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Production And Evaluation Of Water Filter Absorbent Pot Using Ceramic And Biomass As Alternative Source Of Water Purification For Rural Areas

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Abstract
The use of contaminated drinking water by some villagers results in the spread of waterborne diseases such as diarrhea, cholera, and other long-term illnesses. This present study aims to produce ceramic water filter pot blend biomass as an alternative water purifier for rural areas. Clay and bimass samples were obtained from Kaura Namoda Zamfara. The physical properties of clay, namely moisture content (10.54%), specific gravity (1.74%), dry density (1.61%), liquid limit (32.84%), and shrinkage (12.70%), and proximate analysis of the biomass were determined using standard analytical methods. The two ceramic pots produced from different biomass at different ratios of clay to biomass were used to filter stream water obtained from Yankaba village. The results show an efficient reduction of turbidity, conductivity, alkalinity, iron, sulfate, and silica by an average of 58%, 60%, 40%, 68%, 76%, and 81%, respectively. Total removal of bacteria and E. coli was recorded, and 78% of coliform was removed. Using statistical analysis to compare the ceramic pot, a significant difference was observed in filtration efficiency between the ceramic pot produced with groundnut shell and rice husk. Therefore, it was concluded that the use of a ceramic pot filter should be encouraged in rural areas to reduce the spread of waterborne disease.

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I. Introduction

The water challenge in rural communities in Nigeria is indeed a pressing issue with significant implications for public health and development (Ajibade et al., 2015). The statistics provided by the World Health Organization underscore the severity of the situation, particularly regarding access to safe drinking water (WHO.2008). Various factors, including inadequate infrastructure, climate change, and governance issues, contribute to this challenge

Both governmental and non-governmental organizations have made efforts to address this issue. Initiatives such as the Rural Nurture Initiative in Zamfara State highlight attempts to provide clean water to rural dwellers. However, more comprehensive and sustained efforts are needed to ensure that all rural communities can access safe drinking water (Bain et al., 2012). One promising solution that may be mentioned is the use of ceramic water filtration pots. The production of a clay ceramic filter for water purification offers a cost-effective and efficient means of water treatment, significantly reducing waterborne diseases (Shigut etal.,2012).

Filtration is indeed a widely used and effective method for water treatment. By passing water through a filtration system, contaminants such as suspended particles, microorganisms, and some toxic metals can be removed, thus improving water quality (Oyandel and Smith, 2008). This process helps reduce the risk of waterborne diseases like cholera and diarrhea, which are major causes of morbidity and mortality, particularly in developing regions (Rayner 2009).

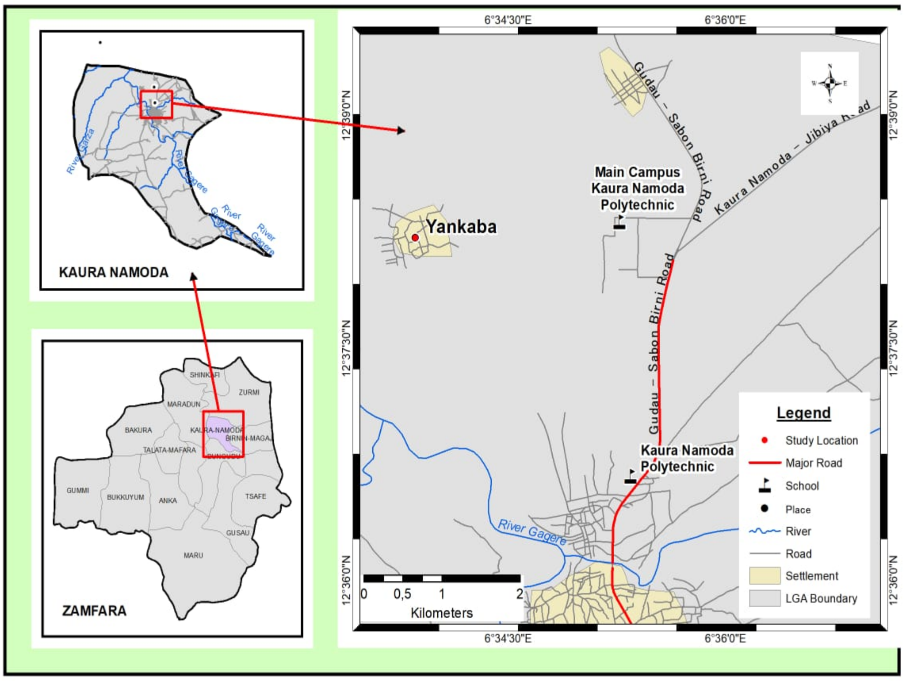
Ceramic filters have been proven to be effective over the years and offer flexibility in design, making them suitable for various household needs (Lamichhane and Kansakar, 2012). Therefore, implementing effective water treatment methods, especially in rural areas where clean water access is limited, is crucial for public health and disease prevention (Zeraffa and Bekalo, 2017). However, access to clean water remains a significant challenge in many communities, particularly in African rural areas. These communities often rely on streams and wells for water, which are susceptible to pollution from agricultural chemicals and microorganisms during rain showers (Agbo *et al*., 2015).

Traditional water treatment methods, such as chlorine and activated carbon, can be costly and inaccessible to low-income earners (Subriyer, 2013). As a result, the use of clay filters for water purification has gained attention as a more affordable alternative. Ceramic filtration, utilizing clay-based filters, has become a common household water treatment method worldwide. Various studies have been conducted on the production and effectiveness of ceramics. The findings of this research could have implications for improving access to clean and safe drinking water, ultimately reducing the burden of waterborne diseases among the underserved (Gupta *et al*., 2018)

II. Material And Methods

Samples Collection

Clay, Rice Husk and Ground Shell were sources from Kaura Namoda, Zamfara state. Clay and water samples were sources from village called Yankaba as shows in the map. While the rice husk and ground shell were sources from milling center within the Kaura Namoda area.



Sample preparation and analysis

The rice husk and groundnut shell samples were dried and filtered to remove all deities. The cleaned sample was packed in a polythene bag for the production of ceramic pots. The clay sample was also sieved to remove the particles.

Proximate Analysis of Ground Nut Shell and Rice Husk

Proximate analysis was carried out on the groundnut shell and rice husk samples to determine the percentage content of the following: moisture content, ash content, carbon content, and total fiber in each of the samples. The moisture and ash content were carried out in each sample according to the analytical method described by Grema *et al. (2021).* The percentage carbon content was carried out using the method described by Subriyer (2013) for each sample, while the percentage fiber content in each sample was carried out according to the method used by Nnaji *et al. (2016)*.

Physical Properties of Clay

The clay samples obtained from Yankab village, Kaura Namoda, Zamfara, are from the village where the majority of the local clay factories source their clay. The clay was dark brown in color and crystalline in texture. The following physical properties were carried out on the clay sample: moisture content, specific gravity, dry density, shrinkage, and liquid limit. The specific gravity as well as the shrinkage limit of the clay samples were determined according to the analytical method described by Niazi *et al. (2019),* but slightly modified.

Production of Ceramic Water Filters

The production of ceramic filter pots was carried out using local techniques and methods described by Grema *et al. (*2021). Ground nut shell and rice husk were grated and sieved before being mixed with the clay samples in the following rations: 80: 20, 70: 30, 60:40, and 100:00. The filter was designed to have filtration capacity at the bottom, where the mixture of clay, groundnut shell, and rice husk was affected. This was done to ensure an accurate flow rate. Each mixture was air dried, and the cracking of mold was taken care of by ensuring a homogenous mixture and air drying for 30 days. Then each ceramic filter pot was heated in three stages, namely, vitrification, oxidation, and dehydration, at a temperature of 800 oC to 1000 oC in a furnace.

Areas design for filtration, (Blend with Biomass)

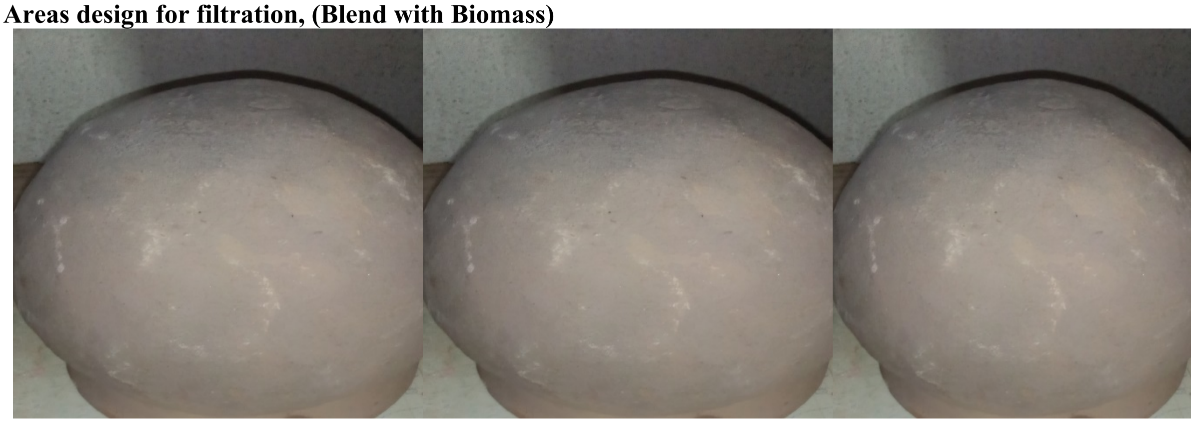


Figure 1 Ceramic Filter pot Produced with Groundnut shells and Rice Husk

Physicochemical Analysis of Open Stream Water Before Filtration and After Filtration

Electrical conductivity, total dissolved solids, and PH of the stream water sampled were measured with a pH meter, the gravimetric method for total dissolved solids, and a conductivity meter, as described by (Shiget et al., 2012). Turbidity was carried out using the nephelometric method .Bicarbonate, carbonate alkalinity as $CaCO_3$, total alkalinity, and total hardness were carried out by the titimetric method as described by (Shiget et al., 2012). The spectrometry method was used for the determination of nitrate and nitrite in the water samples both before and after filtration. Total iron Fe^{3+}, magnesium Mg^{+}, sulfate SO_4, silica SiO_2, free carbon dioxide, and calcium were determined in the stream water sample before and after filtration using the analytical method described by (Bain et al., 2012).

Bacteriological analysis of water samples

The total bacterial count from the water samples before and after filtration was carried out using the pour plate method for isolation and identification with the staining techeques (Gram positive and Negative) counting bacterial and estimating coli former (CfU/100) count in wat from the water samples (Sule and Osegbowa, 2021).

III. Result And Disccussion

Table 1 Proximate analysis of ground nut shell and rice husk

Parameters	Groundnut shell	Rice husk
Moisture %	15.63	11.34
Ash content %	4.5	7.8
Crude fiber %	56.89	46.56

The results of the proximate analysis of the groundnut shell and rice husk obtained from the agricultural milling site in Kaura Namoda are shown in Table 1 above. Ground nut shell has a moisture content of 12.63%, which is higher than rice husk (11.34%). The high moisture content of biomass, such as groundnut shells, has a lower energy density because of the weight of the water; this means that transport is less efficient and significant to the water content. The ash content of rice husk is higher (7.8%) than that of groundnut shells (4.5%). This indicates that the higher the ash content, the higher the quantity of mineral matter and the lower the mass of carbon, which in turn slows the combustion process because of the absence of combustible substances. The crude fiber present in groundnut shells is 56.89% higher than in rice husk, which is 46,56%. The higher crude fiber determined in the groundnut shel sample indicated that it consists of more cellulose and lignin than rice husk (Alumu and Gerumew, 2019).

Table 2. Physical properties of clay

Properties	Amount

Moisture %	10.54
Specific graity %	1.74
Dry density g/cm	1.61
Liquid limit %	32.84
Shrinkage %	12.70

The table above shows some of the physical properties of the clay sample used in the present study. Properties such as moisture, specific gravity, dry density, liquid limit, and shrinkage are important properties to determine the quality of the clay. The composition of the clay is mainly affected by the minerals and chemical properties of the parent materials. The moisture content of the clay sample, which is 10.54%, specific gravity 1.74 g/cm, dry density 1.64%, liquid limit 32.844%, and shrinkage 12.70%, is almost lower than the value of clay properties reported by Grema *et al.* (2021) in Borno State and that of the value reported in the work of (Erodogan, 2015).The variation in the value of the clay properties may be a result of the parental materials and geological location.

Table 3. Campactability Properties of Ceramic Pot Produced

% Ration of clay to GNS/RHS	%Moisture ofGNS	%Dry densityGNS	%Moisture of RHS	%Dry densityRHS
80:20	18.60	1.80	14.80	1.23
70:30	19.50	1.83	16.50	1.34
60:40	21.80	1.98	19.60	1.32
100:0	11.50	0.98	11.50	0.98

Key: GNS = groundnut shell, RHS = Rice husk shell

The compaction of clay soil is the ability of the soil particles to press together. This is done to reduce the pores spaces because highly compacted clay soil contains smaller pores and a higher density. The table below shows the results of the capacity of the ceramic pot produced with groundnut shell and rice husk in different ratios of clay to biomass. The trend of moisture content to dry density shows that dry density decreased with an increase in moisture content. Also, the rice husk compactable moisture content is lower than that of groundnut shell compatibility with soil. This trend of results was also recorded in the work of Grema *et al*. (2021). However, it was also reported by (Erodogan, 2015). compacted clay soil has a reduced rate of water filtration.

Table 3: Physicochemical Analysis of Water Before Filtration and After Filtration

Paramenter	Before filtration	After filter(GBC) Ceramic Pot	After filter (RBC) Ceramic Pot	NSDWQ/ WHO-2015
Turbidity (NTU)	3.42	0.98	1.38	0.5 NTU
pH	4.3	6.5	6.6	6.5-8.5
Thermometer	20.3	20.0	20.3	Ambient
Conductivity (µS/cm)	1200	630	970	1000
Chloride (mg/l)	Nil	Nil	Nil	250
Nitrate (mg/l)	2.20	0.24	0.8	10
Nitrite (mg/l)	0.98	0.02	0.06	0.2
Carbonate Alkalinity (mg/l)	90.40	20.30	26.0	100
Bicarbonate alkalinity (mg/l)	Nil	Nil	Nil	100
Total hardness (mg/l)	37.0	19.50	26.0	150
Total iron Fe^{2+} (mg/l)	50.30	20.50	34.0	0.30
Magnesium (mg/l)	0.89	0.02	0.04	30
Sulphate SO_4 (mg/l)	19.20	10.20	12.0	100
Silica SiO_2 (mg/l)	20.50	4.30	7.0	9.2
Free carbondioxide(mg/l)	0.83	Nil	0.5	500
Total dissolved solid (mg/l)	65.20	10.80	48.5	500
Calcium (mg/l)	15.0	9.8	12.0	75
Generalbacteria count(cfu/100)	230	0.00	0.00	500
Total coliform(cfu/100ml)	450	60.0	126.0	Nil
E.coli (cfu/100ml)	104	0.00	0.00	Nil

Key: GBC = Grandnut shell blend with clay, RBC= Rice husk blend with clay,NSDWQ= Nigeria standard for drinking water quality

Table 1 summarizes the results of the physicochemical properties of stream water before and after the ceramic pot filter was produced. Electrical conductivity (EC) as defined by (Ajibade et al., 2015). Shows a strong relationship with other physicochemical parameters of water. In this present study, the conductivity of the water samples before the filtration process was 1200 us/cm, but the ceramic pot showed the ability to reduce the value to 630 us/cm and 970 us/cm for the groundnut shell and rice husk pot, respectively. This value obtained after the ceramic pot filter (CPF) is within the standard value of 1000 us/cm of NSDWQ 2015. This also indicated that the flow rate of the ceramic pot has a strong correlation to the filtration absorption capacity because the flow rate of rice husk is higher than that of the groundnut shell ceramic pot (Oyandel and Smith, 2008).

The turbidity of raw water was reduced from 3.42 NTU to an average of 0.98 and 1.38 NTU for groundnut shell ceramic pots and rice husks, respectively. This indicated that the ground shell blend with clay has a higher capacity to reduce turbidity than the rice husk blend, maybe because the ground nut shell has a lower flow rate than the rice husk. This value also correlated with the value reported by Grama *et al. (2021).* The trend of turbidity reduction in substantial proportions was also recorded in the work of Joseph and Enugar 2021. Turbidity is one of the parameters used to determine the quality of water. It measures the clarity of the water and its optical characteristics. Bacteria such as algae and other organic compounds cause water to be turbid; however, this ceramic filter may also affect the reduction of microscopic organisms.

The alkalinity of water is predominantly composed of carbonate and bicarbonate. The preliminary study shows that carbonate alkalinity is 30.4 mg/l before filtration, and after filtration, the carbonate alkalinity is 20.30 and 26.00 mg/l for both ceramic pots, respectively. The present results of the reduction of alkalinity were also recorded in the work of Alemu and Geremew (2019). However, the percentage of reduction is lower than in the present studies; this may be a result of the different biomass used. Alkalinity stabilizes the PH value of the water and is also an indicator of the level of toxicity of other substances in the water.

The nitrate and nitrite values determined in stream water are 2.20 mg/l and 0.95 mg/l. After filtration with both ceramic pots, the values became 0.24 mg/l and 0.02 mg/l, respectively. The percentage reduction is 11.2%; this is very important because the stream water nitrite level was higher than the value (0.2) of **NSDWQ-2015.** The percentage reduction of these present studies is lower than the percentage reduction of Alemu and Geremew, 2019. Nitrate (NO_3) and nitrite (NO_2) are found in water through human activities. It was reported that a large amount of nitrate has health effects such as increased heart rate, nausea, headaches, and abdominal cramps. Ebele *et al*. (2014).

Iron ($Fe3^+$), sulfate (SO4), and silica (SiO) are determined in the stream water; while the sulfate is within the NSDWQ value of 100 mg/l, the iron and silica are above the recommended values of NSDWQ (9.5 and 0.3 mg/l). The substantial average percentage reduction after the ceramic pot filter was 79% silica reduction and 52% sulfate reduction, while the iron reduction was 41% on average with both ceramic filters. The average percentage reduction of these present studies is higher than the value recorded in the work of Alemu and Gerenew, 2019.

There is no substantial reduction in the magnesium content of the stream water samples after filtration, but the value of total dissolved solid reduction was substantial enough, with an average 89% reduction after filtration. This value is also consistent with the value recorded in the work of Gramal *et al*. (2021) and Alemu and Geremew (2019).

Many infective microorganisms have been reported to be found in contaminated water, such as Escherichia coli, Shigella, Vibrio, and Salmonella (Alemu and Geremew, 2019.). In the present study, the general bacterial count (cfu/100) in the stream water samples is 230, coliform is 450, and E. coli is 104 cfu/100. The ceramic pot produced from groundnut shel and rice husk has been able to filter all the bacteria and E. coli, but there is a substantial reduction of coliform (98%). This proves that ceramic pots and biomass can reduce or filter out contaminated microorganisms, as reported by Alemu and Geremew (2019) and Joseph and Enugar (2021).

Comparison of the ceramic pot mixed with ground shell and rice husk

Using statistical tools (T-test), we compared the efficiency and capability of the two ceramic pots produced using clay, ground nut shell, and rice husk in the two different ratios. The data obtained before and after filtration and flowing rate in consideration of the two ceramic pots The results show that there is a significant difference in the level of absorption of contaminants or reduction of contaminants by filtration between the ceramic pot produced by blending the ground nut shell and rice husk.

IV. Conclusion

The two ceramic filter pots produced from groundnut shells and rice husk were subjected to different tests, and their respective properties were determined. The suitability and efficacy of each ceramic filter pot were determined by subjecting the stream water samples to filtration and analysis before and after filtration. It was deduced that the ceramic filter pot produced with groundnut shell has a greater filtration and absorption capacity and efficiency than the rice husk. However, both ceramic filter pots have greater efficiency in microbial removal from the contaminated water. Therefore, ceramic filters have proven to be an effective alternative to water purification in rural areas.

Conflict of Interest
The authors declared no conflict of interest.

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