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Production Of Water Filters: Using Infensi Clayas The Base Material

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Abstract:
Various media have been used in the production of water filters. This project is a ceramic filter made from Nfensi clay (as the base material) and sawdust to create a porous body to filter water. The study aim at developing water fillter that is effective for its purpose and can easily be accessed by the indigenous rural dwellers in Ghana who due to economic reasons cannot get access to quality conventional water filters. In Ghana, there are two major companies that produce water filters using various media. TCC uses kaolin with Nfensi clay as a binder whiles Ceramic Tamakloe, uses Nfensi clay, sawdust and colloidal silver, but this project adapts Nfensi clay as the base material. For the production of the filter candle, sketches were first made, and then developed using computer design software called Rhinoceros. Various test samples of clay bodies were composed and taken through series of forming techniques such as, jolleying, throwing, pinching, slip and press casting to obtain a suitable one for the final product. Several percentages of clay, sawdust and grog were also mixed as specimens to enable the researchers to choose the most suitable composition for the project. Selected fired compositions were tested through various stages of porosity, flow rate and microbial tests and the most suitable was chosen. The research has resulted in the in the production of water filters for healthy living at minimum cost. It has revealed the paramountcy of sterilization and hygienic handling of the filter candle and the need for it to be taken into consideration whenever water is being filtered for human consumption.

Key words: *Filtration, Nfensi-Clay, Grog and Sawdust.*

1.Introduction

Rural refers to the countryside. According to Wikipedia (2013), Sociologists define "rural" as those areas which are not urban in nature, and that Rural dwellers are those that do not live in urban, built up areas or cities. Rural dwellers in some remote places in Ghana walk very long distances to fetch water for use in the home, the water is mostly dirty and untreated. Unfortunately, these people have limited knowledge of appropriate domestic treatment of water they fetch from ponds and rivers, more so, research findings indicate that most of these ponds are infested with germs, viruses and diseases like guinea worms and other water borne infestations. These infections ultimately lead to serious crises, able bodied members of the communities are rendered unproductive, some are paralysed and others die.

Conventional filters are the immediate devices that can be secured, however, their cost is also found in the group of necessities tagged avoidable, because of the inability of the rural dweller to buy them. The challenge then is to find the technology that can be used to secure good drinking water for the communities. In other to alleviate these problems the researchers resorted to experiment with Infensi clay (conventional earthenware clay); in composition with combustible material to create water filters for use in the rural areas.

'Contaminated drinking water contributes to disease in developing and developed countries worldwide'. (World Health Organisation report on Water Sanitation and Health programme 2010). The ability to secure quality water for rural dwellers requires the use of some level of technology that is easily accessible.

Since the cost for treated water is always on the ascendency; the research sought to identify some existing conventional ceramic filters with the intention of identifying locally available raw materials that can best be used to produce equally functional and quality water filters.

The descriptive and experimental methods of research were adapted for the study. Pre-experimental design was chosen. Though this is an initial experimental stage, it has a high validity and can set the stage for further research.

The research identify the potential of using local raw materials (a mixture 'Infensi' clay, saw dust and grog) for the production of a filtering body that will reduce the penetration of microbes to an acceptable level. Beside, to test the filtering body after firing, in relation to microbial reduction, flow rate and cleanliness of the water.

The viability of the research brings to the fore:

- The availability of local raw materials useful for producing equally quality water filters at minimal cost to meet the needs of local communities.
- It reveals how the composition of the porous body aided in the filtration of water.
- The results of the test on the filtering body confirmed the suitability of the selected materials.
- The designing of the affordable filter pot also gave technical information that is easily accessible and managed by the average personal without any form of advanced technical skills.

This project (filter candle) is an improvement of existing conventional filters since the raw materials used in production will help reduce the cost of the product and still have the required qualities it ought to have. It will also have a ceramic receptacle into which the filtered water will be kept and this receptacle will help maintain the coolness of the filtered water. The future value of the research is its possibility of being improved and connected directly to taps so that the process of filtration will be done simultaneously from filtering to drinking. The researchers' efforts to design and develop a filtration device that will best satisfy the purpose of the research led to the study of different types of filtrations and their functional values.

The materials used for the production of the water filters for the rural people included the following: Nfensi Clay The term clay is applied to materials having a particle size of less than 2□m (25,000□m= 1 inch) and to the family of minerals that have similar chemical compositions and common crystal structure (Foley, 2004). Stated more scientifically, it is a hydrous silicate of alumina, that is to say, a compound of alumina and silica chemically combined with water. A theoretical formula of this substance reads $Al_2O_3.2SiO_2.2H_2O$ (Chappell, 1979).

There are two types of clay, namely primary and secondary clays. Primary clays are also called residual clays. They are found in the same vicinity as the parent rock from which they decomposed. Primary clays are basically of one type, the kaolin. Kaolin is extremely refractory clay with a melting point of over 1260°C. Secondary clays are those that have been moved from the site of the parent rock by the forces of water, wind or glacial action (Chapell, 1979). Clay products include bricks, stoneware, pottery, tiles and glazes (Worral, 1986).

Nfensi clay which is the main material for this project has low temperature fluxes, summing up to only 6.6 per cent and a refractoriness of 20.7 per cent. Nfensi clay, can

easily withstand high temperatures. It is, thus, suitable for the production of some medium range refractory materials. According to Nsiah, (2007), Nfensi clay is, however, less plastic owing to its low plastic limit. Thus, Nfensi clay is more difficult to form and it can easily crack after forming It, however, shrinks remarkably, with a value of 11.0 per cent after firing. Its mineral assemblage is found to be quartz, kaolinite, microcline and muscovite. The low percentages of Fe_2O_3 give rise to its yellowish brown/cream colour. Clay particles of Nfensi clay have a median diameter of 2.3 μm (Fraser, 1979). The relevant literatures have helped to unveil the potentials of Infensi clay for the project.

2.Materials And Methods

Based upon the relevant information it is clear that a mixture of Nfensi clay and any other clay, with a higher plasticity index, would result a material of varying properties useful for many ceramic products.

Sawdust is also an important material used in the research; it is composed of fine particles of wood. This material is produced from cutting with a saw, hence its name. The sawdust used for the project is derived from a type of soft wood called **cyber** known in a local Ghanaian language as "onyina". The cyber dust may be obtained at different grits depending upon the required finish at the last stage of the processes involved in ply wood production. The saw dust used for the production of the filter candle is obtained from a specific grit ranging from 100-300 grit (plywood sanded with such grits are basically for export).

Plate 1: The cyber dust being sieved into fine particles

The samples of the sawdust having been sieved with 20, 40 and 60 mesh sizes were tested at the lab to know their structure under a microscope, and the average particle size was 10723.32μm²

Water was added to the composition to serve as a binding agent for both the clay and sawdust. Beside water will help in maintaining adequate moisture. The filter candle has a body composition of sieved clay (Nfensi), water and fine sawdust. The use of grog in the experiment is to control the clays porosity, its ability to reduce shrinkage and to aid

drying. This prevents defects such as cracking, crow feet patterning, and lamination. The coarse particles open the green clay body to allow gases to escape. It also added structural strength to the pottery ware during the shaping.

2.1.Types Of Ceramic Water Filters Produced In Ghana

Since the research is meant to meet specific need of people in rural Ghana it becomes necessary to make comparison with other water filters in the country. There are two major types of ceramic water filters produced in Ghana. They include; Filtron and Nnsupa Ceramic water filters. They are produced by companies called Ceramic Tamakloe Company Limited and Technology Consultant Center (KNUST), respectively.

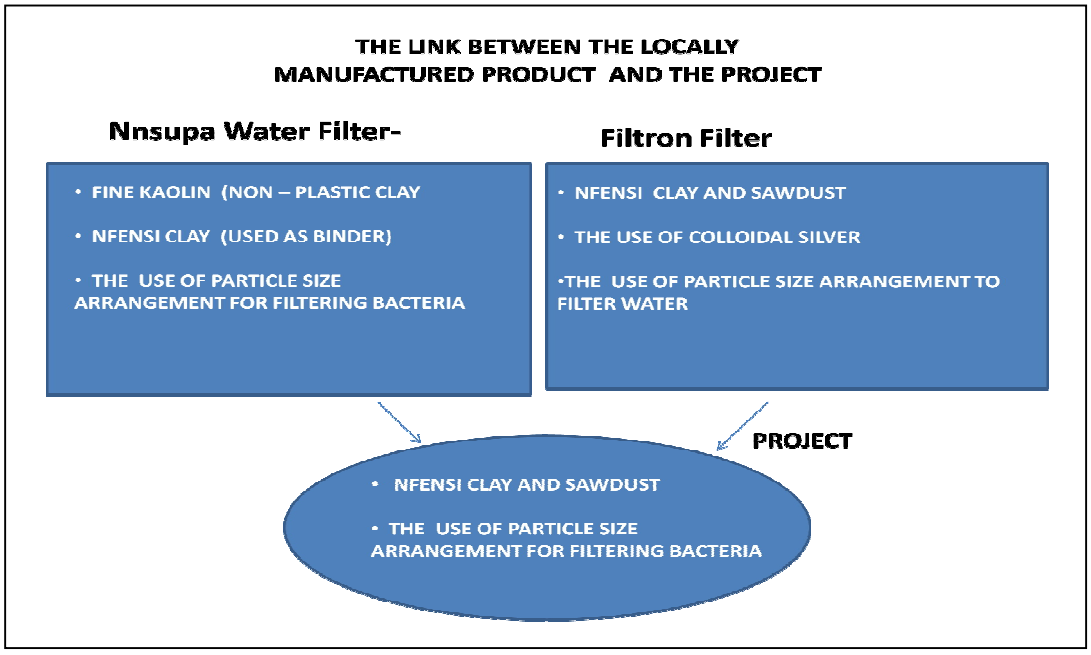

Figure 1: Procedures for executing the project

The descriptive and experimental methods of research were adapted for the study. Pre-experimental design was chosen. Though this is an initial experimental stage, it has a high validity and can set the stage for further research.

2.2.The Project Was Designed By Using A Computer Aided Design Called Rhinoceros

These provided a visual and accurate understanding of the final product.

- Design Of The Final Product In (3D) Rhinoceros

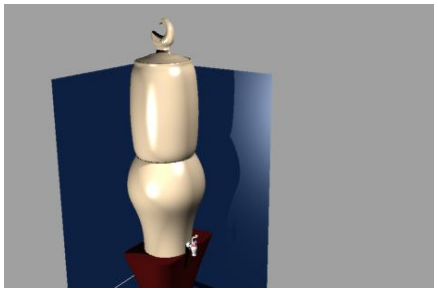

Figure 3: A 3D design of the filtering System

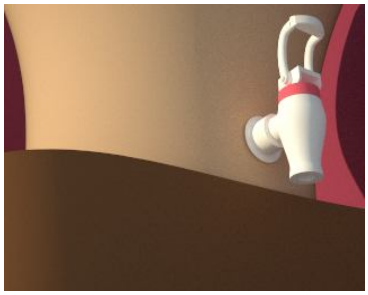

Figure 4: clear view of the spigot

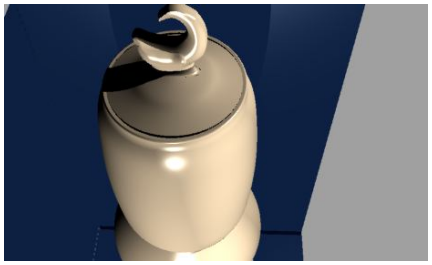

Figure 5: top angled view of the upper chamber of the filtering system

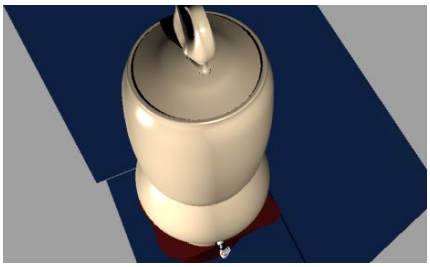

Figure 6: top angled view of the chamber of the filtering system

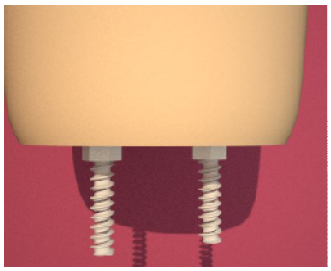

Figure 7: Clear view of candle holder attached to the filter candle

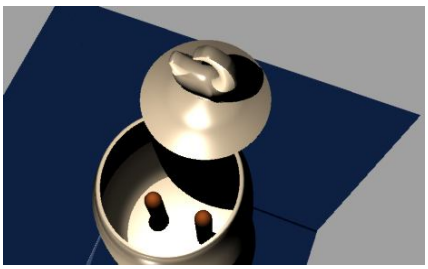

Figure 8: Top view of the filter candle fixed on the filtering system

2.3.Production And Testing Of Models And Prototypes

This aided in checking workability and achievement of set goals. Different forming techniques of Jolleying, Press Casting, Jiggering, Throwing and Pinching, were used systematically. They included, Jolleying, The samples were placed into a plaster mould (this is a little bigger in shape than the usual moulds for press and slip casting). The profiler was lowered into the mould as the jolly machine was in motion, to shape the interior of the clay body while the exterior of the body was yielded by the mould.

Press Casting; during this process, a pressing mechanism for the casting of the Nfensi clay body was adapted. The apparatus used comprised of a P.O.P mould including a cavity for solidifying the molten clay and a heavy press with a rod that goes through the

center of the body in the mould whiles force is exerted on the press to give the body the shape of the mould.

Throwing; the clay body after it had been mixed into the needed consistency was placed on the potters' wheel and put into motion. The power of the electrical potters' wheel, was turned on and as the body revolved on the flat disk of the machine, both hands—one on the inside and the other on the outside of the clay—were free to form the desired shape. This process was adapted for the final production of the filter candle.

Slip Casting; the mould must be able to absorb the water from the slip (liquid clay) in order to form a clay body. When the slip was ready, the mould was filled with it. As the mould absorbed the water, the level of the slip in the mould reduced requiring a top up of the mould for a specific thickness and height. After the required dimension was achieved the excess slip was poured away, creating some kind of hollowness in it.

Pinching; the hand was used to mould the clay body into the desired shape. It involved the use of minimum equipment since the hand was used for the forming of the body into the desired shape.

2.4.Microbial Test

The samples were tested at the laboratory to find their validity for human consumption after filtration. A Dilute Plating or Pour Plate technique was the method used for the test. It is a practical and common laboratory technique used in enumerating the living microorganisms in liquid cultures, blood, intestinal contents, liquid food such as milk, soups etc. It differs from the "streak plate" in that, the agar medium is inoculated while it is still liquid (but cool- about 40°C), and so colonies develop throughout the medium, not only on the surface. (BIOL 251 BASIC MICROBIOLOGY)

Below is an over view of how the test was conducted;

2.5.Bacterial Analysis Of Water Samples

The water used for the test sample was derived from a bore-hole at Ayeduase, a suburb of Kumasi (Ashanti Region, Ghana). The water was tested before and after filtering.

2.6.Preparation Of Serial Dilution

The 10^{-1}or 1/10 dilution

The samples were thoroughly mixed by inverting the sample bottle several times and after, serial dilutions were prepared as follows: using an automatic pipette and sterile 1ml

pipette tip, a 1ml aliquot was taken from an inch below the surface and added to 9ml of sterile Ringers solution (diluents) in a test tube (do not allow the pipette tip to touch the surface of the ringers solution but hold it against the inside of the test tube). This was the 10^{-1} dilution. The pipette tip was then placed in the solution of disinfectant provided.

The 10^{-2} or 1/100 dilution

A fresh sterile pipette tip was taken and the 10^{-1} dilution was mixed by drawing the suspension up and down ten times. With the use of the pipette, 1ml of the 10^{-1} was taken and diluted into another tube containing 9ml of sterile Ringers solution. This is the 10^{-2} dilution. The pipette tip was again placed in the solution of disinfectant provided.

2.7.Subsequent Dilutions

Dilutions were prepared down to 10^{-3}, 10^{-4}, 10^{-5} and 10^{-6} by repeating the above procedure further four times.

2.8.Total Viable Count (TVC) Or Plate Count

Using a fresh sterile pipette tip for each dilution, 1ml of each of the dilutions of the bore-hole water sample was aseptically added to universal bottles (or test tubes) containing molten plate count agar at 40°C. The sample and agar were then mixed by rotating the bottle between the palms (hands) making sure bubbles were not formed. The agar was aseptically poured into a fresh Petri dish. The dishes were labeled with samples' names and dilutions. The set up was allowed to solidify. Afterwards, the Petri dish was bulked by fastening them together with cello tape. The solidified agar plates were incubated in inverted positions at 37°C for 24 hours for growth to occur. After 24 hours, the Colony counter was used to count the number of microorganisms on the countable plates.

2.9.Total Coliform Count

Using a fresh sterile pipette tip for each dilution, 1ml of each dilution of the bore-hole water sample was aseptically added to 5ml of the MacConkey broth provided as follows:

- 1ml of the water sample (undiluted) was added to 3 tubes of MacConkey broth.
- 1ml of the 10^{-1} dilution was added to 3 tubes of MacConkey broth.
- 1ml of the 10^{-2} dilution was added to 3 tubes of MacConkey broth.
- This continued to 10^{-5}.

The bottles and tubes of MacConkey broth contained inverted Durham tubes for the collection of gas (There should be no gas in the inverted tubes before being incubated). The tubes were then labeled with samples' names and dilutions. They were afterwards incubated at 37°C for 24 hours.

After the 24 hours, some of the colours of the mixture turned yellow from pink, showing it being positive. The yellow colour and tubes were recorded. Tubes with no colour changed were negative and the results were concluded.

2.10.Preparation And Examination Of Stained Smears

The bacteriological stains were made on grease-free slides. The slides were cleaned in chromic acid, washed in water and stored in alcohol. They were removed from the jar with forceps (the lid was replaced immediately), drained and flamed to remove the alcohol. Since an agar culture was used, a very small drop of water was placed on the slide and a little bacterial colony was added to the drop with a sterile loop. The drop was spread and the bacteria fixed by passing the slide two or three times through a Bunsen flame.

2.11.The Grain Stain

- A bacterial smear was stained with 5% crystal violet (gentian violet) for 2 minutes.
- The bacterial smear was washed with water, and the water drained off. the bacterial smear was again smeared with iodine for 2 minutes (the crystal violet and the iodine form a purple/black complex inside the bacterial cell).
- Absolute alcohol was carefully dripped unto the smear and allowed to run off. this was done three times then washed off with water (the alcohol dissolves the lipid layer surrounding gram negative cells and allows the crystal violet/iodine complex to wash out).
- It was further counterstained with 1% safranin for 2 minutes. It was then washed and drained off the slide. Gram positive cells stained purple/black and gram negative cells stained light pink.

2.12.Microscopy

After staining, the slides were examined without a cover slip. The stain smears were found by using a low power objective, X 10 or X 20. After, a small drop of immersion oil was put directly unto the smear. The smear was examined using an oil immersion (X 100) lens. The bacterium tested was from white colonies.

3.Results And Dicussion

3.1.Test Results Of Body

MATERIALS/ MEASUREMENTS	**SAMPLE A**	**SAMPLE B**	**SAMPLE C**
Nfensi clay	Plastic measuring cup	Plastic measuring cup	Plastic measuring cup
Sawdust	Plastic measuring cup	Plastic measuring cup	Plastic measuring cup
Water	Plastic measuring cup	Plastic measuring cup	Plastic measuring cup
Sodium Silicate	Plastic measuring cup	Plastic measuring cup	Plastic measuring cup
Mesh size (For Clay and Sawdust)	80 mesh	80 mesh	80 mesh
Forming Technique	Throwing	Throwing	Mould Casting
Fired Weight	50 grams	50grams	50grams
Fired Height	3cm	4cm	6.4cm
Fired Base	7cm	5.5cm	4cm (irregular)
Thickness at the top (width)	1cm (irregular)	0.5cm (irregular)	1cm (irregular)
Total Diameter for the top of Fired work	4.5cm	5.4cm	5.8cm
Physical Appearance(fired work)	Crack at the base, Rough and Indefinite shape	Smoother than sample A, Cracks at the base	Cracks

Table 1:ONE PART CLAY: ONE PART SAWDUST

MATERIALS/ MEASUREMENTS	**SAMPLE A**	**SAMPLE B**
Nfensi clay	Plastic measuring cup by volume	Plastic measuring cup by volume
Sawdust	Plastic measuring cup by volume	Plastic measuring cup by volume
Water	Plastic measuring cup by volume	Plastic measuring cup by volume
Mesh size for clay	80mesh	80 mesh
Mesh size For Sawdust	60 mesh	60 mesh
Forming Technique	Pinching	Pinching
Fired Weight	50 grams	50 grams
Fired Height	4.5cm	2.8cm
Fired Base	2.5cm	3cm (irregular shape)
Thickness at the top (width)	0.8cm	0.6cm
Total Diameter for the top of Fired work	5cm (irregular shape)	6cm
Physical Appearance(fired work)	No Cracks	Quite Smooth when felt, No cracks and wider than the sample A

Table 2: TWO PARTS CLAY: ONE PART SAWDUST

MEASUREMENT	SAMPLE A	SAMPLE B
Weight of Work Before Boiling	50grams	50grams
Starting Time For Boiling	3:00 pm	3:00 pm
End of Boiling	4:00pm	4:00 pm
Time Duration	1 hour	1 hour
Weight of Work After Test	70grams	70grams
Volume of Void of the samples	20grams	20grams
Porosity	0.167	0.286
Porosity Percent	16.7%	28.57%

Table 3: Porosity Test

MATERIALS/ MEASUREMENTS	SAMPLE A	SAMPLE B
Nfensi clay in weight & percentage	250grams/ 83.3%	250grams/ 83.3%
Mesh size for clay	80mesh	60mesh
Mesh size For Sawdust	60 mesh	Rough sawdust (No mesh size used)
Sawdust	50grams/ 16.7%	50grams/16.7%
Water	160grams	160grams
Weight of clay and sawdust	300grams	300grams
Total weight of composition	460grams	480grams
Weight of left over composition	120grams	180grams
Weight of wet sample	340grams	305grams
Ageing time	48 hours	48hours
Forming Technique	Molding	Molding
Dried Weight	222g	192grams
Fired Weight	158.5grams	145.7grams
Thickness at the top (width)	0.8cm	1.5cm

Total Diameter for the top of Fired work	9 cm	7.5cm
Height of Fired Work	9.8cm	8.8cm
Base of Fired Work	4.5cm	4.6cm
Colour of Fired work	Dull Brick	Bright Brick
Shrinkage in weight and Shrinkage Percentage (before firing)	118grams/ 34.71%	293grams/ 60.41%
Shrinkage and shrinkage Percentage (after firing)	63.5g/ 28.60%	47grams/ 24.47%
Physical Appearance Fired Work	Fairly Smooth with a little crack	Very rough due to the size of sawdust
Porosity	0.387	0.407
Porosity Percentage	38.7%	40.7%

Table 4

Measurement	**SAMPLE A**	**SAMPLE B**
Weight of Cup	10grams	10grams
Weight of Body	190grams	160grams
Weight of Water used	80grams (another 40grams was poured in at 02:37pm)	70grams on the scale = 80g/cm³ (another 40grams was poured in the body at 02:35pm)
Draining started	12:43pm GMT	12:42pm GMT
Draining ended	03:45 am GMT	07:11pm GMT
Duration for seepage	15hours, 2minutes	4hours, 36minutes
Weight of sample after seepage	210grams	180grams
Weight of Drained water	30grams on the scale = 50g/cm³	50grams= 70g/cm³ on the granulated cup

Table 5: Test For Flow Rate

SAMPLE A	SAMPLE B
The test was conducted twice, due to inaccurate measurements and calculations	The test was conducted twice, due to inaccurate measurements and calculations.
The first test had dirty particles settling at the base because after firing the body contained some amount of dust particles which drained along with the water during the seepage	There were more particles settling at the base of the drained water than that of sample A. this could be due to more cracks formed during the molding of the sample, porosity test, and dust formed after firing.
After the porosity test, the clay body which already had cracks became weaker; this caused tiny particles if the body to dissolve into the water that had already drained making dirty	The large particles in sample B created bigger pores and this made drainage faster as compared to sample
The thickness of the walls might have delayed the drainage of water	Even though both samples gained an extra weight of 100grams after boiling, the porosity percentage of the sample slightly increase than sample 3 due to the weight of the sample after firing
The porosity was less than Sample B due to the smaller size of the sawdust particles	Porosity was more due to the bigger size of saw dust

Table 6: Observation

MEASUREMENT	SAMPLE A	SAMPLE B	SAMPLE C	SAMPLE D	SAMPLE E
Weight of clay and sawdust	200 grams	200 grams	200 grams	200 grams	200 grams

Table 7

- Sample E got broken after boiling.

Weight of wet sample	Not recorded	Not recorded	Not recorded	Not recorded	Not recorded
Ageing time	7 days	7 days	7 days	7 days	7 days
Forming Technique	Slip casting	Slip casting	Slip casting	Slip casting	Slip casting
Dried Weight	150 grams	140 grams	160 grams	130 grams	70 grams
Thickness at the top of dried sample (width)	0.3 cm	0.4 cm	0.3 cm	0.8 cm (irregular)	0.6 cm
Total Diameter for the top of dried sample	7.6 cm	7.7 cm	7.5 cm	8.2 cm	8.5 cm
Height of dried sample	5.7 cm	7.1 cm	5.8 cm	7 cm	5 cm
Fired Weight	110grams	80grams	130grams	90grams	30grams
Fired Height	5.5cm	6.5cm	5.5cm	3.8cm	5cm
Top Diameter	7.5cm	7.5cm	7.3cm	7cm	6.5cm
Thickness of the Wall	0.2cm	0.5cm	0.3cm	0.3cm	1.3cm
Porosity	0.48	0.67	0.48	0.18	-
Porosity Percentage	47.62%	66.67%	48%	18.18%	-

Table 8

MATERIALS	**SAMPLE A_1**	**SAMPLE A_2**	**SAMPLE A_3**	**SAMPLE A_4**	**SAMPLE A_5**
Nfensi Clay (grams/ percentage)	225grams/ 75%	210 grams/ 70%	195grams/ 65%	180grams/ 60%	165grams/ 55%

Sawdust (grams/ percentage)	15grams/ 5%	30grams/ 10%	45grams/ 15%	60grams/ 20%	75grams/ 25%
Grog	60grams/ 20%	60grams/ 20%	60grams/ 20%	60grams/ 20%	60grams/ 20%
Water	180grams	150grams	180grams	120grams	210grams
Wet weight	480grams	450grams	480grams	420grams	510grams
Diameter of Circumference	-	8.8cm	8.8cm	8.6cm	8.7cm
Dried Weight	-	1.3grams	1.3grams	360grams	-
Dried Height	-	7.3cm	7.5cm	7.7cm	-
Fired Height	-	7.3cm	7.7cm	About 7.4cm	-
Fired Weight	-	170grams	160grams	180grams	-
Thickness of the Wall	-	1.3cm	1.9	1.5cm	-
Diameter of the Top	-	8cm	8cm	8.1cm	-
Porosity	-	0.43	0.41	0.45	-
Porosity percentage	-	43.33%	40.74%	45.45%	-
Flow rate	-	54.26g/h	375g/h	1350g/h	-

Tabble 9: Press Casting

MATERIALS	**SAMPLE B_1a**	**SAMPLE B_2a**	**SAMPLE B_3a**
Nfensi Clay (grams/ percentage)	225grams/ 75%	210 grams/ 70%	195grams/ 65%
Sawdust (grams/ percentage)	15grams/ 5%	30grams/ 10%	45grams/ 15%
Grog	60grams/ 20%	60grams/ 20%	60grams/ 20%
Water	30grams	400grams	300grams
Width at the edge of	1.5cm	1.4cm	1.3cm

the top			
Diameter of Circumference	12cm	12.2cm	11.8cm
Dry Weight Before Firing	1320grams	1220grams	1050grams
Dried Height	14.5cm	14.5cm	14.5cm
Fired height	14.5cm	-	14.5cm
Fired Weight	2020grams	-	930grams
Diameter at the top	12cm	-	11.6cm
Thickness of the wall	1cm	-	1.1cm
Diameter of the Base	8.5cm	-	8.1
Flow rate	10g/h	-	130g /h

Table 10: JOLLEYING

Percentages of samples were measured in volumes with a measuring cup equivalent to 10%.

MATERIALS	**SAMPLE B_1b**	**SAMPLE B_2b**	**SAMPLE B_3b**
Nfensi Clay (grams/ percentage)	830grams/ 60%	770 grams/ 50%	590grams/ 40%
Mesh size for Nfensi Clay	80 mesh	80 mesh	80 mesh
Sawdust (grams/ percentage)	20grams/ 10%	30grams/ 30%	40grams/ 30%
Mesh size for Sawdust	80 mesh	80 mesh	80 mesh
Grog	380grams/ 30%	430grams/ 30%	350grams/ 30%
Mesh size for Grog	80 mesh	80 mesh	80 mesh
Water	300grams	300grams	340grams
Wet weight	1530grams	1530grams	1320grams
Thickness of the Wall (Dried)	1.5cm	1.3cm	1.4cm
Diameter of the Top	14.5cm	11.7cm	11.6cm
Diameter of the Base	8.2cm	8.3cm	8.3cm
Dried Weight Before	1190grams	1080grams	960grams

Firing			
Dried Height	14.4cm	14.5cm	14.5cm
Fired height	14.2cm	14.5cm	14.5cm
Fired Weight	1080grams	1000grams	820grams
Diameter of the Top	11.9cm	11.6cm	11.5cm
Thickness of the wall (Fired)	1.5cm	1.3cm	1.3cm
Diameter of the Base	8.2cm	8.3cm	8.3cm
Porosity	0.23		0.19
Porosity Percentage	22.86%		18.70%
Flow rate	30g/h	100g/h	-

Table 11: JOLLEYING (These ones were Aged)

- Sample B_1b was brittle but a little bit hard. It was less plastic and rough in texture.
- Sample B_2b was quite plastic, soft and easily workable with.
- 300grams of water was not enough for Sample B_3b to have a good consistency; hence, more water was added as compared to the other two samples.
- Percentages of samples were measured in volumes with a measuring cup equivalent to 10%.
- B_3b was cracked after porosity test.

MATERIALS	**SAMPLE A_2**	**SAMPLE A_4**	**SAMPLE A_5**
Nfensi Clay	630grams 70%	540grams 60%	495grams 55%
Mesh size for Nfensi Clay	80 mesh	80 mesh	80 mesh
Sawdust	90grams 10%	180grams 20%	225grams 30%
Mesh size for Sawdust	100 and 200 mesh (1:1)	100 and 200 mesh (1:1)	100 and 200 mesh (1:1)
Grog	180grams 20%	180grams 20%	180grams 20%
Mesh size for Grog	200 mesh	200 mesh	200 mesh

Water added	450grams	500grams	430grams
Wet weight	1350grams	1400grams	1330grams
Diameter of the Top	12.4cm	12.4cm	12.3cm
Diameter of the Base	-	8cm	-
Dried Weight	1010grams	490grams (cracked)	870grams
Height of Dried Weight	14.5cm	13.8cm	14.3cm
Fired Weight	600grams	410grams	370grams
Fired Height	14cm	13.5cm	13.5cm
Thickness of the Wall	1cm	1cm	0.9cm
Diameter of the Top	11.5cm	11.6cm	11.5cm
Diameter of the Base	8cm	8cm	7.8cm
Porosity	0.38	-	-
Porosity percent	37.5	-	-
Flow rate	189.72g/h	-	-

Tbale 12: JOLLEYING

MATERIALS	**SAMPLE 1**	**SAMPLE 2**	**SAMPLE 3**	**SAMPLE 4**
Nfensi clay (grams/ percentage)	190grams/ 95%	180grams/ 90%	170grams/ 85%	160grams/ 80%
Sawdust (grams/percentage)	10grams/ 5%	20grams/ 10%	30grams/ 15%	40grams/ 20%
Mesh size for clay	80mesh	80mesh	80mesh	80mesh
Mesh size for sawdust	20, 40,60 mesh	20, 40,60 mesh	20, 40,60 mesh	20, 40,60 mesh
Fired Weight	140grams	140grams	140grams	120grams
Weight after porosity test	180grams	170grams	180grams	180grams

Table 13: Final Test Sample Used For The Project

4.Processing Of Materials (Nfensi Clay And Sawdust)

4.1.Clay

- The clay was soaked for 24 hours
- It was reduced to a slip into a porridge consistency
- It was sieved through 80 mesh into another container
- It was then left over for 24 hours
- Excess water was drained off after the setup had settled
- The clay slip was left in a POP mould for another 24 hours to turn leather hard
- The leather hard clay was left to dry by air (on top of the kiln)
- The dried clay was reduced to powder using a pulverizer (grinder)
-

4.2.Sawdust

- The sawdust was derived from a wood called "cyber" and brought from "BIBIANI LOGGING AND LUMBER CONSTRUCTION LIMITED"
- It was sieved through three different mesh sizes (20, 40, 60 mesh sizes)

4.3.Composition

Four different recipes were composed.

Materials	Sample 1	Sample 2	Sample 3	Sample 4
Nfensi clay	95%	90%	85%	80%
Sawdust	5%	10%	15%	20%

Table 14

4.4.Preparation

- All the materials for the compositions were dry mixed and after, wet mixed.
- They were aged for two days (48 hours)

4.5.Forming

- The four different recipes were thrown on a potters' wheel and dried in the open
- They were turned (trimmed) the following day
- They were then left over for three days to dry
- They were fired at 800 degrees centigrade afterwards
-

4.6.Testing

- Porosity test
- Fired and soaked weight
- Flow rate test

4.7.Result

- The fourth recipe (sample 4) was chosen for the final work, due to its fast draining and purity.
- Four filters were produced from it. Namely, sample 4A, 4B, 4C, 4D

MEASUREMENT	**SAMPLE 4A**	**SAMPLE 4B**	**SAMPLE 4C**	**SAMPLE 4D**
Height of Dried sample	15cm	15.5cm	15cm	14.5cm
Diameter of Base	7cm	7cm	7.5cm	7.5cm
Thickness of wall	1cm	1cm	1cm	1cm
Dry weight	455.3grams	507.0grams	462.6grams	591.9grams
Thickness of base	2cm	2cm	2cm	2cm
Fired Weight	388.5grams	427.4grams	395.3grams	500grams
Difference in Weight Between fired and Dried work	66.8grams	80grams	67.3grams	91.9grams
Soaked Weight	500grams	561.3grams	513grams	610grams
Difference in Weight Between fired and Soaked Weight	111.5grams	133.9grams	117.7grams	110grams
Porosity	0.22	0.24	0.23	0.18
Porosity percentage	22.3%	23.86%	22.94%	18.03%

Table 15

4.8.Result

- Samples 2 and 3 were chosen and fixed in the filtering system as the final product, due to their bigger porosity levels as compared to Samples 1 and 4.

4.9.Observation

- Though the fourth recipe was used to produce four samples, it had varying weights and heights, after drying and firing. This was basically due to the fact that, they were all hand thrown on the potter's wheel hence not bringing uniformity amongst them.

4.10.Test for Colonies (Coliforms)

Below are various bacteriological test results from specific samples. Samples chosen for the test were not cracked as they went through the various of testing and were fit for accurate assessment.

SAMPLES	RAW	10^{-1}	10^{-2}	10^{-3}	10^{-4}	10^{-5}		
A_2	+ + +	+ + +	+ + +	+ + -	+ + - -	- - -	220	21 * 10^2 cfu/ml
B_3A	+ + +	+ + +	+ + +	+ + -	+ - -	- - -	210	15 * 10^2 cfu/ml
B_1B	+ + +	+ + +	+ + +	+ + -	- - -	- - -	200	22 * 10^2 cfu/ml
A_4 (PRESS)	+ + +	+ + +	+ + +	+ + +	+ + +	- - -	310	43* 10^2 cfu/ml
F W	+ + +	+ + +	+ + +	+ + +	+ + -	- - -	320	93 * 10^2 cfu/ml
H_2O	+ + +	+ + +	- - -	- - -	- - -	- - -		
B_3A	+ + +	+ + -	+ - -.	- - -	- - -	- - -		

		TOTAL VIABLE COUNT						
A_2		TMCTC	TMCTC	196				19.6 * 10^4 cfu/ml
B_3A		180	112	54				5.4 * 10^4 cfu/ml
B_1B		200	128	92				9.2 * 10^4 cfu/ml
B_1A		TMCTC	192	128				12.8 * 10^4 cfu/ml
A_4 (PRESS)		140	TMCTC	100				10.0 * 10^4 cfu/ml
F W		TMCTC	TMCTC	216				21.6 *10^4 cfu/ml
H_2O		192	44	12				1.2*10^4 cfu/ml
B_2B		TMCTC	60	10				1.0*10^4 cfu/ml

Table 16

NOTE:

(+) means "POSITIVE", indicating the presence of bacteria.

(-) means "NEGATIVE", indicating the absence of bacteria.

(TMCTC) means "Too Many Colonies To Count".

(Cfu/ml) means "Colony Forming Unit per mililitre"

5.Explanation Of Result

SAMPLE	RESULT
A_2	Gram + ve Bacillus (presence of Bacteria)
B_1B	Gram + ve Bacillus (presence of Bacteria)
B_3A	Gram - ve rods Bacillus (absence of Bacteria)
B_2	Short Gram + ve Bacillus (presence of Bacteria)
A_4	Gram + ve Bacillus (presence of Bacteria)
B_1A	Long Gram + ve Bacillus (presence of Bacteria)
A_4 (spread)	Short Gram + ve Bacillus (presence of Bacteria)
FINAL WORK	Long and Short Gram + ve Bacillus (presence of Bacteria)

Table 17

5.1.Fixing And Testing Of The Produced Filter Candle

5.1.2.Steps For Fixing And Testing The Filter Candles

- With the epoxy, mix equal proportions of the resin and the binder.
- Apply the solution evenly unto the part of the candle holder the filter candle is to be fixed.
- Sterilize filter candle by boiling in hot water (preferably,100^o C) and allow to cool
- Carefully fix the filter candles ensuring they are secured and not shaky.
- Place them into the holes made in the upper chamber and secure them with the screws that come along with the candle holder.
- Carefully place the upper chamber on the lower chamber.
- Pour the water to be filtered into the upper chamber of the filtering system.
- Patiently wait for the water to be filtered.
- Open spigot and fetch water. For the first ten minutes, the filtered water received should be poured away since it might contain dissolved dust particles (as a result of the firing process).
- The subsequent filtered water is clean for consumption.

5.2.Pictures Of Fixed Filter Candle

Plate 36: A picture of the two filter candles fixed inside the upper chamber of the receptacle

Plate 37: The screw that holds the filter candles to the receptacle

Plate 38: Receptacle for containing filtered water

Plate 39 : Water being fetched from the filtering system

6.Conclution

The results on tests conducted on the use of Nfensi clay and other accompanying raw materials have given credence to the fact that with careful research on local raw materials many problems that indurate life in the rural areas can be mitigated at minimum cost. This project has brought to the fore a broader spectrum of how important water filtration can be for healthy living. It has also created the awareness that it is very paramount for sterilization and hygienic handling of the filter candle to be taken into consideration whenever water is being filtered for human consumption.

It has led to the production of a filtering body that reduces the penetration of microbes to an acceptable level (porous body) using local materials (saw dust, grog and Nfensi clay). The research has further provided education on the production and handling of the device.

- In conclusion, the project has brought the fore the possibility of using local materials like Nfensi clay in the production of ceramic water filters.
- Furthermore, it is possible to give every single Ghanaian home safe clean drinking water with household ceramic water filters.
- The filter candle can be used anywhere from the home to the office or even in an aircraft, etc without changing the basic life style of the people.
- Researching on Nfensi clay has broadened our understanding on how useful the physical and chemical properties of clay can affect its behavior.

The successful use of saw dust in the research demonstrates that further research can be conducted to expand the knowledge on the usefulness of sawdust to the environment than its harmful impact.

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