advanced technological applications.

Keywords: Indigenous Knowledge; Clay; Communities; Clay Products; Health

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1. Introduction

Indigenous knowledge is defined as a set of information, perception and behaviors that guide the local communities in decision making at local levels (Slade and young 2014). It is formulated and maintained by local communities' members as a means to meet their needs for food, shelter, health, transcendental and investments. Indigenous knowledge is not passive but changes with changing ecological, economic and social-political situations based on the creativity, experimentation, experiences, innovations of the community members and as a result of influence of other cultures and advancing technology (Flavier et al., 1995).

There are two types of indigenous knowledge, that is, explicit and tacit indigenous knowledge. Explicit knowledge consist of facts, rules, relationships and policies that can easily be articulated, expressed, communicated and recorded in paper or electronic form and shared without need for discussion (Wyalt, 2001; Tikai and Kama, 2010). Tacit indigenous knowledge refers to the practical, action-oriented knowledge or knowhow based on practice, acquired by personal experience and arduous to express openly with words. It's difficult to extract it from minds of people thus seldom found in books because it's developed from mental models, individual emotions, values, beliefs, perceptions insights, observations, experiences and assumptions. It cannot easily be expressed or articulated to outsiders (Smith, 2001; Tavana, 2002).

Indigenous knowledge has unique characteristics; first, this knowledge is rooted to a particular set of experiences and generated by people living in specific geographical areas (Forsyth, 2013; Sen, 2005). Transferring it to other places runs the risk of falsifying it. Its distribution is usually fragmentary and doesn't exist in its totality in individuals but it's devolved in the practices and interaction in which people engage in. Secondly, it's orally transmitted or transmitted through imitations and demonstration which is a major contributing factor into retention and reinforcement of a culture's customs and traditions. Writing it down changes some of its fundamental properties (Kaniki and Mphahlele, 2002).

Indigenous knowledge is important for management of traditional communities in that it offers the basis for grassroots' decision making in ecological zones, natural resources, agriculture, aquaculture, forest and game management (Posey, 1995). It offers new models for development that are both ecologically and socially sound. Thus development activities that embrace indigenous knowledge have several advantages over those that operate outside them. For example, the reverting back to non-scientific polyculture (mixed cropping) from scientific monoculture. The characteristic of traditional polyculture that makes them desirable were ignored by agricultural researchers in developing countries with the introduction of green revolution concept. Monoculture technology could not address the food demands of many communities in these countries. In recent past the research on polyculture has greatly blossomed in efforts to address food issues and has shown great benefits since it's embraced by most communities as it tend to address their challenges as a result of utilizing indigenous knowledge and blending with modern technology. Polyculture is a sustainable farming that has prevailed in Sri Lanka for more than 2500 years with sustainable characteristics like diet diversity, diversified income generation, production stability, low pest and disease incidences, and intensification of production with limited natural resources and maximization of returns under low level of technology (Senanayake, 2006). Thus indigenous knowledge is important in designing modern development plans and policymaking. The integration increases the understanding of local to regional, biological and ecological

conditions and transition to more powerful decision making on the part of indigenous people (Krupnik et al., 2007). In Asia the integration of environmentally friendly and cost-effective techniques derived from indigenous knowledge such as building contour bunds, leaching the soil, green manuring, and natural compost manure helped in increasing the crop intensity from 37% to 200% and income of farmers by 60% in 5 years reducing in the same magnitude the migration of farmers (Prakash, 2002).

In many African communities, the use of differently coloured clays for cosmetic purposes is a common practice (Mpuchane et al., 2008). The wodaabe men of Niger use different clays for beautifying their faces during their annual gerewol festivals (Wood, 2000). The Himba of Namibia smear clay from head to toe to protect their skin from ultraviolet radiations (Nelda, 2004) and the Maasai of Kenya as well as the Xhosas of South Africa smear clays on their body for skin cleansing purposes (Ettagale, 1999). These practices that are based on indigenous knowledge have been going on for decades and are passed from one generation to another. In the Eastern Cape province of South Africa, the clayey soils are still widely used for cosmetic applications such as sunscreen, cleansing and body beautification by many communities. The cosmetic capabilities of clay are being exploited by many beauty parlors in the world. In these spas the colour of clay determines their application. For example, the yellow clay is used in some spas for prevention of bacterial infection, red clay is used for cleansing the skin, blue clay used against development of acne, green clay is applied to reduce amount of oil on the skin and black clay for general body nourishment (Ma'or et al., 2006). When scientific or modern researchers incorporate traditional knowledge on clay with modern technology the development of all-inclusive cosmetics from clay that finds greater acceptance is inevitable.

Making of ceramic object is at best partly a science and partly intuitive art. Without an intensive understanding of underlying theories concerning ceramic materials, potters are often left with myth and inaccurate information on forming techniques, glaze formulas and firing processes, leading to great losses during production process as a result of breakages. Local communities have various practices they employ in their local industries which when investigated through a survey can be developed to promote the local ceramics production.

The scope of this study survey was to establish the applications and possible health effect of clay found in Bokeire, Kadumo East, South East Kadianga and Tabaita sub-locations of Western Kenya. This survey will be distinctive in the study area since indigenous knowledge about clay applications as a natural resource has never been documented in the region.

2. Materials and methods

2.1. Study area

An informal survey was conducted between September and December 2015 covering four administrative Sub locations in western Kenya (Bokeire in Kisii County, Tabaita in Kericho county, Kadumo East in Homabay County and South East Kadianga in Kisumu County), where clay deposits are found in the region. The study area was chosen because of its indigenous clay deposits that have been used by local communities for ages.

The study sites GPS locations are as follows; Bokeire (S 00° 24.998' E 034° 01.518'; 1522 m), Kadumo East (S 00°24.584' E 034°59.942'; 1486 m), South East Kadianga (S 00°22.473' E 034°57.660'; 1576 m) and Tabaita (S 00°23.163' E 035° 01.235'; 1492 m) in western Kenya. The four counties have a population of 3 837 351 persons (KNBS 2009). The region has a bimodal rainfall distribution pattern with the long rains falling between March and June and the short rains between October and December. The average rainfall ranges between 480 and 2600 mm per year. The ambient temperatures range between 18°C and 29°C, with the lowest temperatures in July and the highest in January. The farmland soils are mainly red sandy clays, acrisols (ultisols); dark coloured loamy clays, ferralsols and nitisols (oxisols) which are highly weathered, (Okalebo et al., 2005; Ngome et al., 2013). The vegetation of the study area has mainly treed and swampy vegetation in some areas where clay deposits are found. Human activities include subsistence farming of food crops like maize, beans, bananas, cassava, groundnuts, and potatoes, with cash crops being tea, sugarcane, cotton, and pyrethrum. Fishing is done by communities in South East Kadianga and Kadumo East. Small-scale livestock keeping is also evident in the region.

2.2. Sampling design

The three complementary methods employed in collection of primary data were a household survey, focus group discussions and direct observations. Simple random sampling method was used for the household survey. According to Mugenda and Mugenda (1999) sampling is a process of selecting a number of individuals in such a way that the individuals selected represent the large group from which they are selected. The portions picked to form a sample and any statement made about the sample should be true of the population (Orodho, 2002). Purposive selection was done on local people in the same age bracket to participate in group discussion since their experiences and exposure periods on clay were similar. This facilitated faster agreements on the responses. The groups were selected based on information provided by the village elders. The research assistants collected more information based on direct observations and inquiries as they interacted with the local people. This information was documented in a field book.

3. Data collection and analysis

A total of 281 structured questionnaires were randomly administered to capture the primary data. Notice of the visit was not given to avoid an influence of the respondents by those that had taken part in the survey earlier. Data collected included gender, age, education, household size, monthly income, sources of income, sources of information on clay and ceramics production, uses of clay, health effects and challenges encountered during applications. Questionnaire design was based on a review of related literature and the objectives of the study. Face validation was carried out by administering the questionnaire to a small section of the local communities in the region who did not participate in the actual survey. All data were analyzed using Statistical Package for Social Sciences (SPSS) version 17 for percentages, standard deviation, and analysis of variance (ANOVA) test for significance of association, between communities' demographic characteristics and their perceptions on the clay applications.

4. Results and discussion

4.1. Socio-demographic characteristics of the respondents

The distribution of respondents based on gender, age, education and household size are summarized in Table 1.

Table 1. Distribution of respondents according to gender, age, level of education and household size. (n = 281)

Sub-location / Variable	Bokeire (%)	Kadumo East (%)	South-East Kadianga (%)	Tabaita (%)	Total (%)
Gender					
Male	51.2	52.9	46.7	46.8	49.8
Female	48.8	47.1	53.3	53.2	50.2
Age					
<20	3.3	31.4	33.3	9.3	14.9
21-40	72.3	47.0	33.3	64.5	59.8
41-50	16.3	15.7	13.3	22.1	17.4
51-60	8.1	3.9	11.1	4.1	6.0
>60	0.0	2.0	8.9	4.3	1.9
Education					
None	0.0	3.9	8.9	4.3	3.2
Primary	18.7	29.4	46.7	32.1	28.1
Secondary	75.6	54.9	35.6	53.2	60.5
A-level	0.8	0.1	8.9	3.1	2.5
College	3.3	7.8	0.0	6.5	4.3
University	1.6	3.9	0.0	0.8	1.4
Household size (number of person)					
<3	6.5	31.4	51.1	9.5	18.9
4-6	83.7	37.3	20.0	72.6	62.6
7-10	8.1	7.8	13.3	17.5	11.0
>10	0.9	0.0	2.2	0.0	0.7
No response	0.8	23.5	13.3	0.4	6.8

Out of the 281 respondents, 49.8 % were male and 50.2 % were female. The study revealed that women participated in clay mining slightly more than men. Women's participation in artisanal mining varies throughout the world. The percentage of female artisanal miners is the highest in Africa ranging between 40 and 50 %. In some places the workforce comprises of 60- 100% women (ILO, 1999; Onuh, 2002). Women plays a much larger role in artisanal mining than in large-scale mining sector (WMMF, 2000). Majority of respondents, 59.8 % (58.4% males, 61.2% female) were aged between 21 - 40 years, 14.9 % (19.0 % male, 10.8% female) were less than 20 years, 17.4 % (16.4% male, 18.4% female) between 41 - 50 years, 6.0% (4.2% males, 7.8% females) between 51-60 years and 1.9 % (2.0 % male, 1.8 % female) above 60 years. The age group (21 – 40 years) was the most active in all the study areas. The survey indicated that Bokeire had 72.3 %, Kadumo East 47.0 %, South East Kadianga 33.3 % and Tabaita 64.5%. This is the most energetic group in any community. This is supported by Mazzeo (2000) where he indicated that average muscle strength decreases

by roughly 10% per decade for age 20-60 years, by 15 % per decade for age 60-80 years and 30% per decade after 80 years. According to Jones (2005) most Nobel laureates do their most important contributions in their thirties. Also a survey by global entrepreneurship monitor on 34 countries indicated that entrepreneurship activities, a startup of new firms, or expansion of existing ones are mainly carried out by relatively young people with peak entrepreneurs activities found among individuals in the age 25-44 years (GEM Consortium, 2000). Backing up the young entrepreneur peak, Aubert et al. (2007) in a French study found out that the more innovative a firm is, the higher the wages of young employees relative to wages of other age groups. The participants in the clay activities above 50 years of age were dismal. This could be attributed to the fact that older people are less energetic and since clay activities are manual, it attracted fewer people in this age group (GEM Consortium, 2000). The high number (14.9 %) of clay workers below 20 years is a worrying trend as it indicates school dropouts who opt for ceramic activities and farming. Also, child labor is evident. According to the child labor analytical report of Kenya Bureau of statistic, the majority of working children were found in the agricultural and local mining sector (KNBS, 2009). Poverty is generally believed to be the most genuine argument to justify child labor (Basu and Van, 1998).

About 3.2 % (2.0 % male, 4.4% female) of respondents had no formal education. This was mainly witnessed among the people above 60 years old. About 28.1% (26.9 % male, 29.3% female) had attained basic primary education, and majority 60.5 % (61.7% male, 59.3% female) had attained secondary education. 2.5 % (3.5% male, 1.5% female) of respondents had A-level education, 4.3% (4.5% male, 4.1% female) had college education and 1.4 % (1.4% male, 1.4% female) had university education. Comparing the four regions, majority of the respondents had secondary education where bokeire was leading with 75% (82.1% male, 67.9% female), Kadumo East with 54.9% (55.2% male, 54.6% female, Tabaita with 53.2% (55.8% male, 50.6% female) and lastly S.E. Kadianga with 35.6% (37.5% male, 33.7 % female). This reveals that across the region most of those who have attained basic secondary education are the males. There is also an indication that majority venture in the clay industry after attaining basic education in the study areas. Low enrolment in tertiary institutions symbolizes few technocrats in clay ventures which greatly drag behind the development of clay industry. Additionally, clay miners with low education levels have their activities impacting negatively to the environment and its inhabitants due to environmental degradation resulting from low knowledge on environmental rehabilitation after the excavation of the clay materials. Sterling (2003) indicates that an ecologically literate society is a sustainable society which doesn't destroy the natural environment on which it depends. Whereas, an ecologically illiterate society can consciously or unconsciously undertake activities that adversely affect the environment.

Majority of households (62.6 %) had 4 – 6 members, 18.9 % had 3 members or less, 11.0% had 7-10 members, 0.7% had families with more than 10 members and about 6.8% of respondents did not respond to this question. A large number of children beyond 3 can be attributed to poverty in the region that leads to early school dropouts, hence, early marriages. Also, African traditional practices that embrace many children as a way of enhancing the workforce on the farm could play a great role in family fertility. Most African societies culturally need males to continue the family lineage in patriarchal societies. This male gender preference may influence the number of children born into a family as the parents strive to get a son (Tabitha and Clem, 2003). Those households with 3 members or less symbolized possibly the enlightened group, mainly, those that had

secondary education and beyond. Small families are influenced by changes in social- economic foundations which forces people to opt for small families they can afford to sustain. Also, the acquisition of western education, especially by women which has brought knowledge on health issues and disadvantages/dangers of early marriages, has greatly contributed to smaller families (De Hauw et al., 2016).

4.2. Social - economic characteristics of the respondents

The data on monthly income, major source of income and duration of pottery/brickmaking are summarized in Table 2.

Table 2. Distribution of respondents according to major source of income, monthly income, and duration of pottery and brick making (n = 281)

Sub location / Variable	Bokeire %	Kadumo East %	South East kadianga %	Tabaita %	Total %
Major source of income					
Pottery	26.0	11.8	15.6	1.6	16.4
Brickmaking	58.5	17.6	84.4	53.9	59.4
Employment	0.8	3.1	0.0	2.5	0.4
Business	0.8	11.8	0.0	0.8	2.5
Farming	13.1	55.7	2.0	41.0	21.0
None of above	0.8	0.0	0.0	0.2	0.3
Monthly income in Ksh.					
<5,000	76.4	56.9	20.0	74.2	63.3
5,001 – 10,000	14.7	33.3	66.7	17.7	24.9
10,001 – 20,000	8.9	9.8	13.3	8.1	11.7
20,001 – 50,000	0.0	0.0	0.0	0.0	0.0
>50,000	0.0	0.0	0.0	0.0	0.0
Duration of pottery/ brickmaking(years)					
<5	8.1	13.7	42.2	11.3	15.3
6 - 10	61.0	15.7	44.4	22.6	41.6
>10	21.1	3.9	13.3	48.4	22.8
Not applicable	9.8	66.7	0.0	17.7	20.3

The survey revealed that major sources of income were brick making 59.4 % (74.2% male, 44.6% female), pottery 16.4 % (6.4% male, 26.4% female), employment 0.4% (0.7% male, 0.1% female), business 2.5 % (2.6% male, 2.4% female), farming 21.0 % (16.0% male, 26.0% female) and 0.3% (0.1% male, 0.5% female) had other economic activities not captured in the questionnaire. This indicates that male participates more in brick making, employment, and business while females are dominant in pottery and farming. Brick making was the major source of income in Bokeire 58.5 % (75.2% male. 41.8% female), South East Kadianga 84.4% (99.6% male, 69.2% female) and Tabaita 53.9% (72.1% male, 35.7% female) while farming was the major source of income in Kadumo East 55.7% (48.1% male, 63.3% female). Majority of respondents 63.3% (68.7% male, 57.9% female) earned less than Ksh. 5,000 with 24.9 % (31.6% male, 18.2% females) earning between

Ksh.5001- Ksh.10000 and 11.7% (19.7% male, 3.7% female) earning in the range of 10001-20000 per month. In all the study areas men earned more than women. This could be attributed to the fact that the majority are peasant farmers and small-scale ceramic artisans. Most of the clay miners 41.6 % (42.9% male, 40.3% female) have been in the industry for a duration of between 6-10 years, 15.3 % (15.4% male, 15.2% female) for ≤5 and 22.8% (27.1% male, 18.5% female) beyond 10 years indicating that it's an occupation that has taken roots in the region despite low returns.

In many African societies the family roles were mainly based on the sex of the individuals, for instance, in the study area, the survey clearly indicated that men mainly specialized in brickmaking while women took an upper hand in pottery and farming. In all cases, the participation of the opposite sex is seen but to a less extent. These findings are in line with research done in other communities, for instance, in a Sudanic belt and Cameroon highlands, digging clay and making of pots is done by women whereas in West Africa it's a preserve of men (Gosselain, 2008; Kayamba, 2017). In a case where men and women are involved in pottery, the processes such as clay extraction, transportation, clay preparation as well as pot marketing are done by both men and women while pot making firing and decoration are done by women alone. This makes women participation in pottery more taxing (Shakila, 2016). This also supports that traditionally men were given a task that demanded more energy and risk involving, therefore a greater participation in brickmaking than women. Women participated more in farming since it is their initiative to provide food for the family. This is in agreement with Fenyes and Meyer (2003) findings that the majority of rural farming household consists of women, children and elderly people. However, majority practice small-scale farming which is labor intensive uses traditional farming techniques and usually lack institutional capacity and support thus low returns. (Louw, 2013). Majority of the respondents are low-income earners earning below the rural Kenya living wage of approximately 13,943 per month as indicated by the Kenya National Bureau of Statistic in 2016 (Richard and Martha, 2017). This deters these people from the provision of essential survival requirements and even education. This is reflected in the low education level of some respondents. It also contributes negatively to the country's economic development. This is an issue of great concern since many have been in the clay industry for a long period as indicated by the survey. This could be attributed to low education, poor tools of work and lack of capital to invest in the industry that would yield higher returns. These findings are in agreement with a report by Browne and Barrett (1991) that lack of education on the part of inferior group deprives them of their productivity level in their activities because they remain ignorant of ways and means of production.

4.3. Organization membership and training

The study sought to establish the existence of ceramics organization, membership and training facilities in these organization or elsewhere. The responses are shown on Table 3.

Majority of the respondents (51.1%) were members of ceramics organizations. Some of these organization offer training to their members (46.3%) on production of ceramics. About 58.0 % of respondents had received training from other avenues. The survey also sought to establish how the knowledge acquired from the training benefited the local people. Table 4 give details on beneficial applications of the knowledge obtained.

Table 3. Distribution of respondents according to organization membership and training (n=281)

Variable	Yes	No
Are you a member of any ceramic organization	51.1	48.9
If yes, does the organization offer training on production of clay products	46.3	53.7
Have you ever received training on manufacture of clay products	58.0	42.0

Table 4. Distribution of respondents according to the applications of the knowledge acquired (n=281)

Variable	%
If you have received training, how do you use the products you make?	
Commercial	34.2
Personal use	16.4
Decoration	8.9
Not applicable	40.6

About 34.2 % used the knowledge obtained from training on making products for commercial use, 16.4% made clay products for personal use, 8.9% used the knowledge for various decorations and 40.6 % did not put the knowledge into practice. Organization groups are important to people with common interest. In clay mining, these groups help the members in the marketing of their products and organizing for training avenues of the members on any upcoming techniques and market needs. These groups are seen in other communities, for instance in Tanzania a group called Tanzania women miners association (TAWOMI) is a nationwide group with branches in mining areas to facilitate women miners to organize and access the required financial, technical and marketing services so that they can carry out mining activities leading to both economic and social development (Joel, 2013). Training enriches the clay miners with relevant skills that promote their activities, hence, the growth of the clay sector. Katar (2009) reveals that investment in education and training produces very high internal rates of return in economic outputs. Unfortunately, many do not apply the knowledge so acquired anywhere, an indication of high levels of demotivation. This could be resulting from poor work environments and inadequate returns. Also, the infiltration of modern ceramic products into the rural communities deters many from venturing into the industry for fear of producing products that do not compete favorably in the market. This can be resolved by giving them more rigorous training and providing them with facilities that can enable them to make quality products that are much more acceptable in the market.

4.4. Sources of information about clay and clay manufactured products

The study used a 5-point measurement 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 percentage and standard deviations were generated from SPSS and are illustrated in Table 5.

Table 5. Distribution of respondents according to degree of agreement or disagreement on sources of information about clay and clay products. (n =281)

Variable	Strongly disagree (%)	Disagree (%)	Neither agree nor disagree (%)	Agree (%)	Strongly agree (%)	Standard deviation
Sources of information						
Radio	83.6	15.3	1.1	0.0	0.0	0.407
Newspaper	97.9	2.1	0.0	0.0	0.0	0.145
Television	98.9	1.1	0.0	0.0	0.0	0.103
Poster	99.6	0.4	0.0	0.0	0.0	0.06
Extension officer	72.6	24.2	2.5	0.7	0.0	0.556
Relative /friends	15.3	22.1	13.9	31.7	17.1	1.288
Internet	97.5	1.4	1.1	0.0	0.0	0.236
Other farmers	11.0	17.8	15.3	21.7	34.2	1.199

Majority of the respondents strongly disagreed of getting information about clay through Radio (83.6%), newspapers (97.9%), television (98.9%), posters (99.6%), extension officer (72.6%) and internet (97.5%). This could be contributed by the fact that the informal clay industry has not been explored locally and no documentation is readily available for local media to disperse. The Internet has well-analyzed research findings on clay internationally, however, lack of exposure to technology, ignorance and low interest in clay-related activities deter many from accessing the internet. Majority of respondents agreed and strongly agreed that they obtained information from relatives/friends (31.7%) and other farmers (34.2%) respectively. This indicated reliance on traditional methods of conveying information (indigenous knowledge). This does not allow progressive development of informal industries on clay in the region. The standard deviations vary from 0.06 to 1.3, an indication that the responses on the source of information were consistent and did not vary to a great extent.

4.5. Application of clay in western Kenya

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.

Majority of the respondents strongly agreed that clay is used for plastering floors/ walls (48.1%) and pottery making (24.5%). Also, many residents agreed they use clay mainly for brick making (54.8 %) and plastering walls/floors (35.3 %). This is an indication that traditional ceramic production and applications are a vibrant traditional art and an established cottage industry for earthenware among local communities in western Kenya. Most of the respondents are ignorant of modern technological applications. However, more can be achieved if the raw material is fully explored, exploited and harnessed. When this is done it will spur industrial development and self-reliance, thus, maximizing the use of local raw materials instead of over-reliance on imported ones, with its accompanying adverse effect on the economy (Alkali, 2003). The mining

and geological research industries should be revitalized to rise up to the challenges of assisting towards maximum utilization of the clay resource. The empowerment of the small-scale ceramics industry with the ability to compete with a foreign product in terms of quality, standard and cost, will better reposition them to contribute immensely to export promotion, employment generation and social economic growth of the nation. The standard deviation varies from 0.0 to 1.669, an indication that the responses were consistent and did not vary to a great extent. Some of the clay applications found in Western Kenya are shown in the pictures below.

Table 6. Respondents distribution on degree of agreement or disagreement, on various clay applications in the region (n=281)

Variable	Strongly Disagree (%)	Disagree (%)	Neither agree nor disagree (%)	Agree (%)	Strongly agree (%)	Standard deviation
Applications						
Medicine	90.9	8.7	0.4	0.0	0.0	0.308
Brickmaking	0.8	14.9	29.5	54.8	0.0	0.766
Plastering of floors and walls	0.4	2.1	14.1	35.3	48.1	0.851
Decoration	69.7	12.9	10.0	3.3	4.1	1.669
Pottery	21.2	17.0	17.8	19.5	24.5	1.480
Refrigeration of drinking water	50.6	12.9	14.9	10.0	11.6	1.439
Storage of cereals	94.6	3.7	1.2	0.0	0.4	0.385
Cooking jikos	39.4	25.3	22.0	10.4	2.9	1.132
Manufacture of pesticides	100.0	0.0	0.0	0.0	0.0	0.0
Manufacture of pharmaceuticals	100.0	0.0	0.0	0.0	0.0	0.0
Manufacture of detergents	100	0.0	0.0	0.0	0.0	0.0
Cosmetics	100.0	0.0	0.0	0.0	0.0	0.0
Water purification	98.8	0.8	0.4	0.0	0.0	0.0
Oil drilling industries	100.0	0.0	0.0	0.0	0.0	0.0
Toothpaste industry	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
Feed additive for animals	64.3	15.8	15.8	3.3	0.8	0.925
Sealing water reservoirs	100.0	0.0	0.0	0.0	0.0	0.0
Agrochemicals	100.0	0.0	0.0	0.0	0.0	0.0
Fillers in textile industry	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	100.0	0.0	0.0	0.0	0.0	0.0

Figure 1. Pot firing near Kadumo East site, at Kadumo East sub location, Homabay County, Western Kenya.

The other uses of clay not captured in the questionnaire were given by respondents as shown on Table 7.

Table 7. Distribution of respondent view on other uses of clay (n = 281)

Variable Other uses	%
Farming	43.3
Fish ponds liners	25.4
No other use	23.3
Modelling	7.9

Majority of respondents said they mainly used the clay resource for farming purposes (43.3%), 25.4% for fish pond lining, and 7.9 for modeling. Clay is the active part of soil because most conditions in soil are as a result of reactions involving clay. Both physical and chemical properties of clay affect plant growth. Poor physical conditions such as tight impervious layers, crust, or overall high density and unfavorable porosity cause soil to be unfit for plant growth. Potassium is usually a limiting macronutrient for plants. The potassium properties of clay can indicate the biological utilization and fertility of the soil. Most potassium in the soil for plants is supplied from potassium ions in the interlayers of the micaceous clay mineral (Churchman, 2018). Of the clay minerals illite is said to have a low capacity to attract and release ambient exchangeable ions such as calcium, magnesium, and sodium but a high potential to accumulate potassium ions, thus making it be the most potassium-rich of the common soil clay minerals (Barre et al., 2006). Thus the clay in the region with high potential for agriculture could be rich in illite mineral but further research can ascertain the hypothesis. Clays are used in fish ponds for a number of uses depending on the clay mineral present. Calcium montmorillonite/bentonite in ponds provides minerals and trace elements like calcium, magnesium, sodium, and iron that make water plants, beneficial bacteria and fish to thrive. Calcium bentonite helps in the digestive system of fish. It has an extensive surface area which allows it to attract and absorb the toxins such as heavy metals, free radicals, and pesticides. When ingested by fish, it binds the toxins which are removed through a waste elimination process. Sodium bentonite, also called high swelling clay is preferred to calcium bentonite for pond sealing application. This clay creates an impermeable layer that disallows water seepage underground thus maintains water levels for long period of time (Claude et al., 2002).

4.6. Relationship between gender and clay applications

Analysis of variance was performed to find out whether gender influenced pottery and brickmaking which are some of the major clay applications in the region; with the null hypothesis that, there is no significant difference between gender and pottery/brickmaking at $p \geq 0.05$. An assessment of normality and homogeneity of variance showed no major violations of assumptions in these tests. Results in Table 8 on one way ANOVA between gender showed that, there is no statistically significance difference in applications between men and women on pottery $F(1,279) = 0.937$, $p > 0.334$ and brickmaking $F(1,279) = 1.555$, $p > 0.213$. Thus we retain the null hypothesis and conclude that gender has no influence on pottery and brickmaking.

Table 8. Analysis of variance on gender

		Sum of Squares	df	Mean Square	F	Sig.
pottery	Between Groups	2.034	1	2.034	0.937	0.334
	Within Groups	605.560	279	2.170		
	Total	607.594	280			
brickmaking	Between Groups	0.847	1	0.847	1.555	0.213
	Within Groups	152.049	279	0.545		
	Total	152.897	280			

Similarly (Table 9), one way ANOVA between different levels of education and pottery/ brickmaking; with null hypothesis that, there is no significant difference between different levels of education and pottery/ brickmaking at $p \geq 0.05$, showed that there was no statistically significant difference in application perception between educated and uneducated respondents on pottery, $F(5, 275) = 1.792$, $p > 0.115$ and brickmaking, $F(5, 275) = 0.863$, $p > 0.506$. Therefore we retain the null hypothesis and conclude that the level of education has no influence on clay applications.

Table 9. Analysis of variance on education level

		Sum of Squares	df	Mean Square	F	Sig.
pottery	Between Groups	19.172	5	3.834	1.792	0.115
	Within Groups	588.422	275	2.140		
	Total	607.594	280			
brickmaking	Between Groups	2.363	5	0.473	0.863	0.506
	Within Groups	150.534	275	0.547		
	Total	152.897	280			

4.7. Health effect of clay

The study sought to establish whether the respondent health was affected by the interactions with clay and responses were as shown on table 10. The study did not involve the health personnels because it involves the study of the indigenous knowledge of the communities on health effect of clay. Indigenous knowledge refers to philosophies, understandings and skills developed by the communities after long histories of interacting with natural surroundings. The study did not involve any experimentation to collect the information for it is acting as a baseline for further research which will now involve experimental work.

From the responses, 43.3 % of respondent reported that they experience skin irritation upon prolonged kneading or wedging of clay to establish the required plasticity. About 40.8 % experience irritations and coughs when they inhale clay dust. However, the majority (59.2 %) of the respondent said there was no effect upon inhalation of clay dust. Also, 70.0 % of the respondents ascertained that food prepared from locally made

clay pots tasted differently from those prepared from other cooking utensils; several people (37.1%) complained of stomach upsets after taking these foods.

Table 10. Effect of clay materials to human health

Variable	Yes	No
Effects of interacting with clay.		
Do you experience effects on the skin while interacting with clay?	43.3	56.7
Does the clay dust affect you in any way after inhalation?	40.8	59.2
Does food prepared from locally made clay pots tastes different from food made from other utensils?	70.0	30.0
Are there any people who complain of stomach upset when they take food prepared from clay pots?	37.1	62.9

Skin hypersensitivity when working with clay usually results when clay has been aged in dump places till molds develop. Molds cause or aggravate skin problems and change workability of clay (Mwiandi and Ombaka, 2017). Also, hand contact with wet clay can result in abrasion and dryness of fingertips and hands which may result in irritation. Clay contains large amounts of crystalline silica which when chronically inhaled can cause scarring of lungs (silicosis) and is carcinogenic (Shaikh et al., 2012). Its main symptom is a dry cough and predisposes one to lung infections like tuberculosis. These findings agree with studies earlier done. For instance, a study done on brick workers in Croatia revealed that there is significant high prevalence of respiratory symptoms such as a chronic cough (31.8%), chronic phlegm (26.2%) and chest tightness (24%) on exposed workers as compared to control workers (20.1%,18.1%, and 0%) respectively (Zuskin et al., 1998). The changes in an organoleptic characteristic of food and stomach upset resulting from ingestion of food cooked in clay pots may be caused by heavy metal poisoning. Leaching of contaminants or heavy metals to food from cooking pots made from clay containing heavy metals may cause poisoning. Even in trace levels, heavy metals are toxic due to bioaccumulation. A study was done by Nsengimana et al. (2012) on leachability of cooking pots made of clay found that Pb, Cd, and Fe from contaminated clays were transferred in considerable amounts to foods in contact with them, which exceeded the safe limits established by WHO. Some elements are essential in low limits but unsafe in excess, for example, zinc/ iron overload (hemochromatosis) causes gastroenteritis and abdominal pains (Macrae et al., 1993).

4.8. Challenges encountered during local ceramics manufacture

Most respondents (99.6 %) experience ceramic breakages at one point in the process of manufacture (Table 11). Unfortunately, a significant number of respondents (34.6 %) do not have a way of minimizing them. This increases the losses incurred during the production process. Also, 49.2 % ascertained that there are clay sites in the region that are not preferred for ceramics. This resulted from conclusions drawn after several attempts of ceramic productions from this clay which were of poor quality. Analysis of physical properties of clay soils in these sites can give a far-reaching reason as to why the site is not being utilized for ceramic production, and also give suitable alternative applications for the unexploited clay.

The study further established that most breakages (42.1 %) occur during firing, 37.9 % after firing and 20.0 % before firing (Table 12). The respondents reported that they minimize breakages by drying their products

under shade before firing, (60.4 %), grinding the broken fired items and using them to make new products (13.8 %), and strong firing (25.8 %) (Maintaining high temperatures through a constant supply of fuel).

Table 11. Distribution of respondents according to the experience of ceramics breakages, ways of minimizing breakages and sites not preferred for ceramics making (n = 281)

Variable	Yes	No
Do you experience breakages of ceramic during manufacture?	99.6	0.4
Do you have a way of minimizing these breakages?	65.4	34.6
Are there sites not preferred for pottery and brick making?	49.2	50.8

Table12. Distribution of respondents according to when they experience breakages, ways of minimizing breakages and reason for specific clays not preferred for pottery and brickmaking (n=281)

Variable	%
When are breakages of clay products experienced?	
Before firing	20.0
During firing	42.1
After firing	37.9
Ways of minimizing breakages	
Drying under shade	60.4
Grinding broken products and using them in making new products	13.8
Strong firing	25.8
Reason for specific areas not preferred for pottery and brickmaking	
Not applicable	50.8
Products easily break	7.1
Very sandy	19.6
Lots of pebbles	22.5

However, breakages are attributed to conditions surrounding the production process and the composition of clay material used. For instance, before firing the clay products should be dried slowly under shade since drastic drying under strong sunlight causes cracking. The green ware should then be heated slowly in a kiln in order to drive off the chemical and physical water molecules that are present in clay. If the temperature rise is too fast the water will create steam and if steam is too strong it will explode the ware. To avoid this the ware is warmed inside the kiln and temperature maintained below the boiling point of water until all steam is driven off. During firing clay particles goes through a process called quartz inversion which is the conversion of quartz from alpha crystal into beta crystal during temperature rise followed by a reverse during cooling. Thus clay will expand and contract when it reaches a temperature of about 570^{o}C. During quartz conversion, rapid temperature changes should be avoided because they cause stress cracks in ceramic wares. Between temperatures of 300-800^{o}C, carbonaceous materials and impurities in clay are supposed to be burnt off before clay seals off when it reaches a high temperature to sinter, otherwise it will remain in clay and cause bloating (distortion of the clay body caused by the evolution of gases during firing) at higher temperatures. During cooling, drastic temperature changes cause cracking of clay. When conditions surrounding production process are controlled the challenge of breakages can be controlled.

It was also reported that some specific sites were not preferred for pottery and brick making by a number of people; they claimed that the sites had a lot of stones (22.1%) or were very sandy (19.6 %), or the products made from these materials were of poor quality (7.1%). The mineralogical, chemical and physical properties of clay materials determine the quality of clay for specific applications.

5. Conclusion

The survey revealed that major clay applications in the study area are brick making (54.8%), plastering walls and floors (48.1%) and pottery (24.5%). Most of the respondents (63.3%) earn less than Ksh.5000 per month. People rely on traditional practices of getting information about clay and clay products, that is, from relatives/friends and other clay miners. Majority of the clay miners are members of clay organization. Some of the organizations in existent offer training facilities to their members but the majority do not offer training. 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 of clay materials, irritation and coughing upon inhaling clay dust, changes in organoleptic characteristics of food cooked in a 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 a 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.

6. Recommendation

This study necessitates further research on the determination of mineralogical, chemical and physical properties of clay in the study area to explain its potential applications. The analysis of mineralogical and chemical composition will give a deep understanding of scientific facts as to why this clay is suitable for use in fish ponds and agricultural production. Analysis of chemical properties will give an insight of the components responsible for the negative health effects like skin irritation, coughs and changes in organoleptic characteristics of food cooked in pots made using these clays. The physical and mineralogical properties will also explain why breakages take place at various levels of ceramic production. Clay artisan's organizations and training of its members need to be exploited and harnessed to promote the growth of clay mining in the region.

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