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Research Article

Seasonal Variations of Sewage Loads of Heavy Metals and Microbial Parameters on River Jakara, Kano Metropolis, Nigeria

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Abstract— The study examined the seasonal variations of sewage loads of heavy metals and microbial parameters discharged into River Jakara, in Kano Metropolis, Nigeria. Data were collected from January 2019 to December 2022. Composite sampling method was employed and collected 288 water samples from eight established points along River Jakara during wet and dry seasons between 0800 – 1100Hrs and 1600 – 1800Hrs. Samples were subjected to analyses in a Laboratory for the determination of heavy metals and microbial parameters according to proceedures stipulated by American Public Health Association (APHA, 1998) using Atomic Absorption Spectrophotometer (AAS) and Membrane Filter (MF) technique. T-test statistical analysis paired at 95% confidence interval was used and compared the significant variations between the concentrations of the river water during dry to wet seasons and that of regulatory bodies such as "National Environmental Standard Regulation and Enforcement Agency", (NESREA, 2011). The results showed that population growth, urbanisation, and poor infrastructure are the main causes of high generation and disposal issues of sewages. The study also revealed that there were significant seasonal variations in sewage quality of River Jakara, with higher concentrations of Cr 7.8, Pb 1.9, Zn 7.45, Cu 7.2, Mn 5.7 (mg/l), 395 and 452 (cfu/100ml) were recorded in wet season while Cad 3.1, Hg 1.08, As 3.4 (mg/l), 285 and 398 (cfu/100ml) in dry season at significant variations $P = .05$. The study concluded that there was a strong correlation between the seasonal variations in sewage loads and water quality parameters in River Jakara and called for proper sanitation and wastewater management in order to reduce the increasing levels of sewage loads and protect the environment.

Keywords— Sewage, heavy metals, microbial, wastewater, concentrations, seasonal variation

1. Introduction

Water is an important asset required for sustenance of life all over the globe; for life in whatever pattern revolves around it [1]. However, Ref. [2] reported that in spite of its significance, little or no attention in some places, especially in the underdeveloped countries to preserve and mitigate pollutions has been accorded to the water. Water quality has continued to get contaminated and population growth, quest for urbanization and industrialization are some the factors contributing to generation of sewages beyond the environment's carrying capacity. In most urban centres, sewages are being indiscriminately disposed into surface water or any adjoining rivers, streams or ponds [3].

Body of water either ocean, lakes, river, stream or pond on the surface of the earth is known as surface water which is about 71% of the globe's landmass. Surface water is often polluted by contaminants through the discharge of sewages into it and place exertions on such river water use for agricultural and domestic activities, aquatic lives and to some extent on drinking water. Other sources of water pollution in urban centres are agricultural and rain runoff, radioactive substances (uranium, radium, polonium and thorium among others) and oil or lubricants from factories, mechanic workshops, households and commercial centres such as restaurants. The fact that water is seen as alkahest often referred to as 'universal solvent' makes it liable to pollution expeditiously in contrast to other liquids when substances get into it [4], [5], [6].

It is very relevant to put into consideration that fact that Kano Metropolis been one of the largest city in Nigeria and the largest in the Northern part of the country being the largest city in northern on the bases of high population of 4,348,000 2023 projected population, commercial and industrial activities [7] is presently experiencing issues of water pollutions emanating from the many exertions of the different kinds. There is high demands of goods and services which nictitated productions of consumable goods and chemical and pharmaceutical goods by the large, medium and small scale industries. Similarly, the city houses many institutions, government establishments and non-governmental organisations as well as agricultural practices. The combine functions, activities and processes generate quantum volumes of wastewater which proper disposal becomes serious environmental issues. In view of the this, Ref. [8] and [9] opined that the visibility seen of polluted lands, water bodies, (river, pond, stream) and filthy environment in urban sub urban and peri-urban areas of the city emerged from the poor management practices by Government, cooperate bodies and individuals in the Metropolis.

Ref. [10] was of the view that pollutions of different sorts are brought about by absence of centralized sewerage system to collect wastewater from the different places of the town, non-functional plants for the treatment of wastewater, integrated municipal solid waste management practices, overcrowded settlements, poor town planning and bad landuse where people constructs structures without the permission of the authority concern. Individual houses in Kano Metropolis, for instance in the ancient city known as *Birni*, Daaci, Dala, Fagge B, Kofar Na'isa, Mata and Brigade among others do not have good drainage system, road network, approved dumpsites and are also have population density which make wastewater management difficult. Government presence to manage the wastes is most often absent, therefore, the households and commercial centres dispose municipal solid wastes and the wastewater also known as sick water freely to any available space without recourse [11], [12], [13]. Further still, [14] posited that the release of sewage into the river water potentially contaminates the water and lead to waterborne related diseases such as gastro-intestinal disorder which could lead to dysentery, diarrhea, premature birth, skin irritation and duodenal ulcers when consumed, used or came into contact with it.

It is against this backdrop that the study investigated the seasonal variations of sewage loads in Jakara River in Kano Metropolis with the view of determining and appraising the accumulations of heavy metals and microbiological (microbial) elements in the river during the dry and wet season attributed to the inflow of the sewages and consequent effects on the aquatic lives and human beings in metropolitan Councils. The investigation brought to fore the effects of disposal of sewage into the river and its aquatic life. Similarly, the knowledge of the concentrations of the water quality pollutants in comparison to (NESREA, 2011) acceptable limits for disposal of wastewater in general serves a challenge to key into No. 6 of the sustainable development goal: good drinking water and sanitation in the Metropolis.

2. Related Works

Ref. [15] studied seasonal variations impacts and discharge of wastewater on river water quality and associated health risks to human beings in Northwest Dhaka of Bangladesh over three seasons and reported results got from water quality indices as unfit for drinking, domestic use and for irrigation as result of high concentrations of physicochemical parameters. In similar vein, [16] investigated seasonal variations in the parameters of the quality of water of Gudlavalleru engineering pond at Krishna District, Pradesh during wet and dry and cold periods and found out that values of temperature, pH and total alkalinity, total hardness, chloride, turbidity and trace metals recorded higher in summer and low in winter and also in monsoon showing a significant variations of water quality per season. Similarly, Ref. [17] looked at variations in the basin of River Orle quality of water in South West over two seasons and reported Chemical Oxygen Demand (COD), Biological Oxygen Demand (BOD5) and Dissolved Oxygen (DO), measured higher concentrations during the wet season and that the river gets very polluted during the wet season than the dry season. Ref. [18] also carried out study on wastewater impacts on the quality of the environment in Gashua and pointed out that during rainy season the effects of runoff is severe and that it carries along wastes down to the River Yobe which is used for fishing and irrigations. Furthermore, it produces contaminated pond water, muddy puddle and dirty environment. Ref [19] equally, assessed the status of River Challawa around the industrial area in Kano State of Nigeria and investigated the physicochemical traits of surface water samples along river Challawa and reported high acidic concentrations of pH values for all the samples and other parameters like DO in surface water all brought about by inflow of contaminants. Ref [20] investigated "the ecological risks potential of aquatic ecosystem that are bound to occur as a result of high load of environmental pollution loads on surface water chemistry in South-Eastern Nigeria and results showed concentrations of COD, $CaCO^3$ and Ca^{2+} above the WHO guidelines, while other parameters such as DO, Magnesium (Mg) turbidity (NTU), Cl−, Sulphate, ($SO_4^{2}+$), Sodium (Na), Phosphate (PO^3_4) and nitrate (NO3−) fall within the permissible limits for drinking water. The measured values were attributed to sewage disposal and high infiltration rates especially during the rainy season. Others are Ref [20] assessed toxic pollutants distribution and risk the lower Yellow China River. Ref. [21] worked on effect of sewage effluent from the domestic wastewater treatment plant on Zhangze Reservoir's water quality and reported that the effluent being discharged from residential areas and flows through the canal to the river contaminate the river and consequently affects aquatic ecosystem. Ref. [22] studied the variation of contaminants during wet and dry season in wastewater treatment plants and river water and investigated 170 wastewater treatment plants' sites over a period of two years and reported that reported variations in the concentrations caused by the seasonal inconsistence changes in river flow. Higher volumes of runoff and river flow are associated with rainy season show casing the largeness of variations between wet and dry season.

3. Theoretical Framework Planning for Wastewater Management

Ref. [23] observes that high population density influences sanitation problems in communities where the capacity of waste being disposed in the environment often overstretches it ability to measure up with the wastewater generations as well as the capability of the community to effectively manage the issues that emerged as a result of waste generated. Enormous wastewater generations due to overpopulation and urbanization lead to public health, environmental issues, social and institutional aspects that often occur as shown in Figure 1. Overtime, the impacts of wastewater have necessitated communities to come together collectively to find some ways out of their common issues such as sweeping and clearing of drainage channels, laying of sewer pipes, wastes collections, contribution of money and help in all manner of ways for environmental sustainability which is in line with Precautionary Principle. These tasks vary from one community to the other depending on the peculiarities.

The institutional dispositions or positioning in an environment often develop within time in order to meet changes in technology and culture and which may not usually keep pace with external changes. One of such change is rapid growth of towns' urbanization which results to accelerated increase in number of people in small geographical areas as in the case of population growth, leading to extreme sanitation issues [24]. The theoretical framework when keyed in will curtail the excesses of wastewater especially sewage effects in the metropolis through adequate planning that could curtail the load effects on river waters.

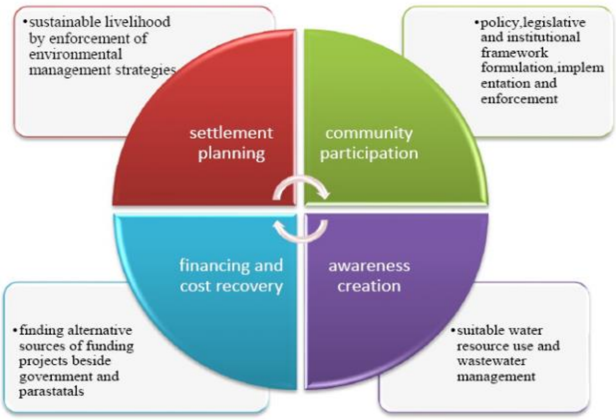

Figure 1: Theoretical Framework Planning for Wastewater Management
Source: Adopted from Adhiambo (2014)

4. Material and Methods

4.1 Location and Extent

Kano Metropolis is found on Latitudes 11^0 55′ 23.93″N and 12^0 3′ 53.10″N and Longitude 8^0 27′ 42.26″E to 8^0 36′ 41.62″E of the while River Jakara and environs, the study area within the metropolis exists on Latitude 12^0 0′ 30″N and 12^0 3′ 30″N and Longitude $8^0$3030″E and $8^0$32′30″E (Figure 2). Kano Metropolis consists of eight Local Government Areaa; covers a land mass of 499Km^2. The 2023 projected population is about 4,301,112 at growth rate of 2.8% and it is reported to be the largest business nerve and hub in the north and second to Lagos in Nigeria [25].

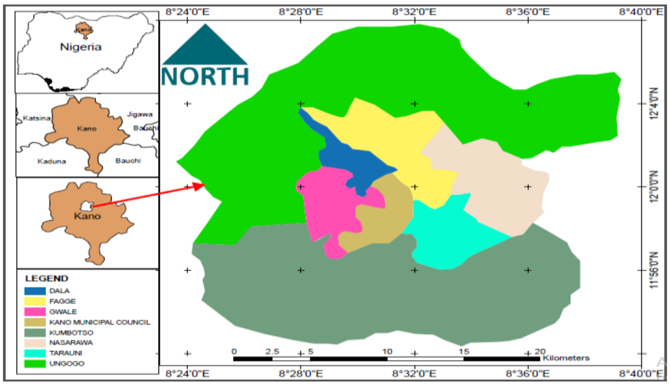

Figure 2: Kano Metropolis
Source: GIS Unit, Department of Geography, Federal University Gashua (2022).

4.2 Weather and Climate

Kano city is located within the tropical climatic region possessing different weather that changes from cold to hot and from dry to humid. The average annual temperature is 27°C influenced by the air coming over Atlantic Ocean known as maritime air mass and the tropical continental dry air masses from the Sahara Desert t. Kano Metropolis is expanded by wet and dry seasons (May – September and October – April) respectively. The wet season mean temperature ranges from 26°C - 33°C usually from June – September while the dry season having dry and cool weather usually in November - February and warm and dry March - May often reach as high as 40°C – 42^{0}C. The mean annual rainfall ranges from 700mm to 1,000mm, averagely about 690mm of precipitation per year [26].

4.3 Hydrology

There are two notable rivers in Kano metropolis; the Challawa River which flow and merge with river Kano and River Jakara which is the study focus. It cut across the metropolis and heavily used for irrigation and other domestic activities. River Jakara is seasonal but continued to get recharged by the quantum volume of wastewater from different parts of the Metropolis. The river also recharges groundwater in the metropolis [27].

5. Experimental Method

5.1 Sample Collection and Laboratory Analysis

The parameters (heavy metals and microbial) were chosen because of their prevalence potential effects on water quality in the metropolis using the Principal Components Analysis (PCA) to sizeable number by transforming the original variables from the acceptable sources to the new set of the variables used for the study (see Table 1).

Table 1: Samples and Parameters Analysed.

Sample	Heavy Metals	Microbial Parameter
Surface/ Groundwater	Lead (Pb)	
	Copper (Cu^{+2})	Total Coliform
	Cadmium (Cd)	Count (TCC)
	Zinc (Zn)	Escherichia Coli
	Iron (Fe^{+2})	(E. coli)
	Mercury (Hg)	
	Chromium (Cr)	
	Arsenic (As)	
	Manganese (Mn)	

Source: Field Survey (2021)

Composite sampling method was employed by dipping the pre-washed and sterilized plastic bottles with iodized water below the surface of the water severally at the eight established points (P1-P8) along River Jakara (see Figure 2) between the hours of 0800 – 1100Hrs and 1600 – 1800Hrs. A total of 288 water samples were collected during the wet and dry seasons over a period of three years 2019 – 2022. Similar method was also employed by [28]. All samples were stored in cooler boxes at 4^{0}C and conveyed to Laboratory for heavy metals and microbial parameters analyses. Samples were digested using HNO_3 acid method in Ref. [29] and diluted to 100cm^3 in volumetric flask and then conveyed into a thoroughly cleaned and labelled plastic container for analysis using Shimadzu Atomic Absorption Spectrophotometer (AAS Model AA-6800), Japan model, equipped with Zeaman background correction and graphite furnace at Japan model and Membrane Filter (MF) technique (HACH, 1996) in accordance with the standard analytical procedures for water quality examinations as prescribed in APHA, (1998) standard methods. The determined concentrations

for both seasons were compared to NESREA (2011) standard for disposal of municipal and industrial wastewater into rivers as well.

5.1 Student T-test Statistical Analysis

Student T-test Statistical Analysis paired at 95% confidence interval of the difference to get the T value and results reported in Standard Alpha Level (SAL) format to obtain significant difference between the both seasons.

Formula:

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

S_1 stands for first sets of values standard of deviation

S_2 represent standard deviation of second sets of values

n_1 means first sets of values of standard deviation

n_2 stands for standard deviation of second sets of values

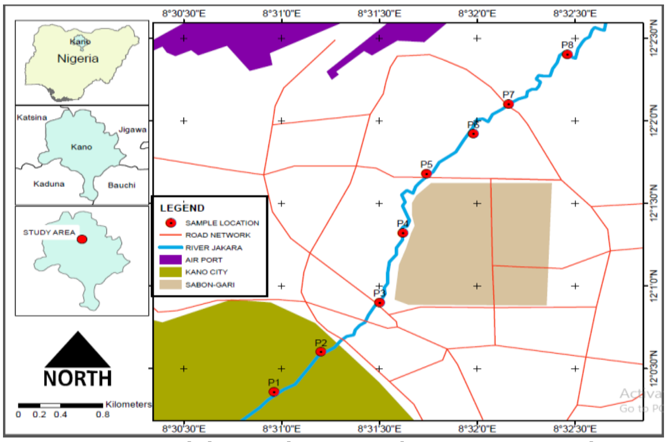

Figure 3: Sampled Points along River Jakara in Kano Metropolis.
Source: GIS Unit, Geography Department, Federal University Gashua (2022).

6. Result and Discussion

The study discovered that absence of centralized sewerage system to collect and dispose sewages in the Metropolis, non-functional wastewater treatment plants, high population growth, improper urban planning layouts and landuse in which settlements, intuitions, motor parks, markets and recreational areas in most our towns not in compliance to the environmental and town planning rules. These acts and illegal emergences of features in urban centres have resulted to discharge of sewages, and other wastewater types to adjoining rivers, open spaces, back or front of houses and ponds or depressed lands in the Metropolis. The study also discovered that River Jakara is the concentration of wastewater streams from different parts of the metropolis which carries municipal wastes from the Kano old city district, Murtala Mohammed Ways, Mazugal Abattoir, Sabon Gari and Nomans' land which runs northeasterly. The sewages when discharged into the River Jakara that cut across the metropolis contaminate the water by adding the dense accumulations of the element and microbiological parameters above the NESREA (2011) permissible limits of discharging wastewater in rivers (Table 2 and 3).

6.1 Seasonal Variations of Heavy Metals and Comparisons to NESREA Standard along River Jakara

The concentrations of Heavy metals were investigated at eight established points along River Jakara during wet and dry seasons. The concentration values are compared with NESREA (2011) Standard for disposal of wastewater into surface water.

a. Cadmium (Cd): The mean ranged values of cadmium showed 0.14mg/L – 3.7mg/L during rainy and 0.54 – 4.4mg/L dry seasons. P1, 3, 5 and 8 during wet period and P3 and 8 in dry season recorded Cd values below the permissible limit of 2.0mg/L stipulated NESREA's (2011) as shown in Table 2 with higher values recorded during the dry season attributed to low seepages, runoff and inflow of sewage into the river that promote dilution. Similar results were reported by Ref. [30] who effluent of paint industry's effects on water quality in Ibadan with a value of 0.57 – 2.66mg/L in both domestic and industrial wastewaters in Ibadan. In similar vein, paired Cd values of $(t\ (39) = 2.13,\ P < .05)$ and $(t\ (39) = 2.21,\ P < .05)$ during wet and dry seasons have significant differences to NESREA standard at $P = .05)$.

b. Chromium (Cr): The study showed mean concentration values of Cr within the range of 2.54mg/L – 7.82mg/L and 0.64 – 7.1m/L in rainy and dry seasons well above the threshold limit of 1.0mg/L stipulated by NESREA standard except P8 during the dry season that measured within the acceptable limit (see Table 2) attributable to indiscriminate disposal of sewages and other wastes into the river as well as geomorphic processes. Similar mean range of 2.85 – 7.41mg/L was also recorded by Ref. [31] who worked on environmental hazards of heavy metals in Southwest, Nigeria. More still, the paired Cr values at T-test $(t(39)= -2.31,\ p <= .05)$ during wet season and $(t(39)= -4.10,\ p < .05)$ showed significant difference in both seasons and to NESREA standard at $P = .05$. Over 70% of chromium in our surrounding occurs from the activities of humans such as leather tanning industries, non-ferrous base metal smelters, industrial effluent and urban storm water runoff moved down to the river and contaminated it.

c. Mercury (Hg): Table 2 showed mean range values of 0.01mg/L - 0.55mg/L during the wet period and 0.006 – 1.04mg/L in dry season well above the permissible limit of 0.01mg/L stipulated by NESREA (2011) for disposal of wastewater into water bodies except 0.01 measured in P8 during wet season and P2, 7 and 8 in dry season. This is in agreement with the investigation of Ref [32] who worked on mercury pollutions on water and its impact on public health in Bompai, India measured Hg of 0.027mg/L - 0.75mg/L. Similarly, the paired Hg values at T-test $(t(39)= -2.34,\ P <$

.05) and *(t(39)= -35, P < .05)* revealed moderate significant variations during wet and dry periods respectively. Higher values can be ascribed to high runoff, municipal wastes as well as the dissolution of organic matter, rocks and geological activities as also observed by Ref. [33] in their worked on the industrial wastewater effects on the quality of groundwater at Challawa Industrial area in Kano Metropolis of Nigeria and recorded Hg within the mean ranged of 0.06 – 1.46mg/L.

d. Arsenic (As): Table 2 showed mean values of As within the range of 0.19mg/L to 0.54mg/L during wet season and 0.02 – 3.4mg/L in dry season. Only P2 during wet season recorded mean As value within the permissible limit of 0.2mg/L stated by NESREA. All values during dry season fall within the threshold limit except P1 which recorded 3.4mg/L very well above the permissible value. Similarly, the paired As values at T-test *(t (39) = -2.41, P < .05)* and *(t (39) = -3.61, P < .05)* in wet and dry seasons respectively showed that there was significant variations at *P = .05* where As measures above the NESREA Standard. Low values can be linked to low seepages and dissolution while greater values to discharge of wastewater from local dyeing centres respectively in the metropolis. The study is in agreement with that carried out by [34] who studied heavy metals in Aurangabad industrial areas and recorded 0.032 – 4.24mg/L of As concentration.

e. Lead (Pb): The mean values ranged from 0.55 – 1.89mg/L and 0.43 – 1.52mg/L rainy and dry seasons respectively. All values were found to be above 0.1mg/L set by NESREA as shown in Table 2. Similarly, the paired Pb at T-test *(t(39)= 2.23, P < .05)* and *(t(39)= -3.90, P < .05)* during wet and dry seasons respectively showed significant differences as well as to the NESREA standard at *P = .05*. This can be linked to disposal of wastewater from the local small scale industries and other anthropogenic activities of man such as farming at the bank of River Jakara as also reported by [35] who studied pollution loads and chemical profile on surface water in Aurangabad industrial areas and of Curvey river water in India.

f. Iron (Fe): The mean values ranged 4.46mg/L – 12.61mg/L and 3.82 – 7.61mg/L in rainy and dry seasons respectively as shown in Table 2. All values were above the 2.0mg/L stated by NESREA (2011) standards for wastewater disposal. This can be attributed to wastewater being discharged from homes mechanic workshops, blacksmith and car wash spots as well as iron that occur spontaneously in underlying rocks basement rocks or soil that contain iron. Similarly, the paired Fe of T-test *(t(39)= 2.37, P < .05)* during the wet period and *(t(39)= -3.24, P < .05)* during dry seasons showed high significant difference, to the NESREA standard at *P = .05*.

g. Zinc (Zn): Table 2 showed mean concentrations fall within the range of 4.45mg/L – 7.47mg/L during the wet season and 4.85 – 7.12mg/L in dry period. Values during both seasons fall above NESREA (2011) threshold limits of 5.0mg/L except 4.45mg/L measured at P7 during dry season. The paired Zn values at T-test *(t(39)= 2.61, P < .05)* also showed significant difference during the wet season while during the dry season showed no significant variations at *(t(39)= 0.90, P < .05)*. The results is similar to the investigation conducted by Ref. [36], who recorded values of 4.56 – 8.54mg/L attributable to inflow of wastewater and runoff during the wet season.

h. Copper (Cu): The study showed mean concentration values of Cu within the range of 3.67mg/L – 7.22mg/L and 5.1 – 6.8mg/L well above the permissible level 3.0mg/L (see Table 2) stipulated by NESREA (2011). The elevated levels can be ascribed to indiscriminate disposal of domestic wastewaters. More still, the Cu concentrations at T-test (*t(39)*= 2.37, *P* < .05) and *(t(39)= -3.93, P< .05)* during dry and wet seasons respectively and showed significant differences well above the NESREA thresholds at *P = .05*.

Table 2: Mean Concentration of Heavy Metals along River Jakara during Wet and Dry Seasons

Location	P1	P2	P3	P4	P5	P6	P7	P8	**NESREA (2011)**
Wet Season River Jakara									
Latitude (N)	12.005	12.011	12.015	12.028	12.035	12.048	12.048	12.055	
Longitude (E)	08.516	08.522	08.525	08.530	08.536	08.541	08.549	08.553	
Cadmium (mg/L	1.12	2.82	1.15	0.14	2.14	3.7	2.54	0.44	2.0
Chromium (mg/L)	2.54	2.64	2.60	3.54	2.63	5.6	7.82	3.56	1.0
Mercury (mg/L)	0.03	0.55	0.26	0.028	0.04	0.02	0.06	0.01	0.01
Arsenic (mg/L	0.26	0.19	0.30	0.31	0.54	0.26	0.05	1.5	0.2
Lead (mg/L	1.66	1.87	1.88	1.89	0.85	1.67	1.2	0.55	0.1
Iron (mg/L)	8.22	7.22	6.66	7.25	5.64	8.5	4.46	12.6	2.0
Zinc (mg/L	7.45	6.71	6.70	6.55	5.15	5.87	4.45	6.8	5.0
Copper (mg/L)	7.12	7.22	6.24	6.1	5.75	3.67	5.6	4.59	3.0
Manganese (mg/L)	4.45	5.43	3.86	3.40	2.12	3.75	2.8	3.5	1.0
Jakara Dry Season									
Cadmium (mg/L	2.09	2.086	1.081	3.078	4.4	2.70	2.83	0.54	2.0
Chromium (mg/L)	5.05	2.13	1.45	0.85	0.25	6.21	7.1	0.64	1.0
Mercury (mg/L)	0.02	0.01	0.08	0.07	1.04	0.21	0.01	0.006	0.01
Arsenic (mg/L	3.41	0.15	0.08	0.04	0.02	0.065	0.05	0.05	0.2
Lead (mg/L	1.52	1.46	1.39	1.05	0.43	1.12	1.2	0.76	0.1
Iron (mg/L)	7.61	6.53	6.11	5.20	3.82	4.65	4.6	7.4	2.9
Zinc (mg/L	6.24	5.15	6.74	6.12	4.85	7.12	5.98	5.1	5.0
Copper (mg/L)	6.80	6.35	5.83	5.44	5.10	3.8	5.6	6.4	3.0
Manganese (mg/L)	3.41	3.17	2.84	2.50	1.82	3.1	2.8	1.82	1.0

P1 – P5= Pont 1 to Point 8
Source: Field survey, (2022).

Manganese (Mn): The mean concentration values of Mn fall within the range of 2.12mg/L – 5.43mg/L and 1.82 – 3.4mg/L as shown in Table 2 during wet and dry season respectively. All the mean concentrations during both seasons fall high above the permissible limit postulated by NESREA (2011) standard of 1.0mg/L and measured similar to Ref [37] of 2.56 -6.10mg/L in Kaltungo Gombe. The paired Mn at T-test between the mean Manganese concentration value and the NESREA (2011) standard *(t(39)= -2.12*, *P* < .05) and (T(39)= -3.99, *P* < .05) showed significant differences in both seasons above the NESREA Standard at *P = .05* attributable to sewage being discharged into the river and naturally occurring Mn in basement complex rocks or to the dissolution of Mn bearing rocks and soils.

6.2 Seasonal Variations of Microbial Parameters and Comparisons to NESREA Standard along River Jakara

The concentrations of microbial parameters of Total Coliform (TC) and Escherichia Coliform (E. coli) were also investigated at eight different points (P1 – P8) along River Jakara and concentrations compared to NESREA (2011) Standard.

a. Total Coliform (TC): The study showed mean concentration values of TC within the range of 202cfu/100ml – 395cfu/100ml during wet season and 125 – 355mg/L in dry season as shown in Table 3. The values are well high above the established acceptable limit of NESREA (2011) standard of 10cfu/100ml and it is agreement with Ref. [38], who reported similar mean values of 265cfu/100ml - 347cfu/100ml and 241 – 410cfu/100ml in India. Similarly, paired TC T-test between the mean TC concentration value and the NESREA (2011) standard *(t(1)= -1.21, P < .05)* and (T(4)= -2.21, *P* < .05) during wet and dry seasons respectively showed great significant differences where, the TC measures higher mean attributable to disposal of wastewater, sewerages, open defecations and other anthropogenic activities of man where blackwater from the toilets, soak aways are also directly released on water bodies.

b. Escherichia Coliform (E. coli): The study showed mean concentration values of E. coli ranges 253 – 452cfu/100ml and 192 – 389cfu/100ml (see Table 3) during wet and dry seasons respectively attributable to enormous domestic wastes of all sorts (sewerages, feacea urines, open defecation, wastewater from different institutions) transported down slopes to the river. Similar results were observed by respectively as well as reported by Ref. [39] in Niger Delta region of Nigeria.

The paired E. coli values T-test between the mean E. coli concentration value and the NESREA (2011) standard *(t(1)= -1.20, P < .05)* during wet period and (*t(4)= -1.14, P* < .05) in dry season showed that there was significant differences at *P = .05*; where the E.coli measures above the NESREA Standard as well as higher values during wet season. The presence of E. coli in the river can be ascribed to sewages from home and institutions. The study also reported that 89.5% of the sampled water in Kano Metropolis on microbial parameters had very high indicator bacteria presence.

Table 3: Mean Concentration of Microbial Parameters along River Jakara during Wet and Dry Seasons

Parameters	P1	P2	P3	P4	P5	P6	P7	P8	NESREA (2011)
Wet Season									
Latitude	12.005N	12.011N	12.015N	12.028N	12.035N	12.048N	12.048N	12.055N	
Longitude	08.516E	08.522E	08.525E	08.530E	08.536E	08.541E	08.549E	08.553E	
TCC (cfu/100ml)	202	285	354	395	285	247	341	248	20
E-coli (cfu/100ml)	253	312	345	402	433	310	422	452	00
Dry Season									
TCC (cfu/100ml)	125	207	226	355	205	201	286	285	20
E-coli (cfu/100ml)	192	255	285	370	388	295	370	389	00

P1 – P8= Pont 1 to Point 8; TCC+ Total Coliform count; E. coli= Escherichia
Source: Field Survey (2022).

7. Conclusion and Feature Scope

The study showed that quantum volumes of sewages are generated on daily basis beyond the environment carrying capacity in Kano metropolis and that the absence of centralized wastewater collection system, treatment plants and poor drainage channels resulted to discharge of sewages into surface water such River Jakara and contaminate the water use for irrigation and other domestic activities. The laboratory analysis of the water samples from the river showed high accumulation of elements and microbiological parameters averagely above the NESREA (2011) standard for disposal of industrial and municipal wastewater (sewage) with higher concentrations recorded during the wet season attributable to runoff, percolation of waste down streams to the river. The indiscriminate disposal of waste of all kinds in the river has added the concentrations of the heavy metals and the microbial parameters on River Jakara. The additions of the sewage and other contaminants have resulted to pollution of the river that has a potential health effects on crops cultivate from the river as also found out by the study. Similarly, the T-test analysis revealed that there was significant variations in the expected disposal concentration values stipulated by NESREA to the concentrations analysed laboratory values. The study therefore recommends provision of centralized and well planned decentralized wastewater collection system in the Metropolis, good soakways and septic tanks, modern wastewater treatment plants and public enlightenment on community sanitations.

Feature Scope

There is also opening for further study on the sewage loads of physicochemical parameters in the study to holistically provide knowledge on water quality parameters and sewage management for permissible water quality required for disposal as stipulated by (NESREA) and drinking by (WHO and NSDWQ).

Data Availability

Data on the 288 water samples collected along River Jakara as well as the statistical analysis results have not been displayed in this work for private policy and confidentiality reasons. They are in the possession of the author and would be provided on requests when contacted on the above email and mobile phone. However, mean average data of the laboratory analysis are tabulated in the work for references and referral purposes.

Conflict of Interest

I declare no conflict of interest.

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