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RESEARCH ARTICLE

A STUDY OF WATER QUALITY IN JOS METROPOLIS

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ABSTRACT

Background and Objectives: Man's health is determined by some factors which play a leading role in making man what he is, these conditions are social, economic, political, natural, manmade and environmental factors. The main aim of this research was to investigate people's access to quality water supply and the common bacteria found in the stored drinking water of household in the study area. **Methods:** To achieve these objectives an Experimental Design (laboratory study) was adopted, water samples were collected from 100 households in target communities. Physicochemical and microbial analysis of the water samples was carried out at the Plateau State Water Board (Laminga Treatment Plant). The physicochemical analysis carried out included; pH, Color, Turbidity, Total hardness, Total alkalinity, Electrical conductivity, Total dissolved solid, Test for water elements like; Calcium, Chloride, Iron, Fluoride, Magnesium, Manganese, Nitrates, Potassium and Sodium. For the microbial analysis, Total coliform bacteria were used as indicator to detect the presence of pathogens. **Results:** The result showed that for all the parameters the mean values fall within the acceptable ranges with the exception of Turbidity and Microbial analysis. The Microbial analysis showed that most water samples have high microbial load which exceeds the maximum permitted level of 10cfu/100mls. **Conclusion:** From the study, it can be seen that the water samples were turbid and contain high concentration of total coliform. Hence the needs to further improve the sanitation and general health of the people.

INTRODUCTION

Human existence in the planet earth is bedeviled with lots of health related problems caused by man's living environmental conditions. These are the surrounding conditions of man's living environment which has been observed by researchers to be consequentially detrimental to the health, social and economic well being of the individual and his family or society where they live (1-3). Man's health is determined by some factors which play a leading role in making man what he is, these conditions are social, economic, political, natural manmade and environmental factors. Human healthy living is tied to some situations where man finds himself. For instance, the environment man lives, access to quality water, transportation and storage of such water for family consumption, hygiene and sanitation level, surrounding environment including waste disposal and management, feeding habit and personal hygiene among others to a large extent determine the extent of one's health (4). WHO/UNICEF (World Health Organization/United Nation's International Children's Emergency Funds) joint monitoring program estimates for water supply and sanitation released in early 2013 shows that 36 percent of the world's population. (25 billion) lack access to improved sanitation facilities and 768 million people still use unsafe drinking water sources. Inadequate access to safe water and sanitation services, coupled with poor hygiene practices, kills and sickens, thousands of children every day and leads to impoverishment and diminished opportunities for thousands more (5). Numerous epidemiological studies and outbreak have found an association between poor water quality and infectious diarrhea. In France, water that did not meet microbiological standards was associated with an increased risk of gastroenteritis (6). In Philippines, (7) reported an odds ratio for diarrhea following consumption of water contaminated with high levels of Escherichia coli (a fecal indicator bacteria (8) reported that children with prolonged diarrheal illness (more than 14 days) were more likely to drink water an unprotected water source. (9) Conducted an epidemiological investigation to identify sources of infection and risk factors for cholera in Burundi during and epidemic in 1992. Water from Lake Tanganyika was implicated as a case control study found that both bathing in the lake and drinking its water were independently related to illness. As seen above, the causal relationship between ingesting water of poor sanitary quality and diarrheal illness has been observed worldwide, using a variety of techniques and assessing quality in a number of different ways. The biological gradient can be illustrated by increases in infectious diarrhea morbidity as contamination levels increase, and also as consumption of water from a single contaminated source increases.

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For example, (10) examined the annual diarrheal incidence rate (per 1000 population) in 39 communities in Imo State, Nigeria, in relation to the Characteristics (including pollution) of their drinking water source. Sources were classified from A to C with A representing the most desirable sources (with favorable geology sparse population and clean unpolluted water). Diarrheal incidence rate was found to show a statistically significant increase with a mean of 1.61 for category A, a mean of 6.25 for category B, and a mean of 15.6 for category.

STATEMENT OF THE PROBLEM

Jos Metropolis is the largest town in Plateau State and serves as the State capital. It doubles as the headquarters of Jos-North and Jos- South Local Government areas of Plateau State. It is indeed an old town whose growth as an urban nucleus is driven by commercial and mining activities as a dominant urban center within the state Jos has continually received influx of migrants from country side and a combination of rural- urban migration and high fertility rates of the families has led to a swell in its population. However, the pace of population growth far out strips the ability of the urban authorities (particularly Ministry of Water Resources and Rural Development, Plateau State Water Board) to provide portable water supply, giving rise to water scarcity, hardship and pipe-borne water diseases. In spite of the water programmes executed within the Jos Metropolis, there is little positive impact and thus diarrhoeal diseases are still very high in the Jos Metropolis. In developing countries, it is not only water contaminated at source or during distribution that is an issue, but water stored within the home which may also become contaminated and in turn influence the transmission of diseases. For example, in a literature review (11) found 11 observational studies showing that mean coliform levels (an indication of contamination) were considerably higher in household. There is therefore need to analyzed the water stored within the household since there is inadequate research that investigates this problem in the study area.

THE RESEARCH QUESTIONS

The following research questions were posed to help address the objectives.

- What is the water quality situation in the study area?
- What are the common bacteria found in stored drinking water of households in the study area?

GENERAL OBJECTIVES

The main aim of this research is to investigate people's access to quality water supply and

The specific objectives were

- To assess the quality of stored household drinking water in Jos metropolis and
- To investigate the presence of common bacteria in the stored drinking water of households in the study area.

THE STUDY SETTING: The Jos City is located in Nigeria's middle belt, with an area of about 26,899 square kilometers, (12). It is located between latitude and N, longitude and East. Barkin Ladi in the south East, Jos South and Riyom in the South West and Bassa in the North (Plateau State Ministry for Lands, Survey and Town Planning). Though situated in the tropical zone a higher altitude means that Jos city has a near temperature climate with an average temperature of between and C. Harmattan winds cause the coldest weather between December and February.

The warmest temperature usually occurs in the dry season months of March and April (13). Jos receives about 1,400 millimeter (55inches) of rainfall, annually, the precipitation arising from both conventional and orographic sources owing to the location of the city on Jos Plateau (13). The low temperature of plateau state has led to a reduced incidence of some tropical diseases such as malaria (14). The Jos metropolis is the largest town in Plateau State and is the state capital. It doubles as the head quarter of Jos South and Jos-North Local Government Area. It is indeed an old town shoes growth as an urban nucleus is driven by commercial and mining activities as a dominants urban center within the state (15).

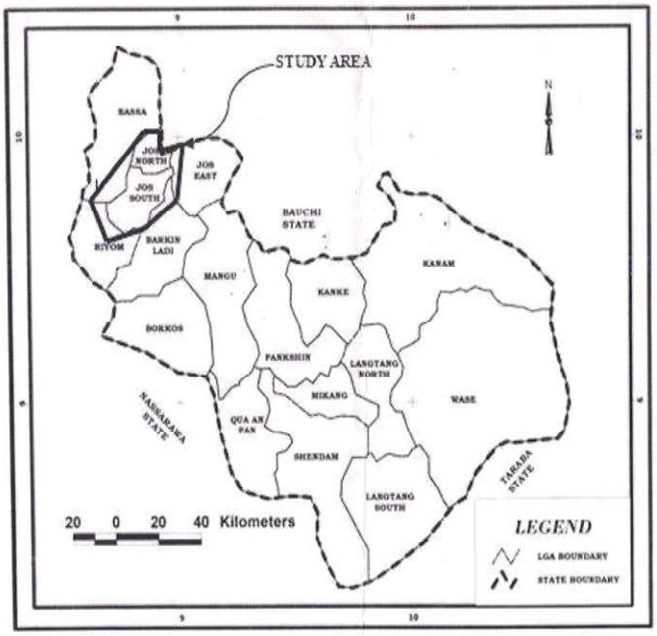

Fig. 1. Map of Plateau State showing Jos Metropolis

STUDY DESIGN

The study design was an experimental (Laboratory analysis) studies. In an experimental design, a test is conducted under a controlled condition, where it is hoped that all variables will be able to be controlled by the researcher (16).

The Laboratory analysis which consists of the physicochemical water analysis and the microbial analysis was use in this study to determine the quality of drinking water in the study area.

STUDY POPULATION

The Jos metropolis is the largest town in Plateau State and is the state capital. It doubles as the headquarters of Jos South and Jos North Local Government area. It is indeed an old town whose growth as an urban nucleus is driven by commercial and mining activities as a dominant urban center within the state (15). Based on the result of 2006 census, Jos has a Population of about 850,000 people (12). Jos has continually received influx of migrants from country side and this combination of rural-urban migrant and high fertility rates of the families has led to an increase in its population

SAMPLE SIZE DETERMINATION: Population of Jos Metropolis was based on 2006 census which was 850,000 formular for projecting the population to 2017

Formular = Pt= Po x $(1+r/100)^t$
Pt = 850,000 x (1 + 0.028)" not Pt = 850,000 x (1+
Pt = projected population
Po = Existing population
r = growth rate = 2.8 (Annual growth rate)
t = projected time
Pt = 850,000 x (1+
= 850,000 x $(1 + 0.028)^{11}$
= 850,000 $(1.028)^{11}$
= 850,000 x 1.3928
= 1,183, 958 persons

Projected number of houses in Jos Metropolis in 2017 = 197,326.34

Sample Size and Selection

Sample size was calculated according to (17) with an alpha error of 0.05 and precision of 5% thus.

N =
Where:
N = sample size, n= the population and e is the alpha error of 0.05
N =
= 399 400

PROCEDURE FOR DATA COLLECTION: Water samples were collected from 100 households, in targets communities (Terminus/Farin Gada, Angwan Rukuba, Miango/Bukuru, Rayfield/Hwolshe) for analysis in all, a total of 300 water samples (including duplicates and blanks) were tested from the 100 household sources. The number of water samples collected for analysis was not equal to the number of household because of resources and financial burdens. Water samples were collected in sterilized standard 500ml bag with sodium thiosulfate tablet. They were transported with ice packs and cooler bags to ensure that a low temperature ($2\text{-}8^0$C) was maintained at all times. This was done to preserve the integrity of the samples since most bacteria reactions related to diarrhoeal diseases cannot progress at that temperature. If this precaution is not taken the result of the analysis may be affected. Analysis of water samples began within 4 to 6 hours of collection at the Plateau State Water Board (Laminga Treatment Plant). The microbial and physicochemical water analyses were carried out. For the microbial analysis, total coliform bacteria were used as the indicator microorganisms to detect the presence of pathogens in water samples. The physicochemical analysis carried out included PH, Colour, Turbidity, Total Hardness, Total Alkalinity, Electrical conductivity, Total Dissolved Solid, Test for water elements like, calcium, chloride, Iron, Fluoride, magnesium, Manganese, Nitrates, Potassium and Sodium.

Water Quality Sampling: The duration of sample tested was limited to 3 months and the main aim was to sample as many household as possible. Water samples were collected between February to April 2017 form stored water containers of 100 households, in target communities for analysis. In all, a total of 300 water samples (including duplicates and blanks) were tested from the 100 household sources. Physical observation of the stored drinking water revealed that some containers had no covers and most households collect water from the containers by dipping cups and bottles into them. The number of water samples collected for analysis was not equal to the number of respondent because of resources and financial burdens. Water samples were collected in sterilized standard 500ml bags with sodium thiosulfate tablet. They were transported with ice packs and cooler bags to ensure that low temperature ($2^0\text{-}8^0$C) were maintained at all times. This was done to preserve the integrity of the samples since most bacteria reactions related to diarrhoeal diseases cannot progress at that temperature. If this precaution is not taken the results of the analysis may be affected.
Analysis of the water samples began within 4 to 6 hours of collection at the Plateau State water board (Laminga Treatment Plant, When testing within 4 to 6 hours was not possible the samples were transferred to refrigerator at a temperature of ($4\text{-}5^0$C) and tested within 24hours. Swan Natural Spring Water (Table water) was used as sterile water; this is because studies done by (18) indicated that all samples of bottled water tested were free of microbial contamination (0 CFU/100ml for total coliforms). Which implies that using bottled water as sterile water could not have been a major source of error for the tests conducted in this study. Blanks were consistently run with this water and came out blank where the household used bagged sachet water; the samples were transported in their original sachet packs. Water samples were only transferred to the Whirl-Pak® bags at the testing laboratory, so that the sodium thiosulphate tablet contained in the Whirl- Pak® bags would neutralize any chlorine in the sachet water. The sodium thiosulfate tablet contained in one bag is capable of neutralization 500ml of a chlorinated water sample (19). The neutralization by sodium thiosulphate ensured that no residual chlorine would interfere with the microbial analysis.

Membrane Filtration Method (MF) method: In the MF method water of a known volume (usually 100ml) was passed through a sterile filter paper with 0.45 microns pore diameter. These pores are small enough to filter out bacteria. The filter paper was then transferred to a Petri dish which contained a pad saturated with medium. For this study, mColi Blue 24 (R) broth (ready to use broth sold in plastic ampoules was the media for coliform growth. mColiBlue 24® is a nutritive membrane filtration media that simultaneously detects total coliforms and *E. coli* within 24hours. The media is lactose based and contains inhibitors to selectively inhibit growth of non- coliform cells (19).

Total coliforms are "highlighted" by nonselective dye, 2, 3, 5-Triphenyl-tetrazolium chloride (TTC), which produces red colonies. Red and blue colonies combined are total coliforms while blue colonies alone are *E. coli*. The media was provided in 2ml ready-to- use ampoules, which have a shelf life of one year when stored under temperature conditions between $2\text{-}8^o$C. The detection limit (or sensitivity) was one CFU coliform bacteria per 100ml of sample (19). The Petri-dish was incubated at $35^o\text{C}\pm 0.5^o$C for 24hours, during which Coliforms, if present, multiplied and grew in size, and were readily identified and counted. For drinking water, the counts are reported as coliforms forming units per 100ml of water (CFU/100mls). Where necessary, various dilutions were applied to obtain coliform counts within a given range. Colonies that entirely covered the plate grid, causing it to be red or pinkish color, were recorded as "too numerous to count" (TNTC).

Physicochemical Water Analysis

Apparatus/ Materials: Test tubes, measuring cylinder, comparator, comparator disc, Nessleriser, Hazen color disc NSA or NSB, conductivity meter, thermometer, turbidimeter, sample cells, burettes, pipettes, conical flasks, pH meter, fluoride ion selective electrode, reference electrode, magnetic stirrer, glassware, glass tubes, discs, Spectrophotometer beakers, 100ml volumetric flask, measuring cylinder, hotplate, fume cupboard, Disc, porcelain crucibles, filtering apparatus, furnace, desiccators, analytical balance

Reagents: Bromothymol-blue, methyl orange indicators, sulphuric acid solution (0.1N), standard EDTA (0.01M), Sodium hydroxide solution (1N), Murexide indicator, standard calcium solution, potassium chromate indicator solution, standard silver nitrate solution, stock fluoride solution, standard fluoride solution, citric acid solution, ammonia solution, thioglycollic acid solution, ammonia chloride buffer solution, erichromeblackT and sodium chloride mixture, concentrated nitric acid, 85% phosphoric acid, potassium periodate, standard manganese solution, glacial acetic acid, silver sulphate, ammonia solution, phenoldisulphuric acid, barium chloride solution, concentrated hydrochloric acid.

Physicochemical Tests

pH: 10mls of water sample was measured inside a test tube, 7-8 drops of Bromothymol-blue was added using dropping teeth. The mixture was shaken and allowed to stand for 10minuts. The test tube containing the sample was then inserted on the right hand side of the comparator with a blank on the left hand side. The comparator disc was taken and put inside the comparator and then rotated for a color match, the color that matches with the colour on the comparator disc is the pH of the sample (20).

Colour: A clean Nessleriser glass tube was filled with the sample to the 50ml mark. It was then placed on the right hand compartment of the Nessleriser. The left hand compartment contained a tube filled with distilled water. The colour of the sample was compared with the matched tube containing distilled water using the Hazen colour disc. The pH of the sample was measured and recorded. Colour of a sample is related to pH (20).

Turbidity: Turbidimeter was turned on; status of battery was checked and allowed 10minutes for stabilization. 25mls of sample was poured into sample cell. 10 NTU standard was selected from the standards provided and the standard put into sample holder in the hole provided. It was covered with light shield. The scale reading was adjusted to 100 using the standardize knob with range switch of 10. The standard was removed and replaced with sample cell. It was covered with light shield before reading the scale and recording what was read (20).

Total Hardness: 50ml of sample was pipette into a 100ml conical flask. 2mls of ammonia ammonium chloride buffer was added to it, followed by 0.1 – 0.2g of eriochrome black indicator. The content of the conical flask was titrated immediately with (0.01M) EDTA switching continuously until the reddish colour disappeared. The end point was clear blue color (20).

Total Alkalinity: 100ml of sample was measured inside a conical flask.2 drops of methyl orange indictor was added to the sample and shaken. The concentrated sulphuric acid was poured inside the burette and titrated against the sample for a colour change. The volume of acid (sulphuric acid) used was calculated by subtracting the initial volume which was zero from the final reading (20).

To calculate the alkalinity

$$= \frac{\text{Volume of acid}}{\text{Volume of sample}} \times 1000$$

Electrical Conductivity: The conductivity cell was rinsed with the water sample three times (3x) before filling up the cell. The button was pressed and the dial was adjusted until a null reading registered in the middle of the indicator. The value on the dial was read, multiplied by the scale factor and recorded. The temperature was recorded after the reading. The procedure above was repeated at 5 different temperatures between 5^oC- 8^oC by warming the sample in a beaker on the hot plate or cooling it in the refrigerator. A graph of conductivity was plotted against temperature and the conductivity was determined in µs/cm at 25^oC (20).

Total Dissolved Solid: A clean evaporating dish was heated in the drying oven at 105^0 C for 30 minutes and cooled in desiccators for 10mnutes. The dish was carefully weighed on a balance and placed on a boiling water bath. About 100mls of water was filtered through the glass fibre into the treated evaporating dish. It was then transferred to an oven at 105^0C and dried for about 1-2hours. The dish was allowed to cool in the air and the placed while still warm in desiccators to complete cooling in a dry atmosphere. As soon as it was cooled the dish was weighed and value obtained recorded. The steps were repeated till a constant weight was obtained (20).

Total dissolved solid (TDS) =(B-A) x 1000/

in mg/l ml of sample
Where B:Weigh of residue and dish
A: weigh of dish alone

Test for Calcium: 50mls of sample was pipette into 100ml conical flask. 2mls of Na0H solution was added using a dispenser followed by 0.1-02g of the Murexide/Nacl indicator. It was titrated immediately with EDTA swirling the content of the flash continuously until the colour changes from pink to purple.

Calculation

Calcium, Ca^{2+}

$$\text{mg/l}Ca = \frac{\text{ml of 0.01m EDTA X 1000}}{\text{ml of sample}} \text{ X } 0.4008$$

Test for Chloride: 1ml of potassium chromate indicator was added to the sample obtained from alkalinity determination. The sample was titrated by swirling the flask continuously with silver nitrate solution until a brick red end point was obtained. Occasionally, an indicator blank was determined by adding 1ml of potassium chromate to 100ml deioned water and titrating drop wise until the end point.

Calculations

$$Mg/l\ Cl^- = \frac{(A-B) \times N \times 35,450}{ml\ of\ sample}$$

Where
A:titer value in ml for sample
B:titer value in ml for blank
N:normality of silver nitrate
To convert to sodium chloride (Nacl) mg/l Nacl = mg/l Cl^- x 1.65. (20).

Test for Iron: Calorimetric method employing thioglycollic acid was used. Visual comparism of the characteristic colour produced by the reagent was compared with standard disc. One (1) Nessleriser glass was filled to the 50ml mark with the sample water. 2ml of 20% citric acid was added then 0. 1ml thioglycollic acid and mixed.

The resultant mixture was rendered alkaline by adding 2ml of ammonia solution. It was mixed and left to stand for five minutes. For the second glass, 50ml of distilled water was added, after which 2mls of citric acid, 0.1ml of thioglycollic acid and 2mls of ammonia solution were added. The mixture was place in the left hand compartment of the Nessleriser while the test solution was placed in the right hand compartment and matched (20).

Calculations

$$mg/l\ Iron\ (Fe) = \frac{Disc\ reading}{Ml\ of\ sample}$$

Test for Fluoride: The pH meter was calibrated according to manufacturer's instruction. Fluoride standards were prepared by measuring 1, 2, 3, 4, 5, 6, 8 and 10ml standard fluoride solution into series of 100ml volumetric flask to produce fluoride concentration of 0.2, 0.4, 0.6, 0.8, 1, 1.2, and 1. 6 and 2.0mg/l. To each of the flask, 50ml TISAB solution was pipetted/added into it.

This was further diluted to form a well mixed solution using the sample solution i.e. TISAB solution. Each standard and sample was transferred to a series of 150ml beakers. The electrodes were immersed and the developed potential was measured while stirring the test solution on a magnetic stirrer. The electrodes were allowed to remain in the test solution for 3 minutes before taking a final millivolt reading. The electrodes were rinsed with distilled water and blotted dry between each reading.

A standard curve was then prepared by plotting fluoride concentration in mg/l on a logarithmic graph paper and the reading was taken by using the potential measurement for the sample to read the corresponding fluoride concentration off the standard curve (20).

Calculation

$$Mg/l\ F = \frac{\mu gf}{Ml}$$

Test for Magnesium: 50ml of sample was pipetted into a 100ml conical flask. 2mls Ammonia/ Ammonium chloride buffer was added using tilt measure or dispenser after which 0.1-02g indicator mixture was added using the end of a clean spatula. The resultant mixture was titrated with standard EDTA, Swirling continuously until the last reddish tinge disappeared. The end point was indicated by a clear blue color (20).

Calculations

- Total hardness as mg/l CaC03

$$= Ml\ of\ \frac{0.01MEDTA}{Ml\ of\ sample} \times 1000$$

- Magnesium as $Mg2^+$ Total hardness titer of 0.0ml

EDTA x 1000 x 0.743 in mg/l

$$\frac{Calcium\ titer\ of\ 0.01N\ EDTA}{Sample\ volume}$$

Test for Manganese: 100ml of the sample was measured using a measuring cylinder and transferred to a 250ml glass beaker. 100ml of deionised water was treated as another sample for reagent blank. Using the special measuring cylinders, 15ml of mixed acid reagent (HN03, H_2S0_4 and H_3P0s_4) was carefully added and the solution was made to boil on the hot plate in the fume cupboard. The volume of solution in the beaker was reduced by boiling to about 90ml and cooled by allowing to stand in the fume cupboard. About 1g of potassium periodate was then added using a spatula after which beakers were heated to boiling for one minute. The hot plate was turned off and the beakers were allowed to stand on hotplate for 9 more minutes. The beakers were cooled while the solution was carefully transferred to a 100ml volumetric flask. The resultant mixture was diluted to 100ml mark and the solution mixed. The pink colour was measured with spectrophotometer at 540nm and 1cm cell against reagent blank (21).

Test for Nitrates: 10ml of the sample was placed into a 100mlconical flask. 1ml glacial acetic acid was added followed by 0.1g solid silversulphate (nitrate free) and shaken well. The mixture was filtered through a whatman No. 32 paper. 5ml of the filtrate was taken into a small porcelain dish and evaporated to dryness on boiling water bath after which it was allowed to cool. To the cooled residue, 1ml of phenol disulphoric acid solution was added. It was ensured that reagent made contact with the whole solid material derived from the sample. The residue and phenoldisulphuric acid solution was allowed to stand for 10minutes before being transferred to a Nessleriser glass using 30ml of wash water and cooled. To the cooled mixture, 10ml of ammonia solution was added, cooled again and diluted with distilled water to 50ml after which it was being placed in the right hand compartment of the Nessleriser. Into another Nessleriser glass, 1ml of phenol- disulphoric acid, 10ml of ammonia solution were added and diluted to 50ml with distilled water.
The blank was placed in the left hand compartment of the Nessleriser. The colours produced by the test solution were compared with that produced by the standard disc. This was carried out at a temperature between 20^0c and 25^0c (21).

Calculation

The markings on the disc represent, the actual amount of nitrite nitrogen (N) producing the colors in the test.

Mg/l (ppm) N = $\frac{\text{Disc reading}}{\text{Ml/sample}}$

Test for Sulphate: 50ml of the sample was pipetted into a 25ml beaker and diluted to 150ml with deionised water. 2ml of concentration Hcl was added followed by 4 drops of methyl orange indicator. The mixture was brought to boiling point on hot plate and then 10ml 10% barium chloride was added to the solution and boiled for 5 minutes. The solution was removed from the hot plate and left to stand overnight. It was then filtered through 12.5cm filter paper, while the porcelain crucible was ignited in a furnace at 800^0C for 1 hour then cooled in the desiccators. The beaker was washed and precipitated with hot deionized water. Using a rubber tipped glass rod any precipitate sticking to the beaker were removed. The precipitate was washed until it was free from chloride after which it was weighed. The precipitate in filter paper was added to the crucible to burn off paper oven Bunsen burner. It was cooled in desiccators and weighed. The weight of barium sulphate precipitate was also weighed. (Weight of crucible and content (m) = weight of empty crucible (j) (20).

Calculation

$S04^{2-}$ in mg/l = $\frac{\text{wt of } Baso_4 \text{ppting x 411 . 5 x 1000}}{\text{Ml of sample}}$

Test for Potassium: The flame photometer was switched on, the lid of the filter chamber was opened and appropriate filter for the test opening was inserted after which the lid was closed. The free end of the PVC was inserted and the capillary in distilled water or the reagent was taken up. The zero controls were adjusted to obtain 00 displays on the read out. The free end of the PVC was inserted and the capillary taken up in the K/li and Na and Ca, working solution of highest concentration of the elements to be determined. The coarse selector of each of the channels were set to low, medium or high range as depending on the working standard of highest concentration. The control of each channel was adjusted to obtain a display of exactly 100 on the read out of the channel. The operators were repeated to ensure 00 and 100 are displayed respectively when the blank and the working standard solution of highest concentration were aspirated into the flame. The free end of the PVC was inserted and the capillary in distilled water was taken up for a minute or two to wash the mixing chamber thoroughly before the actual test. The free end of the PVC was inserted again, and the capillary in the sample was taken up the value of the concentration displayed in the read out was read. The working standard solution of known concentration was feed from time to time in a series of test to check the calibration. The samples were then introduced at a constant rate and the reading was read on the read out. The stock standard solution contains 1000ppm of potassium. From the stock standard solution, 100, 80, 60, 40, 20ppm solution of lower concentrations were prepared. To make the stock 1.909gm of Kcl was weighed and transferred into volumetric flask, the solution was made up to the mark with double distilled water (20).

Test for Sodium: The stock standard solution was prepared using Nacl and distilled water from the stock standard solution 100, 80, 60, 40 and 20ppm solution of lower concentrations were prepared. The spectrophotometer was calibrated by inserting the free end of the PVC and taking up the capillary in distilled water to obtain a zero display on the read out. After calibration, the working standard solutions of known concentration were fed from time to time in a series of a test to check the calibration. The test water samples were then fed into the machine. The samples were introduced at a constant rate. Filters select which colors the photometer detects and exclude the influence of other ions (20).

THE DATA ANALYSIS

On the basis of making scientific decision (0.05) was used as a level of significance. The primary data was entered in the SPSS Package Version 22 and both descriptive and inferential statistics worked out. Comparison of mean parameters to the study point using Analysis of Variance (ANOVA) at 0.05 significant was used to determine mean difference across the study area.

RESULTS

WATER QUALITY ANALYSIS: The result shows that for all the parameters the mean values fall within the acceptable ranges with the exception of Turbidity and Microbial analysis. Comparison of Mean Parameters in Relation to the Study Points using Analysis of Variance (ANOVA) at 0.05 Significant Level to Determine means Difference across Study Areas.

MEAN pH IN THE STUDY AREA: The result in Table 3.10 below revealed that there is no statistically significant difference in pH across different locations. This is because the p-value of 0.358 is greater than the level of significance 0.05.

MEAN COLOUR IN THE STUDY AREAS: The result in Table 3.11 below revealed that there is no statistically significant difference in colour across different locations. This is because the p-value of 0.087 is greater than the level of significance 0.05.

MEAN TURBIDITY IN THE STUDY AREA: The result in Table 3.12 below revealed that there is no statistically significant difference in Turbidity across different locations. This is because the p-value of 0.748 is greater than the level of significance 0.05.

MEAN TOTAL HARDNESS IN THE STUDY AREAS: The result in Table 3.13 below revealed that there is no statistically significant difference in total hardness across different locations. This is because the p-value of 0.847 is greater than the level of significance 0.05.

MEAN TOTAL ALKALINITY IN THE STUDY AREA: The result in Table 3.14 below revealed that there is a statistically significant difference in Total alkalinity across different locations. This is because the p-value of 0.008 is less than the level of significance 0.05.

MEAN ELELCTRICAL. CONDUCTIVITY IN STUDY AREAS: The result in Table 3.15 below revealed that there is no statistically significant difference in E. conductivity across different locations. This is because the p-value of 0.057 is greater than the level of significance 0.05.

MEAN TOTAL DISSOLVED SOLID IN STUDY AREA: The result in Table 3.16 below revealed that there is a statistically significant difference in Total dissolved solid

Table 3.9. Overall Mean and Standard Deviation for Water Analysis test for Different Parameters

Descriptive Statistics				
Parameters	N	Mean	Remark	Std. Deviation
Ph	100	6.614	Accepted	0.463
Colour (Hazen)	100	9.3728	Accepted	5.809
Turbidity (NTU)	100	13.3205	not accepted	14.229
Total hardness (mg/L)	100	105.4	Accepted	135.363
Total alkalinity (mg/L)	100	154.873	Accepted	230.701
E conductivity (us/cm	100	837.16	Accepted	115.205
Total dissolved solid (mg/l)	100	891.17	Accepted	62.902
Calcium (mg/L)	100	74.985	Accepted	54.151
Chloride (mg/l)	100	114.87	Accepted	92.036
Iron (mg/l)	100	0.0215	Accepted	0.011
Fluoride (mg/l)	100	0.0418	Accepted	0.035
Magnesium (mg/l)	100	19.2819	Accepted	35.531
Sulfate (mg/l)	100	116.46	Accepted	20.829
Nitrate (mg/l)	100	18.8	Accepted	3.739
Potassium (mg/l)	100	8.91	Accepted	2.383
Sodium (mg/l)	100	116.27	Accepted	23.355
Manganese (mg/l)	100	0.0176	Accepted	0.009
Microbial analysis (Cfu/ml)	100	37.67	not accepted	35.467
Valid N (list wise)	100			

Table 3.10. Mean pH in the Study Areas

		N	Mean	Std. Deviation	*P-value*
pH	Terminus/Farin gada	25	6.532	0.40591	0.358
	Angwan Rukuba	25	6.536	0.42119	
	Miango/Bukuru	25	6.66	0.46993	
	Rayfield/Hwolshe	25	6.728	0.54046	
	Total	100	6.614	0.46298	

Table 3.11. Mean Colour in the Study Areas

		N	**Mean**	**Std Deviation**	**P-value**
Colour (Hazen)	Terminus/Farin Gada	25	8.0368	5.58235	0.087
	Angwan Rukuba	25	10.2064	6.52951	
	Miango/Bukuru	25	7.864	5.32783	
	Rayfield/Hwolshe	25	11.384	5.27681	
	Total	**100**	**9.3728**	**5.80899**	

across different locations. This is because the p-value of 0.0001 is less than the level of significance 0.05.

Table 3.13. Mean Total Hardness in the Study Areas

		N	**Mean**	**Std. deviation**	***P-value***
Total hardness (mg/L)	Terminus/Farin Gada	25	96.44	122.136	0.847
	Angwan Rukuba	25	117.52	225.534	
	Miango/Bukuru	25	117.52	71.3542	
	Rayfield/Hwolshe	25	90.12	63.8392	
	Total	**100**	**105.4**	**135.363**	

Table 3.12. Mean Turbidity in the Study Areas

		N	**Mean**	**Std. deviation**	***P-value***
Turbidity (NTU)	Terminus/Farin Gada	25	11.7828	17.9337	0.748
	Angwan Rukuba	25	12.576	11.9856	
	Miango/Bukuru	25	15.9712	13.5051	
	Rayfield/Hwolshe	25	12.952	13.3058	
	Total	**100**	**13.3205**	**14.2293**	

Table 3.14. Mean Total Alkalinity in the Study Areas

		N	**Mean**	**Std**	***P-value***
Total alkalinity (mg/L)	Terminus/ Farin Gada	25	214.84	283.047	0.008
	Angwan Rukuba	25	248.32	320.656	
	Miango/ Bukuru	25	77.4	80.81	
	Rayfield/ Hwolshe	25	78.932	70.5432	
	Total	**100**	**154.873**	**230.701**	

Table 3.15. Mean E. Conductivity in the Study Areas

		N	**Mean**	**Std**	***P-value***
E conductivity (us/cm	Terminus/ Farin Gada	25	847.84	94.6809	0.057
	Angwan Rukuba	25	854.8	75.7039	
	Miango/ Bukuru	25	783.56	173.988	
	Rayfield/ Hwolshe	25	862.44	75.3603	
	Total	**100**	**837.16**	**115.205**	

Table 3.16. Mean Total Dissolved Solid in the Study Areas

		N	Mean	Std	*P-value*
Total dissolved solid (mg/l)	Terminus/Farin Gada	25	916.2	36.3031	0.000
	Angwan Rukuba	25	907.44	36.0822	
	Miango/Bukuru	25	920.28	49.7046	
	Rayfield/Hwolshe	25	820.76	65.2344	
	Total	**100**	**891.17**	**62.9017**	

MEAN CALCIUM IN STUDY AREAS: The result in Table 3.17 below revealed that there is a statistically significant difference in Calcium across different locations. This is because the p-value of 0.025 is less than the level of significance 0.05.

MEAN CHLORIDE IN STUDY AREAS: The result in Table 3.18 below revealed that there is no statistically significant difference in Chloride across different locations. This is because the p-value of 0.248 is greater than the level of significance 0.05.

Table 3.17. Mean Calcium in the Study Areas

		N	Mean	Std	*P-value*
Calcium (mg/L)	Terminus/Farin Gada	25	61.228	19.5153	0.025
	Angwan Rukuba	25	56.26	70.318	
	Miango/Bukuru	25	92.812	46.4276	
	Rayfield/Hwolshe	25	89.64	59.1426	
	Total	**100**	**74.985**	**54.1512**	

MEAN IRON IN THE STUDY AREAS: The result in Table 3.19 below revealed that there is no statistically significant difference in Iron across different locations. This is because the p-value of 0.156 is greater than the level of significance 0.05.

Table 3.18. Mean Chloride in the Study Areas

		N	Mean	Std	*P-value*
Chloride (mg/l)	Terminus/Farin Gada	25	106.68	28.2145	0.248
	Angwan Rukuba	25	103.84	24.0567	
	Miango/Bukuru	25	147.2	177.786	
	Rayfield/Hwolshe	25	101.76	22.236	
	Total	**100**	**114.87**	**92.0364**	

MEAN FLUORIDE IN THE STUDY AREAS: The result in Table 3.20 below revealed that there is a statistically significant difference in Fluoride across different locations. This is because the p-value of 0.0001 is less than the level of significance 0.05.

Table 3.19. Mean Iron in the study areas

		N	Mean	Std	*P-value*
Iron (mg/l)	Terminus/Farin Gada	25	0.0184	0.00987	0.156
	Angwan Rukuba	25	0.0252	0.01122	
	Miango/Bukuru	25	0.0216	0.01068	
	Rayfield/Hwolshe	25	0.0208	0.01038	
	Total	**100**	**0.0215**	**0.01067**	

MEAN MAGNESIUM IN THE STUDY AREAS: The result in Table 3.21 below revealed that there is a statistically significant difference in Magnesium across different locations. This is because the p-value of 0.000 is less than the level of significance 0.05.

Table 3.20. Mean Fluoride in the Study Areas

		N	Mean	Std	*P-value*
Fluoride (mg/l)	Terminus/Farin Gada	25	0.0672	0.05639	0.000
	Angwan Rukuba	25	0.0356	0.01981	
	Miango/Bukuru	25	0.0344	0.0196	
	Rayfield/Hwolshe	25	0.03	0.01803	
	Total	**100**	**0.0418**	**0.03549**	

MEAN SULPHATE IN THE STUDY AREAS: The result in Table 3.22 above revealed that there is no statistically significant difference in Sulphate across different locations. This is because the p-value of 0.399 is greater than the level of significance 0.05.

Table 3.22. Mean Sulphate in the Study Areas

		N	Mean	Std	*P-value*
Sulphate (mg/l)	Terminus/Farin Gada	25	116.28	18.1533	0.399
	Angwan Rukuba	25	120.2	26.7005	
	Miango/Bukuru	25	110.72	20.9951	
	Rayfield/Hwolshe	25	118.64	15.8899	
	Total	**100**	**116.46**	**20.829**	

MEAN NITRATES IN THE STUDY AREAS: The result in Table 3.23 below revealed that there is no statistically significant difference in Nitrate across different locations. This is because the p-value of 0.062 is greater than the level of significance 0.05.

Table 3.23. Mean Nitrate in the Study Areas

		N	Mean	Std	*P-value*
Nitrate (mg/l)	Terminus/Farin Gada	25	19.44	3.29242	0.062
	Angwan Rukuba	25	19.96	2.90803	
	Miango/Bukuru	25	17.32	4.16053	
	Rayfield/Hwolshe	25	18.48	4.10406	
	Total	**100**	**18.8**	**3.73896**	

MEAN POTASSIUM IN THE STUDY AREAS: The result in Table 3.24 below revealed that there is no statistically significant difference in Potassium across different locations. This is because the p-value of 0.518 is greater than the level of significance 0.05.

Table 3.24. Mean Potassium in the Study Areas

		N	Mean	Std	*P-value*
Potassium (mg/l)	Terminus/Farin Gada	25	8.48	2.0232	0.518
	Angwan Rukuba	25	9.36	1.97653	
	Miango/Bukuru	25	9.16	2.68763	
	Rayfield/Hwolshe	25	8.64	2.76707	
	Total	**100**	**8.91**	**2.383**	

MEAN SODIUM IN THE STUDY AREAS: The result in Table 3.25 below revealed that there is no statistically significant difference in Sodium across different locations. This is because the p-value of 0.222 is greater than the level of significance 0.05.

Table 3.25. Mean Sodium in the Study Areas

		N	Mean	Std	*P-value*
Sodium (mg/l)	Terminus/Farin Gada	25	117.4	29.7349	0.222
	Angwan Rukuba	25	115.12	16.8729	
	Miango/Bukuru	25	123.12	20.596	
	Rayfield/Hwolshe	25	109.44	23.5957	
	Total	**100**	**116.27**	**23.3549**	

MEAN MANGANESE IN THE STUDY AREAS: The result in Table 3.26 below indicated that there is no statistically significant difference in Manganese across different locations. This is because the p-value of 0.816 is greater than the level of significance 0.05

Table 3.26. Mean Manganese in the Study Areas

		N	Mean	Std	*P-value*
Manganese (mg/l)	Terminus/Farin Gada	25	0.0168	0.00852	0.816
	Angwan Rukuba	25	0.018	0.00866	
	Miango/Bukuru	25	0.0188	0.00927	
	Rayfield/Hwolshe	25	0.0168	0.00852	
	Total	**100**	**0.0176**	**0.00866**	

MEAN MICROBIAL ANALYSIS IN THE STUDY AREAS: The result in Table 3.27 Below indicated that there is no statistically significant difference in Microbial analysis across different locations. This is because the p-value of 0.110 is greater than the level of significance 0.05.

Table 3.27. Mean Microbial Analysis in the Study Areas

		N	Mean	Std	*P-value*
Microbial analysis (Cfu/ml)	Terminus/Farin Gada	25	40.08	26.0383	0.110
	Angwan Rukuba	25	48.6	54.7974	
	Miango/Bukuru	25	37.64	30.4095	
	Rayfield/Hwolshe	25	24.36	16.3857	
	Total	**100**	**37.67**	**35.4675**	

DISCUSSION

The output in Table 3.9 indicates that any value that fall outside the standard value is not accepted. In all the parameters the mean value fall within the acceptable range with the exception of turbidity and microbial analysis, which means value are outside the standard. The pH of water is a very important property because it determines the acidity and the alkalinity of water and decides whether the water is suitable for drinking purposes the pH of water sample collected was in the range of 6-5 to 8-5 which indicates that it can be used for drinking. Even though pH has no direct effect on human health, its indirect action on physiological process cannot be overemphasized (22-23). The Total dissolved Solids (TDS) is a term used to describe the inorganic salt and small amount of organic matter present in a solution or water. The principle constituents are usually calcium, magnesium, sodium and potassium Cation, carbonate, hydrogen carbonates, chloride, sulphate and nitrate anions (24).

The presence of total dissolved solids in water affects the test. It has been reported that drinking water with extremely low concentration of TDS may be unacceptable because of its flat insipid taste (24-25). The TDS of the water sample from the study area is within the standard of 1, 000mg/L recommended by (26-27). The turbidity of Most water samples used in this study have exceeded the WHO and NSDWQ standards of 5NTU (26-27), water turbidity is very important because high turbidity is often associated with higher levels of disease causing organisms such as bacteria and other parasites (28). The Total alkalinity of all water samples are in agreement with both WHO and NSDWQ standard of 300mg/L. (26-27). Alkalinity is a measure of the basic constituents of water. Generally alkalinity has no sanitary significance but it is important in connection with coagulation, softening and corrosion control.

It is therefore essential that this parameter be monitored in both raw and treated water to ensure optimum dosage of treatment chemicals (26-27). The colour of water samples analyzed were within the recommended or maximum permitted level of 15NTU based on (26) and (27), recommendation. Chloride, in natural waters such as well water results from the leaching of chloride containing rocks and soil with which the water comes in contact. (29). Chlorides are the most stable components in water and its concentration is largely unaffected by most natural, physio-chemical and biochemical process. Hence the value of its concentration in water is a useful measure in water sample. The chloride level in water samples falls within the standard value of 250mg/L (26-27). The magnesium level in the water sample is within the maximum permitted level of 150mg/L based on (26) and (27) recommendation. Fluoride is known to prevent early stage tooth decay, high levels of its concentration in drinking water and food has been found to have serious health effect in humans and animals causing mottled teeth that occur in children (29). Although the concentration of fluoride found in the stored drinking water are within the standard of 1.5mg/L (26-27), high concentration of fluoride usually occurs because of the presence of both organic and inorganic fluoride in water such as hydrofluoric acid (HF), sodium fluoride (NAF) and Uranium hexafluoride (UF6) (29). Manganese level in the water samples collected was within the standard of WHO and NSDWQ which is 0.1mg/L (26-27). The conductivity was also within the normal range or standard value of 1000us/cm, even though there is no disease or disorder associated with conductivity of drinking water (27). Nitrates are compounds of nitrogen oxidation which shows the effect of organic pollution on water quality. Nitrates level in the water samples fell within the standard of 45mg/L. This is in agreement with NSDWQ and WHO standards. Sulphate occurs naturally in water as a result of leaching from gypsum and common minerals (30). From the analysis sulphate concentration in all the water samples was within the standard of 400mg/L based on (26, 27 & 31) standards. Fe^{2+} (Iron) concentration of all the water samples met the WHO and NSDWQ guidelines of 0.3mg/L for drinking water quality.

Though the level of Fe^{2+} in the water samples is within permitted limit, High Concentration of Iron in water can lead to the formation of blue baby syndrome and goiter in adults (32). Ca^{2+} calcium is an important dietary mineral for cell physiology and bone formation (33). Analysis of Ca^{2+} in water samples revealed that it is within the normal range of 200mg/L. Hardness of water is due to the concentration of alkaline earth metals. Calcium and magnesium ions are the principle cations impacting hardness (34). The total hardness of all water samples analyzed were within the (26) and (27) standard. Potassium and Sodium are essential elements and are presents in all animals and plant tissues. The primary sources of potassium and sodium is the diet. Although concentration of potassium normally found in drinking water are generally low and do not pose health concerns, the high solubility of potassium chloride and its use in treatment devices such as water softeners can lead to toxicity (35). Excessive loss of salts especially potassium salts through sweating can result to loss of these essential elements and if the loss is sufficient this can result to a range of effects including cardiac arrhythmia, muscle weakness, nausea and vomiting and low muscle tone in the gut; longer term hypokalaemia is believed to cause a predisposition of hypertension (35).

From the result of this study both potassium and sodium level where within the maximum permitted levels of 200mg/L and 20mg/L respectively based on (26) and (27) standards). Potassium toxicity has been studied in relation to the use of high doses of salt substitutes. The symptoms described have been chest tightness, nausea and vomiting, diarrhea, hyperkalaemia, shortness of breath and heart failure (35, 36).
The most commonly used indicator micro organisms include heterotrophic plate counts, total coliform bacteria, fecal coliform bacteria, E. coli, fecal enterococa, (Perfringes as well as somatic and male specific. ERNA bacteriophage (37). Total coliform bacteria are defined as aerobic or facultative anaerobic, gram negative, non- spore forming, rod shaped bacteria, which ferment lactose and produce gas at 35^0C (38).
Total coliforms include bacteria of known fecal origin such as *E. coli* as well as bacteria that may not be of fecal origin such as *Klebsiella* spp, *Citrobacter* spp, *Serratic* spp and *Enterobacter* spp which are found in nutrient rich water, soil decaying vegetation and drinking water with relatively high level of nutrients (39, 40). The microbial analysis of this study shows that most water samples have high microbial load which exceeds the maximum permitted level of 10cfu/100ml.

This finding is not surprising considering the high population and the close proximity of some water sources like bore holes and hand dug wells to pit latrines and sewage drainage. The sewage could seep slowly into underground water thereby polluting it. Also long term usage of borehole may lead to deterioration of water quality because the pipeline may become corroded with random cracks and in most cases clogged with sediments (41). The implication of this finding is that, there are pathogen in water samples that may cause acute intestinal illness which are generally considered discomfort to health and could become fatal for some susceptible groups such as infants elderly, and those who are sick (27, 42, & 43).

CONCLUSION & RECOMMENDATION

CONCLUSION

According to the World Health Organization (WHO), 1.1 billion people lack access to enhanced water supply in 2002, and 2.3 billion people got ill from diseases caused by unhygienic water (44). The study community, has experienced a high pace of population growth which far outstrips the ability of the relevant authorities like Jos Plateau State Ministry of Water Resources and Rural Development, Plateau State Water Board etc. to provide Safe and Portable drinking water.

The main findings of the study are stated below:

All the parameters mean values fall within the acceptable range with the exception of turbidity and microbial analysis, which means that values are outside the standards. Majority of samples contained suspended particles as shown by the high values of turbidity also, the bacteriological quality was unacceptable since the mean value falls outside the standard.

This imply that most of the water samples contain high concentration of total coliform as seen in the bacteriological analysis, the physiochemical analyses of water also showed that the water sample in the study area was very turbid and water turbidity is often associated with higher level of disease causing microorganisms such as bacteria and other parasites (28).

SUGGESTED INTERVENTION

Water treatment, both in the household and at the source of the supply are options for improving water quality, interventions to treat and maintain the quality of water at the point of use (Pou) are considered to be among the most effective water quality interventions (45). However, (Pou) water treatment offers only the health benefit and so its choice as an intervention depends purely on the epidemiological evidence.

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