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SUITABILITY OF GROUNDWATER QUALITY FOR DRINKING USING WATER QUALITY INDEX IN KANO METROPOLIS, NIGERIA

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ABSTRACT

Groundwater is an important source of drinking water in Kano Metropolis, Nigeria. This study aims to assess the suitability of groundwater for drinking using the water quality index (WQI). 960 water samples were collected from 160 sites in the Kano Metropolis and analyzed 9 physicochemical parameters, 9 heavy metals and two groups of microbial parameters using American Public Health Association standard procedures in a laboratory. The values obtained for the various parameters were then compared to the World Health Organization's (WHO) and Nigerian Standards for Drinking Water Quality (NSDWQ). The overall WQI for each LGA was calculated using Weighted Arithmetic Index guidelines. The results showed that overall WQI is generally unsuitable for drinking with ranged values of borehole water from 47.07 - 149.51 in Dala and Nasarawa respectively while the well water ranged from 94.17 - 251.44 at Tarauni and Kumbotso and spatially represented in map of Kano metropolis. Marginally suitable for drinking were recorded at Dala and some individual wells in well-planned and clean areas (Bompai Quarters, GRAs). The T-Test statistical analysis between borehole and well in Dala, KMC and Nasarawa LGAs showed significant variations at $P = < .05$ while Fagge, Gwale, Kumbotso, Tarauni and Ungogo LGAs showed no significant differences. The study recommends the need for improved water management strategies, such as desalination and water treatment, to increase access to safe drinking water.

Keywords: Groundwater, suitability, contaminate, water quality, index, pollution

INTRODUCTION

Water is one of the most valuable resources on the earth. Its significance necessitated Pindar, a Greek Poet Philosopher in the work of Lawrence (1923) referred to water as the "best of all things" needed by all living things for survival. However, it is disheartening to note that water bodies in urban and peri-urban areas globally are being polluted on a daily basis from on-site sanitation especially the shallow wells and boreholes, industrial effluent discharges and nonpoint pollution sources. Water sources all over the globe especially in underdeveloped world are heavily polluted by physical, chemical and biological discharges from industries and households to nearby adjoining rivers, ponds or streams. They pollute both the surface and groundwater and make them unsuitable for drinking. (Ince et al., 2010; Olatunji and Osibanjo, 2012; Onwughara et al., 2013; Samandra et al., 2022; Mshelia, et al., 2023).

To ascertain the suitability of drinkable water, a numbers of indices have also been postulated to give meaningful water quality data that can be easily comprehended by water board agencies as well as the common man whose life depends so much on it. One of these indices widely being used is the Water Quality Index (WQI). In the 1970s Horton developed the first WQI in which multiple test results of water quality parameters such as physicochemical and heavy metals were mathematically computed to get a single value that describe the quality of water at a particular location (Boyi *et al*., 2017; Mshelia et al., 2023). The calculated index results indicate the suitability of water in wells and boreholes. The quest to know more about water, a very significant resource resulted in more works on WQI based the on rating of different water quality parameters. Some years back, Brown and O'Connor (1971) and Tiwari and Mishra (1985) using WQI gave insights on the apparatus for giving a cumulatively derived, numerical expression to define water quality as suitable for drinking. It is interesting to know that today various statistical approaches can be employed to analyze water quality data based on rank order of observations and factor analysis (Ezeilo and Oba, 2016).

Conceptual Clarification

The water quality index is a pattern or way of encapsulating big and cumbersome data on the quality of water in precise words such as excellent, good, fair, poor and very poor. It is used to indicate to water agencies, management and the public in a tenacious demeanor or tone. WQI reveals if the cumulative quality of water bodies subjected to analyses has a potential threat to the overall uses of water either for drinking, agricultural purposes or for domestic uses as in aquatic ecosystem habitat, social life and aesthetics. WQI also takes into cognizance a set of standards employed to measure divergent changes in the quality of water bodies of different kinds and the comparison of different sources over time, basically under factors: scope, frequency and amplitude having base assessment between 0 – 100 to ascertain the suitability of the water quality of areas and sources (David et al., 2007; Dibofori-Orji and Edori (2015).

Many Scholars such as Boyi et al., (2017), Oko et al., (2014), Chandne (2014), Bolagun et al., (2021), Chiadic et al., (2023), Chen *et al*., (2020), Ibrahim (2019), Choi and Choi (2021), Gamvroula and Alexakis (2022), Makubura et al., (2022) and Parween et al., (2022) investigated WQI for drinking water and applications of technology and models in different parts of the universe which includes Kano, Lagos, India, Lebanon, China, Korea, Washington USA and Sri Lanka respectively. The findings revealed high WQI especially in unplanned populated and low-income quarters devoid of basic infrastructural facilities while well-planned areas, with availability of basic water treatment facilities recorded suitable and moderate WQI for drinking. Further assessments by Mshelia and Bulama (2023) and Mshelia et al., (2021) showed that there are high concentrations of physicochemical, microbial parameters and heavy metals in virtually all surface water and groundwater-based water supplies especially turbidity in surface water most common during the rainy season when rivers carry high sediment load and iron in groundwater. It is against this backdrop that the study seeks to assess the suitability of the quality of drinkable water using WQI through investigation and comparison of boreholes and wells water quality index in different locations such as the highly populated, unplanned settlements and Government Reservation Areas (GRAs) in Kano Metropolis with the view of providing information water suitable for drinking, water pollution and city management.

MATERIALS AND METHODS

Location and Extent

Kano Metropolis is located between latitudes 11º40'N and 12º25'N of the equator and longitudes 8º30'E and 8º 4'E of the Greenwich meridian (see Figure 1). The metropolis which embodied eight Local Government Areas envelopes a land mass of 499Km^2 (Mshelia et al., 2020). Kano metropolis is mostly hot throughout the year, especially the afternoon temperature. The average mean temperature is about 28^{0}C. March, April and May are considered to be the hottest months and December, January and early February are the coldest. The metropolis records an annual average rainfall of 696.4mm (NiMET, 2020).

Water Sample from Boreholes and Wells in the Urban Centres of the Metropolis

Systematic and random samplings were employed in the selection of sampling points in the eight Local Government Areas (LGAs) that constituted the Metropolis. Eight wards were then sampled in each LGA and 8 wells and boreholes were selected in each of the 8 selected wards in Dala, Gwale, Fagge, Kano Municipal Council (KMC), Kumbotso, Nasarawa, Tarauni and Ungoggo (see Figure 2 and Table 1). Water samples were collected 6 times at each sampled well and borehole during both dry and wet seasons.

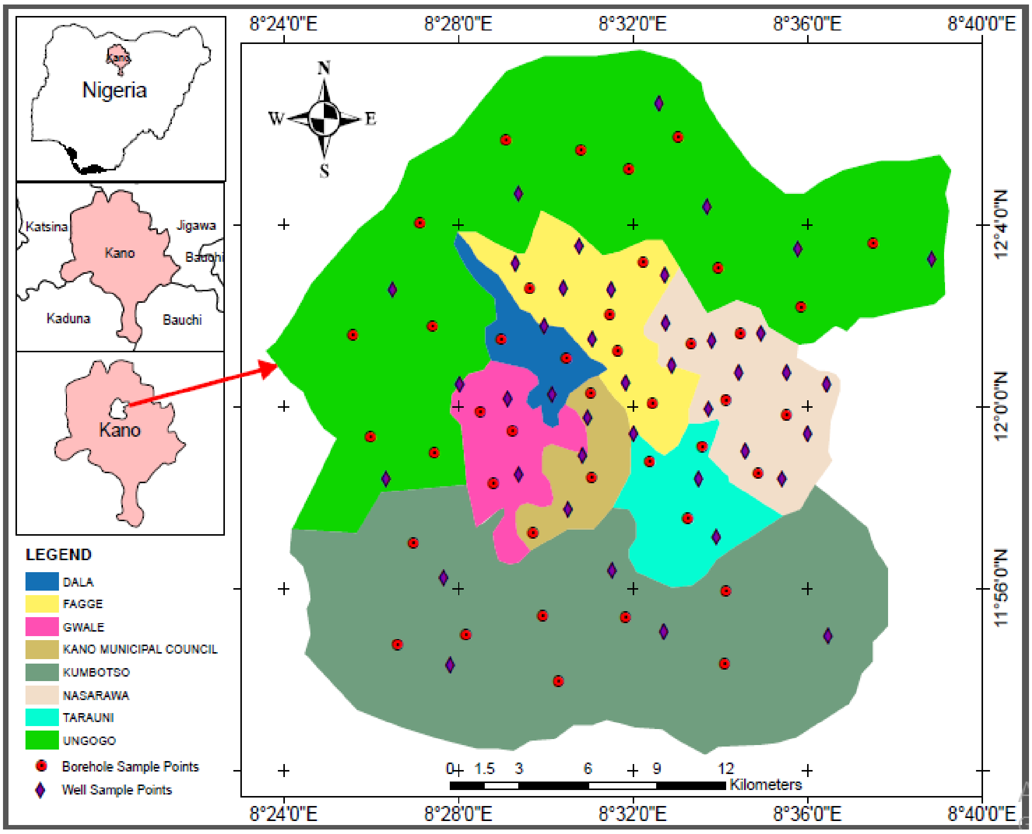

Figure 1: Sampled Points for Well and Borehole Water in Kano Metropolis.
Source: Cartography Unit Geography Department Federal University Gashua (2022).

Table 1: Summary of Groundwater (Borehole and Well) Collected in the Metropolis

Location	Season	Type of sample	Period collected	No of the sampled points	Frequency of samples collected at each sampling point
Kano Metropolitan councils (Urban)	Wet	Well	28-29/06 – 24-25/08/2022	40	6(40 x 6 = 240)
	Dry	Well	28/2-01/3 – 26-27/04/2022	40	6(40 x 6 = 240)
	Wet	Borehole	28-29/06 – 24-25/08/2022	40	6(40 x 6 = 240)
	Dry	Borehole	28/2-01/3 – 26-27/04/2022 (6x @ 1wk interval)	40	6(40 x 6 = 240)
Total				**160**	**960**

Source: Field Survey (2022).

A total of forty of each well and borehole water samples were randomly collected in Kano Metropolis and subjected to laboratory analyses. The well water was allowed to be first fetched by the residents in the morning (6 – 8 am) while the borehole ran for 5 -10 minutes before the samples were collected, put and stored in 250ml – 300ml thoroughly washed plastic bottles with iodized and rinsed with distilled water. Samples were taken to the laboratory and subjected to analysis to determine the concentrations of physicochemical, heavy metals and microbial parameters. The values were used for the computation of the Water Quality Index using the Weighted Arithmetic Index used by Tiwari and Mishra (1985) and Mishra and Patel (2001); Brown et al., (1972); were adopted for the study equation.

$$WQI = \sum_{I-I}^{i-i} Wiqi$$

Therefore, the quality rating scale for each parameter

$$qi = \frac{ci}{si} \times 100$$

Where WQI = Water Quality Index.
Qi = Quality Rating Scale
Ci = Concentration in each Water Sample
Si = Respective Standards
Wi = Relative weight

Table 2: Water Quality Index Level and Status

Water Quality Index Level	Water quality Status/Designation
0 – 25	Excellent
26 – 50	Good
51 – 75	Bad
76 - 100	Very Bad
100 and Above	Unfit for Consumption

Source: Adapted from Mishra and Patel (2001).

The student's t-test is a statistical method that is used to test the significant difference between borehole and well WQI in Kano Metropolis at P = < .05.

Formula

$$T = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_1^2}{n_2}}}$$

S_1 = standard deviation of first sets of values
S_2 = standards deviation of second sets of values
n_1 = standard deviation of first sets of values
n_2 = standard deviation of second sets of values

RESULTS AND DISCUSSION

The concentrations of physicochemical, heavy metals and microbial parameters on groundwater in Kano Metropolis were anlyzed in the laboratory (see Tables 3, 4 & 5) which were used for the computation of well and borehole WQI for Kano Metropolis. The determined results showed that the concentrations of some parameters such as TDS, turbidity and total hardness were recorded above the permissive limits especially during the wet season while some fall within the acceptable thresholds as viewed by WHO (2010) guidelines and NSDWQ (2015) standards. The values above the acceptable limit can be ascribed to variations in organic matter that settle as residue in the well water, infiltrations, seepages, stormwater, location of dumpsites, toilets, pit latrines close to water sources and leaches of the contaminants as well as the wastewater being discharged into the environment in most cases without treatment from the industries and houses (Mshelia et al., 2020).

Water Quality Index in Kano Metropolis

The WQI for the metropolis was determined by computing the values of all the physicochemical parameters, heavy metals and groups of microbial parameters at the different locations established in Kano metropolis. Using the Weighted Arithmetic Index by Mishra and Patel (2001) and Brown et al., (1972) in line with the WHO (2010) drinkable water quality guidelines, the results were computed and discussed based on the general water quality ratings of boreholes and well water sources in the Kano Metropolis.

Table 3: Borehole and Well Water Mean Concentration of Physicochemical Parameters at Urban Centre of Kano metropolis during Wet and Dry Seasons

Parameter/Point	Dala	Fagge	Gwale	KMC	Kumbotso	Nasarawa	Tarauni	Ungogo	WHO (2010)	NSDWQ (2015)
	BH1	BH2	BH3	BH4	BH5	BH6	BH7	PBH8		
BH Urban WS										
Temp (^{0}C)	27	27.5	27.3	28.5	29	30.5	29.0	27.7	27-28	27-28
pH	6.4	7.3	8.6	7.8	8.35	9.51	7.0	8.50	6.5-8.5	6.5-8.5
EC (µS/cm)	666.5	710.3	835.3	713.8	952	1200	689	441.5	1000	1000
Turbidity (NTU)	5.6	4.8	5.2	6.5	7.4	5.8	8.0	7.5	5.0	5.0
TDS (mg/L)	536.5	463.2	321	648.8	354	674.8	501.5	509.2	500	500
TH (mg/L)	152	12.6	123	112.6	152.5	117	165.3	123.4	150	100
DO (mg/L)	4.62	2.5	3.11	4.80	3.7	3.75	3.95	4.15	3	4-7
BOD (mg/L)	1.12	1.50	1.10	1.95	1.01	2.85	2.01	2.18	4	3
Nitrate (mg/L)	98.5	58.5	56.2	74.2	30.5	103.2	65.7	64.3	11	50
BH Urban DS										
Temp (^{0}C)	27	28.2	27.3	28.5	27	28.0	27.0	28.5	27-28	27-28
pH	6.34	6.30	7.50	6.68	6.35	6.51	6.75	7.80	6.5-8.5	6.5-8.5
EC (µS/cm)	455.6	653.1	354.4	525.3	434.5	654	386.7	456.6	1000	1000
Turbidity(NTU)	3.05	2.72	3.28	2.82	5.0	2.70	3.15	2.75	5.0	5.0
TDS (mg/L)	372.5	547.8	575.6	547.4	302.5	426.7	321.6	448.2	500	500

TH (mg/L)	118.7	223.1	92.5	95.9	83.5	109.9	110.5	98.5	100	100
DO (mg/L)	4.62	2.5	3.11	2.80	3.7	3.75	3.95	4.15	3	4-7
BOD (mg/L)	1.10	1.80	2.10	1.17	0.95	4.85	4.01	2.44	4	3
Nitrate (mg/L)	98.5	58.5	56.2	74.2	30.5	103.2	65.7	64.3	11	50
W Urban WS	**W1**	**W2**	**W3**	**W4**	**W5**	**W6**	**W7**	**W8**		
Temp (^{0}C)	27	28	30.2	29.5	30.0	28.5	27.0	30	27-28	27 -28
pH	9.8	8.1	7.1	7.82	9.1	7.07	8.6	7.0	6.5-8.5	6.5-8.5
EC (µS/cm)	651.5	1172	586.5	1202	476.5	1342	805.3	864.3	1000	1000
Turbidity(NTU)	5.4	6.27	6.0	5.5	7.9	5.4	6.5	7.5	5.0	5.0
TDS (mg/L)	762	655	712	721.7	543	385	464	667.7	500	500
TH (mg/L)	152.3	143	285.2	204.6	165.8	252.1	215.6	86.67	100	150
DO (mg/L)	3.22	2.8	4.84	5.82	4.2	2.45	2.90	4.12	3	4-7
BOD (mg/L)	1.10	15.5	1.45	2.07	1.52	0.82	1.04	1.25	4	3
Nitrate (mg/L)	65	55.6	55.0	132.2	145.4	56.6	88.8	64.1	50	50
W Urban DS										
Temp (^{0}C)	26.5	27.5	27.1	27.5	27.0	27.2	27.4	27.5	27-28	27-28
pH	7.28	7.51	7.25	7.82	7.23	7.37	7.42	7.46	6.5-8.5	6.5-8.5
EC (µS/cm)	517.5	371.6	386.5	602	476.5	1042	405.3	464.3	1000	1000
Turbidity(NTU)	4.45	5.61	4.26	3.46	5.17	5.31	4.07	5.33	5.0	5.0
TDS (mg/L)	461.3	642.7	615.2	587.2	395	543.8	436.5	467.3	500	500
TH (mg/L)	66.2	54.32	78.3	180.2	96.8	126.2	170.5	86.67	100	150
DO (mg/L)	3.22	2.8	2.84	2.82	3.2	3.45	2.90	4.12	5	4-7
BOD (mg/L)	1.15	1.1	2.10	2.25	1.88	0.95	1.02	1.76	5	3
Nitrate (mg/L)	24.5	28.3	83.4	95	72.12	48.34	38.2	28.4	50	50

BH= Borehole, W= Well, WS= Wet Season, DS= Dry Season.
Source: Field Survey (2022)

Table 4: Borehole and Well Mean Concentration of Heavy Metals at Urban Centres in Kano Metropolis during Wet and Dry Seasons

Parameter/Point	Dala	Fagge	Gwale	KMC	Kumbotso	Nasarawa	Tarauni	Ungogo	WHO (2010)	NSDWQ (2015)
	BH1	BH2	BH3	BH4	BH5	BH6	BH7	BH8		
BH Urban WS										
Cadmium(mg/L)	0.05	0.05	0.08	0.04	0.082	0.015	0.08	0.25	0.003	0.003
Chromium(mg/L)	0.95	4.4	1.01	0.95	1.25	1.17	0.82	1.25	0.05	0.05
Mercury (mg/L)	0.002	.011	0.005	0.002	0.001	0.012	0.003	0.001	0.001	0.001
Arsenic (mg/L)	1,64	0.03	0.04	0.12	0.02	0.08	0.01	0.12	0.01	0.01
Lead (mg/L)	0.15	0.45	0.26	0.12	0.31	0.027	0.05	0.06	0.3	0.3
Iron (mg/L)	1.31	0.2	0.4	1.25	0.34	0.30	0.3	0.18	0.3	0.3
Zinc (mg/L)	3.2	4.4	2.45	3.0	1.65	3.75	4.3	0.54	3.0	3.0
Copper (mg/L)	4.72	5.63	2.45	3.55	2.32	1.83	2.92	1.0	2.0	1.0
Mn (mg/L)	0.56	0.40	0.11	0.54	0.54	0.75	3.03	0.35	0.5	0.2
BH Urban DS										
Cadmium (mg/L)	0.05	0.04	0.09	0.01	0.015	0.23	0.05	0.003	0.003	0.003
Chromium(mg/L)	0.81	1.01	0.65	0.81	0.88	0.68	0.81	0.96	0.5	0.5
Mercury (mg/L)	0.001	.001	0.002	0.002	0.001	0.002	0.002	0.001	0.001	0.001
Arsenic (mg/L)	0.02	0.01	0.03	0.02	0.02	0.01	0.02	0.02	0.01	0.01
Lead (mg/L)	0.11	0.02	0.02	0.017	0.35	0.02	0.02	0.16	0.3	0.3
Iron (mg/L)	3.01	2.13	1.35	3.75	1.34	2.69	2.78	0.38	0.3	0.3
Zinc (mg/L)	2.81	2.53	1.68	2.13	0.74	1.62	2.54	0.54	3.0	3.0
Copper (mg/L)	1.12	2.30	0.15	1.52	1.14	0.57	0.81	1.01	2.0	1.0
Mn (mg/L)	0.56	0.04	0.11	0.54	0.54	0.75	3.03	0.35	0.5	0.2
W Urban WS	**W1**	**W2**	**W3**	**W4**	**W5**	**W6**	**W7**	**W8**		
Cadmium (mg/L)	0.009	0.009	0.012	0.015	0.012	0.009	0.009	0.010	0.003	0.003
Chromium(mg/L)	1.72	5.11	2.62	1.61	0.75	3.42	2.51	0.56	0.05	0.05
Mercury (mg/L)	0.004	0.001	0.002	0.0113	0.004	0.004	0.012	0.052	0.001	0.001
Arsenic (mg/L)	0.04	0.015	0.05	0.08	0.04	0.06	0.01	0.02	0.01	0.01
Lead (mg/L)	0.32	0.3	0.21	0.23	0.25	0.22	0.15	0.28	0.3	0.3
Iron (mg/L)	2.62	1.50	0.55	1.85	0.5	0.4	0.4	0.21	0.3	0.3
Zinc (mg/L)	4.18	3.11	3.00	3.74	3.25	5.62	5.12	2.34	3.0	3.0
Copper (mg/L)	5.12	2.54	4.11	4.23	2.98	1.30	2.10	1.0	2.0	1.0
Mn (mg/L)	1.38	0.97	1.00	0.77	0.98	0.86	4.10	1.0	0.5	0.2

W Urban DS										
Cadmium (mg/L)	0.005	0.01	0.015	0.009	0.012	0.008	0.006	0.01	0.003	0.003
Chromium(mg/L)	0.54	3.38	0.78	0.65	0.55	0.90	0.73	0.66	0.05	0.05
Mercury (mg/L)	0.003	0.001	0.001	0.002	0.001	0.005	0.003	0.002	0.001	0.001
Arsenic (mg/L)	0.015	0.003	0.07	0.02	0.015	0.01	0.01	0.02	0.01	0.01
Lead (mg/L)	0.03	0.01	0.4	0.03	0.04	0.02	0.015	0.2	0.3	0.3
Iron (mg/L)	2.40	3.1	2.15	2.15	2.34	2.32	2.05	2.01	0.3	0.3
Zinc (mg/L)	2.48	1.53	1.25	1.50	1.44	2.52	2.54	1.12	3.0	3.0
Copper (mg/L)	2.03	0.56	2.15	1.25	1.00	0.30	1.20	0.45	2.0	1.0
Mn (mg/L)	0.75	0.11	0.01	0.12	0.22	0.042	5.07	0.31	0.5	0.2

BH= Borehole, W= Well, WS= Wet Season, DS= Dry Season
Source: Field Survey (2022)

Table 5: Borehole and Well Mean Concentration of Microbial Parameters in Urban Centres of Kano Metropolis during Wet and Dry Seasons

Parameters	Dala	Fagge	Gwale	KMC	Kumb Otso	Nasar awa	Tarauni	Ungogo	WHO (2010)	NSDWQ (2015)
	BH1	**BH2**	**BH3**	**BH4**	**BH5**	**BH6**	**BH7**	**BH8**		
BH Urban WS										
TC (cfu/100ml)	68	56	122	96	75	55	54	78	10	10
E-coli (cfu/100ml)	43	65	198	120	54	94	55	122	0	0
BH Urban DS										
TC (cfu/100ml)	32	66	97	52	25	75	21	22	10	10
E-coli (cfu/100ml)	27	132	129	70	83	118	55	21	0	0
W Urban WS	W1	W2	W3	W4	W5	W6	W7	W8		
TC (cfu/100ml)	76	76	142	176	94	104	72	110	10	10
E-coli (cfu/100ml)	52	70	145	203	64	82	186	65	0	0
W Urban DS										
TC (cfu/100ml)	46	45	96	132	127	89	62	34	10	10
E-coli (cfu/100ml)	34	46	105	170	34	54	73	61	0	0

BH= Borehole; WS= Wet Season; DS= Dry Season; W= Well
Source: Field Survey (2022).

Borehole and Well Water Quality Index

The concentration values of borehole and well water were computed statistically and obtained results as shown in Table 2. The WQI rating showed that only Dala borehole water; 47.07 is good and fit for drinking while the other WQI values in the seven LGAs: Fagge, Gwale, KMC, Kumbotso, Nasarawa, Tarauni and Ungogo obtained WQI of 139.86, 145.94, 101.04, 106.32, 149.51, 82.77 and 97.78 respectively were unfit for consumptions having WQI ranged between of 47.07 in Dala and 147.32 in Nasarawa. Similarly, the WQI computed for well water sources in all the eight LGAs exceeded 100, except Tarauni which recorded 94.17 (very poor) makes well water in the metropolis unsuitable for consumption. Well WQI falls within the range of 94.17 in Tarauni – 275.62 in Gwale in the metropolis as shown in Table 5.23. Similar values were recorded by Bolagun et al., (2021) who studied groundwater quality assessment of Kano Metropolis using WQI and geospatial techniques.

Table 6: Water Quality Index (WQI) for the LGAs in Kano Metropolis

WQI Index Level (WHO 2010; Mishra and Patel 2001)	Water Quality Status	Kano Metropolis	WQI for Water Sources	
			Borehole Water	**Well Water**
0 – 25	Excellent	Dala	47.07	105.23
26 – 50	Good	Fagge	139.86	154.71
51 – 75	Poor	Gwale	145.94	275.62
76 – 100	Very Poor	KMC	101.04	138.66
>100	Unfit for	Kumbotso	106.32	251.44
	Drinking	Nasarawa	149.51	232.14
		Tarauni	82.77	94.17
		Ungogo	97.78	187.04

Source: Laboratory Analysis (2022).

The study is in agreement with the result of the works carried out by Oko, *et al.*, (2014) who investigated the assessment of the water quality index of borehole and well water in Wukari town, Taraba State, Nigeria and reported water quality unsuitable for drinking ratings for well water WQI 136 in Wukari Town, Taraba State. It is also in agreement with the study of Ishaku (2011) on the assessment of the groundwater quality index for Jimeta Yola area, North-eastern Nigeria who reported WQI of 138.5 as unfit for human consumption without treatment as well as Olowe, Oluyege and Famurewa (2016) who reported poor water quality ratings for borehole WQI 54.16. Mohammad et al., (2015) also obtained WQI of borehole WQI within the range of 115.45 – 279.72 of borehole water and 312.76 and 201.14 of well water in their work on groundwater quality assessments for suitable drinking and agricultural irrigation using physicochemical water analysis in the Rancaekek Jtinangor District, West Java, Indonesia. However, this is in disarray to the work of Chandne (2014) who studied physicochemical parameters of the drinking water in Yavatmal, Maharashtra India, where results of the findings from well water reported WQI of 38.3 to 42.6 ascribed to modern and functional wastewater treatment plants, well-planned town and healthy disposal systems in the area.

The water Quality analyzed shows that only Dala borehole water is fit for consumption while all WQI concentrations in the other LGAs are considered unfit for drinking. In a similar vein the well water WQI in the metropolis reported >100 except for Tarauni which recorded 74.17 (very poor). Ibrahim (2019) also made similar observations in assessing groundwater quality for drinking purposes in Jordan. The WQI was further represented based on the locations and areas of its suitability for drinking using spatial mapping for boreholes and wells water in the Metropolis as shown in Figures 2 and 3.

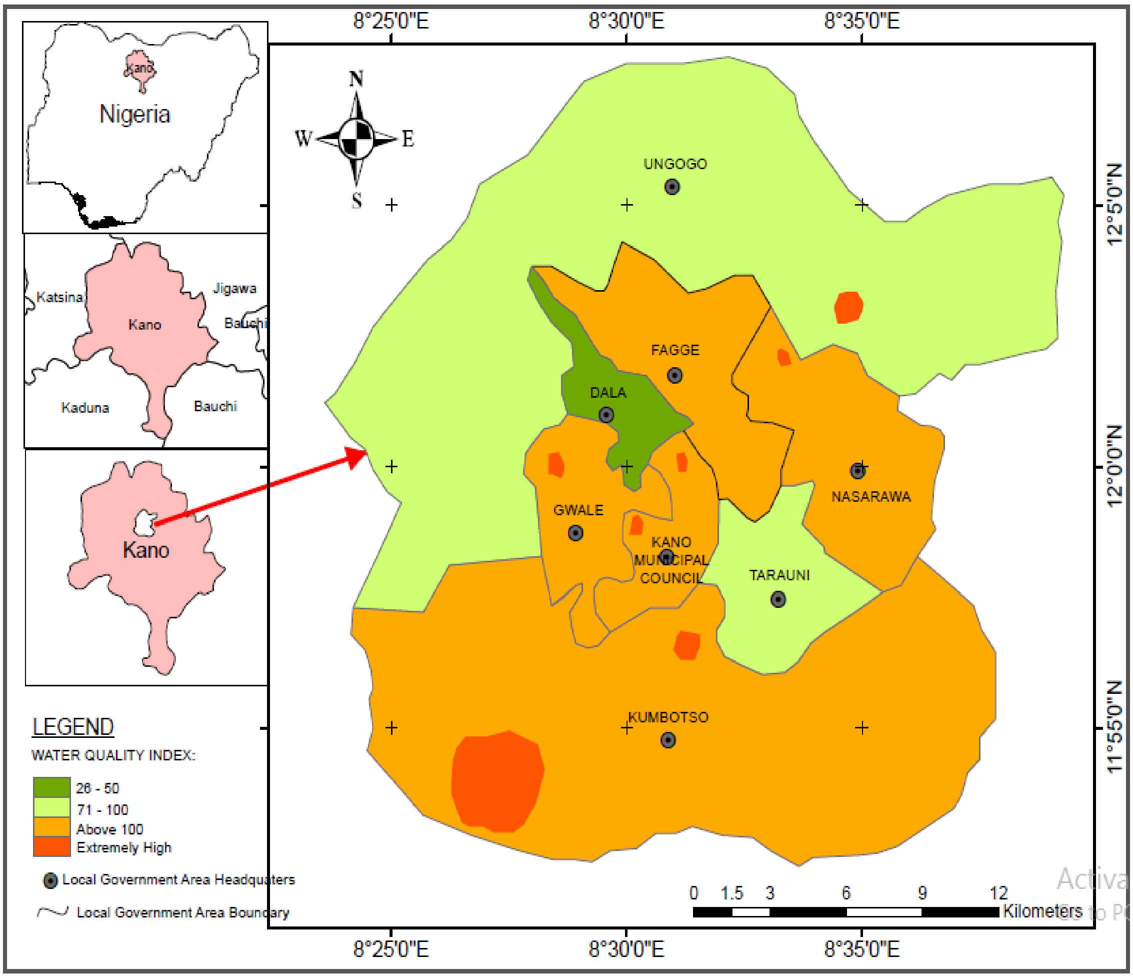

Figure 5:1 Spatial Borehole Water Quality Index in Kano Metropolis
Sources: GIS Laboratory Federal University Gashua (2022).

Similarly, the spatial mapping for well water in the Metropolis as shown in Figure 5.2 showed the overall well water quality index in the Kano metropolis.

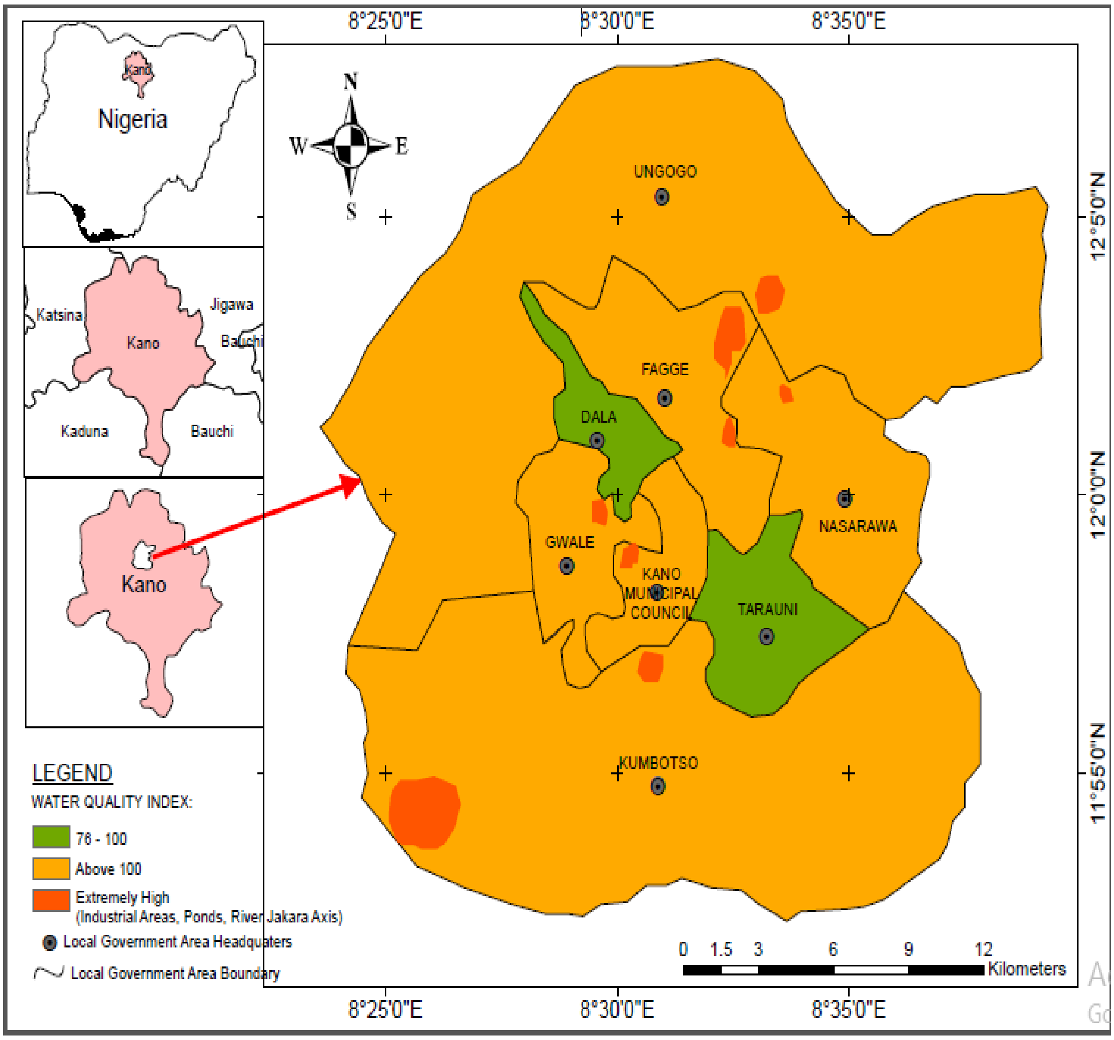

Figure 5:2 Spatial Well Water Quality Index in Kano Metropolis
Sources: GIS Laboratory Federal University Gashua (2022).

Water Quality Index Variations between Borehole and Well Water in Kano Metropolis

The Water Quality Index (WQI) for borehole and well were paired using Student T-Test to find out the status of their variations and the results in P1, 4 and 6; statistically presented as *(t(15)= 2.25, P < 0.05)*, *(t(15)= 2.92, P < 0.05)* and *(t(15)= 2.21, P < 0.05)* between borehole and well in Dala, KMC and Nasarawa LGAs showed that there were significant variations between each of the paired points between borehole water and well water because the T-values recorded significant 2-tailed values < 0.05 at 95% confidence interval. While P2, 3 ,5, 7 and 8 statistically presented as *(t(15)= 1.21, P < 0.05)*, *(t(15)= 1.93, P < 0.05)*, *(t(15)= 0.54, P < 0.05*, *(t(15)= 1.97, p < 0.05)* and *(t(15)= 0.66, P < 0.05)* that is between borehole and well in Fagge, Gwale, Kumbotso, Tarauni and Ungogo LGAs showed no significant differences since the T- values measured above 0.05 at 95% confidence interval.

The results substantially showed differences in WQI values between borehole and well water in each LGAs of the metropolis with higher values measured in well water but statistically, significant differences were recorded only in Dala, KMC and Tarauni attributable to the location of boreholes and wells in the few GRAs and other residential areas having clean environment devoid of lithered wastes and good basic infrastructure as also pointed out by Mshelia *et al.*, (2020) in their study on municipal solid waste in Kano metropolis. The other areas: Fagge, Gwale, Kumbotso, Tarauni and Ungogo that showed no significant variations can be attributed to locations of wells and boreholes close to wastewater ways, pit latrine, soakaways, at the bank of the river Jakara and ponds in the metropolis which house wastewater non-spacious and filthy compounds.

CONCLUSION

The assessment was conducted by subjecting the water quality parameters to laboratory analysis where the values were used and computed the WQI. The results showed that most boreholes and wells water sources in Kano Metropolis measured above the expected value of 0 – 25% which has been considered to be very suitable for drinking. The study discovered that only borehole water located in Dala is fit for consumption while all well water recorded very high WQI considered to be very poor and unfit for drinking. The poor WQI is attributable to high population, poor waste management and sanitation practices in the metropolis, lack of wastewater collection system and functional treatment plant, poor and dilapidated soakaways and septic tanks, filthy surroundings of wells and boreholes and also the location of these water sources close to soakaways, pit toilets, wastewater channels in the metropolis. Wastewater from industries and homes also contributed to high concentrations of contaminants in groundwater at different locations of urban centres through infiltration. The study recommends:

i. Treatment of both well and borehole before use.

ii. Siting of water sources far away from soakaways and wastewater bodies or canals.
iii. Boring of shallow boreholes for drinking water should be discouraged.
iv. Sustainable waste management practices should be made a point of duty and religiously adhered to.

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