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Filtration Rate of Ceramic Clay Filters Treated With Rice Husk

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ABSTRACT

The availability of pure, clean and safe usable water for drinking and other domestic use is a major challenge faced by most developing nations' rural communities. In the pursuit to make available safe, pure and clean usable water, a ceramic clay filter produced from clay soil is used as an absorbent barrier in household water treatment. To investigate the effectiveness of rate of flow through ceramic clay filters when treated with up to 20 % rice husk, five different ceramics filters were produced at 0 %, 5 %, 10 %, 15 %, and 20 % addition of rice husk in the laboratory and were sintered at 1000^{O} C. Water flow rate were measured for the ceramic clay filters produced by measuring the volume of filtrate. It was found that the volume of filtrate increased as the percentage of rice husk added to the clay soil increased.

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Water, Ceramic Clay Filter, Rice Husk, Clay soil and Filtrate.

INTRODUCTION

Water is very essential to every living species to survive on the earth surface. The availability of safe, pure and clean water has being a global issue, particularly in remote communities of the emerging nations (Odenigbo and Musa, 2018). In the pursuit to make available safe and clean usable water, ultra-violet (UV) distillation and chlorine treatment have been used to purify water. Those in the rural communities find it difficult to use these modern methods of purification before using the water due to lack of resources availability. Clay soil is one of materials that are available in most parts of the world, it can be moulded easily into any desirable shapes, and when fired in the kiln/furnace at high temperature it chemical composition changes resulting into a strong material which does not deteriorate in water (Ebenezer, 2016). It is generally well known that clay soil is used as the most vital raw material in the production of ceramic water filters. It was reported in (Hagan et al. 2009), that clay soils that are fit in making other pottery production should be appropriate in making ceramic filters. Ceramic clay filters are often affordable and have become very instrumental in water purification to a suitable standard for usage especially in rural communities of developing nations where access to safe usable water is limited (Brown and Sobsey, 2006). Ceramic water filters are produced in different variety of pore sizes and shapes which include candle filters, disc filters and pot filters (Matteiletea, 2006). The world health organization (WHO), SDG and other NGO's have being devoted in making sure that those living in rural communities gain access to safe usable water.

Studies on the effectiveness reveal that ceramic clay filters reduces *E.coli* bacteria up to 99.9 % with mean reduction of approximately 99 % in both laboratory and field testing. It reduces diarrhoea disease outcome by approximately 40 % in users of ceramic clay filters versus non users (Brown, 2007). The results of the water quality tests carried out on twenty four ceramic clay filters in seven communities in Nicaragua, showed that in the fifteen(15) homes which had E. coli in their source drinking water, 53% tested negative for E.coli after filtration test (Lantagne, 2001 b). According to (Johnson et al. 2008), ceramic clay filter users in rural communities in Ghana were 70 % less likely to have diarrhea. Ceramic clay filters are effective because of the micro pores which are formed when the combustible or burnout material is burnt off during firing and can sometimes achieve turbidity levels below WHO standards of 1 NTU

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(NephelometricTurbidity Unit) or slightly above it (Mcallister, 2005).

The effectiveness of ceramic clay filters can be enhanced by the addition of burnout materials which raise the flow rate by producing a network of pores. The most commonly used materials are burnable materials and when placed in the kiln/furnace, the material burns completely leaving corresponding pore spaces. The porosity of the fired mass is roughly proportional to the amount of combustible matter added. The main combustible materials are hard wood sawdust, naphthalene, cork seeds, corn husks and rice husks (Kabagambe, 2007). Petroleum waste products can also be used, however they burnout at higher temperatures than wooden sawdust (Kabagambe, 2007). The volume of burn out material added to clay soil varies depending on the dominant mineral content in the clay and is adjusted until the appropriate filtration rate in the heated elements is achieved.

In this study a clay soil collected was combined with rice husk up to 20 % addition. Use of agricultural waste from different industries has received increasing attention in recent researches. Rice husk is a by-product of rice milling and is abundantly accessible in rice growing communities within the Niger River of Nigeria. When rice husk recycled by burning, it generates rice husk ash, which contains a huge quantity of amorphous silica (Chiarakorn, 2007). Rice husk ash has been used in various fields for manufacturing of different silicates, catalysts, zeolites, insulators, lightweight construction materials, and adsorbents. Amorphous silica obtained from rice husk ash provides a potential alternative to conventional silica sources (e.g. quartz) for the production of value added ceramics for practical applications.

The aim of this paper is to determine the variation in flow rate of ceramic clay filters manufactured from clay at an incremental percentage of rice husks addition.

METHODOLOGY

Methods of Samples Collection

The clay used was collected from a pit of 1 m deep at Auchi, Edo State, Nigeria. The soil contains kaolinite as the dominant clay minerals. The soil is classified as CL according to the Unified Soil Classification System (ASTM, 1992).

The rice husk used in this study was collected from Osamede rice mill at Ekperi in Etsako central local government area of Edo state. It is washed, dried and sieved through 80 µm.

The water used was from a borehole within Edo State University Uzairue, Engineering faculty.

Procedures

The clay soil and rice husk were mixed in stepped increment of 5 % from 0 % to 20 % by volume of dry clay soil to form five different samples. Little water added and mixed in small amounts until the clay soil and rice husk clumps together completely and is soft and workable. A disc mold was used to shape the mixed samples in proper shape of 30 cm diameter and 20 mm thickness. The samples were dried at 110^{o}C for 24 hours and an electric programmable furnace was used to fire the samples up to a temperature of 1000^{o}C. The samples were soaked in water for 24 hours to saturate the pores and avoid cracking before experimented the rate of flow through the samples.

Experimental Analysis

Five separate test runs were completed as summarized in Table 3.1. The rice husk was mixed with the soil in stepped increment of 5.0 % from 0 % to 20 % by volume of dry soil to form five different soils – rice husk mixture.

Table 3.1: Ceramic filter produced without rice husk

S/NO	TIME INTERVAL	VOLUME OF FILTRATE (ml)
1	2 hours	5
2	4 hours	21
3	8 hours	54

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Table 3.2: Ceramic filter produced with 5 % rice husk addition

S/NO	TIME INTERVAL	VOLUME OF FILTRATE (ml)
1	2 hours	10
2	4 hours	29
3	8 hours	77

Table 3.3: Ceramic filter produced with 10 % rice husk addition

S/NO	TIME INTERVAL	VOLUME OF FILTRATE (ml)
1	2 hours	14
2	4 hours	33
3	8 hours	81

Table 3.4: Ceramic filter produced with 15 % rice husk addition

S/NO	TIME INTERVAL	VOLUME OF FILTRATE (ml)
1	2 hours	18
2	4 hours	48
3	8 hours	110

Table 3.5: Ceramic filter produced with 20 % rice husk addition

S/NO	TIME INTERVAL	VOLUME OF FILTRATE (ml)
1	2 hours	21
2	4 hours	55
3	8 hours	127

RESULT AND DISCUSSION

RESULT

For each of the ceramic filters, the rate water that percolated through the disc was calculated by dividing the volume of filtrate by the time at which the volumetric measurement was taken (Equation 3.1).

$$Flow\ rate = \frac{Volume\ of\ water\ measured\ at\ time\ T\ (ml)}{Elapsed\ time,\ T,\ from\ start\ of\ test\ (hours)} \qquad 3.1$$

Table 4.1 show the result of the flow rates for the ceramic filters, where T = the duration of filtration, A = volume of water filtered from ceramics filter 1 (which is the ceramic filter produced from clay without RH), B = volume of water filtered from ceramic filter 2 (Which is the ceramic filter produced from clay and 5 % rice husk), C = volume of water filtered from ceramic filter 3 (which is the ceramic filter produced from a mixture of clay and 10 % rice husk), D = volume of water filtered from ceramic filter 4 (which is the ceramic filter produced from a mixture of clay and 25 % rice husk) and E = volume of water filtered from ceramic filter 5 (which is the ceramic filter produced from a mixture of clay and 20 % rice husk).

Table 4.1: Flow rate computation for each samples

Time (hr)	A (ml)	B (ml)	C (ml)	D (ml)	E (ml)	Q1 (ml/hr)	Q2 (ml/hr)	Q3 (ml/hr)	Q4 (ml/hr)	Q5 (ml/hr)
0	0	0	0	0	0	0	0	0	0	0
2	5	10	14	18	21	2.5	5	7	9	10.5
4	21	29	33	48	55	5.25	7.25	8.25	12	13.75
8	54	77	81	110	127	6.75	9.63	10	13.75	15.88

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Q1 = flow rate of ceramic filter 1
Q2 = flow rate of ceramic filter 2
Q3 = flow rate of ceramic filter 3
Q4 = flow rate of ceramic filter 4
Q5 = flow rate of ceramic filter 5

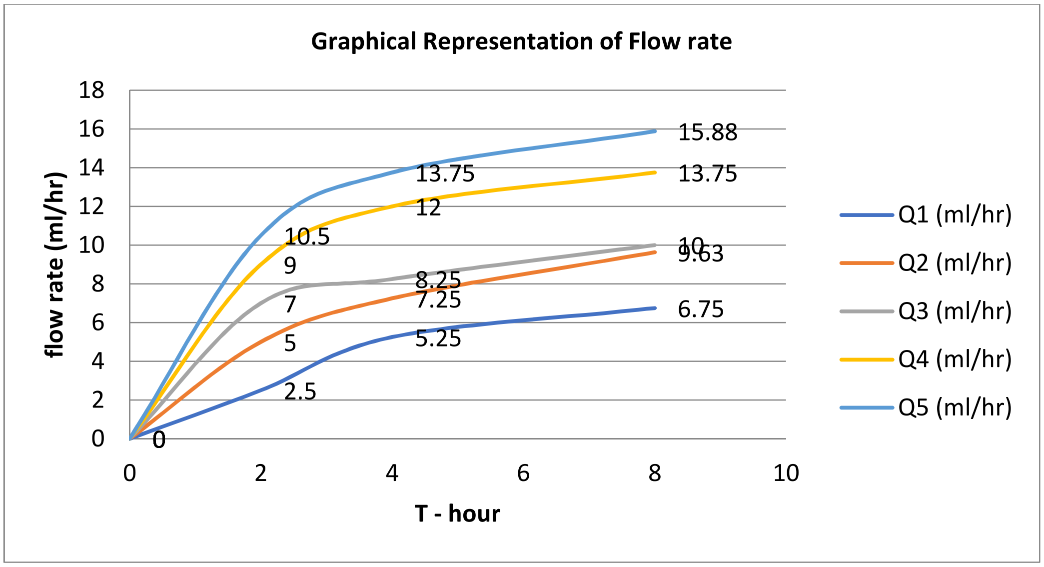

Fig. 4.1: Variation in flow rate

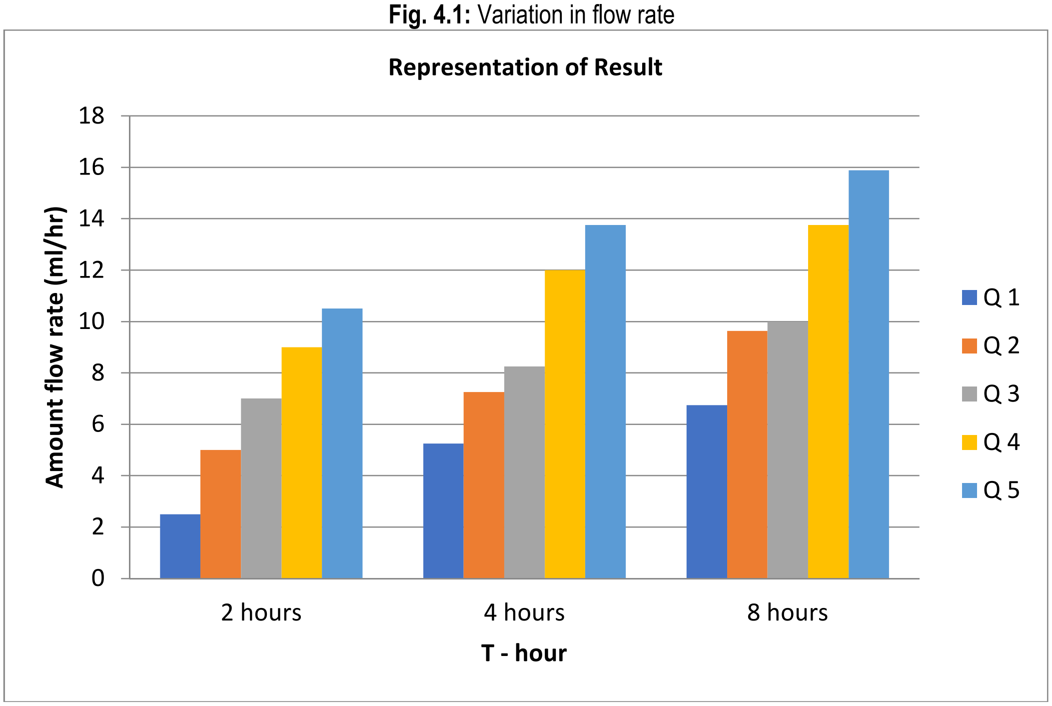

Fig. 4.2: Graphical result of flow rate

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DISCUSSION

As seen from table 4.1, figure 4.1 and figure 4.2the ceramic filter produced from clay without rice husk yielded a lower filtrate of 2.5 ml in 2 hours, 5.25 ml in 4 hours and 6.75 ml in 8 hours than the ceramic filter produced from clay with 5 % rice husk which yielded a filtrate of 5 ml in 2 hours, 7.25 ml in 4 hours and 9.63 ml in 8 hours. The amount flow rates increase with time and with increase in percentage of rice husk added to the clay soil. The increased in flow rates with higher rice husk additive is due to the large network of pores created in the filters after the combustion of the rice husk and it imply that the rice husk burnt out completely at 1000^{0}C. This indicates that the ceramic clay filter produced with more rice husk will do better with respect to filtration though the higher the risk of impurities that will percolate through. Due to the availability of clay and rice husk in most part of the country, before production of ceramic clay filters in large quantity using clay and high percentage of rice husk additive, a further research is encourage to determine the removal efficiency of microbes by the ceramic clay filters using this combination.

CONCLUSION

Based on the results of this study, it can be concluded that: rice husk can be used as a pore-forming agent in the production of low-cost ceramic membranes, the higher the percentage of the rice husk in the mixed the increase in the rate of filtration. The increase in filtrates is due to total combustion of the husk at 1000^{o}C.

RECOMMENDATIONS

A high amount of flow rate could reduce the effectiveness of filtration and may not be able to remove the required bacteria, parasites and other impurities therefore a further research should be carry out to determine the maximum percentage of rice husk to be added to a clay soil for effective filtration.

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