International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 07 Issue: 05 | May 2020 www.irjet.net p-ISSN: 2395-0072

Evaluation of Potential Use of Charcoal as a Filter Material In Water Treatment

Awwal Musa[1], Sani Saleh[2], Kasim Mohammed[3], Yahaya Hassan Labaran[4], Jabir Zakari Yau[5], and Hussaini Mato[6]

[1]*Lecturer, Division of Agricultural Colleges, Ahmadu Bello University Zaria, Kaduna, Nigeria.*
[3]*Senior Lecturer, Department of Civil Engineering, Bayero University, Kano, Nigeria.*
[2,4,5,6]*Post Graduate Research Scholars, Department of Civil Engineering, Sharda University, Uttar Pradesh, India.*

Abstract - *This research evaluated the contaminant removal efficiency of an improvised charcoal filter. The filter had four layers with 6.3, 2.0, 1.18 mm sized, and powdered charcoal responsible for the filtration process. The water sample was collected from river Challawa from the region believed to have the highest concentration of contaminants. The physicochemical and bacteriological characteristics of the water sample before and after filtration were determined and evaluated. Although testing for coliform bacteria in the samples before and after filtration read positive, the charcoal filter showed very high turbidity removal efficiency (i.e. up to 98%) after a seven-number repeated filtration runs. It also showed high odor, hardness, and chloride removal efficiencies. However, an increase in conductivity was observed in the filtered samples which may be correlated to the ability of charcoal to enrich the water with elements like sodium and potassium. In addition to these the pH value of the sample before filtration was acidic (i.e. 5.7) but increased to 7.7 after filtration which is suitable for drinking water. Hence, it is recommended here that charcoal filters can be used to produce high-quality water.*

***Key Words*: Charcoal, River Challawa, pH, Charcoal activation, Test of water sample, physicochemical, bacteriological.**

1. INTRODUCTION

The use of water by man, plants, and animals is universal. Without it, there can be no life. Careless pollution and contamination of the streams, lakes, reservoirs, wells, and underground water has greatly impaired the quality of available water (Shelton, 2004). Water is a good carrier of disease germs. If water is not made safe against disease germs, it may become responsible for so many Epidemics. Diseases such as Typhoid, Cholera, Dysentery, etc. are direct causes of defective water supply (Hughes and Koplan, 2005).

Water is a very good solvent. If the water contains an excessive amount of minerals or poisonous dissolved substances, it will again cause so many difficulties to the public. Therefore, water that is used by the public should be wholesome and must be free from disease-producing bacteria, poisonous substances, and an excessive amount of minerals and organic matters (Singh, 2003).

Water is essential for the social and economic development of human beings and the preservation of a healthy environment (WHO, 2006). About 1.2 billion people are facing physical water shortage, one-quarter of the world's population is facing economic water shortage (WHO,2010), in total 62% of the world population will face physical or economic water scarcity by 2030 (Rijsberman, 2006).

With the growing world population, the lack of clean water is becoming an increasing problem. Research has predicted that by 2025 two-third of the world's population could be living under water stress and 1.8 billion people may be under extreme water stress (Taylor and Francis, 2013).

More effort has been put to develop an effective water purifier which can reduce color and turbidity, pathogenic organism and chemical contaminants through extensive research. Most existing purification methods not only remove the impurities but drain out the essential minerals as well. Moreover, they are expensive and required extensive maintenance. Therefore, there is an obvious need to assess community prepared charcoal (bamboo, coconut, and wood) scientifically for its potential to remove dissolved iron, turbidity, and pathogenic organism from drinking water (CWE, 2015).

1.1 Need for the research

Effective point-of-use devices for providing safe drinking water are urgently needed to reduce the global burden of waterborne disease. Sand filters that can remove pathogens required large area and knowledge of how to maintain them, while membrane filters capable of removing pathogens suffer from high cost, fouling, and often require pumping power due to flow rates that prevent their wide implementation in developing countries. In this context, new approaches that can improve upon current technologies are urgently needed. Specifically, filter materials that are inexpensive, readily available disposable, and effective at pathogen removal could greatly impact our ability to provide safe drinking water to the global population (Boutilier et al., 2014).

1.2 Significant of the study

Water that is used by the public should be wholesome and must be free from diseases producing bacteria, poisonous substances, and an excessive amount of minerals, and organic matter. To achieve this, a good filtration system is essential for water treatment.

When used as filter material, charcoal traps impurities in water including solvents, pesticides, and industrial waste and other chemicals. Research also shows that charcoal has the potential ability to remove dissolved iron, turbidity, and pathogenic organism from drinking water. Also, the charcoal base filter resulted in tastier water by enriching water with mineral, like Sodium and Potassium.

Moreover, charcoal is readily available, affordable, disposable, inexpensive, and easier to handle.

1.3 Aims and Objectives

Aim

This study aims to investigate the potential use of charcoal as a filter material for water treatment.

Objectives

i. To conduct bacteriological, chemical, and physical analyses on river water samples.
ii. To carry out the filtration of the water sample using charcoal as filter material.
iii. To determine the contaminant difference before and after filtration.
iv. To determine the removal efficiency of charcoal as filter material in water treatment.

1.4 Scope and Limitation

Scope

The research covered the physical-chemical and microbiological analysis of raw water collected from River Challawa, Kano.

Limitation

The research focused only on evaluating the physicochemical and bacteriological quality before and after filtration of the sample collected from the region of possible highest contamination of River Challawa (Sulaiman and Bello, 2014).

1.5 Literature Review

The use of carbon in the form of charcoal has been used since antiquity for many applications. In Hindu documents dating from 450 BC charcoal filters are mentioned for the treatment of water. Charred wood, bones, and coconut charcoals were used during the 18th and 19th centuries by the sugar industry for decolorizing solutions. Activated carbon is a material prepared in such a way that it exhibits a high degree of porosity and an extended surface area (Lemly et al 1995). A typical carbon particle has numerous pores that provide a larger surface area for water treatment.

During water filtration through activated carbon, contaminants adhere to the surface of the carbon granules or become trapped in the small pores of the activated carbon (Amirault et al.2003). This process is called adsorption. Activated carbon filters are efficient in removing certain organics (such as unwanted taste and odors, micropollutants), chlorine, fluorine, or Radon, from drinking water or wastewater. However, it is not effective for other contaminants. Activated carbon filtration is commonly used in centralized treatment plants and at the household level, to produce drinking water and in industries to treat effluents. It is also an upcoming treatment applied for the removal of micropollutants both in drinking water production and for the purification of treated wastewater before disposal. There are two basic types of water filters; particulate filters and absorptive/ reactive filters. A particulate filter excludes particles by size, and adsorptive/reactive filters contain a material (medium) that either adsorb or react with a contaminant in water. The principles of adsorptive activated carbon filtration are the same as those of any other adsorption material. The contaminant is attracted to and held (adsorbed) on the surface of the carbon particles. The characteristics of the carbon material (particle and pore size, surface area, surface chemistry, etc.) influence the efficiency of adsorption.

The characteristics of the chemical contaminant are also important. Less water-soluble compounds are more likely to be absorbed into a solid. A second characteristic is an affinity that a given contaminant has with the carbon surface. This affinity depends on the charge and is higher for molecules possessing less charge. If several compounds are present in the water, strong absorbers will attach to the carbon in greater quantity than those with weak adsorbing ability, (Lemley et al. 1995).

Activated carbon filtration is recognized by the water quality Association as an acceptable method to maintain certain drinking water contaminants within the limit of the EPA National Drinking Water Standards.

The safe drinking water ACT mandates EPA to strictly regulate contaminants in community drinking water systems (SSWM, 2011).

1.6 Cost of the Charcoal

Charcoal is a readily available, affordable, and disposable material. It is relatively cheap and easier to handle. Charcoal for filter material performs better when it is of good quality. The cost of charcoal depends on its quality. The higher the quality of the charcoal, the higher its cost.

Charcoal produced from hardwood is heavy and strong, whereas that produced from softwood is soft and light. Therefore, hardwood charcoal cost higher than soft charcoal. A 1.5kg of hard charcoal sells at ₦100 whereas a 25kg bag of it costs between ₦1000 to ₦1200. Hence, the cost of using charcoal as a filter is affordable considering the high cost of other filter materials.

2. RESEARCH METHODOLOGY

2.1 Sample Collection

The water sample was collected from River Challawa from the region of highest concentration (Sulaiman and Bello 2014) into a ten liters gallon, and the following water quality parameters were determined on the water sample; Temperature, Turbidity, Total dissolved solids (TDS), Conductivity, Dissolved Oxygen (DO), pH, Hardness, Acidity, Alkalinity, Iron, Chloride and Faecal Coliform.

2.2 Preparation of the Charcoal

The charcoal used was hard charcoal collected at a charcoal depot and had been prepared by the pyrolysis process. This means burning off the hardwood under high temperature in the absence of air. The charcoal obtained was boiled to remove impurities sticking to the surface of the charcoal and also to open up the tiny pores between the carbon atoms.

Drying and sizing

The charcoal obtained was dried under the sun by spreading it on a polypropylene mat for a period of five days. Dried charcoal was crushed using mortar and pestle into small bits from powder up to the size of 10 mm gravel. It was then sieved into three different particular sizes (6.3 mm, 2 mm, 1.18 mm, and powder).

Activation

The sieved charcoal was activated by soaking it in boiled water for about two hours to re-open up tiny pores between the carbon atoms.

Washing

The activated charcoal was washed thoroughly with distilled water and was then dried under the sunlight.

2.3 Description of the Filter

The filter was improvised and consists of a 1.5L plastic bottle with the bottom end cut off. Some small holes were poked in the cap of the bottle and a fine – mesh material was used to fill the smaller opening to prevent the charcoal from falling out or running through with the water. The charcoal was then packed tightly into the container in three layers with the finest size on top while the 6.3 mm gravel size charcoal was at the bottom. This was to create as fine a matrix as possible for the water to drip through slowly, thus trapping more sediment and wee beasties. Another piece of a fine –mesh material was placed at the top of the uppermost charcoal layer to prevent it from becoming displaced when water was added. However, about 18 L of raw turbid water can be filtered continuously without clogging of the filter. Also, the flow rate of the filter decreases after continuous use of two months continuously and a higher flow rate could be achieved by washing the charcoal layer and replacing the powder charcoal.

2.4 Filtration Procedure

The raw water sample was poured slowly into the filter and allowed to percolate through the charcoal layers. After all of the water has run through the filter, it was poured back again seven times to make it clearer. The filtered water sample was then analyzed for the same water quality parameters been analyzed earlier on the unfiltered water sample.

2.5 Laboratory Tests

i. Determination of Temperature

Apparatus; The apparatus used include Mercury in glass Thermometer and Cotton Wool

Procedure: The mercury end of the thermometer was cleaned and the mercury end of the thermometer was inserted immediately into the water sample and the rise in mercury level was allowed to stabilize. The value of the rise in mercury level was noted and recorded in °C. The initial temperature measurements were conducted in-situ.

ii. Determination of Turbidity

Apparatus: Apparatus used include turbidimeter and clean towel.

Procedure: The Glass bottle in the turbidimeter was rinsed and the glass bottle was half-filled with the sample, sealed, and dried with the towel. The bottle was then inserted into the slotter for auto-sensing by the meter. The reading on the screen was observed until it was stable and the value was then recorded as the turbidity in the nephelometric turbidity unit (NTU).

iii. Determination of Total Dissolved Solids

Apparatus: Apparatus used is Total Dissolved Solid meter and beaker.

Figure 3.2 Total dissolve solid meter

Procedure: The meter above was used to measure the Total Dissolve Solid. The sample was measured into a beaker; the mode key was pressed until the icon was above the Total Dissolved Solid annunciator. The probe was then inserted into the sample solution. The tip was immersed beyond the vent holes and the probe was agitated vertically and it was ensured that air bubbles were not trapped near the temperature sensor. The readings were allowed to stabilize and the measurements were recorded.

iv. Determination of pH

Apparatus: The apparatus used is pH meter, Beaker, and distilled water.

Procedure: 100 ml of the sample was poured into a clean beaker and the electrode of the pH meter was inserted into distilled water. The electrode of the pH meter was inserted into the water sample and allowed to stay in it until the reading on the screen was stable. The observed value was taken as the pH of the sample.

The steps were repeated for two more samples and the mean was taken.

v. Determination of Acidity

Apparatus: Apparatus used include Burette, pipette, Beakers and measuring cylinders

Reagents: The reagents used are Phenolphthalein Indicator, 0.02N Sodium Hydroxide

Procedure: The required quantity of the sample was measured and poured into a beaker thereby adding 2 to 3 drops of the indicator (phenolphthalein). 0.02N sodium hydroxide was then added from the burette with a constant swirling of the content until the solution changed color. Readings were then taken of the volume of the titrant used. The process was repeated 2 times and the mean value was taken as titer value.

vi. Determination of Alkalinity

Apparatus: Apparatus used include Burette, Pipette, Beakers and Measuring Cylinder

Reagents: Reagent used are Methyl Orange Indicator, 0.1N Hydrochloric Acid

Procedure: The burette was filled to mark with the hydrochloric acid. The required quantity of the sample was put into the beaker, thereby adding 2 to 3 drops of the indicator (methyl orange). The sample was titrated with hydrochloric acid until a pink color was observed. After the color change, the sample was boiled and titrated again with the hydrochloric acid for the titration. The process was repeated two times and the mean value was taken as the titer value.

vii. Determination of Hardness

Apparatus: Apparatus used include Burette, Pipette, Funnel, Beakers.

Reagents: 0.1N HCL disodium, ethylene diamine tetraacetic acid (EDTA), Erichrome T Indicator, Buffer solution pH 10

Procedure: 50mL of the sample was measured into a beaker, and 0.5mL of 0.1N HCL was added to the sample. It was then heated to expel Co2and cooled to 50C. 2mL of the buffer was then added and then two drops of the indicator. It was then titrated with EDTA titrant until the color changed to blue from wine red. The volume of titrant used was measured.

viii. Electrical Conductivity

Apparatus/ Materials: Apparatus and materials used are Electrical Conductivity Meter, Distilled Water, Beaker, and Cotton Wool.

Procedure: The electrical conductivity meter was adjusted to zero using distilled water. A sample of 250 mL was measured in to clean beaker and the meter probe was dipped into the water sample the reading is taken directly from the screen and recorded.

ix. Chloride Test

Apparatus: Apparatus used are test tubes, pipette, timer, spectrophotometer.

Reagents: chloride reagent.

Procedure: the test tubes were labeled standard, blank, and sample. 15mL of chloride reagent was pipped into each test tube, 0.01mL of the standard was then added to the respective sample and mixed. It was then incubated at room temperature for 5 minutes. The spectrophotometer was set to 480mL and was zeroed with a reagent blank with a wavelength of 480nm. The readings were computed to obtain the chloride values.

Chloride content = ((absorbance of unknown)/ (absorbance of standard)) × concentration of standard…….. (1)

x. Determination of Iron

Apparatus; Atomic absorption spectrophotometer,0.738 g of FeSO4.7H2O, Flask distilled water, and samples.

Procedure: Dissolve 0.738 g of FeSO4.7H2O in distilled water in a 100 mL volumetric flask and dilute up to the mark, pipette 10 ml of the sample into 100 ml volumetric flask and dilute up to the mark with distilled water. This serves as a standard solution with a 1000 ppm iron solution respectively. From the solution 1.0, 0.5, 0.2, and 0.1 is pipette into a 5 ml volumetric flask and dilute with distilled water up to the mark. This solution contained 10, 5, 2, and 1 ppm iron solutions respectively.

The atomic absorption spectrometer (AAS) was checked and is allowed to warm for 30 min with the iron lamp inserted in the installation. The AAS is set to zero readings. The standard solutions are aspirate once at a time, followed by the blank (distilled water). Plotting the absorbance against the concentration of the standard solution made calibration curve and iron content of the sample is derived from the plot.

xi. Determination of Dissolved Oxygen

Apparatus: Apparatus used include DO meter and beaker

Figure 3.3 Dissolved Oxygen (DO) Meter

Procedure: The sample was measured into a Beaker, the DO meter was connected to the battery and turned on. Since the measurements were being conducted in mg/L it was necessary to enter the barometric pressure. The probe was then inserted into the sample solution. The tip was immersed beyond the vent holes and the probe was agitated vertically and it was ensured that air bubbles were not trapped near the sensor. The readings were allowed to stabilize and the measurements were recorded.

xii. Determination of Feacal Coliform (E. coli)

Apparatus: Apparatus used include Auto Clave, Incubator, Test Tubes, Racks, Durham's Tubes, Wire loops, Slides, and Petri Dishes

Reagents: Lactose Broth and Eosin Methylene Blue (EMB) Agar

Procedure: The procedure for the determination involves steps wise analysis as shown below;

Presumptive Test; water samples were inoculated into tubes of lactose broth containing Durham's tubes. Durham's tubes are a collection of gases. This was done triplicate test tubes. The tubes were incubated at 37o Celsius for 24hours and examined for gas production. If there is no gas in Durham's tube, the test is negative. However, the presence of gases gave a positive result and thus leads to the next test.

Confirmatory Test; Positive test tubes are inoculated into EMB agar and incubated at 37°Celsius for 24 hours. This was then observed for the presence of small dark colonies with greenish metallic sheen indicating E-Coli colonies

Completed Tests; Colonies suspected to be those of E-coli were inoculated into lactose broth and incubated at 37°Celsius for 24 hours. The gas was observed for production

3. RESULT

The results obtained from this research work are presented in Figures 3.1, through 3.7

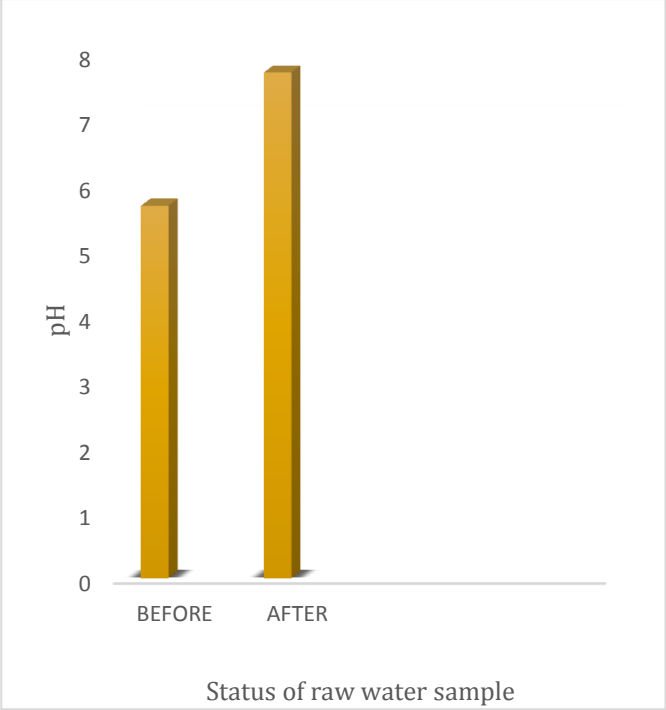

Figure 3.1 pH values for the water sample before and after filtration with the water sample

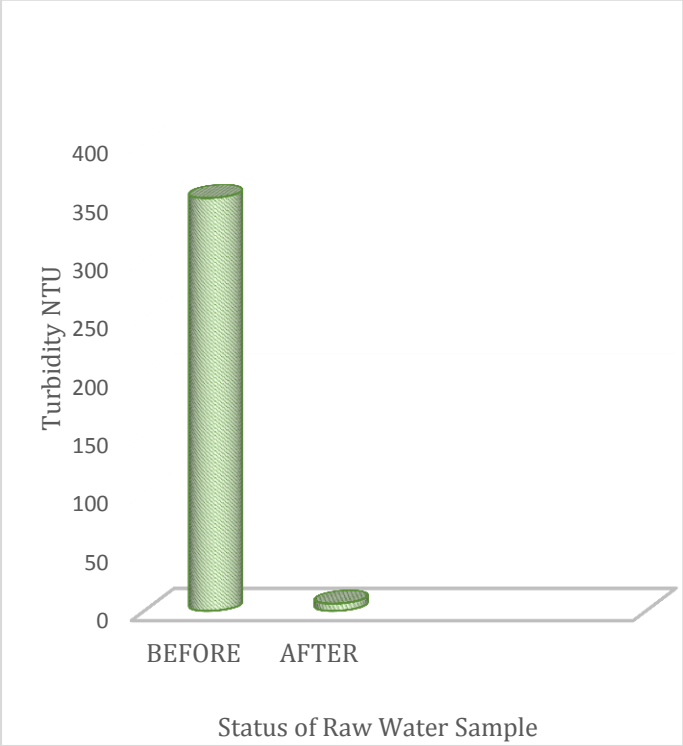

Figure 3.2 Turbidity values for the water sample before and after filtration with the charcoal filter

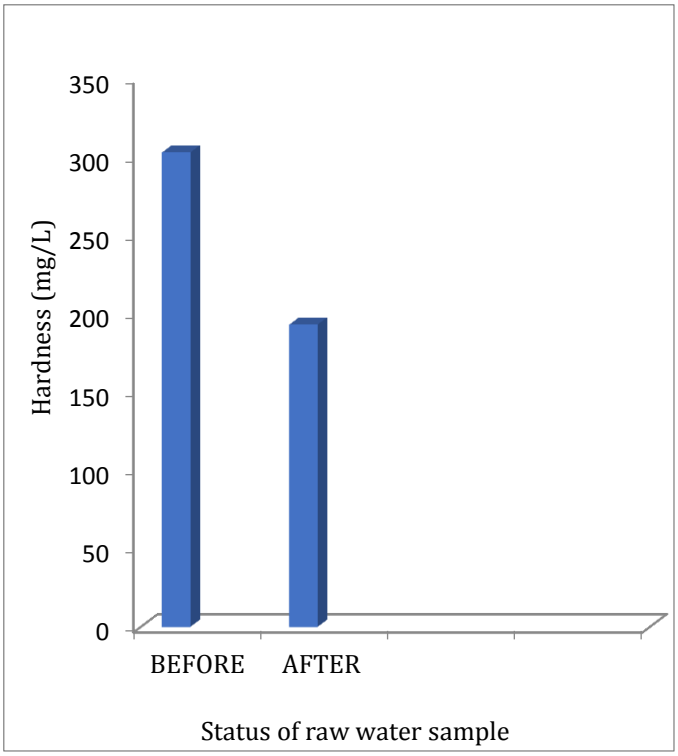

Figure 3.4 Hardness values for the water sample before and after filtration with the charcoal filters

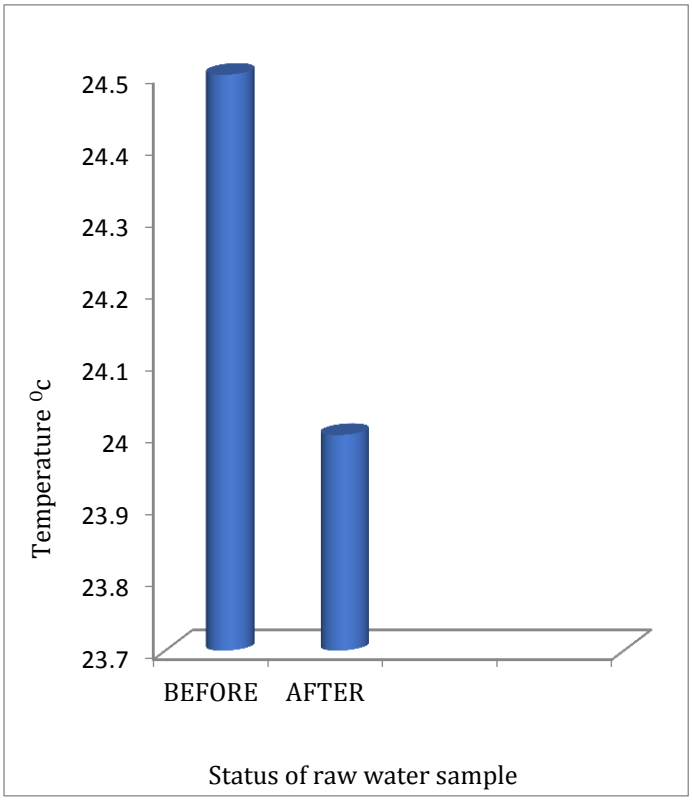

Figure 3.3 Temperature values for the water sample before and after filtration with the charcoal filters

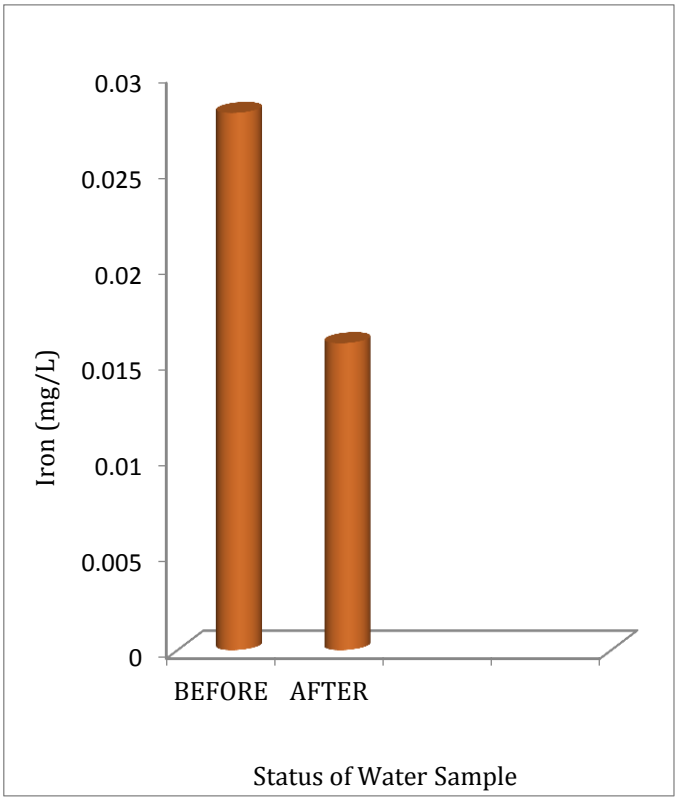

Figure 3.5 Iron values for the water sample before and after filtration with the charcoal filter

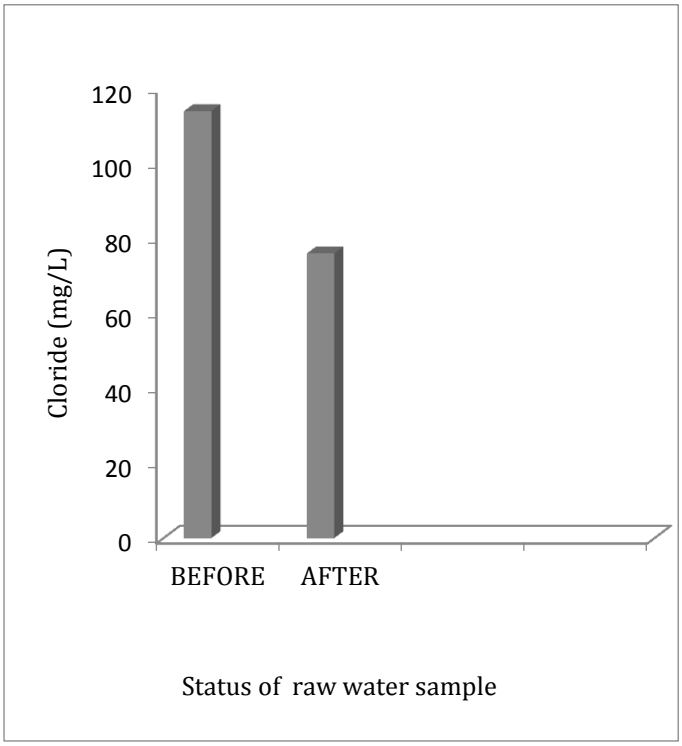

Figure 3.6 Chloride values for the water sample before and after filtration with the charcoal filter

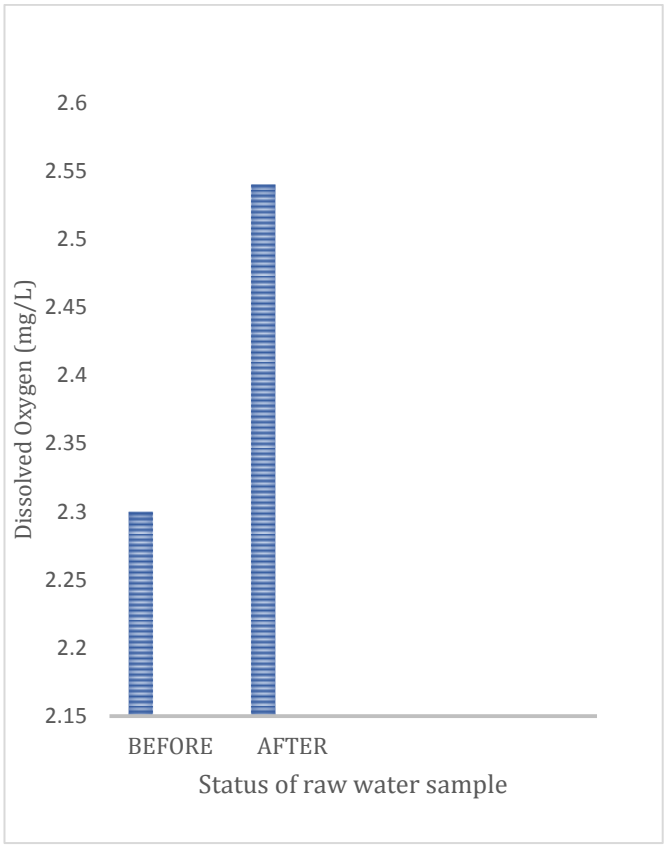

Figure 3.7 Dissolved Oxygen values for the water sample before and after filtration with the charcoal filter.

4. DISCUSSION OF RESULTS

pH; The pH of the water sample before filtration was found to be 5.67 which is unsuitable for drinking water. The filtered water sample was found to have a ph. of 7.7 which is well within the (WHO 1996) limits 6.5 – 8.5. This has indicated that the charcoal filter has the potentiality for changing the pH of the unfiltered water sample from slightly acidic to alkaline after filtration.

Turbidity; The sample was fund to have a turbidity of 353.7NTU and after passing it through the charcoal filter for about six times it decreases drastically to 6.21 NTU which is also not within the (WHO 1996) acceptable limits of 5 NTU for drinking water. The charcoal filter shows high turbidity removal efficiency (98.2%).

Temperature; There was a slight change in the temperature of the sample before and after filtration. The temperature of the sample before filtration was24.5 while after filtration was 24 which are with the (WHO 1996) limits for domestic supply water.

Conductivity; The conductivity of the sample before and after filtration was found to be 29 µS/cm and 633 µS/cm respectively. Hence, they all fall within the acceptable (NIS 2005) limit of 1000 µS/cm.

Odor; The odor of the sample before filtration was highly objectionable this may be due to the presence of decomposing organic matter or excessive concentration of chemical compounds. After filtration the filtered water sample was found to be unobjectionable (odorless).

Hardness; Although the total hardness of the sample before filtration (303 mg/L) and that of the filtered sample (130 mg/L) fall within the acceptable (WHO 1996) limits of 500mg/L, the charcoal filter has shown a about 57.1% removal efficiency of total hardness.

Iron; The iron concentration of the sample before filtration was 0.028 mg/L. this has indicated that the sample has a low iron concentration. After filtration, the iron content was reduced to 0.016 mg/L. Both concentrations are within the (BIS 1991) limit of 0.3 mg/L.

Chloride; The chloride content of the sample before and after filtration were respectively 114 mg/L and 76 mg/L all falls within the required limits 200 mg/L thus, showing about 33%removal efficiency of the chloride content by the charcoal filter.

Dissolved Oxygen; The result obtained shows a slight increase of dissolved oxygen in the filtered sample which is an indication of a healthier water body since higher dissolved oxygen concentration is correlated with high productivity and little or no pollution.

Coliform Bacteria; Testing for coliform of the sample before and the sample after filtration read positive for presumptive, confirmatory, and completed test.

Table1 Result for the water quality parameters analyzed

S/N	Parameters	Units	Before Filtration	After Filtration
1	Temperature	^{0}C	24.5	24
2	Turbidity	NTU	353.7	6.21
3	Total Dissolve Solid (TDS)	mg/L	485	96
4	Odor	-	Objectionable	Un objectionable
5	Conductivity	µS/cm	291	633
6	pH	-	5.67	7.7
7	Acidity	mg/L	150	--
8	Alkalinity	mg/L	--	182.5
9	Hardness	mg/L	302.6	129.94
10	Iron	mg/L	0.028	0.016
11	Chloride	mg/L	114	76
12	Dissolved Oxygen	mg/L	2.3	2.54
13	Faecal Coliform	cfu/100ml	Present	Present

Table 2 Efficiency of the charcoal filter used

S/N	Parameters	Units	Efficiency (%)
1	Temperature	^{0}C	2.04
2	Turbidity	NTU	98.24
3	Total Dissolve Solid (TDS)	mg/L	80.21
4	Odor	-	NIL
5	Conductivity	µS/cm	54.03
6	pH	-	26.36
7	Acidity	mg/L	NIL
8	Alkalinity	mg/L	NIL
9	Hardness	mg/L	57.06
10	Iron	mg/L	42.86
11	Chloride	mg/L	33.33
12	Dissolved Oxygen	mg/L	9.45
13	Faecal Coliform	cfu/100ml	0

Table 3 Assessment of the Result

Parameters	Recommended Limits Set by Agencies	Before Filtration	Assessment	After Filtration	Assessment
Temperature (^{0}C)	25	24.5	Suitable	24	Suitable
Turbidity (NTU)	5	353.7	Un suitable	6.21	Un Suitable
Total dissolve solid (TDS) (mg/L)	500	485	Suitable	96	Suitable
Odor (Un objectionable)	Un objectionable	Objectionable	Un suitable	un objectionable	Suitable
Conductivity (µS/cm)	1000	291	Suitable	633	Suitable
pH	6.5 - 8.5	5.67	Un suitable	7.7	Suitable
Acidity (mg/L)	NIL	150		--	
Alkalinity (mg/L)	200	--		182.5	Suitable
Hardness (mg/L)	500	302.6	Suitable	129.94	Suitable
Iron (mg/L)	0.3	0.028	Suitable	0.016	Suitable
Chloride (mg/L)	250	114	Suitable	76	Suitable
dissolve Oxygen (mg/L)	NIL	2.3		2.54	
Coliform Bacteria (cfu/100ml)	0	Present	Unsuitable	Present	Unsuitable

5. CONCLUSION

The microbial analysis test result shows that the presumptive test reads positive for both samples before and after filtration. Similarly, the physiochemical analysis test result shows that charcoal has high removal efficiency of turbidity, but still the filtrate turbidity was slightly outside the limit of drinking water standard after a number of repeated filtrations. There was a decrease in hardness, chloride and iron concentrations while an increase in pH and conductivity were recorded after filtration

6. RESEARCH GAP FOR FUTURE

In view of the overall findings of this study, the following recommendations were suggested.

Charcoal material should be incorporated with other filter material of higher filtration capability to provide a combined filter media which will be more effective in removing turbidity as well as microbial contaminants.

Research should be carried out to evaluate the potentiality of charcoal for removing other contaminants that were not involved in this research work such as nitrates, sulphates etc.

REFERENCES

[1] CDC (2015) Center for Disease Control [online] Received from www.cdc.gov/healthywater/drinking/public/watersource.html

[2] www.cdc.gov/healthywater/drinking/public/water-diseases.html

[3] www.cdc.gov/healthywater/drinking/public/drinkingwaterfaq.html. [octOctober15]

[4] Chemical Properties of Charcoal (2015) received from http://ukrfuel.com/newschemicalpropertiesofcharcoal_23.html

[5] ukrfuel.com/newsphysicalpropertiesofcharcoal22html [October 2015}

[6] Conserve Energy Future (2015) [online] retrieved from http://www.conserveenergyfuture.com/sources_and_causesofwater_pollution.php, on [October 2015]

[7] CWE (2015) Estimation of filtration potential of Iron, Turbidity From Various Sources Of Water [Online] Received from Current World Environment http://www.cwejournal.org/vol10no2/estimationofeffectivebiosandfilterforremovalofironturbidityfromvariuossourcesof_

[8] Contaminants and Pollution in Drinking Water (2015) Received from http://extronet.orst.edu/faqs/safedrink/cintam.html [22 October 2015]

[9] Desliva F. (2000) Activated Carbon Filtration [online] Received from Plos one www.watertreatmentguide.com/activatedcarbonfiltration. [October 2015]

[10] Boutilier MSH, Lee J, Chambers V, Venkatesh V, Karnik R, (2014) Water Filtration Using Plant Xylem [online] Available from plosone http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0089934 [October 2015]

[11] NSDWD (2007) Nigerian Standard for Drinking Water Quality, Standard Organization of Nigeria. Available from www.unicef.org/nigeria/ng-publicationsStandardforDrinkingWaterQuality.pdf

[12] Shelton T. B (2004) interpreting drinking water quality Analysis Available from www.walrus.com

[13] Singh G. (2003) Water Supply and Sanitary Engineering Sixth Edition

[14] SSWM (2011) Sustainable Sanitation And Water Management [online] received from http://www.sswm.info/content/adsorption_activated carbon [October 2015]

[15] http://www.sswm.info/content/coagulationfloculation [October 2015]

[16] http://www.sswm.info/content/sedimentationflocula tion [October 2015]

[17] Sulaiman and Bello (2014) Assessment of Water Quality for River Challawa and River Kano

[18] UNEP (2004) Challenges of Water Scarcity United Nations Environmental Programme, Washington, Harless Street, Suite 100 Baltimore, Maryland

[19] CACETS (2015) Technical Column [online] received from www.vacets.org/eng/eng19.html [October 2015]

[20] Water pollution/sources and causes of water pollution/Biology@Tutorvista.com Received from http://biology.tutorvista.com/environmental_pollution/waterpollution.htwl?=simple [October 2015]

[21] WHO (2004) Guide Lines For Drinking Water Quality and Waste water, 18th edition, American public health association

AUTHOR'S BIOGRAPHIES

Awwal Musa:
Lecturer, Division of Agricultural Colleges, Ahmadu Bello University Zaria, Kaduna, Nigeria.

Sani Saleh:
Post Graduate Research Scholar, Civil Engineering Department, Sharda University, Uttar Pradesh, India

Kasim Mohammed:
Senior Lecturer, Department of civil engineering, Bayero University, Kano, Nigeria

Yahaya Hassan Labaran:
Post Graduate Research Scholar, Civil Engineering Department, Sharda University, Uttar Pradesh, India

Jabir Zakari Yau:
Post Graduate Research Scholar, Civil Engineering Department, Sharda University, Uttar Pradesh, India

Hussaini Mato:
Post Graduate Research Scholar, Civil Engineering Department, Sharda University, Uttar Pradesh, India