27

DESIGN AND CONSTRUCTION OF WATER FILTER CANDLE

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Abstract
The use of water filter candles to purify water has been in existence for a significant period now. Filter candles are suitable and affordable medium for the separation of heterogeneous water mixture through filtration. This article centers on the development and construction of a water filter candle from local raw materials available in selected areas of Nigeria. This design and construction is meant to compliment the ongoing efforts of the water board to provide safe, drinking water. Materials involved in the construction and development of the water filter candles include, silica, sand, refractory sand (Grog) clay and well graded pore creating medium. They also include materials like kaolin, saw dust and binding materials all sourced locally in Nigeria. In this work, efforts were made to establish the right composition and proportion of the materials used, based on experimental results. More was also done in terms of establishing safe and economical methods of production and modes of approach to get the technical data, quality, strength and properties of the materials used. The operating principles of the filter candle in relation to filtration, the quality of filtrate, its efficiency and the possible life span of the filter candle are all outlined within the context of this study.

Key Words: Water, Design, Construction, Filter, Materials

Introduction

In Nigeria today the use of water filter candles to purify water is not a new process. Filter candle can be defined as a medium through which heterogeneous water mixture can be separated by filtration. This filter candle therefore is used for the filtration of domestic water mostly for drinking. Attempt has been made by many scholars and researchers to write papers and project out on these subject matters. But to the best of my knowledge, development of such filter body has not been made to an acceptable technical quality as yet. The aim of this project is therefore to develop and construct a water filter candle (a candle) from local raw materials available in Nigeria. This is to complement the effort of the water board to produce safe and clean drinking water. It also becomes a necessity in the field of ceramics to boost Nigeria's technical achievement in this field. The raw materials involved in this project are silica, sand refractory sand (grog) clay and well graded pore creating medium. They also include kaolin, saw dust and binding materials. This water filter candle is like a thick walled tube made from refractory composite materials.

The open part of the tube is covered with a supporting base cape, with a manifold projected out of it, or screwed into it. It is on this supporting base cape that the whole filter is fitted into a container to serve its purpose. The tube is made from composite materials. As mentioned above the base cape is generally made from corrosion resistant materials since the medium in which it operates water.

In this work, effort has been made to establish the right composition and proportion of the materials used, based on experimental results. However, it is not being the ultimate. Effort has also been made to establish methods of production and modes of approach to get the technical data, quality, strength and properties of the materials used (Shehu, 1995). The operating principles of the filter candle in relation to filtration, the quality of filtrate, its efficiency and the possible life span of the filter candle are all outlined. Cleaning method and maintenance are also stated. The main materials for ceramics are clay. The term clay is applied to those natural earthly material deposits, which possess the property of plasticity.

Clay is a secondary rock that been formed by weathering of certain rocks and it is a mixture of different types of materials. The weathering of these rocks were achieved by the mechanical action of water, wind, glaciers and earth movements working together with the chemical of water, carbone dioxide, humus acids and more rarely sulphorous and flourous gasses assisted by elevated temperatures. The removal of pathogens and suspended particles from water by filtration involves exposing the suspension to a porous material which selectively permits the fluid medium to penetrate through it. The pores size of the filter must be smaller than the particles to be moved. However, for best efficiency the total pore area exposed to the suspension must be as large as possible.

Ceramics water filtration involves the use of porous ceramics (fired clay) to filter microbes or other contaminants from drinking water. Porosity in the ceramic products.is created by mixing burnout material into the unfired clay which is typically very fine sawdust, ground rice husks or some other combustible materials that burnout during the firing process to leave behind pore space. In this study water was filtered

through ceramics filter candle made from clay and hardwood sawdust. The quality of water was determined by evaluating the turbidity of water, the number of total coliform in 100ml of water before and after filtration, the percolation rate of the water, colour changes on the water after filtration and die pore size of filter candle.

Statement of problems

Nigeria is faced with the challenge of low safe drinking water. This poor access to safe water has a lot of implications for sustainable development. The methods of purification like chlorination and large scale filtration cannot be afforded by many Nigerians especially rural people who live below poverty levels. Boiling would encourage cutting down of leading to environmental degradation. Ceramic water filtration becomes a cheap and efficient method since all the materials required are available locally and has relatively long life time of 1-3 years. The technology can work all year round in different climates and does not impart an objectionable taste to the treated water. Vinlca and Lubiclc n.d have reported that there is no information available on how relative amounts of the raw materials used to make the filters affect performance.

Purpose of the study

The aim of this study is to develop a ceramic filter candle for house hold water treatment using locally sourced materials from Yola metropolis.

The Specific Objectives include:

The specific objectives of the study are to:

1. determine the effect of the proportion of hardwood sawdust on the porosity of ceramic filter made from selected Nigeria clay samples,
2. determine the rate of PH before and after filtration
3. determine the rate of tot& dissolved solids (TDS) before and after filtration,
4. determine the dependence of the turbidity removal efficiency on the and thickness of the filter
5. determine the dependence of total coliform removal efficiency on the porosity and the thickness of the filters
6. substance from water, the scope of study is narrowed down to the production of water filter candle using clay and hardwood sawdust

Kaolin clay

Kaolin is clay which is most used because it is pure and it is hydrated aluminum silicate kaolinite exclude to be able to stay in water and a reasonable strength to the whole structure will be required. In addition to the properties mentioned above, the material has to be non- reactive to oxides and non-poisonous. It has to be chemically inert and mechanically fit in its operating environment. Having considered the above mentioned properties, the materials are finally chosen

Method Adopted

Experimental method was adopted in executing this work. Experiment research employs different treatments and establishes their effects in the study. The outcome leads to clear interpretation of effects and findings.

Collection of material

Materials and methods

1. Clay samples: The clay samples used in this study are kaolin and ball clay from Sangere. Kaolin and ball clay preferred because of their purity and plasticity respectively.
2. Hardwood sawdust: hardwood sawdust was used as a burnout material.it was obtained from Jimeta bye –pass timber workshops Yola, Adamawa State. Hardwood sawdust is preferred because according to McAllister (2005), resulting in more uniform pores and less defects in the filter
3. Sieve A 30-gauge sieve wire mesh which is equivalent to 600um wire mesh was used for sieving of both the clays and sawdust. A mesh is the number of spaces or openings in one linear inch of the sieve.
4. Material for the Filtration Unit: Two local pots where used as filter tasks. They were bonded together by an adhesive and a hole was drilled, at the bottom of the upper pot. The opening is where the filter candle is going to be fixed, for the filtration of water from the upper pot to the lower pot.
5. Adhesive: PVC adhesive was used for bonding ceramic filter and the pots. It was used because according to the specifications of this adhesive it is suitable for household and industries repair and welds, bonds to all metals, aluminium. Stainless steel would have been better but its cost and throws availability it out of the question.

Selection of Materials

The selection of materials is analyzed, first of all, in ceramics materials to be chosen for a specific purpose depend on what type of work the equipment is going to be used for the purpose of the filter candle, choice of the materials for the filter medium is often the most important consideration in assuming satisfactory operation of a filter. The medium should be selected primarily for its capability to retain the solids that filter –media are manufactured from materials that exhibit most of the characteristics mention above. Materials in use so far include Cotton, synthetic polymers, and glass, asbestos, cellulose, refractories, carbon metals and other particulate solids capable of forming a permeable bed, i.e. in case of sand gravity filters. In the water filter candle, the following materials were used:

1. Clay (black clay)
2. Kaolin (china clay)
3. Grog (refractory sand)
4. Sawdust (pore creating materials).

These materials were chosen in consideration of the points mentioned earlier. The WHO has put guidelines for designing sustainable water filters which include the following:

1. Limit non-renewable energy consumption.
2. Lessen environmental impact.
3. Select appropriate materials which are readily available and easy to process.
4. The Manufacturing process should not cause harm to individuals and be as simple as possible

Effectiveness of ceramic water filter

Ceramic water filters have been shown to be effective system for point –of –use water treatment in low income communities. The technology is simple, affordable and utilizes local materials and knowledge. Brown, (2007) studied the effectiveness of ceramic water filter and found that ceramic water filter reduces E-coli bacteria up to 99% with mean reduction of approximately 99% in both laboratory and field testing. Use of the ceramic water filter reduces diarrhea disease outcome by approximately 40% in user, maintain effectiveness over long period up to 44months in field use. According to McAllister, (2005) ceramic water filters, impregnated with colloidal silver, have 99.9% removal of most types of water born bacteria.

Materials and Methods

Pore Creating Material (Saw Dust)

Generally, pore creating materials include wood, coke, straw, chaff, corn husk and any saw dust that can burn out leaving very tiny holes that sometimes cannot be seen with naked eye. To obtain a porous body, a pore creating medium has to be introduced; the one used in developing this work was saw dust of fine grade. The sieve used was 0.01mm aperture. Therefore, the recipe should consist of an impregnating self-supporting porous metric body which is composed of materials capable of being removed by heat, with a powdered ceramic material (powdered mixture of ingredients which will form a ceramic material on heating.)

Materials and Methods

Composition of Raw Materials

As analyzed under section of materials, the raw materials chosen for the development of this filter were:

1. Kaolin (China clay)
2. Fine
3. Clay
4. Saw dust
5. Silica

These materials were chosen so as to get the desired quality of the item in question. However, some of the materials could be substituted by other raw materials like Bentonite, quartz sand, stone ware, porcelain, alumina carbon graphite, roam etc.

Plastic, rubber, wood, ceramics, glass and concrete. The adhesive is also not shrinking, water proof and hardens quickly. These properties are very important for the use of the adhesive in the study.

Materials and Methods

Procedures of Execution

The following are the ways in which the study was carried out:

1. Clay preparation: The kaolinite and ball clay samples were sieved with a 30um mesh sieve to get fine clays
2. Sawdust Preparation: The sawdust was dried in the sun and then sieved through the 30 mesh sieves to get fine powered sawdust.

3. Mixing the Dry powders: The clay and sawdust was weighed in the proportion of 95:5, 90:10 and then thoroughly mixed manually. To ensure that the powders were properly, mixed, the mixing process was done for a long time
4. Forming of Slip: Water was added to the powder mixture, in their right proportion. It was stirred vigorously until it became creamy.
5. Production of Models Model: was produced by throwing on the potter's wheel using plastic clay. Potter's wheel was preferred because of the cylindrical nature of the candle. Moulds was produced using the following materials; model, POP, water, Cottles, oil, and plastic clay. The plastic clay was used to cover parts of the model; Cottles was then used to build walls around the model. Pop was mixed with slip poured inside the Cottles, it was allowed to harden, and then turn to the other side of the model covered with plastic clay, and the process was repeated. Note that the mould is in two pieces.
6. Firing: The filter samples were subjected to a change in temperature by firing to 1000^{0}C. The firing to 1000^{o}C was enough for the burnout material to escape leaving pores.

By preparing/composition of the materials that is by mixing all of the materials according to the prospection them sew with fine mesh live to settle after settling the slip to dry to make it a bit leather, Ready to mould.

Moulds are generally made from metals, sand, and plaster ceramics and other refractory materials. In this case, the mould was out of plaster based on the fact that plaster gives excellent characteristics. The most important characteristics of plaster in this regard is that it absorbs s moisture from cay slip much faster than fire clay moulds. Its shrinkage is negligible for the production of very fine details; plaster has no grain or lump, so when mixed with water it becomes quite plastic at one stage and hard at another. Hence, it can readily be powered, paddled cured and polished. In fact, this is an ideal material for working into shapes.

They mould whatever you want but thrown water filter on wheel the throwing what makes it to be easier than handmade also the wheel thrown filter can is easier band and made handmade Locally. Mould be little variation in the shrinkage that would arise from the various composite materials.

Preparation of Recipe (SLIP)

Recipe is a soaked proportion composite material that is used for casting. This recipe was prepared by weighing the appropriate amount of the various materials and 25-45% of water by weight of the dry ingredient was added to mixed materials. This was allowed to stay for two days so that the saw dust ages and a deflocculated (Sodium silicate) was added in a small amount. This deflocculated was to keep clay particles in suspension. At this stage, the clay was ready for casting.

Casting of the Filter Candle

After preparing the slip, the mould was tied

Firing the Tested Candle

When the candle was completely dried, it was subjected to a firing temperature range of 500^{o}C to 800^{o}C. The aim of it was for the candle to acquire refractoriness so that it could wristband its environment its environmental stresses and strains. In addition to that, it allows the saw dust which was used in the recipe to be burnt out thereby creating the pores through which water was to be filtered.

The firing temperature was restricted to a range of 500^{o}C to 800^{o}C because at a temperature higher than that, some easy fusing clay fuse and envelope some of the clay grains that were yet to be fused thereby sealing the pores and the whole structure turns out to be stone which is not desired. Blow this temperature, some of the saw dust deep inside the filter candle core might not be completely burnt. After firing, the filter was now ready to take up its cape and face the challenge for which it was made. It permanently stuck to it for life. Therefore, at this stage the filter candle is ready for testing.

Results and Discussion

Physical Appearance of the Fired Filter Samples

The Sample of the filters were light golden brown after firing as shown in plate I below.

This could be due to lose of moisture, organic matter, sculpture and carbon IV oxide during firing, as the temperature rises, some of the clay particles begin to fuse, destroying the original clay structure and binding the mass together. But the pores also open s space for air to pass due to the materials that burns of saw dust.

Plate I. Constructed Water Filter Candle

Plate II. Fixing of Water Filter Candle into Pots Which Heterogeneous Water Mixture Separation by Filtration takes place

Plate III, Fixing of the Pipe Head that Filtered Water Can Pass through

Water Absorption and Porosity of the candle

The water absorption and porosity rate of sample B is higher compared to sample A in table. High absorption rate of sample B is due to the increase in saw dust which burns out during firing

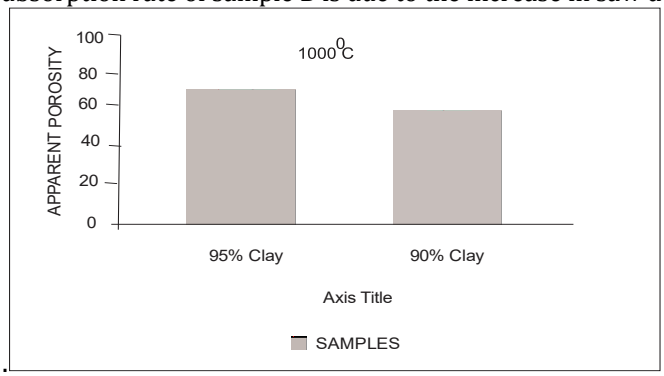

Fig 1: Water absorption at various proportions of Sawdust.

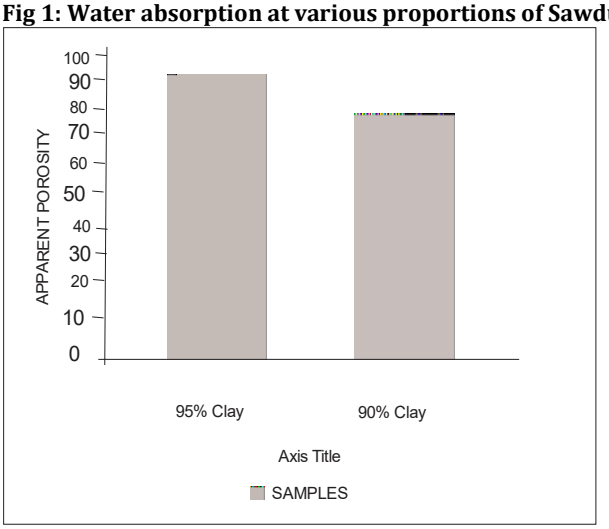

Fig. 2: Apparent Porosity of Water Filter Candles

Turbidity of water

The average turbidity removal efficiency of the filters generally decreased with increase in porosity as shown in table 1. This could be because as the porosity increases, the volume of pores in the filter increases and hence more water and particles percolate through the filters. This increases the turbidity of the filtered water and hence reducing the turbidity removal efficiency. The turbidity removal efficiency was general higher in sample A filters than sample B filters as seen from table,1. The filter could reduce the turbidity water up to 98 to 0.7% and 99=0.7% Sample A and B. hardness and absorbency of the mould, which is the most important factor in this case. The less the water, the harder and stronger the mould, and the less absorbent it is. The more water is used the softer it becomes and the less durable it is. The water plaster ratio known as the consistency is when it ranges 60-75 part of water to 100 parts of plaster.

Moulds generally undergo wear put typically 25-50 piece can be cast out of a well-prepared moulds before wearing predominates. Although deflocculates in clay slips may attack the mould, this is not of concern here, the above outlined characteristics of plaster has secured a place for its application in this regard. Moulds making consists of some sub-steps:

1. Making the mould
2. Making clay slabs
3. Making a moulds box
4. Preparing and pouring of plaster.

Cost the model than mould out from the model. So the mould will be use to pour the slips models bring out the replacement of the wheel throwing.

Making Clay Slabs

Some rolling it reasonable amount of clay was worked and placed in between two uniform rods on a working bench. A wooden roller was used to prepare the slab by rolling it across in the direction parallel to the two uniform rods the purpose of this lodes is assuming information of the slops.

Make the Model

The model of filter was made using ball clay. The model is a replica of the desired shape of the object to be made, so in this case a model of the water filter with mould you can produce mass is a shorter time than wheel thrown. Can build out of ball clay. In building this model, a tolerance and shrinkage allowance was included so that when it dries its size approximates the design. This model was then allowed to set, and then a parting line was drawn vertically dividing the model into two halves before allowing it to dry.

The slab is cut into the required of sheets so that a box will be formed out of it. A template is cut from a thin sheet of a clay according to the shape of the line of preparation on the model. To do this, a sheet of a clay is placed behind the model and a rough sketch is made on the clay sheet indicating the shape of the model. The profile of this model is cut out and the model placed into the space. It is adjusted so that the parting line on the model coincides with surface of the clay slab which looks like it. One face was dressed with a soap film or oil readily waiting for the plaster to be poured. This soap or oil is to make separation easier. So it is called separator.

Preparation and pouring of the plaster

The plaster was mixed with the appropriate amount of water, poured into the box and book. This was to enable the plaster fill every corner of the box. After five minute the plaster solidifies. The whole set up is now disassembled leaving only the plaster with the model half covered by the mould and half opened like a shoulder (fig 1.3). Little key holes were then made on that half of the mould at four strategic points and another box was formed round the s putting a little water alone sets up to complete the other half by repeating the above procedure. The mould was achieved and separation was done by putting a little water along the separation line and applying a little effort separating them. The mould was generally made with small allowance, expecting that their technical data imposed a final limit to achieve the desired quality. These filter body variables are the raw material mentioned above. As the Experiment conducted, best combinations of the raw materials were:

Kaolin =40%
Grog =50%
Clay =10%
Sawdust =25%

This material was used to prepare strong filter candle especially the grog that was mixed with the other materials. The general result of the experiment conducted is shown in table 1.0. In the table shown, the firing temperature range is seen to be the same. The reason is that the sawdust used as a pore creating medium burns out within this temperature range of 500-800^{0}C, although, the higher the firing temperature the higher the filament because. It is not advisable to fire it above just as seen in Fig (1)

(b)This filter cap is produced out of the aluminum alloy (1100). It is primarily a support and collecting medium. It is required to withstand corrosion as earlier mentioned, at least to have enough strength to support the structure in question.

Development and production of the filter Candle

The filter candle was developed from grog, kaolin, clay and sawdust. This Was achieved by varying the filter composition that produced the desired quality. According to the experiment, Kaolin=40%, grog =50%, clay =10%, And saw dust =25% by volume. The general method of production was by casting or ramming. The steps for the production of these candles are analyzed one after the other.

Testing of Filter candle performance

Testing and Results

The filter candle was tested by planting it into a container; the container was filed with water to its brim and placed upon the collector. It was tested for one hour and result was noted. It was then repeated for about five (5) times and the average flow rate was taking. This was done for every candle made and the results obtained tabulated are in table below.

Total Coliform Removal

Total coliform removal did not have a define pattern with porosity. Total coliform removal depends on the pore size, pore arrangement and path that they pass through coliforms take the more. The longer the path that the coliforms takes the more they are suffocated to death, this also explains why some filters had a good total coliform removal of up to 0.7%.

PH of the Water Sample

Table 1 shows the PH before and after filtration. The result of PH obtained before and after filtration, is close to the value of the WHO standard for drinking water (6.50 to 8. 50).

Table 1, The PH of water before and after filtration

Filter sample	Before	After filtration
Sample A	6.20	6.52
Sample B	6.20	6.47

Table 2, Results of filter could performance

S/N	Kaolin (%)	Clay %	Grog %	Saw-dust %	Absorbity %	Firing Temperature ^{o}C	Vol. of filtration Liter	Quality of filter
1	60	10	30	25% By V	28.33	500 to 800 $500^{o}C$- $800^{O}c$	2.4	Fair
2	55	10	35	25% By. V	25.92	500 To 800 $500^{0}C$-800^{0C}	2.7	Good
3	50	10	45	25% By. V	28.5	500 To 800	3.5	V. Good
4	45	10	45	25% By. V	27.6	500 To 800	4.5	V. Good
5	40	10	50	25% BY.V	27.0	500 To 800	5.6	Excel
6	35	10	55	25% By .V	28.3	500 To 800	4.6	Good
7	30	10	60	25% By. V	28.3	500 To 800	3.8	Fair

Discussion of result

As shown in the table 1 the best combination of the materials that gives the greatest amount of filtrate is experiment no .5 which has Kaolin =40%, clay =10%, grog =50% and 25% by volume of sawdust. This filter candle was able to produce 5.6 little's of clean filtered water in one hour. The filtrate obtained was colorless, tasteless and clean. It was kept for three days under an undisturbed condition to see if there was settlement of fine particle, but none of such was found. It was then subjected and microscopic tests, the results revealed that there was no growth and no organism was found.

Although no other standard test was performed it was discovered that the results where good. The absorptivity of the particular filter was found to be 28.46%.

Flow of Water in the filter cable

The mechanism by which is filtered through the filter candle is by mechanical straining, adhesion, sedimentation and flocculation.

Straining has been identified as the principle mechanism responsible for the removal of the suspended solid particles during the filtration process. Adhesion – Is the attachment of impure particles to the filtering medium either because of the force of flowing water or by the sticky nature of some materials. Sedimentary – This the process where by some heavy particles settle downside the side of the filter medium.

Flocculation –This is the process whereby some particles join to form yet bigger particles which are subsequently removed by straining. The sketch of flow of water through the filter medium is shown in fig 3.1 The rate of flow through a filter may be expressed as:

$$\frac{(I - MC)\ W = V}{Fc}$$

The equation of continuity can as well be applied to this type of situation. Detailed analysis of flow.

Conclusions

Countries like Nigeria face tough challenges in terms of providing safe clean drinking water for tis citizens. Ceramics water filters offer an affordable and effective means of treating water for standard; suitable for drinking. In this study, water filter candle was designed, constructed with locally sourced Materials and tested to evaluate its performance. The system compromises the ceramic filter element and local pot receptacle. The local pot receptacle houses both the filtered water and the filter element in its compartments. Water sample from a local well in Sabon Gari was subjected to a test before and after filtration. The filters were effective in reducing the turbidity level to the recommended values, the results

of PH of water samples obtained after filtration was within the range of the Who standard for drinking water. The values obtained after filtration for total dissolved solid (TDS) and total suspended solid (TSS) rom water samples were 15 Mg/L, respectively. Water absorption rates, apparent porosity rate, percolation and permeability rate showed that the increased with increase in ratio of sawdust to clay. Slip casting method produced good filter sample with even thickness with all –round the filter. Techniques is the cheapest methods of production when compared with pressing which involves hydraulic press that is capital intensive. Some adjustment like using colloidal silver chloride of reducing the particle size of the samples could be made.

Recommendations

Based on the findings and discovery in the course of this study, the following recommendations are made:

1. Considering the effectiveness of the slip casting method in the shaping of ceramics pot filters as shown in this study, it is recommended that this technique be employed in the production of ceramics filters
2. Further study and research be carried out on the developed filters to improve upon its performance in water treatment by government and private investors to bring about mass – production of ceramic filters.
3. Further study to compare other burnout materials and their effects on the microstructure of the filters and water treatment is recommended.

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