Journal of Advanced Research in Applied Chemistry & Chemical Engineering
Volume 3, Issue 3 - 2018, Pg. No. 1-5
Peer Reviewed Journal

Research Article

Development and Physicochemical Analysis of Ceramic Water Filters

Olajide Tunmilayo Sanya[1], Yinusa Daniel Lamidi[2], Babajide Olugbenga Fatile[3], Olushola Bamidele Nenuwa[4]

[1,2,3]Department of Glass and Ceramic Technology, Federal Polytechnic Ado-Ekiti.
[4]Department of Mineral & Petroleum Resources Engineering, Federal Polytechnic Ado Ekiti.

Abstract

Ceramic water filters (CWFs) are promoted in developing nations by World Health Organisation (WHO) to improve water quality. In this study, CWFs were developed from raw materials such as cullet, limestone and clays. The aim of the study is to evaluate the role of cullet and limestone on the physicochemical properties of filtered water samples. Total numbers of eight CWFs were formulated with various percentages of cullet and limestone. Physical and chemical analyses were carried out on selected water samples including borehole (BH), well (WL), and pond (PD). Physicochemical parameters examined were pH, total dissolved solids (TDS), total suspended solids (TSS), electrical conductivity, hardness, and turbidity. Results showed significant increase in the values of TDS and electrical conductivity after using developed CWFs. The values of TSS reduced while slight changes were observed in pH and hardness readings of filtrates. Most CWFs helped to reduce the turbidity content in filtered water samples.

Keywords: Ceramic water filter, Physicochemical, Water quality, Turbidity

Introduction

Water is essential because all life form depends on it. Water is a natural inorganic compound that accounts for approximately 55–65% of the body mass, depending on age and body fatness of human beings. Water plays vital roles and functions in the human body. It serves as the body's transportation medium, lubricant, regulates body temperatures, and participates in the body biochemical reactions.[4] However, several infectious diseases are caused by the presence of pathogenic bacteria, viruses, protozoan and helminthes in water that can be contracted by human bodies causing diseases such as cholera, typhoid, amebiasis, giaediasis, polio, legionnaires disease, paratyphoid, shugellosis, etc., to mention but a few. The consumption of drinking water containing these microbes poses grave risks to public health, although other sources and routes of exposure may also be significant. Waterborne outbreaks have been associated with the inadequate treatment of water supplied and unsatisfactory management of drinking-water distribution.[7,10]

Development and studies on reliable methods to eliminate microbes from drinking water are attracting increasing attention across the globe, in particular, among the developing nations. There are several methods to remove pathogenic microbes from drinking water. Some methods commonly used to process or serve as barriers for eliminating pathogen microbes from potable drinking water include pre-treatment, coagulation, flocculation, sedimentation, filtration, disinfection, and protection of the distribution system.[7] Filtration is one of the oldest and safe technologies widely used for removing microbes and particles from water. It is a simple and cost-effective method for household or point-of-use treatment of water. The efficiency of the filters depends on the types and sizes of the microbes and the composition and quality of the filtration medium or the system. In granular media filtration, gravity separation principle is employed to achieve filtration through porous granular media such as sand, anthracite, crushed sandstone or soft rock and charcoal. In recent years, several granular media filters have been developed for household use including bucket filters, drum or barrel

Corresponding Author: Olajide Tunmilayo Sanya, Department of Glass and Ceramic Technology, Federal Polytechnic Ado-Ekiti.
E-mail Id: tunmilayo@gmail.com
Orcid Id: https://orcid.org/
How to cite this article: Sanya OT, Lamidi YD, Fatile OB et al. Development and Physicochemical Analysis of Ceramic Water Filters. *J Adv Res Appl Chem Chem Eng* 2018; 3(3): 1-5.

filters and roughing filters. In the granular media filtration process, particle removal occurs either on the surface of the media (cake filtration) or throughout the depth of the media (depth filtration). The fundamental mechanism of granular media filters include: sedimentation, adsorption, absorption and straining. Some research efforts have been carried out using different materials as filtration membranes.[2,3,6,11] However, the use of filtration membranes often result in introduction of substances into the filtrates thereby altering their physicochemical parameters. Limited information is available in literature on physicochemical properties of filtrates being treated with CWFs manufacture from cullet and limestone. In this study, the role of admixture of cullet, limestone and clay filtration membrane on the physicochemical analysis of water was evaluated.

Materials and Methods

Preparation of Ceramic Membranes and Their Properties

The raw materials used in this study were cullet, limestone and clay. Cullet was obtained from waste soda lime glass. Soda lime glass samples were washed with detergent, dried and milled into powder form in an electric ball mill for 12 h. The particle size range of 0–45 μm was obtained for powdered cullet. Clay mineral was collected from deposit near Ikere-Ekiti area, Ekiti State, while the limestone was collected at Igbeshi area, Oyo State, Nigeria. Clay mineral was sieved to obtain a uniform particle size range of 2.36–4.74 mm. A sensitive weighing balance (Mettler Toledo, AG 204) was used to weigh eight different mixes of clay, cullet, and limestone. The weight of clay within the matrix of CWF was fixed to 45 g while weight of cullet and limestone varied inversely by 0, 15, 30, 45, 60, 75, 90 and 105 g (as shown in Table 1).

Table 1.Composition of Kaolin, Cullet and Limestone (in grams)

Sample Designation	Clay (g)	Cullet (g)	Limestone (g)
CC	45	105	0
CCL_1	45	90	15
CCL_2	45	75	30
CCL_3	45	60	45
CCL_4	45	45	60
CCL_5	45	30	75
CCL_6	45	15	90
CL	45	0	105

CWF samples were mixed thoroughly and specific volume of water was added into the mixture to enhance the plasticity of the mixture. Afterward, the green clay mixture was kneaded by hand until a consistent texture was obtained and to remove any available pores in the mixture. A wooden roller and base were used to flatten the mixture and a circular-shaped body was obtained with a circular mold. The dimension of CWF produced was measured to have a diameter of 7.0 cm and a thickness of 1.0 cm. The green samples were dried in open air for 3 days and oven dried at 105 °C for 72 h to expel the moisture content. Afterward, the green bodies were sintered in a gas-fired kiln to a temperature of 850 °C for 5 h. The samples were furnace cooled after firing for 12 h.

Filtration Experiments

Water samples were selected from three different sources, which included borehole (BH), well (WL), and pond (PD). The criteria for selecting sampling points were based on the water sources that were readily available and frequently used for household, agricultural, and industrial applications. Developed CWFs were soaked in borehole water for 24 h before starting the filtration tests. Image of the sintered CWFs produced is shown in Fig. 1.

Figure 1.Sintered Ceramic Water Filters (CWFs)

Physicochemical Analysis

Total dissolved solids (TDS) were measured using the Hanna Instrument HI 9032 microcomputer conductivity meter. The HACHI DR2400 spectrophotometer was used to measure total suspended solids (TSS) and color. The HACH turbidity instrument was used to evaluate the turbidity. The pH of the water samples was measured using model HI 98130 HANNA pH meter. The pH meter was calibrated, with three standard solutions (pH 4.0, 7.0 and 10.0) prior to pH readings. pH value of each sample was recorded after immersing the pH probe in the water sample and holding for 3 min to attain a stabilized reading.

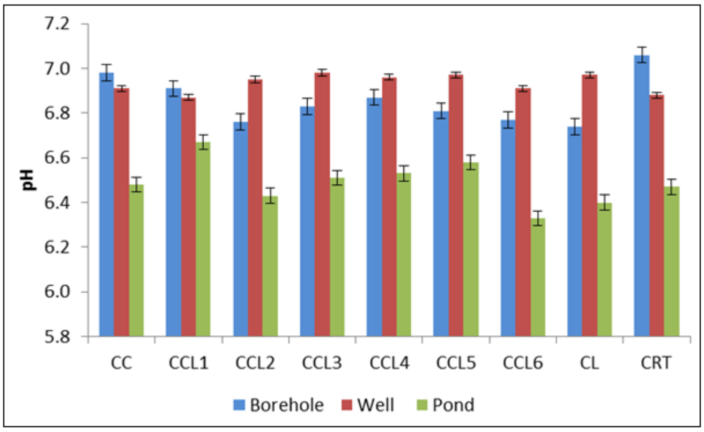
Results and Discussion

Physicochemical Analysis

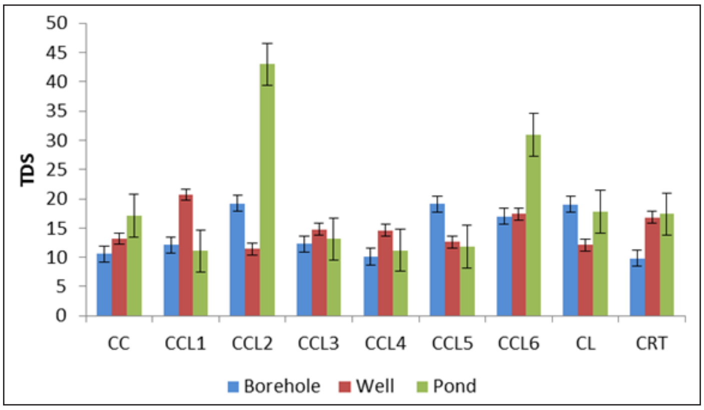
The physicochemical tests carried out on the various water samples before and after filtration included pH, total dissolved solids (TDS), total suspended solids (TSS), conductivity, hardness, and turbidity. Table 2 shows physicochemical parameters for water samples without filtration as well as safe limit recommendation by WHO and Nigerian Standard for Drinking Water Quality (NSDWQ).

Table 2.Physicochemical Parameters of BH, WL and PD Water Samples alongside NSDWQ, 2007 and WHO Safe Limits for Determining Water Drinking Quality[8-10]

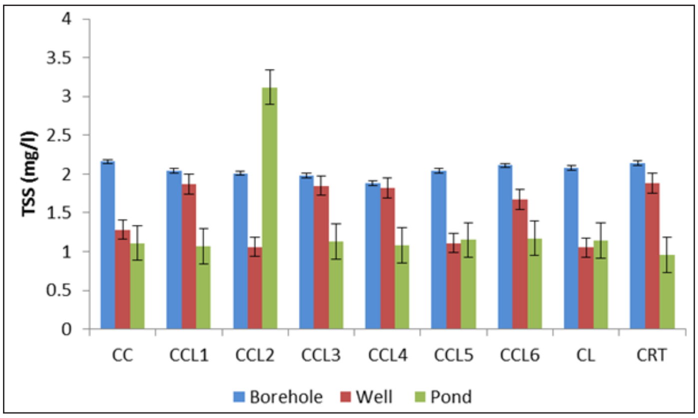
Parameters	Unit	Borehole	Well	Pond	NSDWQ limits	WHO limits
pH	-	7.04	6.88	6.46	6.50–8.50	6.50–8.50
TDS	ppm	98	168	174	500	1000
TSS	mg/l	2.14	1.88	0.96	25	-
Conductivity	μS/cm	142	243	305		
Hardness	mg/l	19.90	36.90	23.45		
Turbidity	NTU	2.14	3.12	4.11		



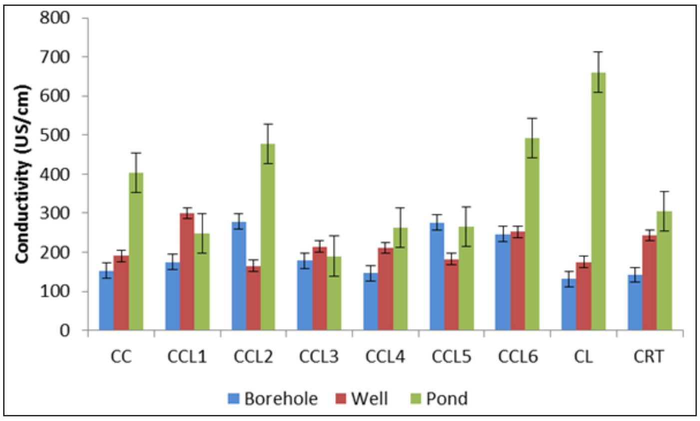
(a)



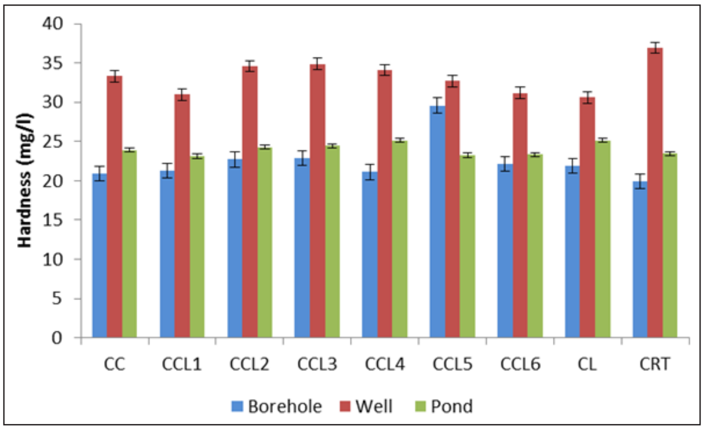
(b)



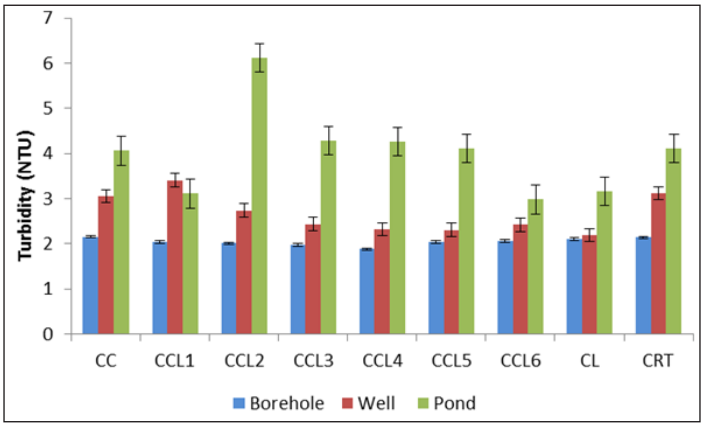
(c)



(d)



(e)



(f)

Figure 2.Variation of Physiochemical Parameters of Filtered Water Samples (a) pH, (b) TDS, (c) TSS, (d) Conductivity, (e) Hardness and (f) Turbidity

The results of physicochemical analyses of both treated and control water samples using the various developed CWFs are shown in Fig. 2 (a)–(f). Figure 2 (a) presents the result of pH of filtered and un-filtered water samples using different CWFs. pH range of untreated and filtered water samples for BL and WL was 7.1–6.8 and was within acceptable standard recommended by WHO and NSDWQ. However, pH readings for PD water samples were weak acids and acidity increased after filtration with CCL1 and CCL5 to 6.6-6.7. pH values of PD samples were either close to or outside the safe water quality limit.

TDS increased significantly after filtration by 98–191 ppm, 168–207 ppm and 174–430 ppm for BH, WL and PD respectively (as shown in Fig. 2 (b)). The highest values of TDS were noticed in samples treated with CCL2 and CCL6. This is as a result of poor adhesions of constituents within the matrix and/or incomplete sintering of CWFs. Increase in TDS values has been reported to be due to the dissolution of substances such as calcium, magnesium, bicarbonates, chlorides and sulfates in filtration membranes into treated water samples.[1]

TSS results for tested water samples are shown in Fig. 2 (c). Unlike TDS, there were reductions in TSS from 2.14 to 1.88 mg/L and 1.88 to 1.06 mg/L of filtered BH and WL water samples respectively for all CWFs. However, TSS values increased in PD from 0.96 to 3.12 mg/L. TDS and TSS values for examined water samples were within safe water quality limits of 500 ppm and 25 mg/L respectively.

Results of changes in electrical conductivities of water samples are shown in Fig. 2 (d). From the result, there exist wide variations in the values of conductivity of the tested water samples. Conductivity increased after filtration by 53%, 42% and 71% for BH, WL and PD respectively. TDS results obtained in Fig. 2 (b) suggest that high concentration of particles dissolved (such as carbonates and others) might be responsible for wide margin in conductivity values. Just as in the case of TDS, conductivity values of untreated water samples were lower when compared filtrates. While high conductivity does not have direct impact on human health, it could result in loss of aesthetic value of water by giving mineral taste to water. Moreover, water with high conductivity may cause corrosion of metal surface of equipment such as boiler.[8]

The maximum and minimum hardness readings of control water samples analyzed are 36.90 and 19.90 mg/L for WL and BH respectively. Hardness values increase in treated BL and PD and decrease in WL. Slight variations in hardness values were observed in the course of the experiment. The presence of dissolved calcium carbonate (limestone) could have contributed to rise in filtrate hardness readings.

Maximum turbidity limit set by NSDWQ and WHO for drinking water is 5 nephelometric turbidity units (NTU). Turbidity values for control water samples are 2.14 NTU, 3.12 NTU and 4.11 NTU for BH, WL and PD respectively (Table 2). Therefore, from the results on turbidity presented in Fig. 2 (f), waters from WL and PD sources was not suitable for drinking because their turbidity values are close to the safe limits for determining water drinking quality. There are reduction in turbidity values for BH and WL samples with highest reduction values observed with CWFs, CCL3 and CCL4. However, turbidity readings of PD filtrates using CWFs, CCL3 and CCL4 increase although significant reduction were observed when CWFs CCL1 and CL were used. Most CWFs reduce turbidity values of treated water samples.

Conclusion

CWFs were developed from cullet, limestone, and clay using simple material processing procedure. Physicochemical parameters of sourced waters as well as treated water samples using newly developed CWFs were examined. Slight variations in pH and hardness values for after filtration all tested samples. There are significant increase in the values of TDS and conductivity of the filtrates for all water samples when compared with control samples. Conversely, the values of TSS for filtrates of BH and WL reduce except for PD samples where noticeable increases were recorded. Most CWFs help to reduce the turbidity content in treated water samples.

References

1. Achio S, Kutsanedzie F, Ameko E. Comparative analysis on the effectiveness of various filtration methods on the potabilty of water. *Water Quality Research Journal of Canada* 2015; 42-46.
2. Ajayi BA, Lamidi YD. Possibility of using Glass-Snail shell for industrial waste water treatment. *International Research Journal* 2013; 3: 8-11.
3. Ajayi B, Lamidi Y. Formulation of ceramic water filter composition for the treatment of heavy metals and correction of physiochemical parameters in household water. *Art and Design Review* 2015; 3: 95-100.
4. Boeckner L. Water: The Nutrient. *United States: University of Nebraska Lincoln* 2009.
5. Harabi A, Guechi A, Condom S. Production of supports and filtration membranes from Algerian kaolin and limestone. *Procedia Engineering* 2012; 220-24.
6. Hristov P, Yoleva A, Djambazov S et al. Preparation and characterization of porous ceramic membrances for micro-filtration from natural zeolite. *Journal of the University of Chemical Technology and Metallurgy* 2012; 47(4): 476-80.
7. LeChevallier M, Au K. Water Treatment and Pathogen Control. *Cornwall, UK: World Health Organisation* 2004.
8. Rahmanian N, Ali S, Homayoonfard M et al. Analysis of physiochemical parameters to evaluate the drinking water quality in the state of Perak, Malaysia. *Journal of Chemistry* 2015; 1-10.
9. Standards Organisation of Nigeria. Nigerian Standard for Drinking Water Quality. *Abuja, Nigeria: Standards Organisation of Nigeria* 2007.
10. WHO. Guidelines for Drinking-Water Quality. *Switzerland: WHO* 2017.
11. Wongsakoonkan W, Prechthai T, Tantrakarnapa K. Suitable types and constituent ratios for clay-pot water filters to improve the physical and bacteriological quality of drinking water. *Environment Asia* 2014; 7(2): 117-23.

Date of Submission: 2018-07-20
Date of Acceptance: 2018-08-17