



Analysis of Water Supply and Demand in Kaduna North Local Government, Kaduna, Nigeria

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ABSTRACT

Water supplies monitored in Kaduna Urban area have shown persistent shortages relative to demand in some areas. This study aims to evaluate the availability of water supply in Kaduna North local government area of Kaduna metropolis. A questionnaire survey and structured interviews were administered to determine the sources of water and water consumption in the study area using stratified random sampling. The medium and low-density households mostly use Tap and borehole water as their sources, the high-density areas relied on Tap and well water while the commercial, industrial and institutional establishments adopted Tap and boreholes. The result of the analysis from the random sample surveyed in low, medium and high-density areas showed that the residential per capita water uses in low density ranged between 70.25 L/d to 115.22 L/d with an average value of 92.74 L/d, for medium density areas ranged from 55.50 L/d to 66.94l/d, with an average of 61.22 L/d. The results obtained from the comparison of water demand in sectors using billing, survey and Kaduna State Water Board (KSWB) water demand, show that the total water consumption by billing method is lower compared to the other cases with a value of 39,185,300 L/d for the three sectors, followed by the KSWB standard with a higher value of 56,061,124 L/d for the three sectors, while survey data happens to be the one with a higher value of 56,473,837.5 L/d total water demand for the three sectors in comparison with the other cases, this shows that the water supply to the consumers is lower than the demand. Also, the quality of the water was assessed by carrying out laboratory tests on 17 physiochemical and 2 microbiological parameters in comparison with the World Health Organization (WHO) standard of drinking water and the Nigerian standard (NSDWQ). The results indicated that sample 1 (S1) is a raw water sample collected from river Kaduna, Malali before treatment is above all the limits set by WHO and Nigerian standards, while other points of the collection have most parameters within the limits except for some heavy metals and total dissolved solids.

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INTRODUCTION

Water is a natural resource of fundamental importance and supports all forms of life. Water demand already exceeds water supply in many parts of the world, and as the world population continues to rise at an unprecedented rate, many more areas are expected to experience this imbalance shortly Rahaman and Varis (2008.).

Water is a very basic necessity of life. The planet earth has an enormous quantity of

water, but usable water is very limited. About 71% of the earth's area is covered by water. Out of the total quantity of water, 97.2% is salt water and 2.8% is fresh water. Out of the 2.8% fresh water, 2.2% is surface water and the remaining 0.6% is groundwater (Yao, 2013).

Nigeria is endowed with abundant natural water resources evident in substantial yearly rainfall, large surface bodies of water-rivers, streams and lakes, as well as abundant reservoirs of underground water whose extent



and distribution have not been fully assessed (Mohammed, 2016). Over eighty per cent of the rains in the country fall within the six wet months (April to September), of each year (Mohammed, 2016). A sizeable amount of the rainwater is lost by percolation to underground flows. The bulk of the rain, however, flows as runoff into rivers, streams and lakes. From these surface water bodies and through vegetation some of the rainwater is lost to the atmosphere by evapotranspiration. Water is at the centre of economic and social development; it is vital to maintain health, grow food, manage the environment, and create jobs. Despite water's importance, over 663 million people in the world still lack access to improved drinking water sources.

Yao (2013), presented a study on performance evaluation in the water distribution system by using the value engineering methodology. He considered two primary objectives: The first was to understand the evaluation of an installed municipal water supply delivery system by identifying all the physical components of any specific water distribution system. The second objective was to provide recognized practices for conducting water supply tests at prescribed intervals to measure the water system delivery capability and ensure that the system is meeting.

Municipal water demand for current and future use is a key element in water demand analysis. Municipal water values reflect multiple waters uses by urban dwellers, with different values associated with different uses. Water used for indoor purposes such as drinking, cooking and bathing is thought to be the most highly valued and to be the least responsive to price changes Colby (1989). Water used outdoors for landscape watering and swimming pools is somewhat less highly valued (Colby, 1989). Some analyses have differentiated between summer and winter urban water demand (Colby, 1989). In general, water rates for urban residents do not change much in real terms (that is, they rise at about the inflation rate), so the opportunity to observe how quantity demanded changes over a substantial price range is rare.

According to the estimation of water demand figures of WHO/UNICEF Joint Monitoring Programme (2015) a figure of 120litres per capita per day (l/c/d) wholly inclusive water demand figure for urban areas

as it represents the latest recommended standard (KSWB detailed engineering design report phase II Volume 1, Dec 2006). Similarly, according to the detailed engineering report phase II Volume 1 Dec 2006 designed the overall water demand across the 48 enumeration localities in Kaduna metropolis gave a figure of approximately 176,125,000 202,879,000 233,955,000 and 270,118,000l/d as an average water demand estimated for the year 2005, 2010, 2015 and 2020 respectively.

Kaduna Metropolis consists of four Local Government Areas (LGAs), namely: Kaduna North, Kaduna South, Igabi and Chukun with a total number of about 48 wards in the metropolis. Kaduna North LGA is the study area which is located within the Metropolis and consists of about 12 wards with 14 localities out of the total 48wards in the metropolis. The study area in the metropolis is situated in the centre of Northern Nigeria; it is cited on gently sloping ground on the west bank of River Kaduna, which serves as a good source of water. It has a population of about 364,575 (2006 census) the figure projected with a growth rate of 2.47% to 465,323 as the current population in 2016.

Kaduna lies in the guinea savannah zone as the rainfall diminishes in the transition from south to Northern Nigeria the rain forest gives way to the savannah woodland, which consists mainly of grasses and scattered trees. The rainfall is normally from April to October with an average of 1500mm (52.2inch). The month of August/September has the highest record with 5 months less than 22mm (11inch) and 4 months with relative humidity at noon 20% or less. The average temperature is 32°C (Ajibade & Okwori 2009).” The distribution of rain varies in different parts of the state. High evaporation during the dry season creates water shortage in many parts of the LGA in the state (Ajibike, 2012). Kaduna River is the main source of water supply for the community of Kaduna Metropolitan.

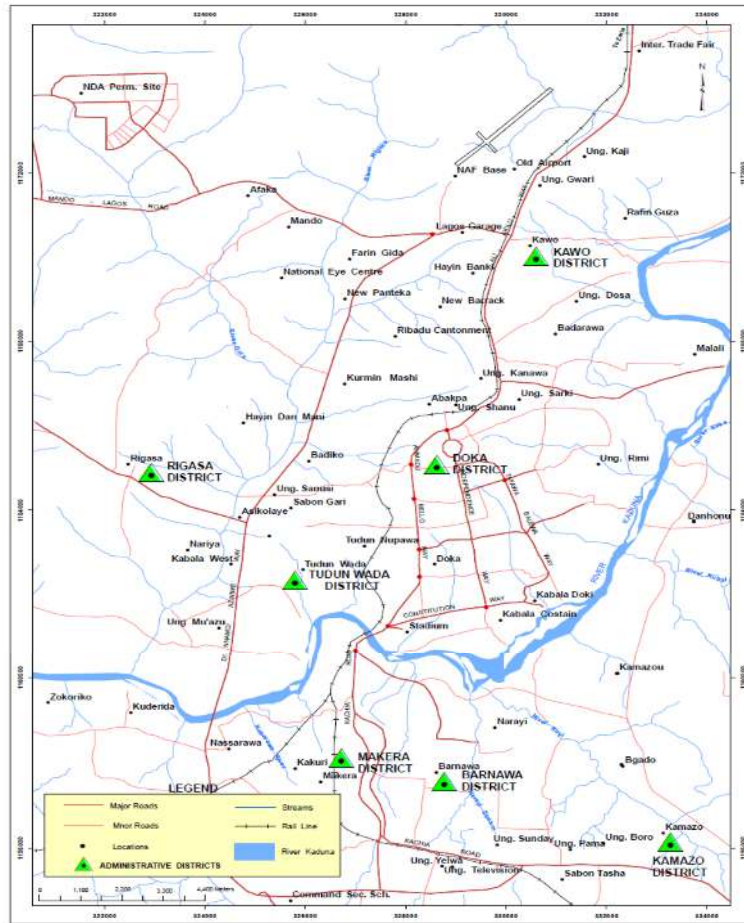


Figure 1: Map of Kaduna Metropolis Showing Some Administrative District Areas

MATERIALS AND METHOD

The materials used include a structured questionnaire survey, population data and oral interview the method adopted in this study is the use of questionnaire survey and structural interview to determine the water consumption and sources while laboratory tests were used to assess the quality of water supplied in the study area.

A stratified random sampling technique was adopted to administer the questionnaire. A total of 280 samples of the questionnaire were administered to 280 households spread across the thirteen political wards in Kaduna North LG in Kaduna Metropolitan town at the rate of 20 households per ward. The household heads were randomly

interviewed based on the streets. Four streets were selected from each political ward using random sampling and a total of 5 questionnaires were administered on each street.

Method for Population Forecast

The geometric increase method being the most popular method used for future population forecast was also adopted to forecast the future population of Kaduna North LGA. In this method, the per decade percentage increase or percentage growth rate (r) is assumed to be constant, and the increase is compounded over the existing population every decade. This method is therefore also known as the uniform increase method. Hence geometric increase is given by:

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$$P_n = P_o (1 + r/100)^n \dots (3.1.)$$

Where P_n the population forecast,

P_o is the initial population,

r is the growth rate

n is the number of forecasts in years.

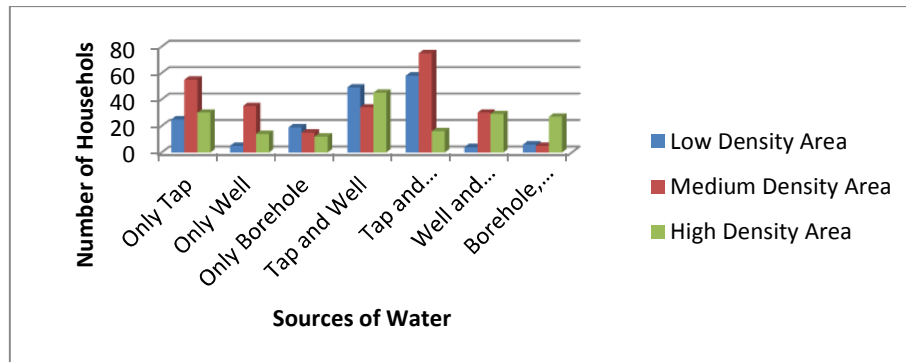
The latest population data for the study area is for the census of 2006 and it was used to obtain a new projected figure with a growth rate of 2.47% for the year 2016.

The method for the analysis adopted is laboratory experimentation for the physiochemical parameters and bacteriological analysis/examination of water samples collected from the river (raw water) and various units of operation in the treatment plant and some selected service outlets. A total of (17) physiochemical and 2 microbiological parameters were considered adequate to evaluate the water quality in the study area.

Method for Evaluating Water Quality

Table 1: Sources of water supply to the Residential Areas

Sources of Water	Number of Households indicating Various Sources of Water		
	Low-Density Area	Medium Density Area	High-Density Area
Only Tap	25	55	30
Only Well	05	35	14
Only Borehole	19	15	12
Tap and Well	49	34	45
Tap and Borehole	58	75	16
Well and Borehole	04	30	29
Borehole, Well and Tap	06	05	27



Source: Field Work 2018

RESULTS AND DISCUSSIONS

The results show the survey of sources of water according to the different areas obtained for medium-, low- and high-density areas. The surveyed results indicated that those

who use tap and boreholes in low and medium-density areas have the highest record of their water sources. While in high-density areas, households depend mostly on tap and well water as their sources of water supply.

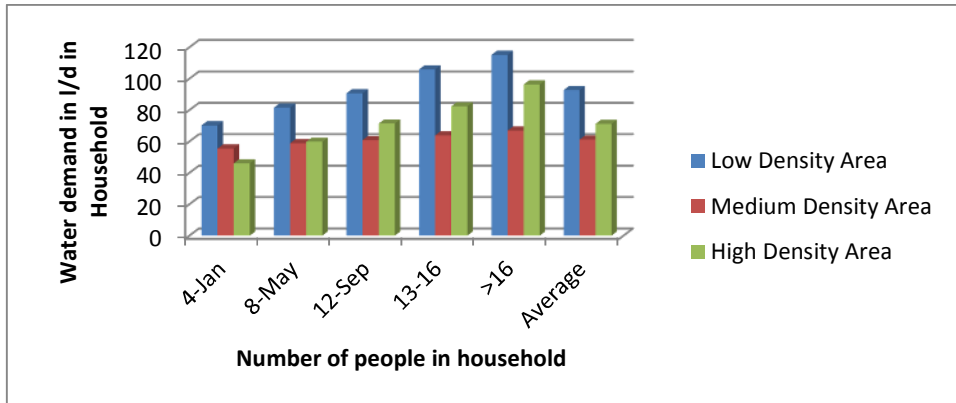
Table 2: Water demand according to population density

Number of people in a household	Water demand in l/d in Household according to density area		
	Low-Density Area	Medium Density Area	High-Density Area
1-4	70.25	55.50	46.07
5-8	81.62	58.85	59.80
9-12	90.70	60.91	71.45
13-16	105.91	63.90	82.41
>16	115.22	66.94	96.37

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Average	92.74	61.22	71.22
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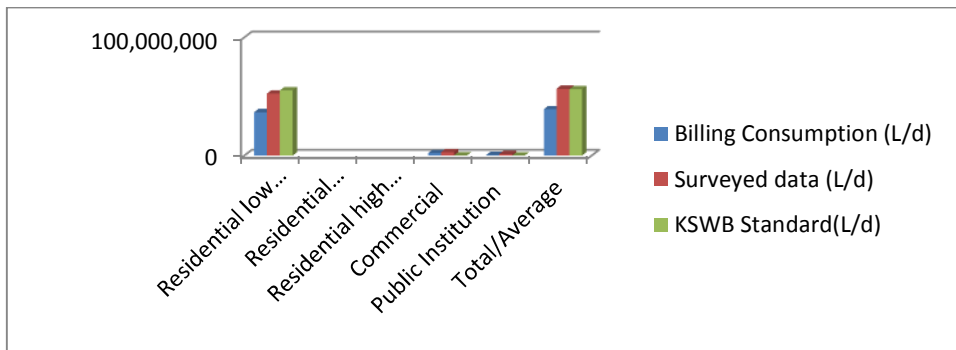
Source: Field Work 2018

The results show the analysis from the random sample surveyed in low, medium and high-density areas per household occupants showed that the residential water used in low-density areas ranged between 70.25 l/d to 115.22 L/d with an average value of

92.74 L/d. The residential water used for medium-density areas ranged from 55.50 L/d to 66.94l/d, with an average of 61.22 L/d. Also, the residential water use in high-density areas was between 46.07 L/d and 96.37 L/d with an average value of 71.22 L/d.

Table 3: Comparison of water demand/Consumption estimation in sectors

Sectors	Billing Consumption (L/d)	Surveyed data (L/d)	KSWB Standard(L/d)
Residential low densities areas	36,542,300	52,348,837.5	55,061,120
Residential medium densities areas			
Residential high densities areas			
Commercial	2,111,667	2,868,000	172,080
Public Institution	531,333	1,257,000	50,280
Total/Average	39,185,300	56,473,837.5	56,061,120



Source: Field Work 2018

The results show the summary of the comparison of water demand/Consumption in sectors using billing, survey and KSWB



Standard water demand. In the result, the total water demand by billing data is 39,185,300 l/d for the three sectors, in the survey, the total water demand for the three sectors is 56,473,837.5 l/d while the total water demand

by the standard KSWB for the three sectors is 56, 061, 12. This comparison showed that the water supply to the consumers is lower than their demand.

Table 4: Analysis of Water Quality of Malali Treatment Plant

S/N	Parameter	Unit	S1	S2	S3	S4	S5	NSDWQ	WHO
A									
Aesthetic									
1	Ph	-	5.5	6.8	6.8	6.7	6.1	6.5-8.5	6.5-8.5
B									
Chemical									
2	Electrical conductivity	µS/cm	1200	300	405	500	610	1000	1000
3	Total Dissolve solid	Ppm	1110	860	866	960	1003	500	500
4	Turbidity	NTU	8.8	0.2	0.8	2.1	5.1	5	5
5	Temperature	0c	23	25	25	25	25	-	No. obj
C									
Microbiological									
6	Total Hardness	mg/l	620	192	204	220	260	150	500
7	Iron	mg/l	2.11	0.01	0.11	0.44	0.46	0.3	0.3
8	Calcium	mg/l	288	76	88	92	176	-	75-200
9	Magnesium	mg/l	280	68	76	76	164	0.2	0.2
10	Zinc	mg/l	ND	ND	ND	ND	ND	-	0-3
11	Mercury	mg/l	1.8	1.5	1.5	1.4	1.7	-	0.001
12	Lead	mg/l	2.5	0.07	0.05	0.04	0.05	0.01	0.01
13	Fluoride	mg/l	2.6	2.0	2.0	1.6	1.9	1.5	1.5
14	Nitrate	mg/l	69	10	10	28	28	50	50
15	Chloride	mg/l	291	78.1	78.1	205.9	205.9	200	250
16	Sulphate	mg/l	408.86	122.11	123.48	412.97	426.68	100	200
17	T.ResidualChlorine	mg/l	NA	0.3	0.03	Nil	Nil	-	0.2
C									
Microbiological									
18	Fecal Coliform	Cfu/100ml	18	2	2	2	2	0	0
19	Total Coliform	Cfu/100ml	Trace	Not detected	Not detected	Not detected	Not detected	10	10

Table 4 shows the analysis of some parameters of water quality in the Kaduna water treatment plant to supply potable water to the consumers and the value was compared with the standard value of the World Health Organization (WHO) standard of drinking water. Samples at five different points were collected to test the quality of the water namely sample 1 (S1) is a raw water sample collected from river Kaduna, Malali before treatment, sample 2 (S2) is treated water at the clarifiers, sample 3 (S3) is treated water at the reservoir, sample 4 (S4) is a treated water sample at Doka booster station and sample 5(S5) is treated water sample at Tudun Wada booster station. The result of the analysis is shown in Table 4.7 in comparison with the World Health Organization (WHO) guidelines of drinking water standards and the Nigerian Standard of drinking water quality (NSDWQ

CONCLUSION

From the results obtained it can be concluded that those who use tap and boreholes in low and medium-density areas have the highest record of their water sources. While in high-density areas, households depend mostly on tap and well water as their sources of water supply.

For the case of demand, the result of the analysis from the random sample surveyed in the low, medium and high-density area showed that the residential per capita water use in low-density areas ranged between 70.25 L/d to 115.22 L/d with an average value of 92.74 L/d. The residential per capita water use for medium-density areas ranged from 55.50 L/d to 66.94l/with an average of 61.22 L/d.

The summary for the comparison of the water demand in sectors using billing, survey and KSWB water demand, shows that the total water consumption by billing method is

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lower compared to the other cases with a value of 39,185,300 L/d for the three sectors, followed by the KSWB standard with a higher value of 56,061,124 L/d for the three sectors, while survey data happens to be the one with a higher value of 56,473,837.5 L/d total water demand for the three sectors in comparison with the other cases, this shows that the water supply to the consumers is lower than their demand. VI.

RECOMMENDATIONS

1. It is recommended that the government should introduce a system of meter policy to ascertain the actual demand used by the consumers.
1. 2. Further research on determining water supply efficiency in Kaduna should be carried out using other indicators such as water coverage and distance of water supply.

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