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# SPATIAL ASSESMENT OF RIVER WATER QUALITY AT THE MIDDLE SECTION OF RIVER KANO, NIGERIA

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**KEYWORDS:** Water Quality, Physico-chemical Parameters, Land Use, Spatial Source of Pollution

## Abstract

Water quality is essential for public health, aquatic ecosystem sustainability, and effective water resource management. This study assessed the spatial variation of physico-chemical water quality along the middle section of River Kano to identify pollution sources, evaluate the influence of land use, and compare water quality with established standards. Water samples were collected from Ten (10) sampling points (SP1–SP10) and analyzed for temperature, pH, electrical conductivity (EC), turbidity, total dissolved solids (TDS), dissolved oxygen (DO), biochemical oxygen demand ($BOD_5$), chemical oxygen demand (COD), nitrate, and phosphate using standard laboratory methods. Results showed significant spatial variation, with downstream sites near dense settlements, abattoirs, and agricultural areas recording higher turbidity, $BOD_5$, COD, nitrate, and phosphate concentrations, while upstream sites in less disturbed areas exhibited relatively good water quality. Pollution sources identified included domestic wastewater, abattoir effluents, agricultural runoff, and solid waste dumping. Comparison with WHO and Nigerian Standard for Drinking Water Quality (NSDWQ) revealed exceedances in turbidity, DO, $BOD_5$, COD, and phosphate at several locations, indicating that water is unsuitable for direct domestic use without treatment. The study concluded that human activities and land use practices are major contributors to river pollution, with cumulative downstream effects. Recommendations include improved waste management, adoption of sustainable agricultural practices, regular monitoring



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of water quality, enforcement of environmental regulations, and public education to reduce pollution. These findings provide critical insights for water resource management and policy formulation in Kano State.

## Introduction

Water is important for maintaining a vibrant economy. Most industries require water for their Production processes. Many industries also use water in processing raw materials such as in the food and beverages, pharmaceutical, tannery and textile industries. They also use water for their waste transportation and disposal. However, water quality is becoming increasingly degraded Owing to anthropogenic stressors including climate change, urbanization, agriculture, and the introduction of invasive species (Michalak 2016). Consequences of multiple stressors on water quality include a higher risk of algal blooms, changes in water chemistry, and unprecedented disturbances to biodiversity in aquatic ecosystems (Jackson et al. 2016).

The over exploitation of groundwater as well as pollution of ground and surface water by human activities like dumping of toxic substances and solid wastes into the water body; the washing of agrochemicals and fertilizers applied to farms by erosion and runoff into streams and rivers cause serious concerns for water resources management. Also, with the increase in world population, which has led to increase in developmental activities such as increase in industrial production, increase in agricultural activities and urbanization, there has been an increase in waste generation from industrial, agricultural, and domestic sources. All these wastes end up directly or indirectly in rivers and streams which serve as sources of water supply for communities. The continual introduction of harmful, unwanted, and unhealthy substances into water bodies deteriorates their quality. When consumed or used, such water can have adverse effects on the health of the community or individual users. This justifies the need for continuous water quality evaluation of our water bodies such as streams, rivers and lakes in order to determine the true nature and quality of the water body and to identify the source region of the pollutants.

Pollution from the Latin word pollutes which means 'to soil or defile' can occur naturally or through human activities. 'Water is considered to be polluted if it is unusable for a particular purpose' (Cech, 2005). Pollution can be classified into different categories based on types of pollutants as chemical, radioactive, and thermal pollution. Among these types of pollution, chemical pollution consists of major ions water pollution, heavy metals water pollution, and organic matter water pollution. Major ions chemical water pollution

is caused by discharge of liquid waste from industrial plants; or by discharge of residential effluents through gutters to the streams (Garba, 2025). Pollution of the natural environment by heavy metals is a universal problem because these metals are indestructible and most of them have toxic effects on living organisms, when permissible concentration levels are exceeded (Mmolawa, Likuku, and Gaboutloeloe, 2011; Science Daily, 2012; Omenesa, 2011; Bichi, Iguisi, Bello, Oladipo, and Butu, (2015).The presence of some toxic metals in our rivers is posing a serious challenge to our society. Though some of such metals occur naturally (as a result of geological processes like weathering, leaching), others occur due to some human activities (like burning fossil fuels, mining, industrial, and agricultural discharges) (Bichi, Iguisi, and Bello, 2009; Lentech, 2011; Nistha, Lokhande, and Dhar, 2012).

The quality of water depends on the management of anthropogenic discharges as well as the normal physicochemical characteristics of the catchment areas (Efe, Igban, Horsfall, and Akporhonor, 2005). Both natural conditions and human activities affect the quality of water resources. Through his various socio economic and industrial activities, man has caused severe water pollution of variable environmental problems; such as diseases, sudden deaths, and disabilities. Water related diseases such as dysentery, diarrhea, bilharziasis, typhoid fever, cholera, guinea worm and so on are very common among communities that live close to polluted river sources which flow through large urban centers.

Pollution sources are divided into two categories: point source and nonpoint sources. 'Point source pollution is generally defined as contamination discharged through a pipe or other discrete, identifiable location (this type is relatively easy to quantify, and impacts can be directly evaluated); while nonpoint source of pollution is generally from broad, diffuse sources that can be very difficult to identify and quantify' (Cech, 2005; Lentech, 2006). The point source pollution receives more attention since they are easy to identify and their impact is more than the nonpoint source pollution.

**RESEARCH QUESTIONS**

i. What are the sources of the pollutants?
ii. Which of the land use contributes the highest pollutants to the river?
iii. Is the physico- chemical variables within the acceptable limit by standard from different organization?

**STATEMENT OF THE PROBLEM**

The various socio-economic activities along the bank of the middle section of Kano River precisely Wudil town and its environs lead to increasing contamination / deterioration of the water quality in the afore mentioned section. A number of residential and commercial



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establishments are developing within the catchment area of the river and are continually discharging wastes into the river. The increasing level of water pollution by physical and chemical contaminants from various land use activities may alter the water quality of the river. Rain fed cultivation, irrigation agriculture and market gardening going on along the banks of this river also contribute various kinds of wastes into the river.

The effect of those contaminants containing degradable and non-degradable organic compound, nutrients, industrial effluents and agricultural waste on the Surface water quality can be observe at Kano River. The anthropogenic influences which constitute both points as well as non-points source of pollution constitutes the constant polluting source to this river. The natural factors may include precipitation rate, weathering processes, soil erosion as well as run-off which is a seasonal phenomenon and is largely influenced by the climate and climatic type in the basin and largely affect the quantity and quality of the water available. Many researches were carried out at the upper section of the river i.e along river kano and also downstream of the river i.e along river Yobe. But to the best of my knowledge none was carried out at the middle section of the river. Hence, this research is intended to fill this gap.

**AIM AND OBJECTIVES OF THE STUDY**

The aim of this study is to spatially assess the water quality of Kano River at the middle section. This aim will be achieved through the following objectives:

i. To identify the spatial source of water pollution,
ii. To examine the variable contributions of each land use type to the river water pollution,
iii. To compare the value of physio- chemical parameters with the standard.

**JUSTIFICATION AND IMPORTANCE OF THE STUDY**

Water is one of those resources that people take for granted until there is shortage of it or it becomes unsuitable for domestic uses. River Kano serves some purposes such as providing water for drinking, fish farming, domestic uses, and provides water for irrigation farming of vegetables like lettuce, cabbage and carrots during the dry season. Therefore, the pollution of this river will in no small way affect the end users adversely. Much attention has been given to this river because of the numerous settlements, commercial settings as well as irrigation activities taking place within the catchment area. Unfortunately, the river is prone to pollution due to the various land use activities that take place within the catchment area of the stream. There is a strong need, 'therefore, to determine the pollution status of the river as it relates to the socio-economic wellbeing of the inhabitants of the area.



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The findings of this study will be valuable to several stakeholders. Environmental regulatory agencies will benefit from empirical data that can guide monitoring and pollution control efforts. Water resource managers and planners will find the results useful for developing sustainable river management strategies. The study will also contribute to academic knowledge by providing baseline data on river water quality in Kano State, thereby serving as a reference for future research. Additionally, local communities will benefit indirectly through improved awareness of water quality issues and potential health risks.

**SCOPE OF THE STUDY**

The study focuses on the middle section of River Kano, covering selected sampling points that reflect different land use activities along the river course. The assessment is limited to physico-chemical parameters of water quality obtained through field sampling and laboratory analysis. Biological parameters and GIS-based spatial modeling are outside the scope of this study.

**LIMITATIONS OF THE STUDY**

Possible limitations include seasonal variation in water quality, limited access to certain sampling locations, and financial constraints associated with laboratory analysis. However, these limitations were minimized through careful sampling design and standard analytical procedures.

**LITERATURE REVIEW**

Water is the most valuable natural resource available to man, without which no life can survive. Therefore, adequate and safe water supply is a pre-requisite for significant socio-economic development of any community (Algaon-odot et al.,2012). Water bodies' pollution is the introduction of contaminants into water bodies. Water pollutants are directly or indirectly discharged into water bodies without adequate treatment to remove harmful substances (Michael Hogan, 2014). Water pollution affects plants and animals living in these water bodies, and also, affects other aquatic biota. Globally, the most prevalent water quality problem is eutrophication -the introduction of nutrients (mainly phosphates and nitrates) into water bodies. Eutrophication substantially impairs beneficial uses of water (UNDESA,2015).

Water quality refers to the chemical, physical, biological, and radiological characteristics of water (Dier song etal.,2009). It is a measure of the conditions of water relative to the requirement of one or more biotic species, and or to any human need or purpose. It is most frequently used by reference to a set of standards against which compliance can be assessed. The most common standards used to access water quality relate to health of



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ecosystems, safely of human contact and consumption (USEPA, 2005). Water quality parameters are parameters in which the assessment of water quality is based. Water quality parameters are divided into three categories; physical parameters, chemical parameters and biological parameters (Ben-coker, 2012).

Some of the physico-chemical parameters include turbidity, temperature, electrical conductivity (EC), total suspended solids (TSS), pH, dissolved oxygen (DO), nitrates, nitrites-phosphates, biochemical oxygen demand (BOD), etc.… Water is adjudged safe if these parameters fall within certain range that is tolerable by human when consumed; and also tolerable by living organism, within the aquatic environment (Standard organization of Nigeria,2007). Water quality standard or guideline describes the quality parameters set for drinking water (Arokoya et al.,2014).

Despite the truism that every human on this planet needs water to survive, and that water may contain many harmful constitutions, there is no universally recognized or acceptable international standard for drinking water. Even where standards do exist, and are applied, the permitted concentration of individual constituents may vary by as much as ten times from one set of standards to another. Many developed countries specify standards to be applied in their own country. In Europe, this includes the European Drinking water directives; and in U.S.A, the United States Environmental Protection Agency (Arokoyu et al.,2004).

Water quality has become a subject of concern to every nation of the world, since without water life cannot exist (Adamu, 2003). This is why 'it has been a subject of study in many parts of the world' (Porter, 1973; CES, 1983; Ademorati, 1983). Even though water is a common resource, its distribution, quantity, and quality are not yet satisfactory. On the availability of water in the world, Fish, (1973) stated that 'of the hydrosphere, which together with the atmospheric water, and the water held in land which complete the hydrological cycle, about 97% consist of sea water, 2% is ice mainly located at the poles, while the remaining 1% consists of fresh and brackish inland water'. Also, Morgan, (1982) stated that 'of the worlds' stock of fresh water, about 8.2 million cubic kilometers or more than 97% of the total available is inside the earth itself and exists as groundwater, while the rest are in lakes, streams, and rivers.

This shows that fresh water despite its necessity in demand is seriously in scarce supply. This is why Andrew, (2004) emphasized that 'despite the fact that water is in vast quantity, useful water is not readily available and is not sufficient to meet demand of the people'.

**Prevalence of Water Pollution in Some Nigerian Rivers**

Similar appalling situation exists in Nigeria as in other parts of the world. 'Although both ground and surface waters in Nigeria can be described to be of good quality, its utilization

by man either for energy production, or manufacture of products can lead to the development of pollution hazards in the water' (Olofin, 1992). 'Continued use of the water without careful quality assessment and periodic monitoring, may give rise to the accumulation of the problems, making them more difficult to overcome when the need arises' (Tanko, 1996). According to studies by Nigeria Environmental Study/Action Team (NEST, 1990) it is believed that there is increase in pollution of the country's water resources. Nwosu, (1983) reported that 'about 25.8 million tones official wastes were dumped into the Lagos lagoon in 1973. Ekinadoesereyhe, (2004) similarly assert that the various human activities / indiscriminate disposal of domestic wastes affects the quality of river Abraka in Delta state'. Sati, (1990) also reported the indiscriminate dumping of large quantities of domestic and industrial wastes into the Kaduna River. Beecroft et al, (1988) reported that 'the Kaduna River (particularly downstream of Kaduna south water works) is highly polluted with domestic and industrial wastes from the Kaduna south industrial layout at Kakuri and Nassarawa'. 'Stream water in the Upper Kubanni basin Samaru-Zaria is being heavily polluted with effluent (Smith, 1975 as in Jeb, 1996). 'In the Kano Region, attempts by organizations and individuals at investigating the surface and ground water characteristics for various uses, mainly irrigation and domestic started long ago' (Tanko, 2000). Subsequent reports by Bello, (1985); Sokoto, (1987 as in Olofin, 1997); and Tanko, (1989) were for Sharada estate.

**Effects of Water Pollution**

It has been estimated that contaminated water and poor sanitation cause 30,000 deaths around the world daily, the equivalent of 100 Jumbo Jets crashing everyday' (Garnett, 1981). Also, Awwa (1990) reported that 'over one billion of the five billion world population lack access to safe drinking water and 1.7 billion lack access to adequate sanitation'. Therefore, the negative impact of water quality deterioration is a serious one which needs global attention. Biswas, (1977) also reported on water and health situation on global basis as has been estimated as follows: - - Gastro-enteritis, 400 million cases every year - Schistosomiasis, 200 million cases every year - Filariasis, 200 million cases every year - Onchocerciasis, 20 – 40 million cases every year. All these diseases are water related and can be infected through contact with polluted water bodies.

**WATER QUALITY**

At the same time that humans were learning to exert some control over the quantity of water available to them, they found different waters varied in qualities such as temperature, color, taste, and odor etc They noted that these qualities influenced the suitability of water for certain purposes. Salty water was not suitable for human and livestock consumption or irrigation. Clear water was superior over turbid water for



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domestic use. Some waters could cause illness or even death when consumed by humans. The concepts of water quantity and water quality were probably developed simultaneously, but throughout most of human history, there were few ways for evaluating water quality beyond sensory perception and observations of the effects that certain waters had on living things or other water uses. Any physical, chemical, or biological property that influences the suitability of water for natural ecological systems or the use by humans is a water quality variable, and the term water quality refers to the suitability of water for a particular purpose.

Water quality refers to the chemical, physical, and biological characteristics of water, particularly in relation to its suitability for human consumption, agriculture, industry, and ecosystem health (Chapman, 1996). It is typically assessed using a range of parameters such as pH, temperature, dissolved oxygen, conductivity, turbidity, nutrients (nitrates and phosphates), and organic load indicators such as biochemical oxygen demand (BOD) and chemical oxygen demand (COD) (APHA, 2017). Poor water quality often results from pollutant inputs that exceed natural assimilative capacities, causing negative impacts on aquatic life and human health.

**Physico-Chemical Parameters**

Physico-chemical parameters describe the physical and chemical properties of water. These parameters are essential indicators of water quality because they reflect the presence of pollutants and the degree of contamination. For example: pH measures acidity or alkalinity, with values outside the optimal range (6.5–8.5) indicating potential pollution (WHO, 2017). Dissolved Oxygen (DO) is crucial for aquatic organisms; low DO levels often indicate organic pollution (Wetzel, 2001). Turbidity reflects the presence of suspended solids, which can carry pathogens and reduce light penetration (Davies-Colley & Smith, 2001). Nitrates and Phosphates indicate nutrient enrichment from agricultural runoff, often leading to eutrophication (Carpenter et al., 1998).

**Land Use and Water Quality**

Land use activities such as agriculture, urban settlements, and industrial operations influence water quality through surface runoff, waste discharge, and soil erosion. Agricultural lands may contribute fertilizers and pesticides, while urban areas often discharge untreated sewage and solid waste into rivers (Allan, 2004). Land use also affects sediment load, affecting turbidity and nutrient transport (Paul & Meyer, 2001).

**Pollution Sources**

Pollution sources are typically classified as point and non-point sources. Point sources include identifiable discharge outlets such as industrial effluent pipes, sewage outfalls,



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and abattoir drains. Non-point sources are diffuse, such as runoff from agricultural fields, road surfaces, and urban landscapes (Novotny & Olem, 1994). Both sources contribute to degradation of river water quality.

## THEORETICAL FRAMEWORK

This study is underpinned by the River Continuum Concept (RCC) and the Land Use-Water Quality Influence Model.

### River Continuum Concept

The River Continuum Concept (RCC), proposed by Vannote et al. (1980), posits that river systems represent continuous gradients from headwaters to downstream reaches, with predictable changes in physical and biological characteristics. According to RCC, human disturbances such as land use changes disrupt these gradients, altering water quality downstream. This concept underscores the importance of examining spatial variation along the river course.

### Land Use-Water Quality Influence Model

This model explains how different land use types influence water quality through pollutant loading. Urban land use contributes organic waste and heavy metals, agricultural land contributes nutrients and pesticides, and industrial areas may contribute toxic effluents (Allan, 2004). The model supports the study's objective to link land use to variations in physico-chemical parameters.

### Studies on River Water Quality

Studies across Nigeria and other regions have documented deteriorating river water quality due to anthropogenic pressures. For example, Abdullahi and Ajibade (2015) examined water quality in the Challawa River, Nigeria, and found elevated levels of turbidity, BOD, and nutrients above WHO standards, which were attributed to industrial and domestic wastewater discharge. Similarly, Olutona and Ipinmoroti (2014) investigated water quality of the Osun River and reported high concentrations of heavy metals and organic pollutants linked to agricultural runoff and urban waste, indicating significant health risks.

### Land Use and River Water Quality

A study by Adewale et al. (2017) in the Ogun River Basin demonstrated significant correlations between agricultural land use and increased nitrate and phosphate levels in river water. The research highlighted how runoff from farmlands contributed nutrient loading and degraded water quality. In Ghana, Amoako and Asare (2019) assessed spatial variation in the Pra River and found that river segments near urban centers had higher



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levels of suspended solids and pollutants than upstream rural sections, showing the impact of urbanization on water quality.

**Standards Comparison**

Comparative assessments of water quality with national and international standards are common in empirical research. Ejidike and Mmom (2013) compared physico-chemical parameters of the Imo River with WHO standards and found pH, turbidity, and nitrate levels exceeding acceptable limits, emphasizing the need for regulatory enforcement.

**Studies in Kano and Northern Nigeria**

Research specific to Kano River and its tributaries is limited, though few studies have noted pollution concerns. Musa et al. (2018) assessed water quality along river courses in Kano State and identified elevated nutrient levels during rainy seasons, linked to runoff from cultivated fields. However, detailed spatial assessment focusing on the middle section of River Kano remains inadequate, indicating a knowledge gap the present study addresses.

## RESEARCH METHODOLOGY

The study adopted a descriptive and analytical research design based on field sampling and laboratory analysis. This approach is appropriate for assessing spatial variation in river water quality and identifying pollution sources through direct measurement of physico-chemical parameters (Chapman, 1996). The design allows comparison of observed values across sampling locations and against established water quality standards.

## TYPES OF DATA

The data used in this study comprises of Ten (10) water quality parameters. These parameters where selected because of their high level of impact in determining water quality characteristics. The selected parameters comprises of temperature, pH, electrical conductivity (EC), turbidity, total dissolved solids (TDS), dissolved oxygen (DO), biochemical oxygen demand ($BOD_5$), chemical oxygen demand (COD), nitrate, and phosphate.

## SOURCES OF DATA

The data on physiochemical parameters was obtained from laboratory analysis, while the secondary data was obtained from text books, journals and internet.



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**SAMPLING DESIGN, TECHNIQUES AND PROCESS OF DATA COLLECTION**

A total of Ten (10) sampling sites will strategically be located along the surface water of Kano River. Sampling points and coordinates will be noted. Water sample will be collected in triplicate in each of the sampling points at 6am, 12pm, 6pm. Prior to the sample collection, the bottles will be sterilized in the laboratory using Autoclave, which will then be rinsed twice with the water to be collected as sample thoroughly, and each bottle will be dipped into the river for the sample to be collected below the surface. The collected samples will be filtered using pre-conditioned plastic mill, pore filter unit with 0.45pm filter membrane and kept in the ice block for laboratory analysis. In order to provide greater data confidence from the analytical procedure regarding bias and variability appropriate Quality assurance and Quality control (QA/QC) on water samples will be ensured. The QA/QC are to be followed to ensure that data products are of documented high quality and reproducible, the overall data quality will be assessed through precision, accuracy, representativeness, completeness, sensitivity and comparability (Aris et al.2012).

**METHOD OF DATA ANALYSIS**

The data obtained from the laboratory analysis will be subjected to analysis. Firstly, descriptive statistics will be used. Measure of dispersion includes the standard deviation; the coefficient of variance to describe the data on physiochemical parameters to detect or identify errors and mistakes and to provide medium for assumption normality of the data. Principal Component Analysis (PCA) will also be applied to identify the sources of water pollution at the middle section of River Kano One-way analysis of variance (one-way ANOVA) to compare the variation of quality status of water at each selected water sample point. The following hypothesis are to be tested;

Ho: There is no significant different in the water quality status between the sampling points. Moreover, pearson product moment correlation analyses will be conducted on the data to obtained a linear relationship between the physiochemical parameters.

**MATERIALS NEEDED FOR THE STUDY**

Some of the materials used include: micropipette, pipette tip, test tubes, centrifuge tubes, cuvette, glass spreader, membrane filter, wire loop, Bunsen burner, ethanol sprayer, beaker, conical flask, Scott bottles, HACH tube, BOD glass bottles (300-Ml), petri dishes, universal bottles, measuring cylinder, nutrient agar, nutrient broth, effluent sample, distilled water. Reagents for Gram staining, biochemical test, 16s rRNA gene sequence analysis, COD, BOD, ammonical-nitrogen and heavy metals determination would also be provided for use.



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**DESCRIPTION OF THE STUDY AREA**

The study area Kano River at middle section extend from longitude 80 31'E to 80 45'E and latitude 120 10'N and 120 13'N. It is located about 481m (1,580 ft) above mean sea level covering an area of about 150 km. The Kano River is one of the most significant water bodies that are supporting residential, industrial, and agricultural activities in its middle section it is surrounded by a population of more than 500,000 inhabitants. i.e at Wudil town Wudil Local Government is bordered to the northeast by Ajingi, to the east by Gaya, to the southwest by Albasu, to the south by Garko, to the west by Dawakin Kudu, and to the north by Warawa local government area.

River Kano is a major river in Kano State, Nigeria, and a tributary of the Hadejia–Jama'are river system. The river flows through urban, peri-urban, and agricultural landscapes, making it highly susceptible to anthropogenic pollution. The middle section of River Kano, which forms the focus of this study, lies between the upstream rural stretch and the downstream floodplain areas. This section passes through densely populated settlements and zones characterized by mixed land use, including residential areas, farmlands, abattoirs, markets, and small-scale industries. The climate of the area is tropical continental, marked by distinct wet and dry seasons. These climatic conditions influence river discharge and pollutant transport, particularly during the rainy season when surface runoff is high.

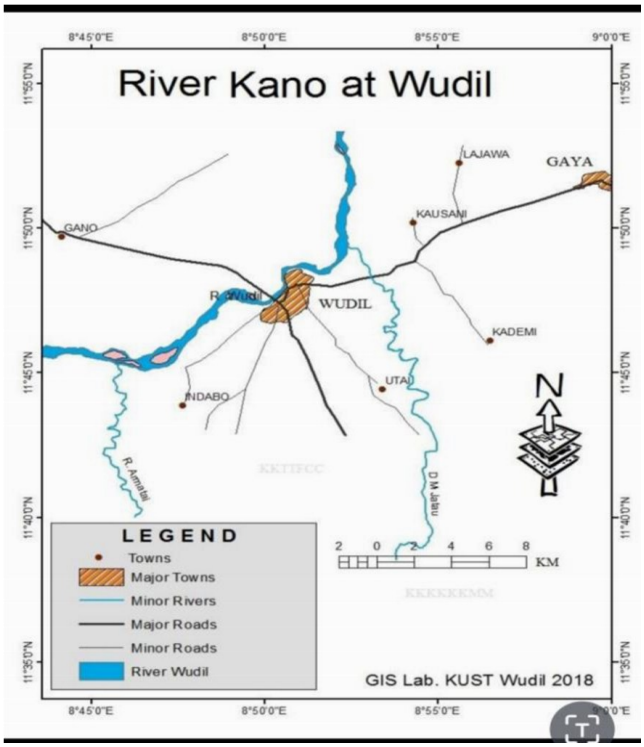



**FIGURE 1; WUDIL LGA SHOWING KANO RIVER**



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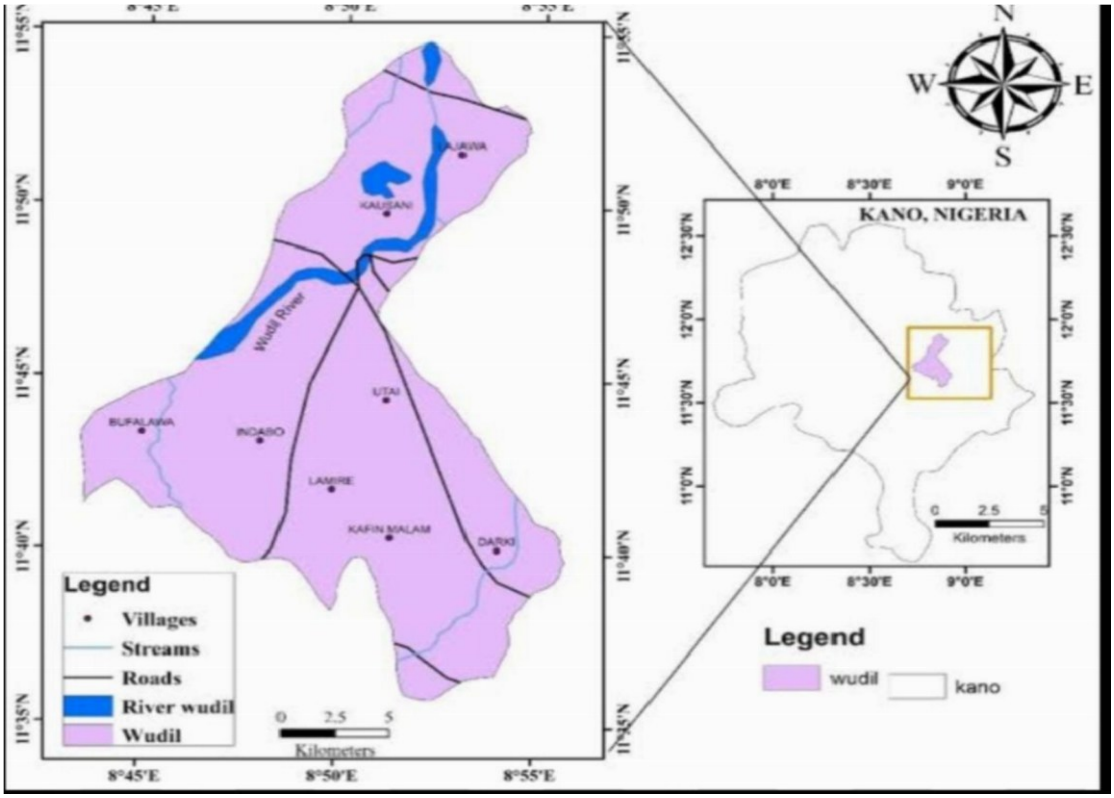



**FIGURE 2; MAP OF WUDIL INSERT KANO**

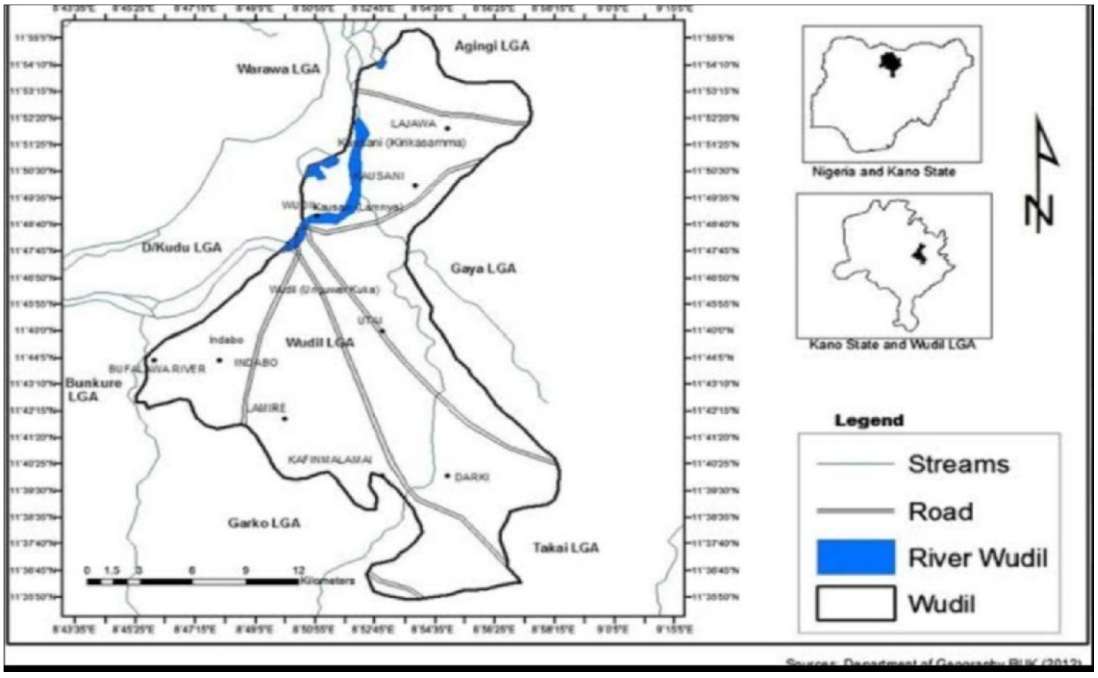



**FIGURE 3; MAP OF WUDIL INSERT KANO AND NIGERIA**



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## RESULTS AND DISCUSSION

The results indicate clear spatial variation in water quality along the middle section of River Kano. SP1, located near relatively less disturbed areas, recorded the lowest turbidity, BOD, COD, and nutrient concentrations. SP3 and SP4, located near dense settlements, abattoirs, and farmlands, showed elevated levels of turbidity, BOD, COD, nitrates, and phosphates. SP5, downstream of intensive agricultural activity, also recorded high nutrient levels, though lower than SP4. This spatial trend suggests increasing pollution load from anthropogenic activities along the river course.

## SPATIAL SOURCE OF WATER POLLUTION

Observed pollution sources during fieldwork included: Direct discharge of domestic wastewater, Abattoir effluents, Agricultural runoff containing fertilizers and organic waste, Solid waste dumping along riverbanks. High $BOD_5$ and COD values at SP3 and SP4 indicate significant organic pollution, likely from sewage and abattoir waste. Reduced dissolved oxygen levels at these points further confirm organic matter decomposition consuming oxygen. These findings agree with Chapman (1996) and Abdullahi & Ajibade (2015), who linked elevated BOD and low DO to untreated organic waste discharge in Nigerian rivers.

## LAND USE CONTRIBUTIONS TO WATER POLLUTION

Different land use types contributed variably to river pollution: Residential areas contributed domestic sewage, increasing BOD, COD, and turbidity. Agricultural land use contributed nitrates and phosphates through fertilizer runoff, particularly evident at SP4 and SP5. Commercial and abattoir zones contributed organic waste and suspended solids, resulting in high turbidity and oxygen depletion. The highest phosphate concentration (8.4 mg/L) at SP4 exceeded WHO limits, reflecting intense agricultural and abattoir activity. This supports Allan (2004) and Carpenter et al. (1998), who emphasized land use as a key determinant of river water quality.

### Physico-Chemical Parameters of River Kano Water

**Table 1: Physico-Chemical Parameters of River Kano Water**

| S/N | PARAMETER | UNIT | S1 | S2 | S3 | S4 | S5 | S6 | S7 | S8 | S9 | S10 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | Temperature | ℃ | 27.4 | 28.1 | 28.6 | 29.0 | 28.8 | 27.4 | 28.1 | 28.6 | 29.0 | 28.8 |
| 2. | Ph | - | 7.1 | 7.3 | 7.6 | 7.8 | 7.5 | 7.1 | 7.3 | 7.6 | 7.8 | 7.5 |
| 3. | EC | µS/cm | 420 | 610 | 880 | 940 | 790 | 420 | 610 | 880 | 940 | 790 |
| 4. | Turbidity | NTU | 6.2 | 9.8 | 14.5 | 18.1 | 12.7 | 6.2 | 9.8 | 14.5 | 18.1 | 12.7 |



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| S/N | PARAMETER | UNIT | S1 | S2 | S3 | S4 | S5 | S6 | S7 | S8 | S9 | S10 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **5.** | Total Dissoved Solids (TDS) | mg/L | 210 | 340 | 460 | 510 | 420 | 210 | 340 | 460 | 510 | 420 |
| **6.** | DO | mg/L | 6.4 | 5.8 | 4.6 | 3.9 | 4.8 | 6.4 | 5.8 | 4.6 | 3.9 | 4.8 |
| **7.** | $BOD_5$ | mg/L | 2.4 | 3.6 | 5.8 | 7.2 | 4.9 | 2.4 | 3.6 | 5.8 | 7.2 | 4.9 |
| **8.** | COD | mg/L | 6.1 | 9.4 | 14.7 | 18.3 | 12.8 | 6.1 | 9.4 | 14.7 | 18.3 | 12.8 |
| **9.** | Nitrate | mg/L | 18.2 | 26.4 | 38.7 | 44.1 | 33.5 | 18.2 | 26.4 | 38.7 | 44.1 | 33.5 |
| **10.** | Phosphate | mg/L | 1.9 | 3.2 | 6.8 | 8.4 | 5.6 | 1.9 | 3.2 | 6.8 | 8.4 | 5.6 |

**Source: Authors**

**Comparison with Water Quality Standards**

Comparison with WHO and NSDWQ standards reveals that: pH and temperature were within acceptable limits across all sampling points. Turbidity exceeded permissible limits at all points except SP1, indicating widespread sediment and waste input. TDS slightly exceeded the standard at SP4. DO fell below recommended limits at SP3, SP4, and SP5, posing risks to aquatic life. $BOD_5$, COD, and phosphate values exceeded standards at several locations, particularly SP3 and SP4. These exceedances indicate that water from the middle section of River Kano is unsuitable for direct domestic use without treatment.

**Table 2: Physico-Chemical Parameters of River Kano Water and WHO/NSDWQ STANDARD**

| S/N | PARAMETER | UNIT | WHO/NSDWQ STANDARD | S1 | S2 | S3 | S4 | S5 | S6 | S7 | S8 | S9 | S10 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1.** | Temperature | ℃ | ≤ 30 | 27.4 | 28.1 | 28.6 | 29.0 | 28.8 | 27.4 | 28.1 | 28.6 | 29.0 | 28.8 |
| **2.** | pH | - | 6.5–8.5 | 7.1 | 7.3 | 7.6 | 7.8 | 7.5 | 7.1 | 7.3 | 7.6 | 7.8 | 7.5 |
| **3.** | EC | µS/cm | 1000 | 420 | 610 | 880 | 940 | 790 | 420 | 610 | 880 | 940 | 790 |
| **4.** | Turbidity | NTU | 5 | 6.2 | 9.8 | 14.5 | 18.1 | 12.7 | 6.2 | 9.8 | 14.5 | 18.1 | 12.7 |
| **5.** | Total Dissoved Solids (TDS) | mg/L | 500 | 210 | 340 | 460 | 510 | 420 | 210 | 340 | 460 | 510 | 420 |
| **6.** | DO | mg/L | ≥ 5 | 6.4 | 5.8 | 4.6 | 3.9 | 4.8 | 6.4 | 5.8 | 4.6 | 3.9 | 4.8 |
| **7.** | $BOD_5$ | mg/L | ≤ 3 | 2.4 | 3.6 | 5.8 | 7.2 | 4.9 | 2.4 | 3.6 | 5.8 | 7.2 | 4.9 |
| **8.** | COD | mg/L | ≤ 10 | 6.1 | 9.4 | 14.7 | 18.3 | 12.8 | 6.1 | 9.4 | 14.7 | 18.3 | 12.8 |
| **9.** | Nitrate | mg/L | ≤ 50 | 18.2 | 26.4 | 38.7 | 44.1 | 33.5 | 18.2 | 26.4 | 38.7 | 44.1 | 33.5 |
| **10.** | Phosphate | mg/L | ≤ 5 | 1.9 | 3.2 | 6.8 | 8.4 | 5.6 | 1.9 | 3.2 | 6.8 | 8.4 | 5.6 |

**Source: Authors**

**DISCUSSION OF FINDINGS**

The observed deterioration in water quality along the middle section of River Kano is strongly linked to human activities and land use practices. Elevated organic and nutrient pollution reflects poor waste management and uncontrolled discharge into the river.



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Seasonal runoff likely amplifies pollutant transport, particularly during the rainy season. The spatial pattern observed aligns with the River Continuum Concept, which predicts cumulative downstream impacts of anthropogenic disturbances (Vannote et al., 1980). Similar findings have been reported in other Nigerian rivers, including the Challawa and Ogun Rivers (Adewale et al., 2017; Musa et al., 2018). The study assessed water quality along the middle section of River Kano through field sampling and laboratory analysis. The key findings are summarized as follows:

i. Spatial Variation in Water Quality; Water quality exhibited distinct spatial variation along the river course. SP1, situated near relatively undisturbed areas, recorded the lowest turbidity, $BOD_5$, COD, and nutrient concentrations, indicating relatively good water quality. SP3 and SP4, located near dense residential settlements, abattoirs, and farmlands, exhibited high turbidity, $BOD_5$, COD, nitrate, and phosphate levels, reflecting intense anthropogenic pollution. SP5, downstream of agricultural activities, recorded elevated nutrient concentrations, although lower than SP4. These findings demonstrate that pollution load accumulates downstream, consistent with the River Continuum Concept (Vannote et al., 1980).
ii. Pollution Sources; Direct discharge of domestic wastewater, abattoir effluents, agricultural runoff, and solid waste dumping along riverbanks were identified as primary pollution sources. High $BOD_5$ and COD values, along with reduced DO levels at SP3 and SP4, indicate substantial organic pollution from sewage and abattoir effluents. These observations are in agreement with Chapman (1996) and Abdullahi & Ajibade (2015), who linked elevated BOD and low DO to untreated organic waste in Nigerian rivers.
iii. Land Use Contributions; Residential areas contributed significantly to turbidity, $BOD_5$, and COD, due to domestic sewage discharge. Agricultural lands contributed high levels of nitrates and phosphates through fertilizer runoff, particularly evident at SP4 and SP5. Abattoirs and commercial zones contributed organic matter and suspended solids, exacerbating oxygen depletion in the river.
iv. Comparison with Water Quality Standards; Temperature and pH were within WHO and NSDWQ recommended limits at all sampling points. Turbidity exceeded permissible limits at all points except SP1, suggesting widespread sediment and waste input. DO fell below recommended limits at SP3, SP4, and SP5, posing risks to aquatic life. $BOD_5$, COD, and phosphate concentrations exceeded standards at several points, particularly SP3 and SP4, indicating that water is unsuitable for direct domestic consumption without treatment.

**SUMMARY OF FINDINGS**

Findings revealed that; The deterioration in water quality is closely linked to human activities and land use practices. The spatial pattern of water quality parameters confirms the cumulative impact of settlements, agriculture, and abattoir activities along the river course. The water quality analysis along the middle section of River Kano. The findings revealed significant spatial variation in physico-chemical parameters, with several exceeding recommended standards. Land use activities such as agriculture, residential settlements, and abattoirs were identified as major contributors to river pollution.

**CONCLUSION**

Based on the findings, the following conclusions are drawn:

Water quality along the middle section of River Kano is significantly impacted by anthropogenic activities, with the poorest quality recorded downstream. Organic and nutrient pollution are the primary water quality concerns, largely due to domestic sewage, abattoir effluents, and agricultural runoff. Spatial variation in water quality reflects the influence of land use patterns, confirming that areas with dense settlements and intensive agriculture contribute most to river pollution. The middle section of River Kano does not fully meet WHO and NSDWQ standards for safe domestic use, particularly in terms of turbidity, DO, $BOD_5$, COD, and phosphate concentrations. Effective management of land use and waste discharge is crucial to protect the river ecosystem and ensure safe water supply.

**RECOMMENDATIONS**

In light of the study findings, the following recommendations are proposed:

i. Waste Management Improvement; Implement proper sewage and solid waste management systems in residential areas along the river. Abattoirs should adopt pre-treatment of effluents to reduce organic pollution before discharge.
ii. Sustainable Agricultural Practices; Farmers should employ controlled fertilizer application, buffer strips, and soil conservation techniques to reduce nutrient runoff into the river. Promotion of organic farming practices is recommended to minimize chemical inputs.
iii. Water Quality Monitoring; Conduct regular monitoring of key water quality parameters to track pollution trends and inform management interventions. Community-based monitoring programs can enhance awareness and accountability among local residents.
iv. Policy and Regulatory Measures; Strengthen enforcement of environmental regulations regarding waste disposal, industrial effluents, and abattoir operations.



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Integrate river protection measures into urban planning to prevent uncontrolled settlement and land use along riverbanks.

v. Public Awareness and Education; Educate local communities on the health risks of consuming untreated river water. Promote campaigns on proper waste disposal and river stewardship to reduce pollution inputs.

## FINAL REMARKS

The study revealed that River Kano's middle section is under significant anthropogenic stress, with water quality deteriorating downstream due to settlements, agriculture, and abattoir activities. Immediate interventions, including improved waste management, sustainable land use practices, and continuous water quality monitoring, are essential to safeguard both human health and the river's ecological integrity.

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