Quality Assessment of Groundwater of Kajola, a Town near Owu Falls in Kwara State

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Abstract

This study was conducted in Kajola a town near Owu falls in Kwara State. It was aimed at assessing the quality of groundwater and its suitability for drinking and other domestic use. Groundwater from 2 boreholes and a reservoir (containing well-water) were sampled and analysed for the following physico-chemical water quality parameters using standardized procedures: (pH, dissolved oxygen, Electric conductivity, Turbidity, Total dissolved solids, Total solids, Chloride, Alkalinity, Magnesium, Sodium, Biochemical oxygen demand, Chemical oxygen demand, Total hardness, Nitrate, Total suspended solid, Sulphate) and Temperature which was measured in-situ. Results obtained from the laboratory shows that all parameters tested for except BOD and Temperature of all samples were within the permissible limit of World health organization for drinking water, Nigerian standard for drinking water quality and other agency's guideline available for comparison. The temperature of samples 1, 2 and the reservoir having a mean value of 28.7^{O}C was slightly higher than the desirable limit of 25^{O}C indicating thermal pollution which can be corrected by installing Thermostatic mixing valves to ensure safe temperature. Also, the BOD concentration can be reduced by application of hydrogen peroxide hence making the water in Kajola safe for drinking and other domestic purpose.

Keywords

Water Quality, Kajola, Borehole, Reservoir, Owu falls

1. Introduction and Concept

Water is one of the most indispensable resources hence life is not possible on this planet without water. There is a constant increase in the demand for water due to rapid growth of population as well as the accelerated pace of industrialization in the last few decades. This demand has led to the use of ground water not only for its wide spread occurrence and availability but also for its constituent good quality which makes it ideal supply of drinking water.

Water plays an indispensable role in life sustenance and it is a key pillar of health determinant, since 80% of diseases in developing countries are due to lack of good quality water. Drinking water quality management has been a key pillar of primary prevention for over one and half centuries and it continues to be a foundation for the prevention and control of waterborne diseases (WHO, 2011). Contaminated water is a global public health threat placing people at risk of a host of diarrhea and other illness as well as chemical intoxication. The major risk to human health is fecal contamination of water supplies (Mustafa et al, 2012).

Water quality expresses the suitability of water to sustain various uses or processes. Any certain use will have certain requirements for the physical, chemical or biological characteristics of water. Consequently, water quality can be defined by a range of variables which limit water use (Menim, 2016). The importance attached to quality will depend on the actual and planned use of water (i.e water to be used for drinking should not contain chemicals or microorganisms hazardous to the health). Since there is a wide range of natural water qualities, there is no universal standard against which a set of analyses can be compared. If the natural pre-polluted quality of water body is unknown, it may be possible to establish some reference values by surveys and monitoring of unpolluted water in which natural conditions are similar to those of the water (UNEP/WHO. 1996).

The quality of water may be described in terms of concentration and state of some or all of the organic and inorganic material present in the water, together with certain physical characteristics of water. It is determined by in-situ measurements and by examination of water samples on site or in the laboratory. The main elements of water quality monitoring are therefore, onsite measurements, the collection and analysis of water samples, the study and evaluation of the analytic results, and the reporting of findings. The results of the analysis performed on a single water sample are only valid for the particular location and time at which that sample was taken (UNEP/WHO 1996).

The ability to achieve a guideline value within a drinking-water supply depends on a number of factors, including:

(i) the concentration of the chemical in the raw water;
(ii) control measures employed throughout the drinking-water system;
(iii) nature of the raw water (groundwater or surface water, presence of natural organic matter and inorganic solutes and other components, such as turbidity); and
(iv) treatment processes already installed.

2. Methodology

2.1 Location of Study

Kajola is a town near Owu falls in Isin local government area, Kwara state. Isin LGA lies on the latitude (N08^{o}15'-N08^{o}21') and longitude (E05^{o}00'-05^{o}05'), it covers an area of about 633km square. Owu falls is the highest and most spectacular natural water fall in West Africa, and is located in Ifelodun LGA of Kwara state, Nigeria. The waterfall stand as one of the symbol of nature which its existence is untraceable, but can be appreciated and promoted by exploring. The waterfall is 120m above water level and cascades 330m feet down an escarpment with rocky out crops to a pool of ice cold water below. The waterfall is surrounded with beautiful natural ambience and hills which makes sightseeing a memorable experience. The waterfall is characterized with fall of ice cold water, beautiful rocky part and evergreen surrounding.

2.2 Sample Collection

Samples were taken from two boreholes and a reservoir at different locations at Kajola. Each bottle was rinsed with distilled water a couple of times then water samples were collected into several 0.75 litre plastic bottles with stopper each clearly marked and labelled with the location it was taken from to prevent mix-up. The bottles were then preserved in a cooler containing cool water while being transported to the laboratory for analysis of physico-chemical parameters excluding temperature which had already been measured and recorded on site.

2.3 Physico-Chemical Analysis of Samples

The physicochemical parameters of the water samples were determined using standard methods. The sample's parameters determined include Temperature, Turbidity, Total solids, Total dissolved solids, pH, Nitrate, Sulphate, Hardness, Chloride, Dissolved Oxygen, Biochemical Oxygen demand, Chemical oxygen demand, Alkalinity, Electrical Conductivity, Sodium. The sampling analysis was done in compliance with World Health Organisation Standards in water quality.

3. Results and Discussion

3.1 Temperature

Temperature is the degree of hotness or coldness of a body or an environment. The temperature of the samples was measured on site with values 29^{o}C for borehole 1 and 2 and 28^{o}C for the reservoir sample having a mean value of 28.7^{o}C indicating temperature pollution since it is above the ambient level stated by Nigeria standard for drinking water quality and WHO standard. Temperature will have an impact on acceptability on a number of other constituents and physical contaminants that may affect taste. High water temperature (20-30^{o}C) enhances the growth of microorganisms and increase problems related to taste, odour, colour and corrosion (WHO, 2017). Based on the values obtained from the sample's temperature of the water in Kajola isn't at the desirable level and this will enhance microorganism growth occurring in the water thereby causing contamination which could endanger the consumers. To correct this, thermostatic mixing valves should be installed to ensure safer water temperature.

3.2 pH

pH is a measure of the intensity of acidity or alkalinity. In this study, the pH values of the samples tested are 6.67, 6.68 and 6.65 for borehole 1, borehole 2 and the reservoir respectively with a mean value of 6.67. The WHO standard and NSDWQ states the allowable range for drinking water is between 6.5-8.5. Based on the pH the water samples are within the permissible limit for drinking water. Although pH has no direct impact on consumers, pH values beyond the range of 6.5-8.5 gives an indication that there are dissolved chemicals present and it is recommended to use an alternate water source in this scenario if possible (WHO, 2007).

Table 1- Summary of the Physio-Chemical Properties of the Groundwater Samples

Parameters	Borehole 1 Sample	Borehole 2 Sample	Reservoir Sample	Mean Value
Temperature (^{O}c)	29	29	28	28.70
Turbidity (Ntu)	3.2	3.1	3	3.1
Total Dissolved Solids (Mg/L)	10.7	10.82	10.92	10.81
Total Suspended Solids (Mg/L)	5.6	5.3	5.1	5.33
Total Solids (Mg/L)	16.3	16.12	16.02	16.15
Electric Conductivity (Us/Cm)	80.40	80.10	80.30	80.27
Ph Value	6.67	6.68	6.65	6.67
Dissolved Oxygen (Mg/L)	40.2	40.50	52.60	44.43
Chloride (Mg/L)	0.64	0.44	0.52	0.53
Calcium (Mg/L)	0.7	0.92	0.98	0.87
Magnesium (Mg/L)	0.55	0.73	0.77	0.68
Hardness (Mg/L)	1.25	1.65	1.75	1.55
Sodium (Mg/L)	0.56	0.50	0.51	0.52
Alkalinity	1.41	1.42	1.4	1.41
Nitrate (Mg/L)	1.28	1.24	1.22	1.25
Sulphate (Mg/L)	20.63	20.55	18.50	19.89
Biochemical Oxygen Demand (Mg/L)	24.50	24.70	30.40	26.53
Chemical Oxygen Demand (Mg/L)	3.04	3.02	3.03	3.03

3.3 Dissolved oxygen (DO)

Dissolved oxygen concentration depends on the physical, chemical and biochemical activities in the water body, and its measurement provides a good indication of water quality (a water body of high dissolved oxygen content contains lesser organic impurities). For this study, the results from the samples are 40.2mg/l, 40.5mg/l and 52.6 mg/l for borehole 1, borehole 2 and reservoir respectively with a mean value of 44.4mg/l (as shown in Figure 1). The recommended guideline value for drinking water is a value not less than 8mg/l (WHO, 1984) and according to World Health Organization (2017) no health-based guideline value is recommended however very high levels of dissolved oxygen may exacerbate corrosion of metal pipes. Dissolved oxygen can be linked to temperature as oxygen dissolves easily in cool water. Lower values indicate microbial contamination. Hence the samples tested contain sufficient dissolved oxygen to indicate no microbial contamination making it eligible for drinking.

3.4 Biochemical oxygen demand (BOD)

Biochemical oxygen demand denotes the amount of oxygen needed by micro-organisms for stabilization of decomposable organic matter under aerobic conditions. High B.O.D. means that there is less of oxygen to support life and indicates organic pollution, no guideline value given by WHO standard as B.O.D is an indication for oxygen requirement in the water body as high B.O.D implies declination dissolved oxygen content. However, WASREB (2008) states a 30mg/l as maximum limit in drinking water. For this study, the values obtained range from 24.50-30.40 mg/l with a mean value of 26.53 mg/l (as shown in Figure 1). Based on the values obtained from the sample analysis, BOD concentration is slightly high in the samples with a mean value of 26.53 mg/l and the reservoir having the same concentration as WASREB limit. When biodegradable organic matter is present in water it provides nutrient (Nitrogen and Ammonia) for the growth of bacterial and microorganism causing them to multiply (EPA, 2001). During periods of heavy rain, organic matter is washed in from farmlands giving rise to BOD concentration. Kajola is a rural area with agriculture as one of the main sources of livelihood, B.O.D contamination becomes a problem as the organic waste used in fertilizing the farmland contributes to contamination of the water distribution system.

3.5 Chemical oxygen demand (COD)

The values obtained for this study range from 3.02-3.04 mg/l with a mean value of 3.03mg/l (as shown in Figure 1) which implies very low chemical activities occur in the water tested.

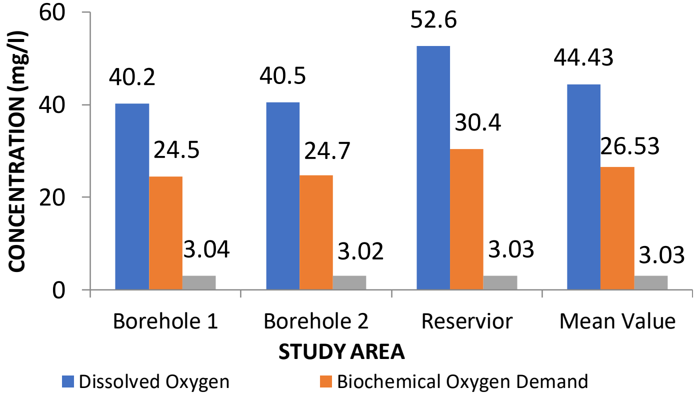

Figure 1 Oxygen demand distribution

3.6 Electrical conductivity

Conductivity is a quantitative measure of the ability of water to pass electric current. High conductivity can be an indicator of excessive mineralization from either natural or industrial sources. In this study, the values gotten are 80.4us/cm, 80.1us/cm and 80.3us/cm for borehole1, borehole 2 and the reservoir respectively with a mean value of 80.27us/cm. testing for electric conductivity doesn't give specific information about the chemicals present in water but it gives estimation of total dissolved solids. WHO gave no guideline value for drinking water but Nigerian standard for drinking water quality states 1000us/cm as the maximum allowable limit in drinking water. Based on the results, the water in Kajola is well under the limit and has no effect in consumers.

3.7 Turbidity

This measures the clarity in other words transparency in water. Turbidity in drinking water is caused by particulate matter that may be present from source water as a consequence of inadequate filtration. The results gotten from tested samples are 3.2NTU, 3.1NTU and 3.0NTU for borehole1, borehole2 and the reservoir respectively with a mean value of 3.1 NTU which is below the permissible limit stated by NSDWQ and WHO standard. Turbidity in excess of 5 NTU may be noticeable and consequently objectionable to consumers WHO (2007). Based on the results gotten, samples tested for will have no adverse effects in relation to turbidity. For samples with high turbidity, sedimentation and (or) filtration process can be put in place to reduce the level because drinking water with high turbidity value increases the consumer chance of getting sick.

3.8 Total solid (TS)

For this study, the values obtained range from 16.02-16.30 mg/l with a mean value of 16.15mg/l (as shown in Figure 2) and these falls within the permissible limit of 1500mg/l as proposed by WHO guideline for drinking water. Based on the values obtained from the samples' analysis, the water in Kajola contains little total solid concentration which isn't harmful to the health.

3.9 Total dissolved solid (TDS)

The total dissolved solids consists of inorganic salts such as calcium, magnesium, potassium, sodium, bicarbonates, chlorides and sulphates and small amounts of organic matter that are dissolved in water. In this study, results gotten from the test carried out on borehole1 is 10.7mg/l, 10.82mg/l for borehole2 and 10.92 mg/l for the reservoir with a mean value of 10.8mg/l (as shown in Figure 2). WHO (1984) gave the palatability for drinking water according to the TDS level with ratings given by Bruvold as less than 500mg/l as excellent level while values greater than 1700mg/l as unacceptable level. Hence, based on the values gotten from the tested samples, concentration of total dissolved solids will have no adverse effect of the consumers since they are within the excellent level.

3.10 Total Suspended Solid (TSS)

This are the portion of the total solid retained on a specific size filter (Whatman glass filter of size 1.58 microns) after drying at 105oC. For this study, the range of values recorded is 5.10 to 5.60 mg/l (as shown in Figure 2) which falls below the permissible limit of 1500mg/l as proposed by WHO guideline for drinking water. Based on the results obtained, the water sample contains very little amount of suspended solid hence it is not of health implication.

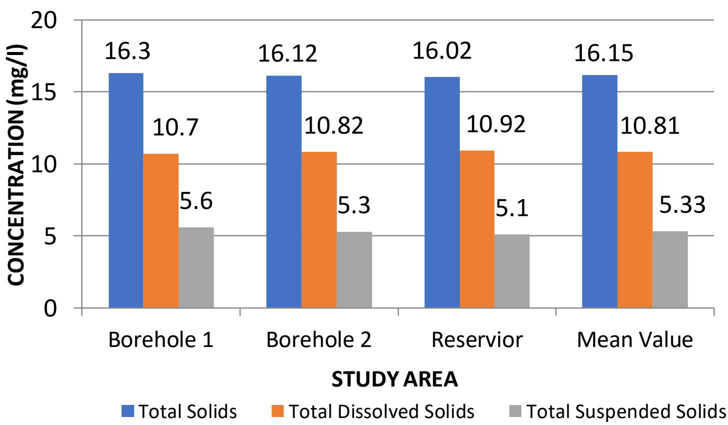

Figure 2: Distribution of Solids in the samples

3.11 Chloride

The values for this study are 0.64mg/l for borehole1, 0.44mg/l for borehole2 and 0.52mg/l for the reservoir with a mean value of 0.53mg/l. Chloride has no guideline value by WHO standard, it is not of health concern at levels found in drinking water (WHO, 2017). It can only affect acceptability of drinking water in term of taste once the concentration is in excess of about 250mg/l which is the maximum allowable limit for drinking water by Nigeria standard for drinking water quality. Excessive chloride concentrations increase rates of corrosion of metals in the distribution system, depending on the alkalinity of the water. This can lead to increased concentrations of metals in the supply. Based on the results gotten from the water sample, there is no likelihood of any adverse effect.

3.12 Alkalinity

For this study, the values gotten from analysis of the samples are 1.41mg/l, 1.42 mg/l and 1.4mg/l for borehole1, borehole2 and reservoir respectively with the mean value of 1.41mg/l. To control corrosion and leaching in water pipes, alkalinity should be between or lesser than 25-75mg/l. There is no proposed permissible limit. Very low and very high values of alkalinity can cause nuisance problems. Alkalinity values less than 75 mg/l can change pH levels in water and make the water corrosive. Corrosive water can then lead to potentially harmful metals dissolving from the plumbing into the drinking water. Based on the results obtained from sample analysis, alkalinity of the water at Kajola is safe from adverse effects of excess alkaline concentration.

3.13 Total hardness

The major portion of total hardness is caused by calcium and magnesium ions. Hardness plays a role in heart diseases in human. The maximum permissible level of hardness in drinking water is 150mg/l based on the acceptability of water for drinking (NSWDQ, 2007). Hardness above approximately 200 mg/l may cause scales in water pipes and distribution systems. Soft water, with a hardness of less than 100 mg/liter may have a low buffering capacity and so be more corrosive for water pipes. For this study, the total hardness values of water samples were in the range of 1.25-1.75 mg/l (as shown in Figure 3) which is way less than the proposed values above hence no adverse effect is expected. Water hardness is classified by the U.S department of interior and the water quality association as shown in Table 2.

Based on the result obtained, samples in this study fall within the soft water classification hence containing low concentration of calcium ion, forms lather with detergents easily and is of no major health concern except for sodium contamination which can be removed by reverse osmosis and distillation method.

Table 2: Classification of groundwater (mg/l)

Soft	Slightly Hard	Moderate Hard	Hard	Very Hard
0 – 17.1	17.1 – 60	60 – 120	120 – 180	>180

3.14 Calcium

Calcium is one of the most abundant elements on the natural surface and in groundwater, and they exist mainly as bicarbonates and to a lesser degree in the form of sulphate and chloride. High calcium content is undesirable for domestic uses as it causes encrustation, scaling and contributes to hardness in water. For this study, the range of calcium is 0.7–0.98mg/l with a mean value of 0.87mg/l (as shown in Figure 3). Guideline value not necessary, as there is no evidence of adverse health effects from calcium in drinking water (WHO, 2017) but Health Canada (2006) states a 200mg/l maximum permissible limit for calcium concentration for drinking water. Based on the results obtained, calcium concentration in Kajola water supply will have no adverse effect on consumer's health.

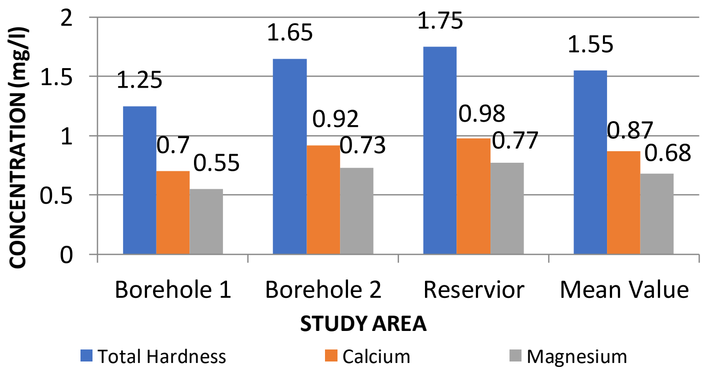

Figure 3: Hardness distribution in the samples

3.15 Magnesium

For this study, values obtained for magnesium concentration in the samples are 0.55mg/l for borehole1, 0.73 for borehole2 and 0.77mg/l for the reservoir with a mean value of 0.68mg/l (as shown in Figure 3).

It contributes to hardness in water. WHO states no guideline value for magnesium because since it is not of health concern in concentration found in drinking water but a 50mg/l permissible limit was stated by Health Canada (2006). Based on the results obtained from the samples, magnesium concentration is way below the permissible limit hence it is of no health concern as stated by WHO standard.

3.16 Nitrate

The nitrate concentration in groundwater is normally low but can reach high levels as a result of leaching or runoff from agricultural land or contamination from human or animal waste as a consequence of the oxidation of ammonia and similar sources. For this study, the results obtained from the samples are 1.28mg/l for borehole1, 1.24mg/l for borehole2 and 1.22mg/l for the reservoir with a mean value of 1.25mg/l (as shown in Figure 4). WHO states a 50mg/l permissible limit so does NSDWQ to be protective against methamoglobinaem and thyroid effects in the sensitive subpopulation and also bottle fed infants (WHO, 2011). For the analysis carried out samples are well under the proposed limits, hence the water is safe from nitrate contamination or effects. For treatment purpose almost 80% of nitrate concentration in the body can be removed by reverse osmosis, biological denitrification and electro dialysis.

3.17 Sulphate

For this study, results obtained for sulphate concentration in the samples are 20.63mg/l for borehole1, 20.55mg/l for borehole2 and 18.50mg/l for the reservoir with a mean value of 19.89mg/l (as shown in Figure 4). Presence of sulphate in drinking water can cause noticeable taste and very high levels have laxative effects in an unaccustomed consumer (WHO, 2017). Sulphates occur naturally in numerous minerals and are discharged into water in industrial wastes and through atmospheric depositions; however high levels usually occur in groundwater and are from natural sources. WHO states no guideline for sulphate since it is not of health concern in concentration found in drinking water but Nigerian standard for drinking water quality states a 100mg/l maximum allowable limits. The results obtained from analysis of the samples show no health concern since its way below the permissible limit stated by NSDWQ (2007).

3.18 Sodium

Sodium occurs naturally in groundwater. In water, it has no smell but can be tasted by most people at a concentration of 200mg/l or more which is the maximum permissible dose (WHO, 2007). Sodium is a principal chemical in bodily fluid and is not considered harmful at normal level of intake. However, increased intake of sodium in drinking water may be problematic for people with hypertension, heart diseases or kidney problem, that require them to follow a low sodium diet (WHO, 2017). For this study, values obtained range from 0.50mg/l for borehole2, 0.56mg/l for borehole1 and 0.51mg/l for the reservoir sample with a mean value of 0.52mg/l (as shown in Figure 4) which falls way below the permissible limit. Based on the values obtained, sodium ion concentration in the samples will have no adverse effect.

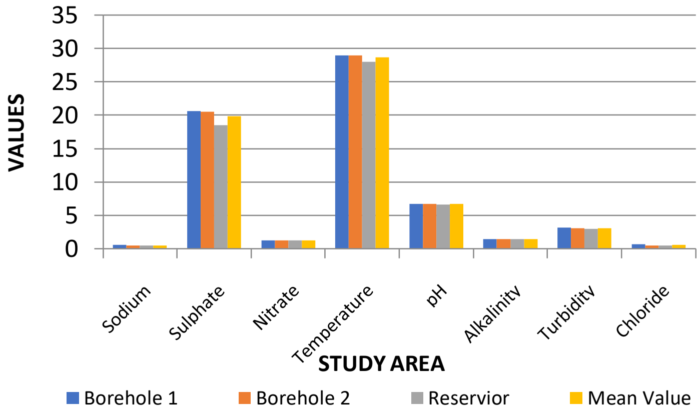

Figure 4: Distribution of other parameters in water samples

4. Conclusion

The following data was obtained from tests conducted; pH ranged from 6.65 to 6.68 falling within the permissible limit of 6.5-8.5. Turbidity, Total solid, Total dissolved solid and Total suspended solids ranged from 3.0 to 3.20 NTU, 16.02 to 16.30 mg/l, 10.70 to 10.92 mg/l and 5.1 to 5.6 mg/l respectively all falling below the permissible limit and having no adverse effect. Value obtained for Total hardness ranged from 1.25 to 1.75mg/l which also falls below the permissible limit of 150mg/l. The values obtained for dissolved oxygen range from 40.2 to 52.6mg/l which is greater than the 8mg/l limit stated by world health organization for microbial contamination, hence the sample contains enough oxygen to prevent contamination. COD and BOD are in the range of 3.02 to 3.04mg/l and 24.5 to 30.4mg/l respectively, no guideline value is stated by WHO standard but the BOD value for the samples are slightly high with the reservoir sample having the same value as the limit given by WASREB (2008), this clearly indicates pollution and can be corrected using Hydrogen Peroxide. Chloride, Nitrate and Sulphate are in the range of 0.44 to 0.64mg/l, 1.22 to 1.28mg/l and 13.5 to 20.63mg/l respectively, values obtained are way below the stated guideline value hence they is no health risk in relation to them. Electrical conductivity ranged from 80.10-80.40 µS/cm which is way below the guideline value stated by Nigeria standard for drinking water quality of 1000µS/cm hence it has no health implication. Total Alkalinity ranged from 1.40 to 1.42 mg/l which is below the 500mg/l limit stated by WHO, based on the results obtained the samples are alkaline contamination free. The temperatures of the samples were recorded as 29^{o}C, 29^{o}C and 28^{o}C which is above the objectionable limit of 25^{o}C which can be corrected by installing Thermostatic mixing valves to ensure safer temperature.

The values of the substances tested for all fall below the permissible limits and is in conformity with the WHO standard, Nigerian standard for drinking water except those of temperature and BOD. Appropriate regulatory agencies should carry out quality assessment of existing groundwater sources to ascertain the quality level of the water before allowing for public usage.

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