DRY SEASON WATER QUALITY ASSESSMENT AND ITS HEALTH IMPLICATIONS IN ANKPA TOWN, KOGI STATE, NIGERIA

Sunny Ishaya
Department of Geography and Environmental Management
University of Abuja, Gwagwalada Abuja
E-mail: ishayasunny@yahoo.com

Abstract
This study assessed dry season water quality and its health implications in Ankpa Town, Kogi State, Nigeria. The objectives of this study include collecting water samples from river, borehole and water tankers, and examined the physio-chemical properties of the water samples and comparing results with the Federal Ministry of Environment and World Health Organization Water Quality Standard. The second objective was to identify the likely health-related implications associating with the quality of sampled water. Water samples were collected from River, Tanker and Borehole in Ankpa Town, Kogi State and analyzed at Department of Soil and Environmental Management Laboratory Kogi State University. Findings show that all physio-chemical parameters of well water fell within acceptable limit of both FME and WHO except for Iron, Zinc, Alkalinity, Calcium and Phosphate. All the physio-chemical parameters of tanker water sample fell within the acceptable limit of both FME and WHO except Iron, Zinc and Alkalinity. Generally, water from river, borehole and tanker water are not fit for consumption due to the exceeding levels of Iron, Zinc, Alkalinity, Calcium and Phosphate. There is need for provision of hygienic potable water supply in Ankpa town by the Kogi State Government to help reduce indiscriminate water acquisition and reduce the impact of poor quality of water on human health.

Keywords: Water quality, assessment, dry season, health implication, acceptable limit.

Introduction

Water is a universal resource which because of its free occurrence in nature, is often taken for granted and abused, especially in third world nations where information is neither readily accessible nor disseminated to society(Omole and Longe,2008). The challenges of water supply have constituted a factor inducing conflicts in some parts of the world (Nigeria inclusive) because the earth's freshwater is diminishing due to man's activities and climate change.Over the past two decades, more considerable attention has been paid to the broader livelihood benefits of water supply, looking beyond direct links between improved water supplies and public health (Ishaya *et al.,*2018).It was observed that in 2015, 29 percent of global population lacked safely manages drinking water supplies, and 61 percent were without safely managed sanitation services despite the fact that clean water and sanitation are among the most potent preventative medicines for reducing mortality mostly among under-five age children (Mundi *et al.,*

2019). Universal access to even the most basic water and sanitation facilities would reduce the financial burden on health systems in developing countries (UNICEF, 2006, United Nation, 2015).The water of good quality is of paramount importance to human physiological and man's continued existence depends much on it. Despite this many people still, lack access to safely managed water supplies and sanitation facilities.

Water supply like energy, capital and communications is an essential infrastructural prerequisite for sustainable development. Apart from its primary role in enhancing human health and wellbeing, it is equally essential for industrialization and commercial developments. Adequate water is necessary to support the population and economic life of urban areas.

Access to safe drinking water supply and sanitation services is fundamental to improving public health and meeting national poverty reduction objectives. In most Africa and Asia countries, the water stress level is above 70 percent, indicating the strong probability of future water scarcity (United Nation, 2015). The alarming rate of population increase, as well as urbanization in Nigeria, instigates an increase in the demand for water for various uses because water is a unique resource with no substitute, the quality and quantity vary over space and time (Aremu, 2013).

It is also widely recognized that lack of access to potable water contributes substantially to the high burden of disease that needlessly foreshortens and impairs the lives of far too many of the citizenry of the developing countries (Chima and Okpe, 2007). About 80% of all diseases may be attributed to water and sanitation-related cause and account for the many child deaths each year from diarrhoea diseases such as dysentery, jaundice, typhoid and cholera (Chima and Okpe, 2007; UN, 2015). Drinking physio-chemically polluted water may also affect cognitive development, lower neurobehavioral tests than children not exposed to arsenic (Tsai et al., 2003; Wasserman *et al.,* 2004). High levels of manganese in water can also have neurological effects (Wasserman *et al.,* 2006). Cognitive impairment can last a lifetime and contributes to a vicious cycle of malnutrition and poverty (Igata, 2012).

In Ankpa town of Kogi State, scarcity of water supply due to lack of pipe-borne water in most parts the town makes most inhabitants resort to boreholes, river and tanker water vendors as sources of water. Over the years, several pieces of research on physio-chemical water quality were carried out for example, Adewumi and Babatola (2009) assessed the status of water supply for domestic purposes in Akure, Ondo State; Ishaya and Abaje (2009) carried out an assessment of bore wells water quality in Gwagwalada town of FCT of Nigeria; Atobatele and Olutona (2013) observed the spatio-seasonal physio-chemistry of Aiba stream; Makwe and Ishaya (2014) assessed the impact of waste dump on Paiko River water quality in Gwagwalada Area Council of Abuja, Nigeria.; Ishaya (2018) assessed of urban drinking water quality of well, borehole and rainwater sources in a part of Kaduna City amongst others. Despite these researches on domestic water quality, water quality assessment in Ankpa town and this research attempts bridging this gap.

Study Area

Ankpa town is located in Ankpa Local Government Area lies approximately between latitudes 7^0 18^1 N and 7^0 43^1 N and longitudes 7^0 22^1 E and 7^0 52^1 E respectively. The town is situated on the eastern part of Kogi State and serves as the headquarters of the Ankpa LGA (See figure 1) (Musa, 2006).

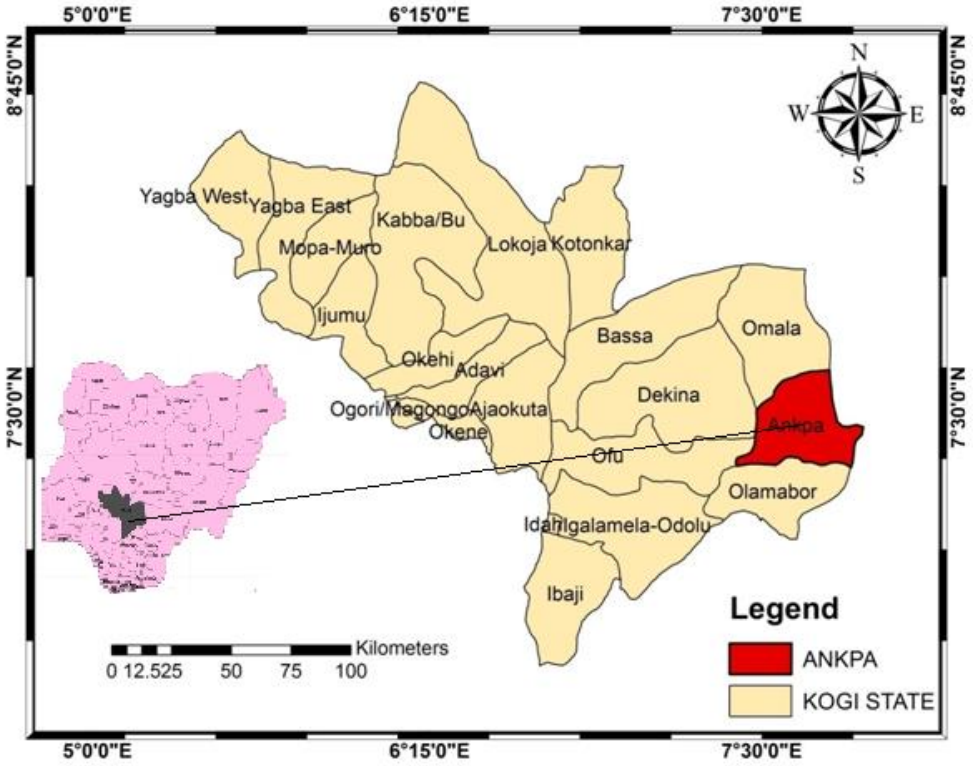


Figure 1: Map of the Study Area

According to Musa (2006), Ankpa is characterized by tropical wet and dry seasons with an average annual temperature of 25^0C and an annual rainfall of about 1500mm. Huruna, (2008) using the Koppen's climate classification technique assert that the study area falls within the AW climate (wet and dry) type. The climate of the area is influenced by the tropical continental air mass and tropical maritime air mass, which determine the area wet and dry seasons. The lowest monthly temperature is being experienced in July to September.

town is within crustaceous sandstone deposit, characterized by lower coal measure, false bedded sandstone and upper coal measure of the lower Paleocene with the area covered by impoverishing soil due to the action of erosion, Due to its undulating nature of the terrain, the action of erosion becomes prominent. The soil in Ankpa is poorly consolidated sediment of tertiary to cretaceous lignite formation. Ankpa soil generally relates strongly to its topography, parent material, drainage conditions and vegetation. The

soil of the study area is majorly luvisols derived from alluvium deposits, well drain thereby water holding capacity is limited with low organic matter content, and the soil is a loose sandy (Musa, 2006).

The study area entirely lies within the Guinea Savanna Vegetation. Within this, the study area, parkland savanna, gallery forest, and derived savanna are commonly sandwiched within the Guinea Savanna. Important trees within the area include; locust-beans, Shea-butter, and isoberlina (Musa, 2006).The Imaboro Rivers is the major river draining the study area with taking its tributaries streams from Ojuwo Ogaji which flows from the northern part to the southern part of the town through a straight course.

Ankpa have a population of 266,176 at the 2006 census, and by 2016, the population had swelled to 359,300 and is composed of predominantly Igalas and people from different tribes in Nigeria. Most inhabitants are farmers who produce crops such as maize, yam, vegetable, palm produce and cassava, among others. Some of the inhabitants are civil servants, and parts of them are into businesses and menial jobs (Haruna, 2008).

Methodology

The research design used for this study is experimental. The water samples were collected from a river, borehole and water tanker in Ankpa Town of Kogi State in February 2019.In carrying out this study, the following materials and types of equipment were used.

a. One litre of plastic containers.
b. Masking tape for labelling samples.
c. Writing pad for jolting location and essential information.
d. GPS 60cx for ascertaining the location of samples collected.
e. Cooling box for storage of samples

All the sampling bottles were washed with sample water before collection of samples to reduce contamination. The samples were marked and labeled with the source of water, sampling locations and dates of water samples collection. The collected samples were preserved in an ice block cooling plastic box and transported toDepartment of Soil and Environmental Management Laboratory Kogi State University for analysis.Quality assurance and control of samples were performed according to the specified method (Ishaya*et al.,* 2018).

Table 3.1: Points of Water Samples Collection

S/N	Items	Time of sample collection	Easting	Northing
1	River Sample	11.30am	7^{o} 24′ 7.9″	7^{o} 38′ 19.7″
2	Borehole Sample	11.48am	7 ^{o} 37′ 42.5″	7 ^{o} 24′ 21.2″
3	Tank Sample	12:50pm	7 ^{o} 24′ 9.5″	7^{o} 38′ 13.8″

Source: Researcher Fieldwork, 2019.

Method of Data Analyses

The physio-chemical properties laboratory test for potassium, nitrogen, calcium, magnesium, alkalinity, pH, electrical conductivity, total dissolved solids, turbidity, dissolved oxygen, zinc and iron were conducted according to the standard guidelines of the APHA-AWWA-WPCF (1998). The choice most of these parameters is based on their toxicity impacts too human health.

Determination of pH value in water samples Using Electrometric method

The pH measurement was carried out at 25.8^0c using an E603 metrohm pH-meter equipped with a glass electrode. The pH-meter was calibrated against Crison buffer standard solutions.

Determination of Electrical Conductivity (EC) in water samples

This was assessed using Standard Potassium Chloride solution (KCI), 0.01M dissolved 745.6mg anhydrous KCI in conductivity water and diluted to 100mL in a class A volumetric flask at 25^0C and store in a CO_2-free atmosphere. The determination of cell constant was done by rinsing conductivity cell with three portions of 0.001M KCI solution. Adjust the temperature of fourth portions to $25.0^0 \pm 0.1^0$C. The Conductivity measurement was done by thoroughly rinsing cell with one or more portions of sample before measuring sample resistance of conductivity and note temperature to $\pm 0,1^0$C.

Determination of Alkalinity in water samples

The Apparatus used include burette stand, funnel, conical flask and beaker, while the chemicals used, were phenolphthalein indicator solution, brome cresol green, Methyl red solution, standard solution (H_2SO_4) having normality 0.02. Six drops of Phenolphthalein indicator in 50ml of water sample in a flask before titration till the colour changes. The Phenolphthalein alkalinity was calculated using the formula alkalinity = (final reading – initial reading) x – 199/50. Six drops of brome cresols green were also added into methyl solution the total alkalinity = (final reading – initial reading) x 100/50.

Determination of Potassium in water samples

In assessing the potassium content in the water samples, the flame photometer was used.

Determination of Turbidity in water samples

In determining turbidity, WHO Nephelometric turbidity meter for mazine solution of the sample by multiplying the scale reading by 0.9NTU, 9NTU, 9.9NTU, test tubes and water samples were used.

Determination of Dissolved Oxygen in water samples

The reagents in determining Dissolved Oxygen in water samples were 2mL Manganese sulphate, 2ml alkali-iodide-azide, 2ml concentration

sulphuric acid, 2ml starch solution and Sodium thiosulfate. Using these reagents, the standard guide of the APHA-AWWA-WPCF (1998) was critically followed in determining Dissolved Oxygen in the water samples.

Determination of Calcium in water samples

The apparatus used in determining the calcium in the water samples include one 500µl automatic pipette, one 5.0mL pipette, one 100 volumetric flasks, one 1000 volumetric flask, 400 or 500ml beakers, 200ml beakers, Shimadzu 6300 AAS AA/E Spectrophotometer and prepared solution. Using these apparatus, the standard guide of the APHA-AWWA-WPCF (1998) was critically followed in determining calcium content in the water samples.

Determination of phosphate in water samples

In analyzing phosphate content in water samples, all the chemical reagents used were of analytical grade and distilled water was used. A weighed amount of ammonium molybdate, 1.7081g was dissolved in about 150ml of warm water; slightly milky solution obtained was cooled to room temperature which was transferred into a 250ml volumetric flask and diluted to the mark with water. Phosphate content in Water samples was then analyzed using spectrophotometric method.

Determination of Magnesium in Water Samples

In assessing the magnesium in the water sample, EDTA titration method was used.

Determination of Zinc and Iron

Zinc and Iron and in water samples were determined using AAS Atomic Absorption Spectrophotometer Model 210VGP Buck Scientific.

Determination of Total Dissolved Solids

The procedure used for assessing electrical conductivity was not different from the procedure used in determining the total dissolved solids. The factor of 0.5 was used in the model. That is to say, Total Dissolved Solids (TDS) value is one half the electrical conductivity (EC) values.

Results and Discussion of Findings

The analyzed water samples results were presented in table4.1compared to Federal Ministry of Environment (FME) of Nigeria and World Health Organization standard for water quality.

Water Samples pH Level

pH is an essential parameter in assessing water quality. pH is a term used to express the intensity of acidic or alkaline conditions. It is the expression of hydrogen ion concentration, more precisely, the hydrogen ion activity. Acidic condition prevails as pH value decreases, and alkaline conditions prevail as the pH value increases. The FME water standard level of pH is 6-9, while WHO standard is 6.5-8.5 shown in table 4.1. pH value in analyzed water samples is 5.60 mg/l for river water sample, 6.70 mg/l for

tank water sample and 4.70 mg/l for underground water (borehole water sample). The low pH does not cause any harmful effect (Boominathan and Khan, 1994). The results show that all the river water sample and borehole water samples fell below the permissible limits of WHO and FME standard. Natural water is expected to have pH value of between 6 mg/l and 8 mg/l (Chatter *et al.,* 2005).

Water Samples Electrical Conductivity Level

The permissible limit of electrical conductivity (EC) is 1000µS/cm for both WHO and FME. EC of the collected samples was 0.02µS/cm for river water, 0.08µS/cm for tanker water and 0.68µS/cm for borehole, (see table 4.1). This means all the samples fell within the permissible of both WHO and FME agreeing with the findings of Aremu *et al.,* (2011).

Water Samples Total Dissolved Solid Content

The electrical conductivity of water samples correlates with the concentration of dissolved minerals or with the total dissolved solids of water samples. The acceptable limit of TDS is 1000mg/l for FME and 500mg/l for WHO. The result of TDS for water samples varied between 28.0 mg/l for river water sample, 60.0 mg/l for tanker water sample and 488 mg/l for underground water sample as shown in table 1. The highest TDS value was observed from underground water sample but still fell within the permissive limit of FME and WHO. TDS in excess quantity is responsible for the widespread of human gastric system, produce undesirable taste, gastrointestinal irritation and corrosion (Pragathiswaran *et al.,* 2008).

Water Samples Calcium Content

The result of this studies, the content of calcium in the sampled water agrees with the findings of Chukwu (2008) and Chadwtrik and Arabinda (2011), that Calcium content of borehole water sample fell above the permissible limit of the Federal Ministry of Environment limit of 150mg/land WHO limit of 75 mg/l, while sample from river having 8.80mg/l calcium content, tanker water 34.40mg/lof calcium content fell within the permissible limit of FME and WHO but the calcium content in borehole water samples with value of 211.80mg/ l exceeds the permissible limits of FME and WHO (see Table 1). This is equally in line with the findings of Atobatele and Olutona (2013).

Water Samples Magnesium Content

The magnesium content of river water sample was 7.00mg/l, tanker water 12.80mg/l and borehole water sample was 32.20mg/lallfell within the permissible limit of FME 50mg/l and WHO 50mg/l (see Table 4.1). The results concur to that observed by Langan (2009); Ishaya and Abaje (2009). Drinking water with high magnesium can have a laxative effect, although research suggests that consumers adapt to these levels as exposure continues. Laxative effects have also been associated with excess intake of

magnesium in water. This finding concurs with that of Langan (2009); Ishaya and Abaje (2009).

Water Samples Turbidity Content

Turbidity values recorded for the samples were 6.40NTU for water from river, 5.10NTU for water from tanker, and 6.20NTU for borehole water as shown in table 4.1, all the samples fell above the permissible limit of both WHO and FME of 5.0NTU which is not far from the findings is similar to that of Halder and Islam (2015) andIshaya (2018).

Water Samples Zinc Content

Zinc in the water samples exceeded the permissible limit of <1 for both WHO and FME with river water sample having 1.70mg/1, tanker water sample having 2.10mg/1 and borehole water sample with 2.80mg/1. The result obtained is not farfetched from that of Fakayode (2005) and Ishaya *et al.,* (2018).

Water Samples Dissolved Oxygen Content

Dissolved Oxygen in the river water sample was8.20mg/1 was above the permissible limit for water quality standard of FME (5-7.5mg/1) but fell within the permissible limit of WHO (30mg/1), while the tanker and borehole water samples with values of 5.10mg/1 and 4.20mg/1 respectively fell within the permissible limit of FME (5-7.5mg/1) and that of WHO (30mg/1). This might be due to the large quantity of waste been dumped into the river. Dissolved oxygen is very crucial for the survival of aquatic organisms, and it is also used to evaluate the degree of freshness of a river, but when used above the permissible limit by, it affects human health (Fakayode, 2005; Ishaya *et al.,* 2014; Makwe and Ishaya, 2014).

Water Samples Phosphate Content

The phosphate content in river and tanker water samples fell within the permissible limit (2.26mg/1 and 3.06mg/1 respectively) while6.11mg/1 forboreholewater sample exceeded the FME and WHO permissible limit of 5mg/1. The finding of this study is in agreement with that of Atobatele and Olutona (2013) but contrary to that ofIshaya and Abaje (2009). Variation in phosphate in underground water is mostly due to geological formation of sample location and the depth of the borehole.

Water Samples, Alkalinity Content

Alkalinity level of river water, tanker water and borehole water samples having 15.35mg/1, 13.60mg/1 and 18.41mg/1 all fell within the permissible limit of WHO respectively. Results obtained is tandem with that of Lobinaand Akoth (2015).

Water Samples Iron Content

Iron content in water samples depicts 2.10mg/1, 2.90mg/1 and 3.30mg/1 for river water sample, tanker water sample and borehole water

sample respectively, were above the permissible limit of FME (1.5mg/1) and WHO (0.3mg/1). The finding coincides with that of Muhammad *et al.,* (2013); LobinaandAkoth (2015); Pawari and Gawande (2015).

Water Samples, Potassium Content

The content of potassium in the water samples was 1.10 mg/1 for river water, 3.70 mg/1 for tanker water and 21.00 mg/1for borehole water respectively fell within the permissible limit of FME (200 mg/1).These make the water safe for consumption, and the finding is in agreement with findings of Muhammad *et al.,*(2013).

Table 4.1: Physical/Chemical parameters of River, Tank and Borehole water samples

SN	PARAMETERS (Units in mg/1)	RIVER WATER		TANK WATER		BOREHOLE WATER		FME LIMIT	WHO LIMIT
	PARAMETERS	Results	Remark	Results	Remark	Results	Remark	Standard limit	Standard limit
1	PH	5.60	Permissible	4.70	Permissible	4.70	Permissible	6-9	6.5-8.5
2	Conductivity(µS/cm)	0.02	Permissible	0.68	Permissible	0.68	Permissible	1000	1000
3	Total Dissolve Solid	28.0	Permissible	60.0	Permissible	488.0	Permissible	1000	500
4	Iron	2.10	Impermissible	2.90	Impermissible	3.30	Impermissible	1.5	0.3
5	Calcium	8.80	Permissible	34.40	Permissible	211.80	Impermissible	150	75
6	Zinc	1.70	Impermissible	2.10	Impermissible	2.80	Impermissible	<1	<1
7	Potassium	1.10	Permissible	3.70	Permissible	21.00	Permissible	200	N/S
8	Alkalinity	15.35	Permissible	13.60	Permissible	18.41	Permissible	N/S	100
9	Phosphate	2.26	Permissible	3.06	Permissible	6.11	Impermissible	5	5
10	Magnesium	7.10	Permissible	12.80	Permissible	32.20	Permissible	50	50
11	Dissolved oxygen	8.20	Impermissible WHO	5.10	Permissible	4.20	Permissible	5-7.5	30
12	Turbidity	6.40 NTU	Impermissible	6.60 NTU	Impermissible	5.0-25NTU	Impermissible	5.0NTU	5.0NTU

Source: Researcher Analyzed Water Samples 2019

The first assumption of this research is that the physio-chemical properties of the water samples within the Nigeria standard water quality (FME) and WHO. Borehole water sample fell within the permissible limit of FME and WHO for most of the physio-chemical properties tasted except for calcium, iron, zinc, alkalinity and phosphate that were above the permissible limit of FME and WHO. River water and water tanker samples physio-chemical properties fell within the permissible limit of FME and WHO except for iron, zinc and alkalinity. This agrees with findings of Godwill, Daniel,

Badamasi, Abaje and Christopher (2013); Soladoye and Ajibade(2014)Ishaya (2018).

The second assumption of which states that the water has no implication to the health of human was rejected due to high concentration of for iron, calcium, zinc, alkalinity and phosphate in well water and high concentration of iron, zinc and alkalinity in river water and water tanker above the permissible limits prescribed by FME and WHO.

The high level of turbidity in water samples is an indication of impurity of water. Turbidity in water is the degradation in the clarity in water due to presence of particles such as silt, clay and other forms of living micro-organisms and non-living materials found in water and these impurities have varied health implications (Rputheti *et al.,* 2008). The finding of this study is in agreement with that of Langan (2009); Ishaya and Abaje (2009); and Ishaya (2018).

Calcium in all the water samples was above the FME and WHO standard; the implication is when much calcium is absorbed than is needed; excess of calcium in drinking water is excreted by the kidney in healthy people who do not have renal impairment. Concern for excess calcium intake is directed primarily to those who are prone to milk-alkali syndrome (the simultaneous presence of hypercalcaemia, metabolic alkalosis and renal insufficiency) and hypercalcaemia. Although calcium can interact with iron, zinc, magnesium and phosphorus within the intestine, thereby reducing the absorption of these minerals, available data do not suggest that these minerals are depleted when humans consume diets containing calcium above the recommended levels (Langan, 2009; Ishaya*et al.,* 2014; Ishaya, 2018).High calcium leads to excess excretion by the kidney in healthy people who do not have renal impairment.

Iron in all the water samples was above the permissible limit of FME and WHO. The implication is that iron in drinking water is classified as a disturbing contaminant according to WHO. Iron content in high doses in water produces neurological effects (Oluyemi *et al.,* 2010). Iron is preferentially toxic to cells with high mitochondrial activity and may inhibit the mitochondrial respiratory enzymes NADH-cytochrome oxidoreductase and succinate dehydrogenase. Long-term iron toxicity may involve iron-mediated oxidative damage to the mitochondrial genome leading to progressive dysfunction (Salem *et al.,* 2000) and DNA damage (Ishaya, 2018). Iron overload can lead to hemochromatosis, which can lead to liver, heart and pancreatic damage, as well as diabetes. Early symptoms include fatigue, weight loss, and joint pain. Excessive iron is never recommended for digestion; it can lead to stomach problems, nausea, vomiting, and other issues (WHO, 2004). The finding also agrees with that of Oluyemi*et al.,*(2010) which assert that toxic metals enter into water and reduce the quality of water 25% pollution is caused by the industries and is more harmful and also Ishaya(2018).

Alkalinity in all the water samples was above the permissible limit of FME and WHO. The finding is in line with that of Ishaya (2009); Langan, (2009) and Lobinaand Akoth(2015).Although alkaline in water is considered not having serious health implication to human(Muhammad *et al.,* 2013). One of

the side effects is that while it may be alkalizing the human body, there is a chance that excessive consumption may ruin the natural acids of human stomach killing the good bacteria. Also, excessive alkalinity in human body may cause problem in the gastrointestinal tract (Ishaya *et al.,*2018).

Phosphate in water samples was within the permissible limit for river and tanker water samples, but phosphates in borehole water sample were above the permissible limit of FME and WHO. Although phosphate is not significantly harmful to humans, but excessive consumption could affect human health. The content of phosphate in borehole water is not farfetched with the observation of Muhammad *et al.,*(2013).

Zincin all the water samples was above the permissible limit of FME and WHO. Zinc is an essential nutrient for body growth and development; however, drinking water containing high levels of zinc can lead to stomach cramps, nausea and vomiting. It can be opalescent and has an undesirable astringent taste. Water with exceeding the limit of zinc concentration may become chalky in appearance with a detectable deterioration in taste (Fakayode, 2005; Ishaya, 2018).

Conclusion and Recommendation

This study concludes that borehole water sample fell within the permissible limit of FME and WHO for most of the physiochemical properties tasted except for calcium, iron, zinc, alkalinity and phosphate that were above the permissible limit of FME and WHO. River water and water tanker samples physio-chemical properties fell within the permissible limit of FME and WHO except for iron, zinc and alkalinity. The water in the study area is not of good quality for consumption during the dry season with possible health problems that could be linked to the poor quality of water but if the water is treated following modern methods the treats to human health could eradicate treated. In achieving sustainable portable water supply in the study area, there is need to annex Offejiji and Ogeneji earth dams both in the east senatorial district of Kogi State towards the provision of portable water in Ankpa and its environs in line with the sustainable development goals.

References

Adediji, A. and Ajibade, L.T., (2005). Quality of Well Water in Ede Area, SouthwesternNigeria.*Journal of Human Ecology.* 17(3): 223-228.

Adelekan, B.A. (2010). Water quality of domestic wells in typical African communities: Case studies from Nigeria. *International Journal of Water Resources, Environment and Engineering.* 2(6):137-147. Available online at www.academicjournals.org/ijwree.

Adewumi, J. R. and Babatola, J. O. (2009).A Case Study on the Status of Water Supply for Domestic Purposes in Akure, Ondo State.*Botswana Journal of Technology.* 18(1):38– 47.

Aremu, M. O. Olaofe, O. Ikokoh, P. P & Yakubu, M. M. (2011). Physicochemical characteristics of stream, well and borehole water

sources in Eggon, Nasarawa State, Nigeria. *Journal Chemical Society Nigeria*.36 (1): 131-136.

Atobatele, E.O. and Olutona, G.O. (2013).Spatio-seasonal physio-chemistry of Aiba stream, Iwo, Nigeria. *African Journal of Biotechnology*. 12(14): 1630-1635.

Azubike, G. (2013).The Challenges of Increased Access to Water in Nigeria. Retrieved from http://www.blueprinting.com/new/2013/03/13. Retrieved 18/10/2013.

Bibi, S., Khan R.L., and Nazir, R. (2016).Heavy metals in drinking water of LakkiMarwat District, KPK, Pakistan. *World applied sciences journal.* 34(1):15-19.

Boominathan R. and Khan S.M., (1994).Effect of distillery effluents on pH, dissolved oxygen and phosphate content in Uyyakundan channel water. 12(1): 850-853.

Chadwtrik R., and Arabinda S. (2011). assessment of drinking water quality. *International Journal of Environmental Sciences.* 2(2) 23-34.

Chatterjee S.N., Chandra G., Dangler T.K. (2005). Physio-chemical Properties and Bacteriological Examination of Mondeswari River of Hoogly Distinct West Bengal. *Journal of Applied Science.* 16 (2): 242 -244.

Chima, G.N and Okpe, V.C (2007) The provision and maintenance of sustainable water supply in Nigeria: a strategic announcement. International Journal of biotechnology. *Allied Science.*2:162-168.

Chukwu, G.U. (2008). Water Quality Assessment of Boreholes in Umuahia South Local Government Area of Abia State, Nigeria.*The Pacific Journal of Science and Technology.*9 (2):592-508.

Fakayode, S.O. (2005): Impact Assessment of Industrial Effluent on Water Quality of the Receiving ALaro River in Ibadan, Nigeria. *Ajeam-Ragee.*10:1-13.

Federal Environmental Protection Agency, (2006).*Guidelines for Contaminant Content of Natural Waters*.Federal Ministry of Environment, Abuja, Nigeria.

Godwill, J.G., Daniel, D.D., J. Badamasi, S., Abaje, I. B, Christopher N. (2013). Assessment of Well Water Quality in Selected Location in Jos, Plateau State, Nigeria.*InternationalJournal of Marine, Atmospheric & Earth Sciences.* 1(1): 38-46.

Halder J.N., Islam M.N. (2015).Water pollution and its impact on the human health.*Journal of Environment and Human. 2*(1):36-46.

Haruna, I. (2008).*Deforestation in Ankpa Local Government Area: A Socio-Economic Aproach*. B.sc, project Submitted to Geography and Planning Department, Kogi State University, Anyigba.

Igata V. I. (2012).An assessment of the quality of domestic water supply in Anyigba. B.sc, project Submitted to Geography and Planning Department, Kogi State University, Anyigba.

IshayaS.(2018). Assessment of Urban Drinking Water Quality of Well, Borehole and Rain Water Source In A Part of Kaduna City, Nigeria. *Journal of Contemporary Urbanology*. 5(1): 37-48.

Ishaya S. and Abaje I. B. (2009): Assessment of bore wells water quality in Gwagwalada town of FCT.*Journal of Ecology and Natural Environment.* 1(2):032-036. Available online at http://www.academicjournals.org/JENE

Ishaya S., Alhassan M. M., Onarigu I. A. (2018), Effects of Barite Mining on Water Quality in Azara-Awe Local Government Area of Nasarawa State, Nigeria. *Ghana Journal of Geography.* 10 (2):36–47.

Ishaya, S., Hassan, S.M., and Adakayi. P.E.(2014).Assessment of River Usuma Physiochemical Water Quality for Irrigation in Gwagwalada Town of the Federal Capital Territory of Nigeria. Geo-Studies Forum: *An International Journal of Environmental Policy and Issues*. 3(1), 92-101.

Langan, S.M. (2009).Flares in childhood eczema.*Skin Therapy Letter*, 14(8),1. Available at (http://www.skintherapyletter. com/2009/14.8/2.html).

Lobina, P. and Akoth, M. (2015).Physico-Chemical and Microbial Analysis of Selected Borehole Water in Mahikeng, South Africa. *International Journal of Environmental Resources and Public Health*.12(8): 8619–8630.

Makwe E., Ishaya S. (2014) Assessing the Impact of Waste Dump on Paiko River Water Quality in Gwagwalada Area Council of Abuja, Nigeria. *American Journal of Science and Technology*. 1(5): 303-309.

Muhammad M., Samira S., Faryal A. and Farrukh J., (2013).Assessment of Drinking Water Quality and its Impact on Residents Health. *International Journal of Humanities and Social Science*. 3(15): 23-45.

Mundi R., Nwankwo B. B., Dakyes S. P., Ishaya S., Yohanna S. (2019)Demographic and Socioeconomic Factors Associated with Under-five Mortality in Nigeria's Federal Capital Territory. *Journal of Social Sciences and Humanities.*2(2): 43-50 http://www.aascit.org/journal/jssh

Musa, S.D. (2006). Solid Waste Management in Ankpa. *Confluence Journal of Environment Studies*. 1(1): 35-42.

Oluyemi, E. A, Adekunle, A. S, Adenuga A. A, Makinde W. O (2010). Physico-chemical properties and heavy metal content of water sources in Ife North Local Government Area of Osun state, Nigeria.

African Journal of Environmental Science and Technology. 4(10):691-697. Available online at www.academicjournals.org/AJES.

Omole, D.O. and Longe, E.O. (2008).An Assessment of the Impact of Abattoir Effluents on River Illo, Ota, Nigeria. *Journal of Environmental Science and Technology.*1(2), 56-54.

Pragathiswaran C., Paruthiral G, Prakash P., Jeya P., Suganandam K. (2008). Status of Ground Water Quality in Hosur during Summer. *Ecology Environment Conservation*. 14(4): 605 – 608.

Salem H.M., Eweida EA, Farag A. (2000).Heavy metals in drinking water and their environmental impact on human health.*ICEHM.* 2000:542-56. arsenic exposure from drinking water on the neurobehavioral development in adolescence. *Neurotoxicology*. 24(4-5): 747-53.

UNICEF (2006). Towards better programming: A water handbook. Water, *Environment and Sanitation Technical Guidelines.* Series No 2, United 26.

Soladoye, O. and Ajibade, L.T. (2014).A Groundwater Quality Study of Lagos State, Nigeria.*International Journal of Applied Science and Technology.*4(4):32-40.

Tsai, S.Y., Chou, H.Y. (2003). The effects of chronic

Nations Children's Fund, New York. Available at http://www.unicef.org/wes.

United Nation (2012) *Millennium Development Goals Report July 2012*, New York.

United Nation (2015).*A Post-2015 Global Goal for Water. Executive Summary.* 27 Jan 2014. http://www.unwater.org/topics/water-in-the-post-2015-development-agenda/en/- Executive Summary.

Wasserman, G.A., Liu, X.H. (2006). Water Manganese Exposure and Children's Intellectual Function in Araihazar, Bangladesh. *Environmental Health Perspectives.* 114(1):124-129.

WHO (2004) *Guidelines for Drinking-Water Quality, 3rd Edition*. Volume 1: Recommendations, WHO, Geneva. (www.who.int/water- sanitation-health).