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Spatiotemporal Variations of Physicochemical Parameters of Water Quality in Kano Metropolis, Nigeria

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Abstract:** The study assessed the spatiotemporal variations on physicochemical parameters in three different locations in Kano metropolis which are: Urban Centre (UC), Effluent Location (EL) and Non-Effluent Location (NEL). They were purposefully selected in the Metropolis where 360 borehole water samples were collected from 120 points during dry and wet season over two seasons. Samples were taken to laboratory and determined the concentrations of the physicochemical parameters in accordance to American Public Health Association (APHA, 1998 & 2005). Analysis of Variance (ANOVA) and student T-test for the analysis of the variability between spatial, temporal and significant variations at 0.05% confidential level were the statistical analysis employed. Findings showed that parameters such as pH, EC, TDS and NO_3 recorded high concentration at the UC and EL above the WHO guidelines and NSDWQ standard during wet season while moderate results were recorded at the NEL. The paired borehole water during wet and dry seasons at each location statistically showed significant variations at $P = .05$ while ANOVA showed that the Electrical conductivity $F(2, 3) = 10.379$, $P = .047$, Total Dissolved Solid $F(2, 3) = 11.094$, $P = .03$ and Nitrate $F(2, 3) = 18.290$, $P = 0.41$ showed that there were significant variations. The study recommends efficient means of wastewater treatment, municipal wastes management, public enlightenment and enforcement of environmental laws in order to have a clean drinking water in all locations of the Metropolis in line with SDG 6.

***Keywords:** Spatiotemporal, Variations, Effluent, Physicochemical Parameters, Wastewater, Pollution.*

1. INTRODUCTION

Is there anybody that can live without water? The answer is 'No' and it is applicable to all living things and as well to processes in the environment. This signifies the importance of

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water. Unprecedented population growth especially in developing countries without sustainable measures, quest for urbanisation and technology have given leeway where impurities are produced and consequently find their ways into the water bodies and pollute various sources [1]. Pollution plays a significant role in the occurrence of global 'water crisis', by reducing the quantity and quality of freshwater resources. Shortage of freshwater is presently occurring in developing nations such as India, Indonesia, Brazil and many African countries like Nigeria [2]. Globally, 2.1 billion people are inaccessible to clean water and about 4.5 billion have no access to adequate sanitation and these are attributed to pollution of the various water resources [3]. Reference [4] further stated that consumptions of the contaminated diseases and death of many especially in underdeveloped countries.

Most domestic wastewater in sewage form which contains human excreta and others wastes from urban areas and industrial wastewaters are discharged from point sources expedited by runoff during rainy season. Non-point sources, on the other hand, are distributed in a diffused manner. The location and origin of non-point sources are sometimes difficult to identify and less amenable to control. Virtually, water been used at homes and industries and no longer wanted becomes wastewater. Every time water is used, it acquires one or more contaminants and its quality declines ([5], [6], [7]).

The major problems of water pollution in Kano metropolis is the non-availability of centralized sewerage system for collection of wastewater from different parts of the metropolis, poor drainage channels, functional wastewater treatment plant, poor urban town planning, high population and poor attitude to sanitation. The absence of these facilities constitutes environmental problems which water pollution is one. During wet season the lithered and dumped wastes are carried by the runoff or storm water down slope to rivers, ponds or any depressed land [8], [9]. Similarly, indiscriminate disposal of municipal solid wastes, untreated wastewater or sewages from commercial settings, institutions and households into ponds, shallow holes at the back or front of their houses ([10], [11], [12]). The wastewater continued to gather in small holes and over flow in the surrounding causing foul pungent smelling stagnant water. Furthermore, residents not mindful of the dangers continued to dump wastes into the stagnant water making the environment filthy and breeding place of vectors ([13], [14]). It is against this background that the study examined and determined the concentrations of physicochemical parameters in borehole water under different locations in the metropolis during wet and dry seasons with a view of keying into the 2015 SDGs 6 and 11 which are the provision of safe water and clean settlements and sanitation as well as sustainable cities and communities by the year 2030.

2. MATERIALS AND METHODS

Study Area

Kano Metropolis arguably the second largest city in terms of population, industrial and commercial activities next to Lagos in Nigeria is the study area. It is located between latitudes 11^0 55′ 23.93″N to 12^0 3′ 53.10″N of the Equator and longitude 8^0 27′ 42.26″E to 8^0 3′ 41.62″E of the Greenwich Meridian and envelopes landmass of 499km^2 [9]. Figure 1 shows the location and extent of the city and urban area (one location) where borehole water samples were collected for laboratory analysis. The climate of Kano is tropical in nature

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according to Koppen's classification. The average annual temperature and rainfall is about 27^0C and 700mm [15]. The presence of many small, medium and large scale industries made it the commercial nerve of the north and invariably generates wastewater and municipal wastes of different sorts which have the potentials to compromise water quality standards in the Metropolis.

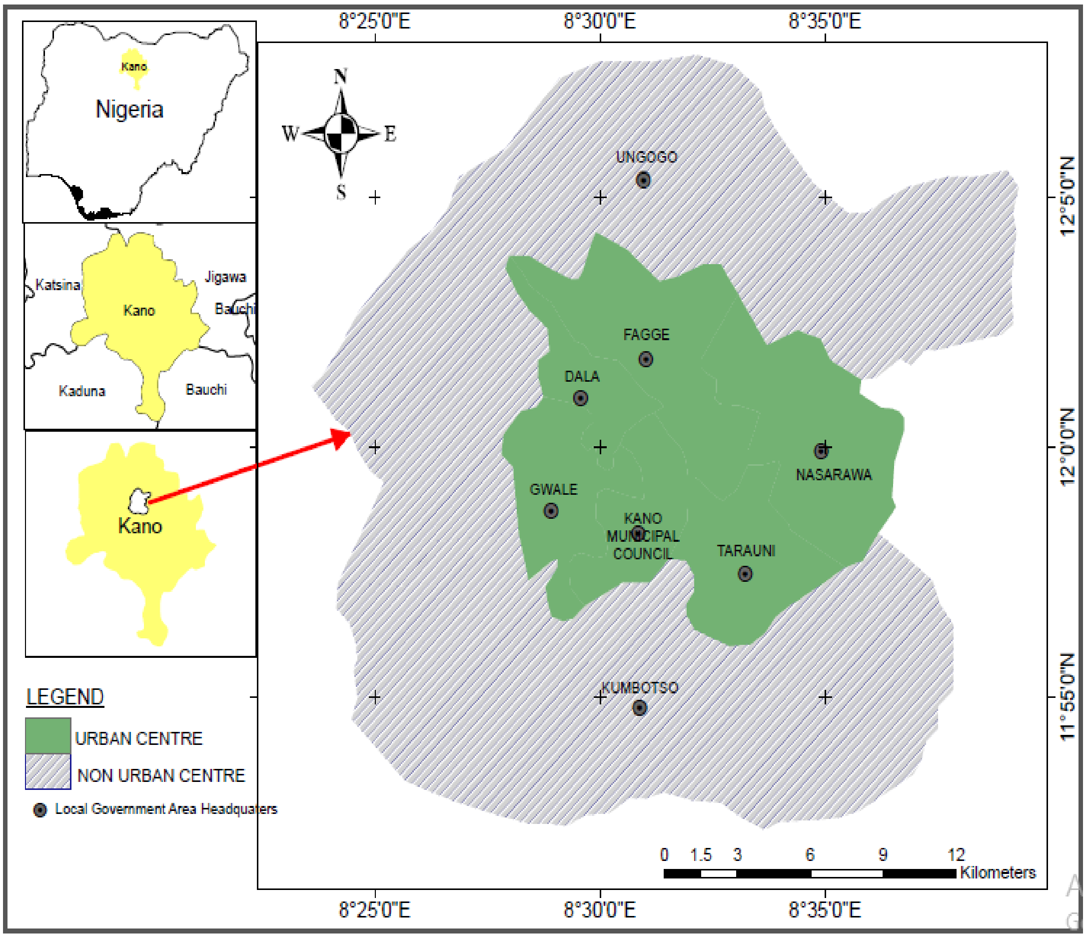

Figure 4.4: Kano Metropolis Urban Centres.

Source; GIS Unit, Geography Department, Federal University Gashua (2022)

Sample Collection

Three locations: Urban Centre (UC), Effluent Locations (EL) and Non-Effluent Location (NEL) were purposefully selected in the Metropolis where water samples were collected from boreholes during dry and wet season as shown on Table 1 and Figure 2 showing EL and NEL. A total of 360 water samples at 120 locations were collected in the metropolis as shown on Table 2 and subjected to laboratory analysis for the determination of physicochemical parameters.

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Table 1: Different Geo Location Areas in Kano

Geo Location Sampled Areas	Location/Settlement Remark
Urban Centre (UC) Highly populated an commercial areas	Fagge, Birni, Sabon-Gari, Daurayi, Gwale
Effluent Location (EL) wastewater canals or industrial areas	Yan Danko, Tsarmawa and Yansamawa
Non Effluent Location (NEL) Urban Centres and estate	Mariri, Zuwa Ciki, Amana City, Challawa Peri Village

Source: Field Survey, (2022)

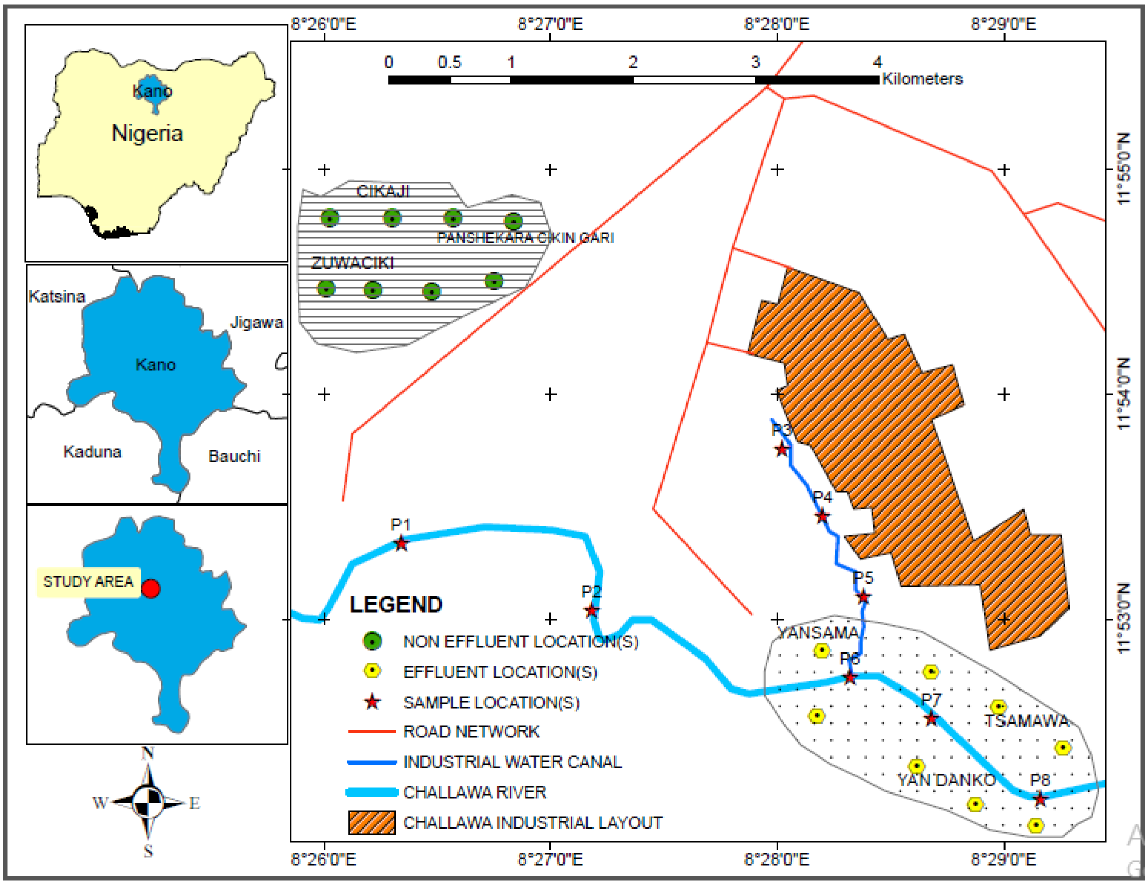

Figure 2: Effluent and Non-Effluent Locations in Kano Metropolis.

Source: GIS Unit, Geography Department, Federal University Gashua (2022).

Table 2: Summary of Borehole Water Collected in the Metropolis

Location	Season	Type of sample	Period collected	No of sampled points	Frequency of samples collected at each sampling point

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Effluent Location (EL)	Wet	Borehole	23/06/ - 24/08/2022	20	6(20 x 6 = 60)
	Dry	Borehole	22/02/ – 19/04/2022 (6x @ 2wk interval)	20	6(20 x 6 = 60)
Non Effluent Location (NEL)	Wet	Borehole	27/06/ – 22/09/2022	20	6(20 x 6 = 60)
	Dry	Borehole	27/02/22 – 24/04/2022 (6x @ 2wk interval)	20	6(20 x 6 = 60)
Urban Centre (UC)	Wet	Borehole	28-29/06 – 24-25/08/2022	20	6(20 x 6 = 60)
	Dry	Borehole	28/2-01/3 – 26-27/04/2022 (6x @ 1wk interval)	20 **120**	6(20 x 6 = 60) **360**
Total					

Source: Field Survey (2022).

Laboratory Analysis

The borehole water samples collected were subject to laboratory analyses to determine the concentrations of nine physicochemical parameters selected using Component of Principle Analysis (see Table 3).

Table 3: Summary of Laboratory Analyses of Physicochemical Parameters

S/N	Parameter	Unit	Methods
1	Temperature	^{0}C	Thermometric APHA (1998)
2	pH	-	pH meter APHA (1998)
3	Turbidity (Tur)	NTU	Nephelometric APHA (1998)
4	Electrical Conductivity (EC)	µs/cm	Electrochemical Method APHA (1998)
5	Total Hardness (TH)	mg/L	EDTA-Titrimetric AHPA (1998)
6	Total Dissolved Solid (TDS)	mg/L	Standard Method 2540C (APHA, 1998)
7	Nitrate (No)	mg/L	Cd Reduction Method (1998)
8	Dissolved Oxygen (DO)	mg/L	Luminescent ASTM D888-12APHA (1998)
9	Biological Oxygen Demand (BOD)	mg/L	5 Days incubation at 20 ^{0}C Titration of initial and final DO 5210B (APHA, 1998)

Source: Reference [16] and Authors Compilations (2022)

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Statistical Analysis

The study used inferential statistics such as Analysis of Variance (ANOVA) and student T-test for the analysis of the variability between spatial and temporal variations at 0.05% confidential level.

AVOVA formula:

Cm= correction for mean = $\frac{\text{(Total of all observation)2}}{\text{Total number of observations}}$

SS (total) = total sum of squares
= (Sum of squares of all observations) – cm = –cm
SST = sum of squares for treatment
= (sum of square of treatments totals with each square divided by the number of Observations for that treatment) - cm
SS Sum of squares for error = SS (total)-SST
MST= mean square for treatments=SST/K-1
MS = mean square for error = SS1
F= test statistic =MST/ MS

Where n= total number of observations
K = Number of treatments
T_1 = total of treatments I (i=1,2………k)

Source: Reference [17]

T-Test Formula

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

3. RESULT AND DISCUSSION

Spatiotemporal Variations of Water Quality Parameters under Different Locations in Kano Metropolis during Wet Season

The mean range concentrations of temperature 27 – 30.5°C, 28.5 – 30 and 27 – 28°C of borehole water within the central parts of the Metropolis considered as urban centre (UC), effluent location (EL) and non-effluent location (NEL) respectively during the wet season. The results showed that there were significant differences in the temperature values as shown in Table 4. Similarly, the mean range concentrations of pH, EC and turbidity which measured 7.0 – 9.51, 4.3 – 8.6 and 6.5 – 8.0 of pH; 441.5 – 1200µS/cm, 403 – 1019µS/cm and 367 – 665µS/cm and 3.4NTU – 6.5, 5.0 – 8.1, 5.0 – 7.0NTU at the UC, EL and NEL respectively as shown in Table 4. Highest pH value of 9.5 indicating high alkaline was measured at UC in Kofar Wambai which can be attributed to leather and tannery works in such locations, while the effluent location recorded the highest mean values of EC and turbidity attributable to high infiltration of industrial wastewater which shows substantial spatial variations in the three geographical locations within the Metropolis during wet season. Similar values of 4.6 –

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9.8NTU were measured by References [18] and [19] who investigated hydrochemical and seasonal characterization and the quality of groundwater in northwest China and obtained EC and turbidity values between 346 and 1004µS/cm and 3.7 – 10.1NTU respectively ascribed to wastewater infiltration.

Similar pattern was also observed in TDS and TH where mean ranged of 321 – 674.8mg/L, 452.8mg/L – 657 and 234 – 416mg/L for TDS and 112.7 – 165.3mg/L, 113 – 767.4mg/L and 97 – 180.9mg/L for TH were recorded during wet season at the UC, EL and NEL respectively. The results showed that they are spatial variations in TDS but no significant variations in TH ascribed to variation in landuse and socioeconomic activities across the Metropolis. The findings are in agreement of with the work of Reference [20] who studied effects of sewage disposal on groundwater in Gombe and obtained mean concentrations of TDS and TH between the range of 478.3 and 785.72mg/L and 89 and 694.56mg/L.

Result shown in Table 4 further revealed greater concentrations of TDS and total hardness were recorded at the effluent location which was attributed to inflow of the wastewater from the industries into the groundwater aquifer in a more dissoluble state. However, individual boreholes at UC in Dala Hospital Road, Bura Street in Fagge, Yan Rini, Dandao and NEXCO B Junction also showed high mean concentrations of TDS and TH of 663mg/L and 398mg/L as well as in DO and BOD where mean range values of 2.5mg/L – 4.8mg/L, 2.0 – 7.2mg/L, 1.5 – 4.5mg/L of DO and 1.01 – 2.85mg/L, 1.06 – 5.7mg/L and 0.89 – 5.3mg/L of BOD at UC, EL and NEL respectively. Lower values of DO but higher values of BOD were obtained at the EL. The locational variations were minimally observed because they are located close to wastewater canals, soak ways, pit latrines and in filthy environment which makes infiltration easy, seepages and inflow of the wastewater.

In similar view, NO_3, was determined and recorded mean range values (mg/L) of 22.1 – 55.7mg/L, 45.2 – 83.5mg/L, 23 - 120.7mg/L of NO_3 at UC, EL and NEL respectively as shown in Table 4. High concentrations of 58.5mg/L and 55.7mg/L were recorded at Nomans' Land in Fagge LGA and at Awaki in Tarauni LGA at UC during wet season while higher concentrations (mg/L) of 78.4, 86.7 and 120.7 were recorded at NEL attributable the high use of fertilizers and animal dungs in the UC and on the outskirt of the town for farming purposes.

The study showed greater mean concentrations at the EL and the UC than at the NEL, attributable to congestions, location of borehole close to effluent canals at Gwammaja, Kofar Ruwa, Sabon Gari, river banks and wastewater sources where infiltrations and percolation are high. Similar results of 19.5 – 134mg/L of NO_3 were reported by Reference [20] who studied physicochemical parameters' seasonal differences on groundwater around Karu Abattoir and attributed to the abattoir's wastewater infiltrates and contaminates the groundwater.

Table 4: Borehole Mean Concentration of Physicochemical Parameters in 3 different Locations of Kano Metropolis during Wet Season

	Dala	**Fagge**	**Gwale**	**KMC**	**Kumb Otso**	**Nasarawa**	**Tarauni**	**Ungogo**	**WHO (2010)**	**NSDWQ (2015)**

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Parameters	BH1	BH2	BH3	BH4	BH5	BH6	BH7	BH8		
BH Urban WS										
Temp (^{0}C)	27	27.5	27.3	28.5	29	30.5	29.0	27.5	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 EL WS										
Temp (^{0}C)	29	30	29	29.5	28.5	30	28.5	29	27-28	27-28
pH	8.0	8.5	8.6	7.5	8.0	5.2	4.3	8.5	6.5-8.5	6.5-8.5
EC (µS/cm)	754.3	601.9	1009.2	475.5	1019	403	417	560	1000	1000
Turbidity (NTU)	5	4.9	4.6	5	6	5.9	7.1	5.88	5.0	5.0
TDS (mg/L)	523.6	567	502.5	650.2	452.8	505	657	529	500	500
TH (mg/L)	589.3	767.4	266.5	603.7	721.8	175	132	113	150	100
DO (mg/L)	3.7	4.8	7.2	5.5	4.95	2.0	5.7	2.4	3	4-7
BOD (mg/L)	2.33	2.67	1.53	1.98	2.15	5.7	1.06	1.9	4	3
Nitrate (mg/L)	65.5	83.5	72	51.5	45.2	56.6	53	54.7	11	50

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BH NEL WS										
Temp (^{0}C)	28	27.8	29	27	28	27	27.5	27.5	27-28	27-28
pH	7.0	7.5	7.6	6.5	7.0	7	6.8	8	6-5 8.5	6-5-8.5
EC (µS/cm)	436	411	367	476.8	398	402	665	449	1000	1000
Turbidity (NTU)	5	5	6	6	6	6.2	7.5	5.6	5.0	5.0
TDS (mg/L)	416	411	367	310	234	414	406	312	500	500
TH (mg/L)	97	159.3	180.6	165.5	157.5	165	101	97	150	100
DO (mg/L)	4.1	4.5	4.3	3.6	4.5	1.5	3.2	3.33	3	4-7
BOD (mg/L)	1.15	1.34	2.10	1.87	0.89	1.1	5.3	2.8	5	3
Nitrate (mg/L)	68.6	67.8	86.7	120.7	78.4	56.6	23	54.7	11	50

BH= Borehole, WS = Wet Season, EL WS= Effluent Location, NEL= Non-Effluent Location.
Source: Field Survey (2022).

Furthermore, pH measured more acidic to alkaline in during the rainy period especially at EL and UC such as Yandanko, Tsamawa and Giginyu and Kofar ruwa where boreholes are mostly located close to wastewater canals, soak ways, pit latrines and in filthy environment which gives room for infiltration, seepages and inflow of wastewater to the groundwater. The areas are also associated with local industrial works such as dyeing, local tannery work with increases the acidic contents of water quality found in these areas of the Metropolis, affecting the water quality parameters in the metropolis. For instance, boreholes located at Sani Kafinta, Yan Rini, Rimishahua and Layin Karo (BH2, 2, 3, 3; BH1, 3, 4; BH1, 3, 5; BH2, 3, 4: and BH2, 4, 5) in Dala, Fagge, KMC, Gwale and Nasarawa respectively located close to wastewater sources.

Spatiotemporal Variations of Physicochemical Parameters of Borehole Water at Urban, Effluent and Non-Effluent Locations during Dry Season

Table 5: shows temperature pH, EC and turbidity values that ranged between 27 and 29.5^{0}C in UC; 27 and 30^{0}C in EL and 27^{0}C and 28.5 ^{0}C in NEL obtained in borehole water in Kano Metropolis. The pH ranged between 6.30 and 7.50, 4.2 and 8.52 and 7.0 and 8.2 in UC, EL, and NEL respectively. In similar view, the EC values ranged between 334.5 and 1003.8µS/cm, 322 and 984.5µS/cm and 302 and 501µS2µS/cm in UC, EL and NEL respectively while turbidity values ranged between 2.72 – 5.0NTU in UC, 3.0 – 5.02NTU in EL and 3.0 – 4.8NTU in NEL Metropolis. BH2 at Gwale UC, BH2, 3 and 5 at Yandanko and

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Tsarmawa in EL obtained greater values of pH, EC and turbidity. References [21] examined source apportionment of water pollution in the Jinjiang River in China and groundwater quality assessment in Kano Metropolis using WQI and geospatial techniques and recorded pH concentrations of 6.82 – 7.89 and 6.61 – 8.45; EC 342.64 – 1428.65µS/cm and 367.65 – 893.28µS/cm; 4.63 – 6.11NTU and 3.65 – 5.98NTU respectively during dry season which are connected to absence of rainfall that aid dilution, low infiltration and presence of high volume of wastewater at UC and EL than the NEL in the study area.

Lower values were recorded during the dry season than in rainy period in the borehole water at Tsarmawa and Yandanko. The findings also showed minimal spatial variation of pH values of 7.50 BH3 in UC with 8.5 obtained in BH6 at EL as well as with 8.2 in BH5 at EL located in Gwale Police Station, Yandanko and Zawaciki respectively. The spatial variations can be attributed to low groundwater recharge and filtration, owing to low precipitation, higher temperature and evaporation as well as different activities and landuse in the Metropolis resulting in lower EC, TDS and turbidity during dry season. The mean range of TDS and total hardness (TH) at the UC, EL and NEL obtained 302.5 – 575.4mg/L, 315 – 620.5mg/L and 254 – 410.5mg/L for TDS and 83.5 – 223.1mg/L, 95 – 482mg/L and 66 – 160.6mg/L for TH respectively during dry season as reported by Ref [22]. Table 5 further showed highest values of TDS and TH recorded at the EL and attributed to seepages of the industrial wastewater to aquifer levels and proximity to the wastewater canals. Greater values were recorded in wet season which portrays effect of runoff, high infiltrations hence, seasonal variations observed.

Similar trend was also observed in the case of DO and BOD where mean range values of 2.5 – 4.62, 2.4 – 5.9mg/L, 2.5 – 4.9mg/L of DO and 0.95 – 4.885mg/L, 1.4 – 3.2mg/L and 1.6 – 8.9mg/L of BOD at UC, EL and NEL respectively. Lower values of DO and higher BOD are measured at the EL and urban centre in well water at Ego street, Sabongari and the in the borehole water at Enugu Road Sabongari. The boreholes are mostly located, in a depressed land and also very close to wastewater canals that drain domestic and small-scale industrial wastewater in the town to River Jakara which give room for infiltrations.

More still, NO_3, recorded mean range values between 17.5 and 75.0mg/L, 25.7 and 125mg/L, 25.7 and 48mg/L of NO_3 and at urban centres, EL and NEL. Greater concentrations of nitrate were obtained at the EL where BH3 in Gwale recorded 120mg/L, 75mg/L in BH8 at UC while lowest concentration of 48mg/L was recorded in BH4 at NEL. Lower values were recorded in borehole water as also reported by Reference [27] in the Kano metropolis recording greater values during wet season.

Table 5: Borehole Mean Concentration of Physicochemical Parameters in 3 different Locations of Kano Metropolis during Dry Season

	Dala	**Fagge**	**Gwale**	**KMC**	**Kumb Otso**	**Nasar Awa**	**Tarauni**	**Ungo Go**	**WHO (2010)**	**NSDWQ (2015)**
Parameters	BH1	BH2	BH3	BH4	BH5	BH6	BH7	BH8		
BH										

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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	654.0	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)	17.5	18.1	20.15	25.7	69.18	48.10	25.7	75.0	11	50
BH EL DS										
Temp (^{0}C)	37	28.5	29	27.5	27	29	29	28	27-28	27 – 28
pH	7.1	8.5	7.6	7.5	8.2	8.5	4.2	7.5	6.5-8.5	6.5-8.5
EC (µS/cm)	658.5	743	984.5	792.4	810.5	322	331	452	1000	1000
Turbidity (NTU)	3	4	3.6	4	4.8	4.4	502	3.95	5.0	5.0
TDS (mg/L)	464	410.5	367.5	620.5	532	315	432	422	500	500
TH (mg/L)	443.5	265	482	289	198.6	120	145	95	150	100
DO (mg/L)	2.6	3.5	3.6	5.9	5.5	4.1	3.0	2.4	3	4-7
BOD (mg/L)	1.5	1.6	2.5	1.7	1.80	3.2	2.45	1.4	5	3
Nitrate (mg/L)	98.7	78.5	125	78	95.4	45	25.7	26.6	11	50
BH NEL DS										
Temp	28.5	28.5	29	27.5	27	28	28`	28	27-28	27 – 28

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(^{0}C)										
pH	7.1	7.5	7.6	7.5	8.2	7.5	7	7.6	6-5-8.5	6-5-8.5
EC (µS/cm)	389	302	287	501	275	331	313	378	1000	1000
Turbidity (NTU)	3	4	3.6	4	4.8	4.1	3.55	4	5.0	5.0
TDS (mg/L)	363	410.5	289	318	342	254	385	286	500	500
TH (mg/L)	122	160.6	135.3	66	78.8	126	85	66.8	150	100
DO (mg/L)	3.6	2.7	2.6	2.9	3.5	3.2	2.5	4.9	5	5-7
BOD (mg/L)	1.8	1.6	1.75	1.6	2.1	4.11	3.4	8.9	5	3
Nitrate (mg/L)	40	28.5	35	48	35.2	31	25.7	26.6	11	50

BH=Borehole, UC=Urban centre, WS = Wet Season, EL= Effluent Location, NEL=Non-Effluent Location
Source: Field Survey, (2021).

The study generally showed greater mean concentrations at the EL and UC than the NEL ascribed to location of boreholes close to wastewater canals. These areas are industrial hubs and high populated areas with little or no good sanitation [24], [24]

Statistical Analysis to show Spatiotemporal Variations in Borehole Water Quality Parameters in Kano Metropolis

Student T-test analysis showed the paired borehole water during wet and dry seasons at each of the UC, EL and NEL statistically showed significant variation at *($t(23)= 2.22$, $p < 0.05$), ($t(23)= 2.12$, $p < 0.05$)* and *($t(23)= 2.01$, $p < 0.05$)* at UC, EL and NEL respectively. The variations can be ascribed to high infiltration, seepages and stormwater or runoff as a result of rainfall as also reported by [13].

The statistical analysis at 95% Confidence interval for mean where one-way analysis of variance for physicochemical parameters in borehole water which showed that the EC $F(2, 3) = 10.379$, $P = .047$, TDS $F(2, 3) = 11.094$, $P = .03$ and NO_3 $F(2, 3) = 18.290$, $P = 0.41$. The ANOVA statistical analysis showed that the water quality parameters of EC, TDS and NO_3 in boreholes located at the UC, EL and NEL across Kano metropolis showed that there were significant variations measured at the mean level $P = <.05$. This is attributable to the differences in landuse pattern, human activities, industrial effluents, runoffs and infiltrations especially during wet season. For instance, the concentration of industries and the release of their wastewater directly into adjoining River Challawa and Jakara are likely to have higher contaminants than NEL.

3. CONCLUSION

Based on the various laboratory determinations of the physicochemical (temperature, pH, EC, TDS, TH, TUR, DO, BOD and NO_3) in three different locations in Kano Metropolis on the spatial temporal variations of physicochemical parameters in the UC, EL and NEL can be deduced that most of the parameters such as pH, EC, TDS and NO are recorded high concentration at the UC and EL above the WHO guidelines and NSDWQ standard during rainy season while moderate results were recorded at the NEL. This makes the borehole water at EL and the UC unfit for the drinking. Apart from the inflow of wastewater in shallow boreholes, most of the ones located in marshy, swampy and dirty areas are found to be polluted. Similarly, geology and hydrogeology factors also play roles on groundwater chemistry as well as natural processes which include mineral weathering, water mixing and ion exchange reactions. The study recommends current wastewater management efforts are inadequate, and that more efficient means of wastewater treatment, municipal wastes management, collection and disposal need to be procured, public enlightenment and enforcement of environmental laws in order to have a clean drinking water in all locations of the Metropolis.

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