AN ASSESSMENT OF THE PHYSICOCHEMICAL QUALITIES OF WATER SOURCES IN KANO METROPOLIS, NIGERIA

BY

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ABSTRACT

The study was based on assessment of physicochemical qualities of drinking water sources in Kano metropolis. It compared and analyzed various sources of water in Kano Metropolis where ninety six (96) water samples were collected from open wells, boreholes, tap water and sachet water in the study area using systematic sampling technique. Standard laboratory analysis were carried out to determine the concentration of major physicochemical elements while major comparisons were made with World Health Organization (WHO), Nigerian Standard for Drinking Water Quality (NSDWQ) and Water Quality Index (WQI) standard ratings. It was revealed that all parameters tested for tap water were within permissible limits except for turbidity. For sachet water gotten from each wards, all values fall within the permissible limits although Dala and Gwale Local Government Areas (LGAs) showed relatively higher concentrations for total hardness. For borehole water, the values were within limits except the concentration of pH for Dala, Fagge and Gwale LGAs. In the case of well water, all values fall within the permissible limits except for iron. Also, copper in Kano Municipal is a bit higher than the Nigerian Standard while lead values are higher in Fagge, Nassarawa and Tarauni which all together makes the water unsuitable for drinking. The results based on WQI revealed that Dala borehole water and well water sources were above the permissible limit and unfit for consumption, while it has no tap water source. In Kano municipal and Gwale borehole water, tap water and well water sources are all above permissible limits, while Nassarawa, and Tarauni had very poor water quality. Only tap water source from Fagge LGA and all sachet water sources across all LGAs are in good ratings fit for human consumption. If not for the waste implication, it can be said that the sachet water followed by tap water are the most suitable for consumption. It is recommended that the government, community and individuals should work collectively in making tap water available and providing proper waste management disposal systems that would take care of waste and refuse dumps within the metropolis.

Key words: Kano metropolis, Physicochemical, Water quality, Water sources.

INTRODUCTION

Human life depends to a large extent, on water. It is used for an array of activities; chief among these being for drinking, food preparation, as well as for sanitation purposes. Since safe drinking water is essential to health, a community lacking good quality of this resource will be saddled with a lot of health problems which could otherwise be avoided (Miller, 1997). Many regions of the world are already limited by the amount and quality of domestic water. According to WHO (2002), in the next thirty years alone, accessible water is unlikely to increase more than ten percent (10%), but the earth's population is projected to rise by approximately one-third. The growing demand for adequate quality of water for domestic purposes requires an urgent need to link research with improved water management, better monitoring, assessment, and forecasting of water resources and sanitation issues with much emphasis on the roles of stakeholders (Yamaguchi and Wesselink, 2000).

It must however be emphasized that adequate water need seems to have improved greatly in some regions and countries especially in the developed world but for poor nations this is still a major issue as contaminated water kills more people than cancer, AIDS, wars, terrorism or accidents. It is pertinent that the water meant for human consumption be free of disease-causing germs and toxic chemicals that pose a threat to public health according to Third World Academic of Sciences [TWAS], (2002). It is therefore necessary to have an update on the quality of the water being supplied to the masses so as to create a consciousness for the need to treat water supplied to ensure healthy living.

The inability of the government to persistently provide adequate potable water for the growing population has tremendously contributed to the proliferation of the so-called 'pure water' producers in some developing nations like Nigeria. This necessitates the Nigerian government to regulate packaged water in the private water sector through National Agency for Food and Drug Administration and Control (NAFDAC) for the sake of public health (Akunyili, 2003).In a bid to ensure safe water for the entire populace many researchers have carried out safe and consumable water related researches, some of which are Etim and Adie (2012) who observed that available sources of potable water for drinking and industrial uses in Nigeria are dwindling because of concomitant increase in population, urbanization and industrial activities. Simialry, Gbadegesin and Olorunfemi (2007), Maconachie (2008) and Adamu (2009) have corroborated the inadequacy of the country's water supply. Gbadegesin and Olorunfemi (2007) while quoting figures from the National Millennium Developmental Goals Report of 2005, lamented that after almost sixty years of water supply in Nigeria, it is regrettable that only 60 percent of the population have access to safe drinking water. Maconachie (2008) and Adamu (2009) provided evidence of this shortage of water in Kano and Kaduna respectively through their state-specific evidence in terms of quality.

Bichi and Amatobi (2013) carried out a study on assessment of the quality of water supplied by water vendors to households in Sabon-Gari Area of Kano, Northern Nigeria. The quality of the water was assessed at commercial sales points, water vendor's distribution Jeri-cans and household storage tanks. The results obtained were compared with standards recommended by the World Health Organization (WHO), the Nigerian Standard for Drinking Water Quality (NSDWQ) and the European Community Drinking Water Quality (ECDWQ) where Total Hardness (as $CaCO_3$), Conductivity and Free Chlorine values were not within acceptable limits in most of the samples and some samples tested positive to coliform organism. It was concluded that water quality was compromised at the private commercial supply, during hawker's distribution and in the household storage.

Also, a study carried out by Mohammed (2013) on quality assessment of potable water in Sabon-Gari, Kano State, compared the quality of some of the most patronized water considered consumable in Sabon Gari Area of Kano State with the World Health Organization (WHO, 2002) set standard which revealed a significant difference in the level of concentration of physicochemical parameters such as conductivity, color, total hardness, total dissolved solid, total alkalinity, turbidity, chlorides, calcium ions, (Fe) iron, and magnesium ions with higher concentrations in borehole water sources which are not within the WHO standard.

The studies above did not consider the use of the Water Quality Index (WQI) which incorporates data from multiple water quality parameters into a mathematical equation that rates the nature of water sources with numbers to determine their suitability for human consumption. The objectives of this study therefore are to identify the sources of water supply in the study area, determine the level of concentration of their physicochemical parameters, compare their level of concentrations with the acceptable drinking water quality standard according to WHO and NSDWQ while lastly, determine the WQI of the different sources of water.

THE STUDY AREA

Kano metropolis is located between Latitudes 11° 56' N - 12° 04' N and Longitudes 08° 26' E - 08° 39' E. It occupies an area of about 683km^2, with a crow fly distance of 19km from east to west and about 15km from north to south (Figure 1). Kano Metropolis is bordered by Minjibir LGA to the North East, Gezawa LGA to the East, Dawakin Kudu LGA to the South East and Madobi and Tofa LGAs to the South West. It is the largest urban center in the Hausa land and most influential commercial town in the Sudan region with a long standing sedentary population in an organized emirate, Kano's growth is phenomenal. McDonnell (2002) described it as a key area of modern Nigeria and one of the largest rural-urban complexes in Africa. Its 2006 population census was approximately 2,163,225 in the city and 2,828,861 in the metropolis, while the projected population of 2015 is 3,876,273 with a growth rate of 3.5% per annum at the time of study (NPC, 2007).

The climate is determined by the movement of two air masses, a moist rather cool southerly mass known as south-westerly and a hot and dry northern air called the north-easterlies meeting in an area of pronounced moisture gradient called the Inter Tropical Discontinuity (ITD). The climate of the area is the tropical wet and dry type with wet season lasting for 4-5 months between May and September (Olofin and Tanko, 2002).

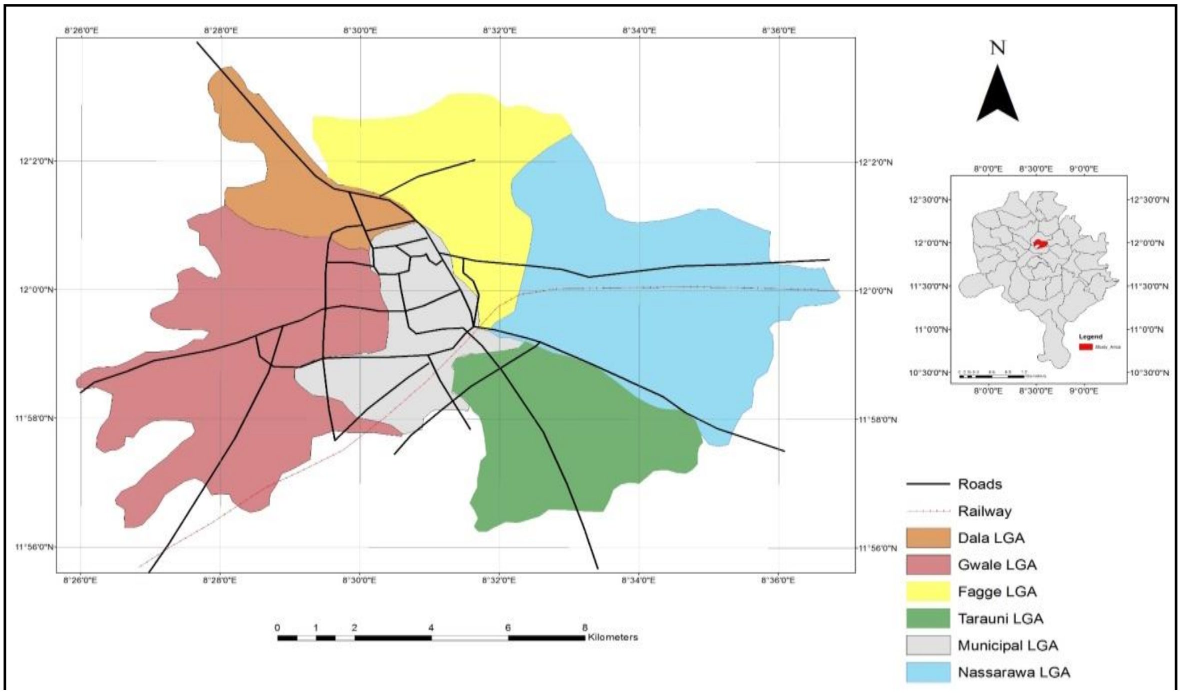

Figure 1 Kano Metropolis
Source: Adapted from the Administrative Map of Kano State.

MATERIALS AND METHODS

Selection of sample points

The identification of the sources of potable water supply was achieved by carrying out a reconnaissance survey of the study area in order to understand the various sources of potable water supply available within the study area, which were open wells, boreholes, tap water and sachet water (pure water).In order to select sample points, a systematic sampling method was employed by drawing a list from all the wards within Kano Metropolis (Kano Municipal, Dala, Fagge, Gwale, Nassarawa, and Tarauni) and arranging them in alphabetical order. Every fourth numbered ward from each LGA that make up the metropolis was selected to make the sample frame.

Four (4) sample points were randomly selected within each of the sampled wards for the selected Local Government Areas, while the GPS coordinate for each source point were located. Samples were taken for each of the water sources with the exception of tap water from Dala LGA which is unavailable.

Sample collection

A total of ninety six (96) water samples were collected from the study area. The water samples were stored in 250ml plastic bottles pre-cleaned by washing with non-ionic detergents, rinsed with distilled water. Each sample was labelled and transported to the Centre for Energy Research and Training, Ahmadu Bello University Zaria, for the analysis using standard laboratory techniques as shown in Table 1.

Table 1 Analytical Methods Adopted for Physicochemical Analysis

No.	Parameter	Method of Analysis
1	pH	Digital pH meter (APHA, 1992)
2	Colour	Alpha Platinum-Cobalt Standard Range (APHA, 1992)
3	Total Hardness	EDTA-Titrimetry (APHA, 1992)
4	Conductivity	Digital conductivity meter (Hem, 1985)
5	Calcium	Flame Photometric (APHA, 1992)
6	Magnesium	Spectrophotometry (APHA, 1992)
7	Chlorides	Mohr'sTitrimetry (APHA, 1992)
8	Sulphate	Turbidimetric Method (APHA-AWWA-WEF, 1998)
9	Sodium	Flame Photometric (APHA, 1992)
10	Turbidity	Nephelometric Method (APHA, 1992)
11	Copper	Spectrophotometry (APHA, 1992)
12	Manganese	Spectrophotometry (APHA, 1992)
13	Zinc	Spectrophotometry (APHA, 1992)
14	Lead	Spectrophotometry (APHA, 1992)
15	Iron (Fe)	Spectrophotometry (APHA, 1992)

Source: Compiled by the Author (2017)

Data Analysis

The differences in concentrations were revealed from the results obtained and then compared with the secondary data gotten from publications of the WHO (2010) and NSDWQ (2007) standards to ascertain conformity with the international and national guidelines, while the water quality assessment using WQI was computed to reduce the large amount of water quality data to a single numerical value. Once the WQI scores were known, it was then compared against a scale (see Table 5) to determine how healthy the water is for different Local Government Areas that make up the Metropolis (Asuquo and Etim, 2012).

RESULTS AND DISCUSSION

Tables 2 – 5 show the summarized laboratory results of water quality for the water sources from the study area in comparison with WHO and NSDWQ standards with the mean for each quality parameter calculated for the sources and each Local Government Areas (LGAs) that constitute the metropolis.

Table 2. Mean Concentrations of Physicochemical Parameters for Tap Water

Physicochemical Parameter	Kano Metropolis						
	Kano Municipal	Fagge	Nassarawa	Gwale	Tarau -ni	WHO Standard (2010)	NSDWQ Standard (2007)
pH	7.29	6.43	7.26	6.90	7.26	6.5-8.5	8.5
Colour (tcu)	3.75	4.00	4.30	4.25	4.63	15	15
Total hardness (mg/l)	12.23	12.03	11.96	12.09	11.98	500	150
Conductivity (µS/cm)	7.58	4.82	6.60	7.59	6.04	NA	1000
Calcium (mg/l)	4.78	4.94	3.49	4.38	5.11	NA	NA
Magnesium (mg/l)	1.00	1.37	1.58	1.43	0.67	50	0.20
Chloride (mg/l)	0.86	1.38	1.32	1.42	1.36	250	250
Sulphate (mg/l)	2.18	2.42	1.76	1.38	1.93	250	100
Sodium (mg/l)	5.38	5.18	4.50	3.93	4.95	50	200
Turbidity (ntu)	12.96	13.5	13.24	11.4	7.71	5.0	5.0
Copper (mg/l)	0.36	0.03	0.67	0.35	0.31	2.0	1.0
Manganese (mg/l)	0.05	0.07	0.04	0.08	0.03	0.1	0.2
Zinc (mg/l)	0.26	0.44	0.22	0.27	0.18	3.0	3.0
Lead (mg/l)	0.02	0.00	0.01	0.03	0.01	0.01	0.01
Iron (mg/l)	0.45	0.28	0.32	0.54	0.48	0.3	0.3

Source: Laboratory Analysis, 2017

Table 3 Mean Concentration of Physicochemical Parameters for Sachet Water

Physicochemical Parameters	Kano Metropolis							
	Kano municipal	Dala	Fagge	Nassarawa	Gwale	Tarauni	WHO Standard (2010)	NSDWQ Standard (2007)
pH	7.52	7.31	7.27	7.37	6.77	7.15	6.5-8.5	8.5
Colour (tcu)	5.00	5.00	5.00	5.00	5.00	5.00	15	15
Total hardness (mg/l)	4.32	8.15	6.56	7.85	8.51	5.72	500	150
Conductivity (µS/cm)	4.59	2.28	2.36	2.20	3.87	1.81	NA	1000
Calcium (mg/l)	4.29	3.68	4.03	3.55	4.23	4.12	NA	NA
Magnesium (mg/l)	0.69	0.35	0.52	0.66	3.09	0.21	50	0.20
Chlorides (mg/l)	0.55	1.01	0.93	0.86	0.32	1.10	250	250
Sulphate (mg/l)	1.34	1.20	1.42	1.31	1.40	1.33	250	100
Sodium (mg/l)	0.59	2.16	0.39	1.40	0.37	1.14	50	200
Turbidity (ntu)	0.30	0.39	0.15	0.48	0.27	0.40	5.0	5.0
Copper (mg/l)	0.02	0.01	0.02	0.03	0.02	0.02	2.0	1.0
Manganese (mg/l)	0.02	0.02	0.01	0.02	0.02	0.02	0.1	0.2
Zinc (mg/l)	0.15	0.18	0.15	0.16	0.13	0.16	3.0	3.0
Lead (mg/l)	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
Iron (mg/l)	0.04	0.04	0.03	0.06	0.01	0.02	0.3	0.3

Source: Laboratory Analysis, 2017

Table 4 Mean Concentrations of Physicochemical Parameters for Borehole Water

Physicochemical Parameters	Kano Metropolis							
	Kano municipal	Dala	Fagge	Nassarawa	Gwale	Tarauni	WHO Standard (2010)	NSDWQ Standard (2007)
pH	6.71	6.28	6.24	6.50	6.48	6.80	6.5-8.5	8.5
Colour (tcu)	5.00	5.00	5.00	5.00	5.00	5.00	15	15
Total hardness (mg/l)	87.68	65.35	52.6	93.90	72.78	102.00	500	150
Conductivity (μS/cm)	530.00	312.25	378.25	388.25	316.00	375.00	NA	1000
Calcium (mg/l)	13.43	15.06	15.35	16.64	16.74	12.98	NA	NA
Magnesium (mg/l)	15.73	15.58	13.40	17.03	15.03	15.35	50	0.20
Chlorides (mg/l)	72.18	48.29	64.23	62.86	48.78	52.16	250	250
Sulphate (mg/l)	7.63	4.01	2.91	2.71	5.08	2.75	250	100
Sodium (mg/l)	12.72	12.90	9.68	12.05	12.64	7.17	50	200
Turbidity (ntu)	2.70	3.25	2.69	2.68	3.24	3.13	5.0	5.0
Copper (mg/l)	0.27	0.25	0.50	0.33	0.18	0.46	2.0	1.0
Manganese (mg/l)	0.02	0.03	0.01	0.04	0.02	0.08	0.1	0.2
Zinc (mg/l)	1.46	1.55	1.56	1.50	1.65	1.09	3.0	3.0
Lead (mg/l)	0.03	0.01	0.01	0.01	0.03	0.01	0.01	0.01
Iron (mg/l)	2.17	2.33	3.20	2.36	2.06	2.05	0.3	0.3

Source: Laboratory Analysis, 2017

Table 5 Mean Concentration of Physicochemical Parameters for Open Well Water

Physicochemical Parameters	Kano Metropolis							
	Kano Municipal	Dala	Fagge	Nassarawa	Gwale	Tarauni	WHO Standard (2010)	NSDWQ Standard (2007)
pH	7.34	7.05	7.39	7.29	6.97	7.29	6.5-8.5	8.5
Colour (tcu)	5.00	5.00	5.00	5.00	5.00	5.00	15	15
Total hardness (mg/l)	74.25	34.03	24.10	77.53	75.30	65.10	500	150
Conductivity (μS/cm)	400.95	648	512.50	519.65	140.38	394.65	NA	1000
Calcium (mg/l)	3.75	9.05	10.41	10.68	11.01	5.95	NA	NA
Magnesium (mg/l)	14.98	15.23	13.86	14.15	13.20	13.83	50	0.20
Chlorides (mg/l)	19.28	25.85	18.66	27.08	21.08	17.08	250	250
Sulphate (mg/l)	3.19	5.53	2.04	5.54	1.94	4.72	250	100
Sodium (mg/l)	16.01	23.85	22.20	15.68	16.10	14.06	50	200
Turbidity (ntu)	3.48	5.03	4.45	4.29	2.77	3.53	5.0	5.0
Copper (mg/l)	1.18	0.41	0.27	0.54	0.13	0.71	2.0	1.0
Manganese (mg/l)	0.92	0.32	0.44	0.19	0.56	0.78	0.1	0.2
Zinc (mg/l)	1.91	2.39	0.59	1.55	1.72	2.01	3.0	3.0
Lead (mg/l)	0.01	0.01	0.03	0.02	0.01	0.02	0.01	0.01
Iron (mg/l)	3.26	2.68	1.87	2.20	1.24	2.95	0.3	0.3

Source: Laboratory Analysis, 2017

Table 2 shows that all parameters tested for tap water were found to be within permissible limits except for turbidity. Also, lead and iron exceeded limits in rare cases as in Kano Municipal, Nassarawa, Gwale and Tarauni. Concentration for turbidity showed much higher values within the metropolis while Tarauni has the least concentration of 7.71mg/l which is still higher than the

WHO and NSDWQ standard. The study is similar to that of Fasae and Omolaja (2014) who worked on the assessment of drinking water quality from different sources (tap, well, rain, stream and borehole) in smallholder ruminant production in Abeokuta, Nigeria where it was found that tap water in the study area is fit for drinking as the organoleptic properties across treatments complies with the standard of drinking water with the exception of stream water where odour and particles were observed.

Table 3 shows much lower values for sachet water within the entire metropolis when compared to the Tap water values earlier presented. All values fall within the permissible limits. It is worth mentioning here that the sachet water source from the entire LGAs within the Metropolis revealed no trace in lead concentration. This study is similar to that of Dada (2009) who worked on sachet water phenomenon in Lagos where it was reported that the sachet water is fit for drinking but the quality is being compromised as it moves from the manufacturer to the consumer as a result of poor hygiene.

In Table 4, representing borehole water values, the concentration for pH was within limits except for Dala, Fagge and Gwale LGAs. All other parameters were within permissible limits except for iron thereby making water in these environments doubtful. Also, lead was above limits in Kano Municipal and Gwale LGAs. This result is similar to the study of Oko, Aremu, Odoh, Yebpella and Shenge (2014) who reported unsuitable drinking quality for borehole water in Wukari town, Taraba State.

In Table 5, all open well water values fall within the permissible limits except for iron and lead in Fagge, Nassarawa and Tarauni. However, the concentration for copper in Kano Municipal is a bit higher than the Nigerian Standard. The situation is similar for lead concentration with values higher than the Standards in Fagge, Nassarawa and Tarauni thereby resulting to water quality which may be unfit for consumption. This is similar to the study of Ishaku (2011) who carried out an assessment on groundwater quality for Jimeta Yola area, Northeastern Nigeria and reported that the well water is unfit for human consumption without treatment.

The results of the WQI for physicochemical parameters of the different sources of potable water supply in Kano metropolis based on the water quality ratings are presented in Table 6 where the WQI rating for tap water source shows different levels of variations from one metropolis to another. Kano municipal and Gwale LGA have ratings higher than 100 thereby rendering the water unsuitable for drinking, similarly the tap water from Nassarawa LGA and Tarauni LGA have very poor water quality rating (76-100), while Fagge LGA has values within the ranges of sachet water (excellent water quality, 0-25) which makes it suitable for domestic use and human consumption, while there is no tap water source in Dala. The result for Kano Municipal, Gwale, Nassarawa and Tarauni LGA is in contrast with the findings of Etim,Odoh, Itodo, Umoh and Lawal (2013) who reported that the WQI from the different sampling stations for pipe borne water falls under the good water quality status in Niger Delta region of Nigeria. However, his result is similar to that of Fagge LGA.

Table 6. Water Quality Index for Kano Metropolis

Water Quality Index Level	Water Quality Status	Kano Metropolis	WQI for Water Sources			
			Tap Water	Borehole Water	Sachet Water	Well Water
0-25	Excellent water quality	Kano Municipal	183.88	284.93	2.20	199.79
25-50	Good water quality	Dala	- -	112.80	2.20	141.72
51-75	Poor water quality	Fagge	9.34	119.51	1.22	318.68
76-100	Very poor water quality	Nassarawa	94.53	113.97	2.40	212.93
>100	Unsuitable for drinking	Gwale	274.56	283.87	1.88	148.49
		Tarauni	94.93	114.47	2.00	270.00

Source: Laboratory Analysis, 2017

The WQI for borehole water in Kano municipal, Dala, Fagge, Nassarawa, Gwale and Tarauni LGAs shows that the WQI exceeds 100 which makes it unsuitable for drinking. These results for borehole water is in contrast with the study of Olowe, Oluyege and Famurewa (2016) who reported poor water quality ratings for borehole water WQI 54.16. But in agreement with the study of Oko et al. (2014) who reported unsuitable for drinking ratings for borehole water having WQI of 136 in Wukari Town, Taraba State. However, the results of the WQI for sachet water source in Kano municipal, Dala, Fagge, Nassarawa, Gwale and Tarauni LGA falls within the excellent water quality ratings of between 0 and 25 which makes it suitable for domestic use and human consumption. This result is far better to the study of Olowe et al. (2016) who reported good water quality ratings WQI 49.59 for sachet water in Ado-Ekiti and its environs, Nigeria.

The WQI for well water source in Kano municipal, Dala, Fagge, Nassarawa, Gwale and Tarauni LGAs all show that the WQI exceeds 100 which makes it unsuitable for drinking. The result for well water source is similar to the findings of Oko et al. (2014) who reported unsuitable for drinking ratings for well water WQI 136 in Wukari Town, Taraba State. It is also similar to the study of Ishaku (2011) on assessment of groundwater quality index for Jimeta-Yola area, Northeastern Nigeria who reported WQI of 138.5 as unfit for human consumption without treatment.

CONCLUSION

Comparative assessment of various sources of water in Kano Metropolis was carried out using laboratory techniques to determine the level of concentration of parameters such as pH, colour, total hardness, conductivity, calcium, magnesium, chlorides, sulphate, sodium, turbidity, copper, manganese, zinc, lead and iron in tap water, sachet water, borehole water and well water sources while making comparison with WHO, NSDWQ and WQI standards. The results revealed that all parameters tested for tap water were found to be within permissible limits except for turbidity. Sachet water had all values falling within the permissible limits. All other parameters were within permissible limits for borehole water except for pH in Dala, Fagge and Gwale LGAs and iron in all the wards thereby making water in these environments doubtful. In the case of groundwater and well water, all values fall within the permissible limits except for iron. Also, copper in Kano Municipal is a bit higher than the Nigerian Standard while lead values were higher than the Standards in Fagge, Nassarawa and Tarauni which all together makes the water unsuitable for drinking.

The water quality index analysis reveals that water samples analyzed from borehole, tap and well sources from Kano municipal and Gwale are above the permissible limit and unfit for consumption while Nassarawa, and Tarauni have very poor water quality. Similarly, Dala LGA well water and borehole water sources are above the permissible limit just like Kano municipal and Gwale LGAs therefore unfit for consumption. Only tap water source from Fagge LGA and all sachet water sources across all LGAs are in good ratings and fit for human consumption.

Overall, it can be said that the sachet water followed by tap water are the most suitable for consumption except for its environmental implication. Residents are therefore advised to consume more of the sachet water and it is recommended that the government, community and private individuals should work collectively in providing proper waste management disposal systems that would take care of waste and refuse dumps within the metropolis in order to limit water contamination and environmental pollution.

REFERENCES

Adamu, S. (2009). Tackling Water Shortage in Kaduna. The Herald, Daily.

Akunyili, D.N. (2003). The Role of Pure Water and Bottled Water Manufacturers in Nigeria. Paper presented at the 29th Water, Engineering and Development Centre International Conference, in Abuja, Nigeria.

Asuquo, J.E. and Etim, E.E. (2012). Water quality index for assessment of borehole waterquality in Uyo metropolis, AkwaIbom state, Nigeria. *International Journal of Modern Chemistry*, 1(3), 102-108

Bichi, M.H. and Amatobi, D.A. (2013) carried out a study on Assessment of the Quality of Water Supplied by Water Vendors to Households in Sabon-Gari Area of Kano, Northern Nigeria. *The International Journal of Engineering and Science*, 2(7), 09-17.

Dada, A.C. (2009). Sachet Water Phenomenon in Nigeria: Assessment of the Potential Health Impacts. *African Journal of Microbiology Research,* 3(1), 15-21.

Etim, E.U. and Adie, G.U. (2012). Assessment of Qualities of Surface Water Sediment and Aquatic Fish from Selected Major Rivers in Southwest Nigeria. *Research Journal of Environmental and Earth Sciences,* 4(20), 1045-1051.

Etim, E.E., Odoh, R., Itodo, A.U., Umoh, S.D. and Lawal, U. (2013). Water Quality Index for The Assessment of Water Quality from Different Sources in the Niger Delta Region of Nigeria. *Frontiers in Science*, 3(3), 89-95.

Fasae, F.O and Omolaja O.E. (2014).The Assessment of Drinking Water Quality from Different Sources in Smallholder Ruminant Production in Abeokuta, Nigeria. *Journal of Food Science and Quality Management.* 29, 25-57

Gbadegesin, N. and Olorunfemi, F. (2007). Assessment of Rural Water Supply Management in Selected Rural Areas of Oyo State. ATPS Working Paper Series No. 49.

Ishaku, J.M. (2011). Assessment of Groundwater Quality Index for Jimeta-Yola area, Northeastern Nigeria. *Journal of Geology and Mining Research*, 3(9); 219-231.

Maconachie, R. (2008). Surface Water Quality and Per-urban Food Production in Kano, Nigeria, Urban Agriculture Magazine. Retrieved March 21, 2014.

McDonnell, G. (2002). The dynamics of geographic changes: The case of Kano. *Annals of Association of American Geographers,* 34:355.

Miller, G.T. (1997). *Environmental Science. Working with the Earth*. 6th ed. WadsworthPublishing Company, USA. 285-6.

Mohammed, F.O. (2013). *Quality Assessment of Potable Water in Sabon-Gari, Kano*.Unpublished BSc project in the Department of Geography, Faculty of Sciences, Ahmadu Bello University, and Zaria.

NPC (2007). *Population Census of the Federal Republic of Nigeria.* National Population Commission retrieved from www.population.gov.ng

NSDWQ (2007). Nigerian standard for drinking water quality. Standard Organization of Nigeria. Wuse, Abuja.

Oko, J.O., Aremu, M.O., Odoh, R., Yebpella, G. and Shenge, G.A. (2014). Assessment of Water Quality Index of Borehole and Well Water in Wukari Town, Taraba State, Nigeria. *Journal of Environment and Earth Science,* 4(5), 1-9.

Olofin, E.A. and Tanko, A.I. (2002). Some Aspect of Physical Geography of Kano Region and Related Human Responses. Handbook for Students' Field Trip, Geography Department Bayero University, Kano.

Olowe, B.M., Oluyege, J.O. and Famurewa, O. (2016). An Assessment of Drinking Water Quality Using Water Quality Index in Ado-Ekiti and Environs, Nigeria. *American Chemical Science Journal,* 12(2), 1-7.

TWAS (2002). Safe Drinking Water the need, the Problems, Solutions and Action Plan. Third World Academic of Sciences, Italy. 8-12

WHO (2002). Report- Reducing Risk and Promoting Healthy Life. World Health Organization Accessed January 02, 2014. http://www.who.int/whr/2002/en/

WHO (2010).World Health Statistics Report and Promoting Healthy Life. World Health Organization. Accessed April 19,2017.http:// www.who.int/bookorders/anglais

Yamaguchi, A. and Wesselink, A. (2000). IHP-V. Technical Documents in Hydrology. 38(2). UNESCO, Paris.