COMPARATIVE ANALYSIS OF TAP, BOREHOLE, WELL AND PACKAGE WATER IN GOMBE METROPOLIS

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Abstract

Water is very essential substances for human existence. It is widely used for industrial and domestic usage. However, increase in wastewater discharge mainly from industrial activities has recently increases the level of water pollution. A report from world health organization (WHO) estimated that several individual die annually due to the comsumption of polluted water. Therefore comparative analysis of some selected water sample was carried in the present study with aim of providing quality condition of water fit for human consumption. Tap, borehole, packet and well water were collected from different location in Gombe metropolis and their physical chemistry and viable cell count were quantified according to the standard method of WHO. The result of the study shows that, physicochemical parameters of the selected water sample agree with the acceptable standard of WHO. The microbial total viable count was found to exceed the standard limit of 1×10^2 cfu/mL for water. The study, a comparative analysis of water sample from different sources can be an effective step to be adopted by water management bodies in order to provide healthy drinking water especially to areas of limited sanitary inspection in Gombe metropolis.

Keywords: Water quality, Gombe metropolis, physicochemical parameters

Introduction

Water is one of the most abundant and an essential resource of man and it occupies about 70% of earth's surface. About 97% of this volume of earth's surface water is contained in the oceans, 21% in polar ice and glaciers, 0.3-0.8% underground, 0.009% in inland freshwaters such as lakes, while 0.00009% is contained in rivers (Eja, 2002). More than 97% of earth's water is in the oceans and ice caps, and glaciers account for another 2% (Eakins and Sharman, 2010). Also, the ocean comprises 97%, while 3% of the earth's water is fresh (Kulshreshtha, 1998). Water in its pure state is acclaimed key to health and the general contention is that water is more basic than all other essential things to life. Man requires a regular and accessible supply of water which forms a major component of the protoplasm and provides an essential requirement for vital physiological and biochemical processes. Man can go without food for twenty eight days, but only three days without water, and two third of a person's water consumption per day is through food while one third is obtained through drinking (Ukpong and Okon, 2013).

Water is very essential substance for human existence. The provision of water in the past was solely a governmental affair however the inability of the government to meet the daily demands of water for people has forced some private individuals and communities to seek alternative and self-help measures of providing water. Private individuals drill their own open and closed well (boreholes). In some localities, they dig wells due to its affordability, these hand wells are constructed to serves as source of water supply. Water meant for good preparation and drinking must be free from contamination (organisms) capable of causing diseases and from mineral and organic substances producing adverse physiological effects. It is regarded as a very vital necessity of life and is a part of every living cell. Water is vital for living processes. Animals, plants and other living thing need available water for survival. Water is such a wide spread material that its presence is accepted without question and it is important is really appreciated when there is a shortage.

Apart from the essential role played by water in supporting human life, it also has, if polluted, a great potential for transmitting a wide variety of diseases. In most developing countries like Nigeria where industrial and domestic wastes are free disposed of in to bare environment such as rivers and streams with total disregard for aquatic lives and rural dwellers, by so doing it will serve as the medium for transmission of enteric diseases in most communities. Recalcitrant chemicals are known to percolate the layers of the earth and get accumulate and integrated in to ground waters affect human life.

The bacterial qualities of ground water, pipe borne water and other natural water supplies in Nigeria have been reported to be unsatisfactory with coliform counts far exceeding the level recommended by W.H.O (Edema *et al*., 2012). Chemically, water contains metallic chlorides, bicarbonates of calcium and magnesium, iron sulfate and clay particles carbonic acid and dissolved gases in varying levels and degrees. At high concentrations the constituents of water become pollutants either thereby making the water unfit for domestic and drinking usage. They often cause odour, depletion of oxygen content of water and aesthetic pollution (Kamyab *et al*., 2014). Increase in anthropogenic activities also contributes to the pollution and degradation of water quality; therefore there is need for periodic assessment of the water body.

Due to rapid industrialization and subsequent contamination of surface and ground water source, water conservation and quality management has nowadays assumed a very complex shape (Cosgrove, W.J. and Rijsberman, 2014). Attention on water contamination and it management has become a need of an hour because of it far reaching impact on human health. It was reported that "on a global scale 25,000 people die each day as a result of contaminated water quality and water related diseases such as cholera, and diarrhea. Typhoid fever represents the largest cause of human morbidity and mortality (Buckle *et al*, 2012). In addition, WHO reported that "contaminated water" causes an estimated of about 6 to 60 billion cases of gastrointestinal illness annually, majority of which occurs in rural areas of developing nations where water pollution is more prone due to limited sanitary inspection. However with the ability to analyses and assess the four selected water body, this problems could be avoided. Comparative analysis of water will give direct information on whether a particular water type is good for light and domestic usage.

Methodology

The study area is Gombe metropolis which is the capital of Gombe state (The Jewel in the Savannah) which is located in the northeastern part of Nigeria, created in October 1996 from Bauchi State by the General Sani Abacha Military government. It is one of the 36 states of the federal republic of Nigeria. It is located between latitude 10^0 and 11^0 within the Sahel savannah belt. It has a population of about 2.1 million people and an area of 18,000 square km. The temperature averages 30^0c with an annual rainfall of 1200mm. The predominant occupations of its people are agriculture and livestock rearing.

Figure 1: Showing the map of the study area

Collection of Water Sample

Water samples were collected using clean containers, labelled and transported immediately to the laboratory in a container of ice for physicochemical analysis. For bacteriological analysis, 5 drops of aqueous sodium thiosulphate solution were added to the sample bottles and sterilized in a hot box oven at 121ºC for one hour. Solutions were later added to neutralize any available chlorine in the samples. For tap water, it was opened fully and was allowed to rush for two minutes before collection. The samples were labeled and transported to the laboratory in a cooler (container) of ice.

Table 1 Random sample selection, location and their identification code

Sample location	Source of Supply	Sample identification code
G.R.A	Tap water	T_1
Pantami	Tap water	T_2
Gaskiya	Package water	P_1
Nasab	Package water	P_2
Jekadafari	Well water	W_1
Bolari	Well water	W_2
Nasarawo	Borehole	B_1
Pantami	Borehole	B_2

Methods of Data Collection and Presentation

Samples of Taps, Wells, Packages and boreholes water were collected at different locations in Gombe metropolis. Water representing different turbidities were collected in two different water plastic containers and were taken to the laboratory and analyzed within 6 hours (maximum transit time- 2 hours, maximum processing time 4 hours). Sample T_1 and T_2 represent water samples from tap water supply. Sample B_1 and B_2 are water samples from a borehole water supply. Sample P_1 and P_2 are water samples from a NAFDAC approved package water supply. Sample W_1 and W_2 are water samples from a well water supply.

Physicochemical Analysis of Samples

Water samples were analyzed for physicochemical and bacteriological quality using standard analytical techniques of APHA (APHA, 2005). pH of water sample was measured using portable pH meter (HI96107). Total dissolved solid meter (DIST-1) was used to measure the Total dissolved solids and Turbidity meter of model (Wag-WT3020) was used to measure the turbidity. Temperature was measured at the point of collection using digital temperature meter. The chemical characteristics were determined by titrimetric method. Other Physicochemical parameters like electrical conductivity were determined using the appropriate instruments**.** Multiple fermentation tubes technology was used for detection of biological parameters (Total coliforms). The media used includes MacConkey broth (MB), Lactose broth (LB). All the media used were weighed out and prepare according to manufacturer's specification with respect to the given instructions and directions.

Methods of Data Analysis

Data collected were analyzed using one-way analysis of variance (ANOVA). ANOVA was used to measure the variance between qualities of water from the four different water samples.

Bacteriological Analysis of Samples

Dilution of Samples: 50 mL of water sample was transferred into 1 100mL sterile Scott bottle containing 50 mL of the media with an inverted Durham's tube. Similarly, 10 mL of the total samples was aseptically transferred into 5 Scott bottles each containing 10 mL of the media with an inverted Durham's tube using a sterile pipette. The prepared sample was then incubated at 37ºC for 24-48 hours. Samples observation was made for turbidity change and gas production.

Results and discussion

Physicochemical Analysis

The physicochemical parameters of the four water samples were analyzed based on the fallowing parameters pH, temperature, turbidity, electrical conductivity, total dissolved solids, alkalinity, hardness and chloride. World Health Organization WHO (2004) standard was used as the criteria for comparing the result of each water analysis collected from each location under investigation (WHO, 2004) (Table 2).

pH

The results of the potential hydrogen ions concentration in the samples show that, Borehole (B1) had a pH of 7.1 while borehole (B2) was 7.5 and that of the Tap (T1) is 8.2 while T2 had 8.3. The pH values for the packaged water P1and P2 were 7.7 and 7.4 respectively and for the Wells W1 and W2 are 6.6 and 7.6 respectively (Table 2). This indicated that all the four water samples has met the standard criteria recommended by (WHO, 2004) of 6.5-8.5.

Temperature

The temperature values of 26.2 and 28.8 were recorded for B1 and B2 respectively. T1 and T2 have 26.6 and 28.8 while PI and P2 have 27.8 and 27.5 respectively. Both W1 and W2 have the same value of 27.5. This shows that all the samples has met the WHO recommended standard of 27-29 except for B1 and T1 with the recorded values of 26.2 and 26.6 respectively (WHO, 2004) (Table 2).

Total dissolved solid (TDS)

The results of total dissolved solid are shown in table 2**.** The recorded values for boreholes B1 and B2 are 184 mg/L and 227 mg/L while T1 and T2 have 290 and 220 mg/L respectively. P1 and P2 have the same value of 430 mg/L while W1 and W2 have 381 and 901 mg/L respectively. This indicates that, TDS have fall within the range of WHO recommended standard of 500 mg/L except for W2 which has higher value of 901 [10].

Turbidity

Based on the result in Table 2, the turbidity values of 0.40 and 2.27 were recorded for water sample B1 and B2 respectively. T1 and T2 have 2.60 and 2.25 while PI and P2 have 1.09 and 0.46 respectively. W1 and W2 have the value of 3.09 and 4.08 respectively. This indicate that all the four water samples has met the WHO recommended standard value of 5.0 [10].

Conductivity

The recorded turbidity values for boreholes B1 and B2 are 448 and 550n while T1 and T2 have 715 and 551 respectively. P1 and P2 have the value of 110 and 117 while W1 and W2 have 919 and 0 respectively. This shows that all the samples has met the WHO recommended standard value of 1000 except for W2 which has lower value of 0 (WHO, 2004) (Table 2).

Alkalinity

The results of alkalinity are shown in table 2.The recorded alkalinity values for boreholes B1 and B2 are 480 (16.02%) and 532 (17.76%).while T1 and T2 have 528 (17.62%) and 520 (17.36%) respectively. P1 and P2 have the value as 40 and 56 while W1 and W2 have 620 (20.69%) and 220 respectively. This shows that most of the samples are above the WHO recommended standard value of 98-276 except for P1, P2 and W2 (WHO, 2004).

Hardness

Table 2 also shows the result of hardness of the water samples. The hardness values of 25.2 and 23.8 were recorded for B1 and B2 respectively. T1 and T2 have 5.2 and 3.2 while PI and P2 have 2.2 and 6.2 respectively. W1 and W2 have the value of 319.2 and 258.8 respectively. Based on the WHO recommended standard, all the water samples are soft water that fall within the range of 0-60 except for well water samples W1 and W2 which are very hard with the value greater than 180 (WHO, 2004).

Chloride

The results of chloride are shown in table 2.The recorded values for boreholes B1 and B2 are 56 and 35.7 while T1 and T2 have 48 and 52 respectively. P1 and P2 have the same value of 240 while W1 and W2 have 1359.6 and 467.9 respectively. This shows that most of the samples are within the WHO recommended standard (2004) value of 250 except for W1and W2 with a greater value of 1359.6 and 467.9 which are equivalent to 65.77% and 22.63% respectively higher in comparison with the WHO standard (WHO, 2010).

The mean pH of borehole and tap water samples stood at 7.3 and 8.25 respectively while the values of 7.55 and 7.1 were recorded for package and well water samples. The mean temperature of the borehole water samples was 27.5ºC while that of the Tap was 27.7ºC and the value of 27.65ºC and 27.5ºC for package and well water samples respectively. Turbidity value of 1.34 NTU and 2.43 NTU were obtained for borehole and Tap water samples respectively while for package and well water samples the value of 0.78 NTU and 3.59 NTU were recorded respectively. Total dissolved solids value of 205.5 mg/L and 255 mg/L were recorded for the borehole and tap water sources while 43 mg/L and 644.5 mg/L was obtained for package and well water samples. The mean value of electrical conductivity for the borehole and tap sources was 499 and 633 respectively and that of the package and well was 113.5 and 459.5 respectively.

The hardness level for the borehole source was 24.5 mg/L while the same value of 4.2 mg/L was obtained for both tap and package water samples. A mean value of 289 mg/L was recorded for well water source. The mean concentration of chloride for borehole and tap water samples was 45.85 mg/L and 50 mg/L whereas 132 mg/L and 913.75 mg/L was recorded for the package and well water samples.

Parameters	Total hardness (mg/L)	Alkalinity (mg/L)	Electrical Conductivity	TDS (mg/L)	Turbidity (NTU)	Tem. (ºC)	pH	Chloride (mg/L)
B1	25.2	480	448	184	0.40	26.2	7.1	56
B2	23.8	532	550	227	2.27	28.8	7.5	35.7
T1	5.2	528	715	290	2.60	26.6	8.2	48
T2	3.2	520	551	220	2.25	28.8	8.3	52
P1	2.2	40	110	043	1.09	27.8	7.7	24
P2	6.2	56	117	043	0.46	27.5	7.4	24
W1	319.2	620	919	381	3.09	27.5	6.6	1359.6
W2	258.8	220	0	901	4.08	27.5	7.6	467.9
WHO Standard [10]	0-60(soft), 61-120 (moderate) 121-180	98-270	1000	500	5.0	27-29	6.5 - 8.5	250

Table 1 Comparison of physicochemical analysis of the four water samples with WHO (2004) standards for drinking water

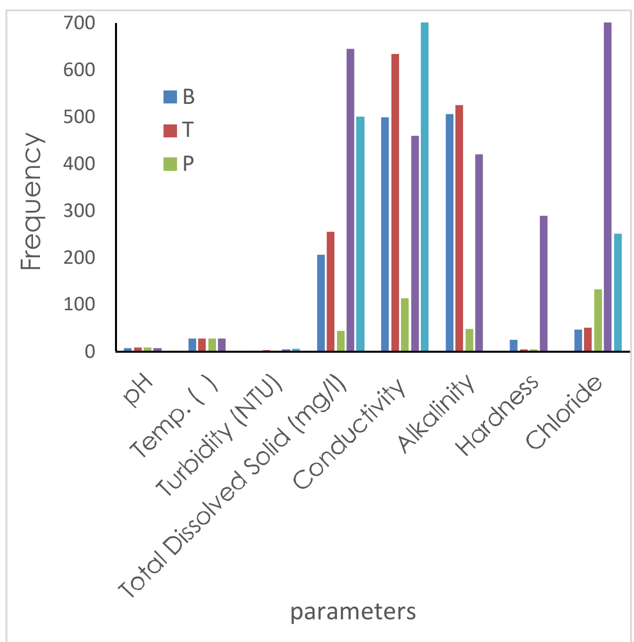

Figure 1 Comparison of physicochemical parameters between Borehole (**B**), Tap (**T**), Package (**P**), and Well (**W**) water with WHO standard for drinking water

For alkalinity, a mean value of 506 mg/L and 524 mg/L were recorded for borehole and tap sources while a value 48 mg/L and 420 mg/L were obtained for package and well sources respectively.

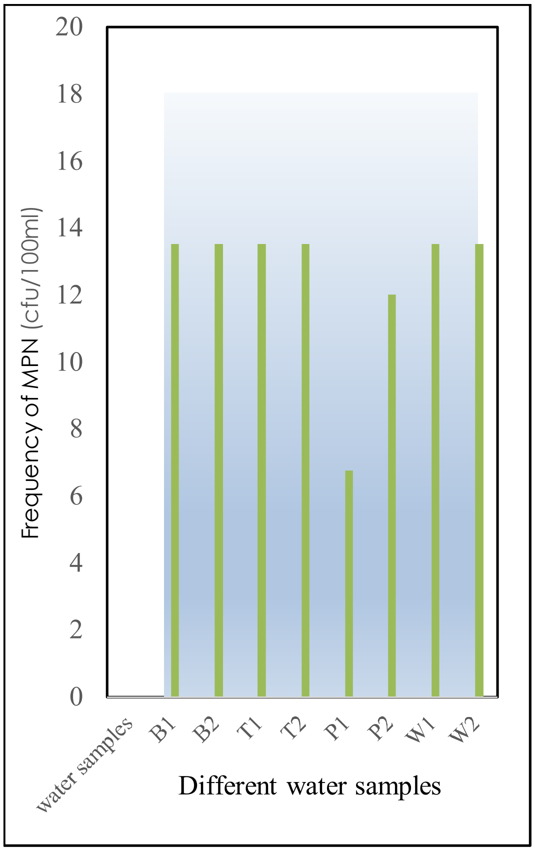

Figure 2 Percentage frequency of coliforms bacteria occurrence in water sample

Bacteriological Analysis Results

The result of bacteriological analysis of the four different water supply sources in the study area was summarized in Table 3. The Most Probable Number of total Coliforms which are the indicators of fecal pollution of water for all the water samples exceed the WHO recommended value of 0 cfu/100ml.

Table 3 Summary of the number of bottles showing positive reaction and the Most Probable Number

Sample location	1×50ml	5×10ml	Most Probable Number(cfu/100ml)
B1	1	5	>18
B2	1	5	>18
T1	1	5	>18
T2	1	5	>18
P1	1	3	9
P2	1	4	16
W1	1	5	>18
W2	1	5	>18

Bacteriological Analysis Results

The result of bacteriological analysis of the four different water supply sources in the study area was summarized in Table 3. The Most Probable Number of total Coliforms which are the indicators of fecal pollution of water for all the water samples exceed the WHO recommended value of 0 cfu/100ml. This practically shows that all the study samples have been contaminated with fecal pollution either from human or animals.

Variance between the Qualities of Water Samples in the Study Area

The analytical data obtained were analyzed using one-way analysis of variance (ANOVA) employing the Statistical Package for Social Sciences (SPSS). ANOVA result revealed that there significant variation in the quality of the water samples $(F_{2}, 8=2.876, P=0.025)$

The pH values of the water samples analyzed are within the acceptable range for drinking water. This was also observed by the research of (Omezuruike *et al*., 2008). The pH of most natural waters range from 6.5 - 8.5, neutral pH of 7 was deviated which is due to presence of CO2/bicarbonate/carbonate equilibrium (Thompson, T.P. and Wernicke, W. 1984). The fluctuations level of optimum pH ranges may lead to an increase or decrease in the toxicity level of water body (Varal *et al*., 2012). The temperature ranges of 26 – 28.8°C reported in the present study was found to be comparable with the temperature ranges reported by other authors in a similar study where temperature ranges of 26 and 30°C was concluded optimal (Alabaster, J.S. and Lloyd, 2013). This was attributed to the insulating effect of increased nutrient load resulting from industrial discharge. The turbidity results obtained were in the range of 0.40 to 4.08 NTU and were within the recommended ranges (Adekunle *et al*., 2007). The values of electrical conductivity obtained from the water samples at the range of 110-919 µs/cm. These values were below the recommended standard of 1000 µs/cm and were better health wise (WHO, 2004). The bacteriological quality of the water samples on the other hand was unsatisfactory for all the samples, with evidence of bacterial growth indicating the presence of total coliforms. The most probable number for all of the water samples was generally high, exceeding the recommended standard limit for water (WHO, 2004). The presence of coliforms in the water samples generally suggested the need for further treatment of the water before drinking (Ige, O.O. and Olaifa, 2013).

Conclusion

The physicochemical parameters of the selected water samples in the study area were within the acceptable limits by World Health Organization (WHO) standards for drinking water except for chloride value of well which was comparatively higher. Although some of the chemical parameters fell below the approved standards, they were judged to be acceptable since they were not above the required maximum permissible limits which could adversely affect human life. The result of the bacteriological analysis of the selected water samples does not conform to the acceptable limit since they yield heavy growth of bacteria, thereby making them unfit for human consumption and other domestic usage.

Recommendation

For Tap water, it is recommended that adequate residual chlorine should be added to the water after treatment so that it may kill the existing contaminant along the distribution channels. Manufacturers of package water are here by recommended to use adequate disinfecting chemicals. In the case of borehole and well water, private individuals should use a water disinfectant or boils the water thoroughly before consumption.

Acknowledgement

The author would like to thank the water board Gombe State for the provision of analytical lab. Furthermore the author thanks the effort of Dr. Danladi Umar of Department of Biological Sciences, Gombe State University.

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