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# COMPARATIVE STUDY OF PHYSICOCHEMICAL PARAMETERS OF WASTEWATERS FROM HOSPITALS, DOMESTIC AND AGRICULTURAL SITES IN KANO METROPOLIS

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**Abstract** **https://doi.org/10.65760/sjgs.v4.i2.10**

*Wastewater pollution is a major environmental and public health concern, particularly in rapidly urbanizing regions. This study assessed the physicochemical parameters of wastewater in Kano Metropolis, Nigeria, across the dry and wet seasons to evaluate its quality and potential environmental impact. Wastewater samples were collected from three sites which are hospital discharge points, domestic drainage systems, and agricultural sites. A six-month sampling campaign was conducted across selected hospital, domestic, and agricultural wastewater sites in Kano Metropolis, Nigeria, yielding a total of 72 wastewater samples. The samples were analyzed for key physicochemical parameters, including pH, temperature, turbidity, electrical conductivity (EC), total dissolved solids (TDS), dissolved oxygen (DO), and biochemical oxygen demand (BOD), using the analytical procedures described in the study methodology. Descriptive statistics were employed to characterize parameter distributions, while paired-samples t-tests were used to evaluate seasonal differences. Correlation analysis was further applied to assess associations among the measured physicochemical parameters. The results revealed seasonal variations in wastewater quality, with higher contamination levels observed during the dry season due to less water flow and reduced dilution effects. All effluents had temperatures within acceptable limits with an overall mean of 28.2°c, suggesting minimal thermal impact on receiving water bodies. The pH values of all sources were within permissible ranges (6.5), although slight acidity was observed in some hospital and agricultural samples. Dissolved oxygen levels were below acceptable standards across all sites with mean value of 3.7 mg/l, indicating poor water quality. The Biological oxygen demand values were low across all sources (1.92 mg/l), suggesting moderate levels of biodegradable organic matter. Also, turbidity mean (14.59 NTU) exceeded WHO guidelines in hospital and domestic sources, highlighting the presence of suspended solids and potential microbial contamination. The findings revealed significant pollution of wastewater in Kano Metropolis, posing risks to environmental and public health. There by recommends the need for decentralized wastewater treatment systems, especially at hospitals and urban households, and regular monitoring to safeguard public and environmental health.*

**Keywords**: *Wastewater Quality, Physicochemical Parameters, Pollution, Kano Metropolis, Water Quality.*

## 1.1 Introduction

Wastewater pollution has become one of the major environmental and public health challenges confronting many developing countries, particularly in rapidly urbanizing regions where population growth, industrialization, agricultural intensification, and inadequate sanitation infrastructure continue to increase the volume of untreated effluents discharged into the environment (Obaid et al.,

2022; Mshelia et al., 2023). Wastewater generated from domestic, hospital, and agricultural activities contains a wide range of contaminants including suspended solids, organic matter, nutrients, pathogenic microorganisms, detergents, pharmaceutical residues, pesticides, heavy metals, and other toxic substances capable of degrading environmental quality and threatening human health if not adequately treated before disposal (Agoro et al., 2024; Varsani et al., 2023). In many developing nations, poor wastewater treatment facilities and weak environmental regulatory systems have resulted in the indiscriminate discharge of untreated or partially treated wastewater into rivers, streams, drainage channels, wetlands, and agricultural lands (WHO, 2017).

Globally, wastewater contamination has been identified as a major contributor to declining water quality, ecosystem degradation, biodiversity loss, and the spread of waterborne diseases (UNEP, 2021). The continuous discharge of untreated wastewater into the environment can result in eutrophication, oxygen depletion, contamination of groundwater resources, accumulation of toxic substances, and deterioration of aquatic ecosystem functions (Singh et al., 2020). Studies have shown that poor wastewater management practices contribute significantly to environmental pollution and public health burdens in many African cities where rapid urban growth and anthropogenic activities continue to outpace environmental infrastructure and sanitation services (Echioda et al., 2024; Abdel-Shafy & Mansour, 2015).

In Nigeria, rapid urbanization and increasing socio-economic activities have intensified wastewater generation in many urban centres including Kano. Kano Metropolis is one of the largest commercials, industrial, and densely populated cities in northern Nigeria and serves as a major centre for commerce, healthcare services, agriculture, transportation, and industrial activities. The increasing population and expanding human activities within the metropolis have significantly increased the generation of wastewater from residential settlements, healthcare facilities, irrigation farms, livestock production systems, markets, and industrial establishments (Shawai et al., 2019; Mshelia et al., 2023). However, inadequate drainage systems, poor sanitation infrastructure, and indiscriminate disposal practices have contributed to environmental pollution and contamination of surrounding water bodies.

Hospital wastewater is considered one of the most hazardous forms of wastewater because it may contain infectious microorganisms, pharmaceutical residues, disinfectants, chemical reagents, radioactive substances, and antibiotic compounds capable of contaminating aquatic ecosystems and increasing antimicrobial resistance in the environment (Agoro et al., 2024). Domestic wastewater generated from household activities such as washing, bathing, cooking, and sanitation contains high concentrations of organic matter, nutrients, detergents, oils, food residues, and microbial contaminants (Obaid et al., 2022). Agricultural wastewater originating from irrigation farming and livestock production may also contain fertilizers, pesticides, manure, sediments, and organic waste materials capable of altering the physicochemical characteristics of receiving water bodies (FAO, 2017). The continuous discharge of untreated wastewater from these sources into the environment may therefore contribute to water pollution, ecological imbalance, and increased environmental health risks.

Assessment of physicochemical parameters is one of the most reliable approaches for evaluating wastewater quality and determining the extent of environmental pollution. Physicochemical parameters such as temperature, pH, dissolved oxygen (DO), electrical conductivity (EC), total dissolved solids (TDS), biochemical oxygen demand (BOD), chemical oxygen demand (COD), and turbidity provide valuable information regarding pollutant concentration, organic contamination, ionic composition, and ecological condition of wastewater (Varsani et al., 2023; Echioda et al.,



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2024). These parameters influence pollutant mobility, microbial activities, oxygen availability, nutrient cycling, and aquatic ecosystem stability. Temperature affects the rate of chemical reactions and dissolved oxygen solubility, while pH influences the acidity, alkalinity, and toxicity of pollutants. Dissolved oxygen is an important indicator of water quality because low oxygen concentrations may indicate high organic pollution and microbial decomposition activities (Singh et al., 2020). Electrical conductivity reflects the ionic content of wastewater, whereas total dissolved solids indicate the concentration of dissolved substances capable of affecting water quality and aquatic organisms. Biochemical oxygen demand is commonly used to determine the level of biodegradable organic matter present in wastewater, while turbidity indicates the concentration of suspended particles and colloidal substances in water (Echioda et al., 2020).

Despite increasing concerns regarding wastewater pollution in many urban areas of Nigeria, limited comparative studies have been conducted on hospital, domestic, and agricultural wastewater within Kano Metropolis, particularly with respect to seasonal variability and differences in pollutant characteristics. Most previous studies focused mainly on individual wastewater sources without adequately comparing pollution levels among different wastewater categories. In addition, limited information exists regarding seasonal variations in physicochemical characteristics of wastewater within the metropolis. The lack of adequate comparative data limits effective environmental monitoring, pollution control, wastewater treatment planning, and implementation of sustainable environmental management strategies. Therefore, this study seeks to comparatively assess the physicochemical parameters of hospital, domestic, and agricultural wastewater in Kano Metropolis in order to determine their pollution status, seasonal variations, compliance with WHO and NESREA standards, and associated environmental and public health implications.

Wastewater management remains a major environmental and public health challenge in rapidly urbanizing cities, particularly in developing countries where sanitation infrastructure, wastewater treatment capacity, and regulatory enforcement may be inadequate. In Kano Metropolis, Nigeria, increasing domestic activities, expanding healthcare services, urban agriculture, and livestock production contribute to wastewater generation, raising concerns about the discharge of inadequately treated effluents into drainage networks and receiving environments. Hospital wastewater is of particular concern because it may contain pathogenic microorganisms, pharmaceutical residues, antimicrobial compounds, and other potentially hazardous chemical contaminants (Verlicchi et al., 2010; Khan et al., 2021). Domestic wastewater typically contains organic matter, suspended solids, detergents, nutrients, and microbial contaminants, whereas agricultural wastewater may transport fertilizers, pesticides, animal manure, and sediment into adjacent water bodies. Where these waste streams are inadequately managed, their discharge can modify the physicochemical characteristics of receiving waters, impair aquatic ecosystem functioning, and increase environmental and public health risks. Previous investigations of wastewater and water-quality conditions in Kano Metropolis have documented the relevance of physicochemical monitoring to understanding local pollution concerns (Akan et al., 2008; Mshelia, 2023).

Despite these concerns, comparative characterization of hospital, domestic, and agricultural wastewater remains important for understanding differences in their physicochemical profiles and potential pollution burdens within Kano Metropolis. Although previous studies have examined wastewater-related pollution and water-quality characteristics in the area, the evidence provided by individual studies may not adequately establish how these three wastewater categories differ under a common comparative framework. Furthermore, assessing seasonal variability is necessary to determine whether changes in rainfall and associated environmental conditions coincide with variations in measured wastewater parameters. Such evidence can support more targeted



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environmental monitoring, wastewater management, and pollution-control planning. Accordingly, this study comparatively evaluates selected physicochemical parameters of hospital, domestic, and agricultural wastewater in Kano Metropolis, with particular emphasis on differences among wastewater categories and seasonal variation. The findings are intended to provide locally relevant evidence for assessing wastewater quality and informing appropriate environmental management interventions.

The aim of this study is to comparatively evaluate the physicochemical characteristics of hospital, domestic, and agricultural wastewater in Kano in order to determine the level of pollution, seasonal variability, compliance with WHO and NESREA standards, and the potential environmental and public health implications associated with wastewater discharge within the metropolis. Specifically, the study seeks to determine the physicochemical parameters including temperature, pH, dissolved oxygen, electrical conductivity, total dissolved solids, biochemical oxygen demand, and turbidity of hospital, domestic, and agricultural wastewater; compare the physicochemical characteristics of wastewater from the different sources with WHO and NESREA permissible standards; assess spatial and seasonal variations in wastewater quality parameters across the selected sampling sites; examine the relationships among selected physicochemical parameters using correlation analysis; evaluate the environmental and public health implications associated with wastewater pollution; and provide recommendations for effective wastewater management, environmental monitoring, and sustainable wastewater treatment practices within Kano Metropolis.

## 2. Materials and Methods

### 2.1 Study Area

The study area lies within Kano Metropolis area of Kano state. Kano Metropolis comprises of eight Local Government Areas namely Gwale, Dala, Nasarawa, Municipal, Tarauni, Fagge, Kumbotso and Ungogo. The metropolis Kano covers about 499 square Kilometer at an altitude of 472 meter above sea level and bound to the northeast by Minjibir and the east by Gezawa, and to the south east by Dawakin Kudu and to the west by Madobi and Tofa Local Government Area. The study Locations includes Murtala Muhammad Specialist Hospital (MMSH), a tertiary healthcare facility in Kano Municipal local government area of Kano state located at latitude 12.0003N and longitude 8.50881E; Abdullahi Wase Teaching Hospital (AWTH) lies at latitude 11.997N and longitude 8.5477E inside a built-up Nasarawa/GRA corridor close to markets, residential compounds and arterial roads; Danagundi Residential Area situated at latitude 11.98642N and longitude 8.52115E, the area falls within the inner core of Kano city, adjacent to one of the ancient city gates; Kofar Dan Agundi; Jakara residential area situated at latitude 12.0007N and longitude 8.50588E, It lies within the vast Chad basin geological formation and the Sudan savannah ecological zone (Figure 1). The area is part of water shed to the Jakara River; Livestock farm located at Yankusa area in Kumbotso local Government Area of Kano state at latitude 11.9161N and longitude 8.4868E, characterized by rural and agricultural landscape which is directly reflected in its drainage and land use pattern; and vegetable farm lies at latitude 11.9597 N and longitude 8.4975E within Sharada Phase II, an industrial–residential district in Kano metropolis.



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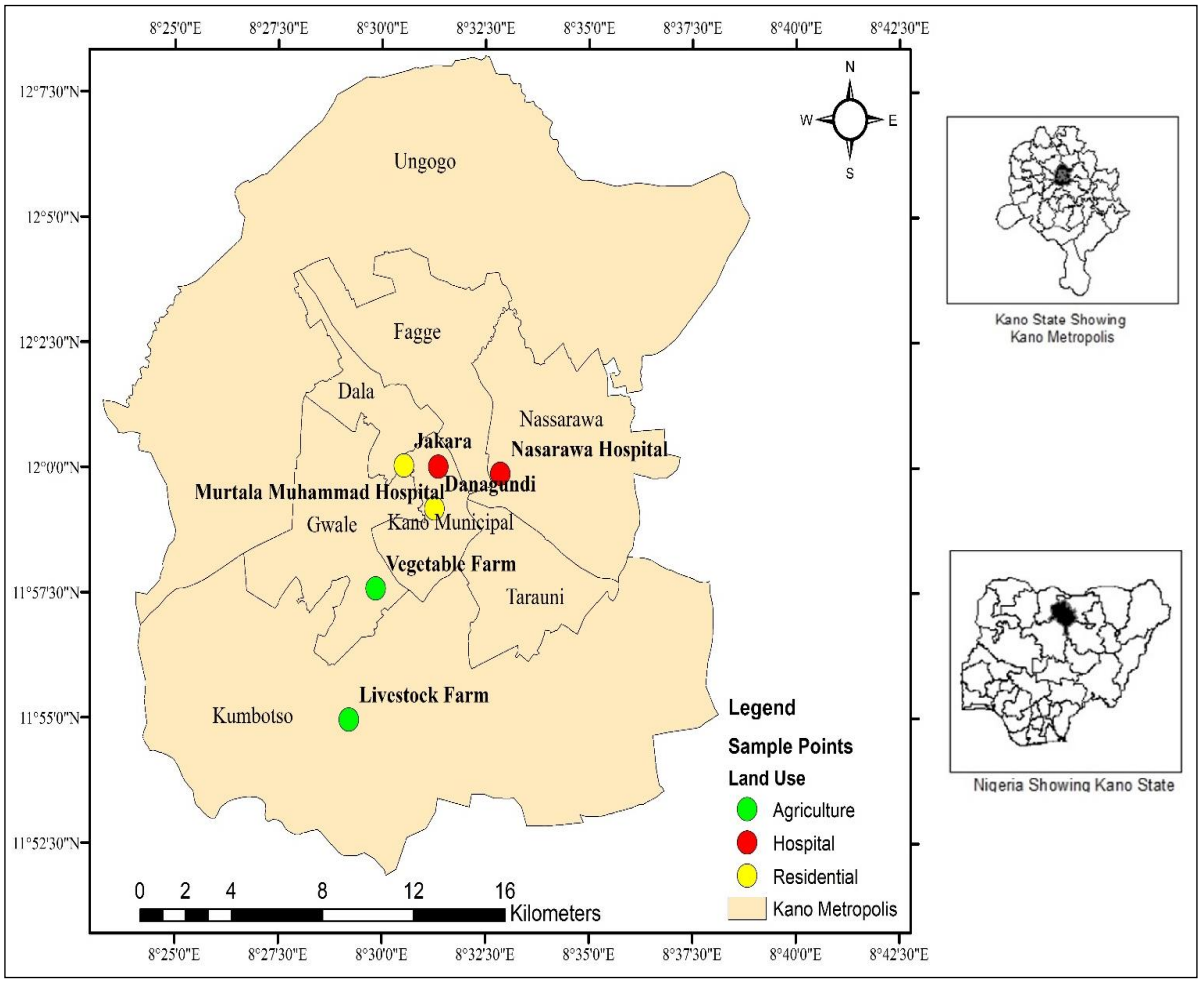


**Figure 1: Kano Metropolis Showing the Study Locations**

## 2.2 Study Design

The study adopted an experimental research design involving the collection and laboratory analysis of hospital, domestic, and agricultural wastewater samples to assess the physicochemical level of contamination within the study area. The experimental design was considered appropriate because it ensured objectivity, accuracy, and reliability in the assessment of wastewater quality parameters and provided a scientific basis for understanding the influence of human and environmental activities on wastewater pollution levels.

## 2.3 Sample Size and Sampling Techniques

A total of seventy-two (72) wastewater samples were collected during the study period. Two samples each were collected from two hospital sites, two residential sites, and two agricultural sites over a period of six months. The sample size was considered adequate in line with the Central Limit Theory, which recommends a minimum sample size of thirty observations for establishing relationships and making statistical inferences in experimental studies.

The study sites were selected using both convenience and purposive sampling techniques. The hospital sites selected for the study were Murtala Muhammad Specialist Hospital and Muhammad



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Abdullahi Wase Teaching Hospital. These hospitals were selected using convenience sampling based on accessibility and the high volume of patient patronage. The residential areas selected were Jakara and Danagundi, which were purposively selected due to high population density, poor sanitation conditions, and the prevalence of wastewater discharge within the areas. The agricultural sites consisted of a vegetable farm and a livestock farm, which were purposively selected based on the confirmed use of livestock manure, agrochemicals, and antibiotics associated with farming activities in the areas.

### 2.4 Wastewater Sample Collection

Wastewater samples were collected using pre-cleaned one-litre plastic bottles from two different points at each sampling site. The samples were carefully labeled immediately after collection and placed in an ice cooler to preserve their physicochemical characteristics during transportation. All samples were transported to the Central Laboratory Complex, Bayero University Kano for laboratory analysis in accordance with standard procedures recommended by the American Public Health Association (APHA, 2017). The collected samples were stored at 4°C and analyzed within 48 hours of collection to minimize changes in physicochemical properties before analysis.

### 2.5 Physicochemical Characterization

The physicochemical parameters of the wastewater samples were analyzed using standard analytical procedures recommended by the American Public Health Association (APHA, 2017). The parameters analyzed included temperature, pH, dissolved oxygen (DO), electrical conductivity (EC), total dissolved solids (TDS), biochemical oxygen demand (BOD), and turbidity.

The pH of the wastewater samples was measured using a portable Hanna microprocessor pH meter. Prior to analysis, the pH meter was calibrated using standard buffer solutions of pH 4.01 and 7.01. Electrical conductivity was determined using a Jenway conductivity meter. The instrument was rinsed and standardized with distilled water before the electrode was immersed into the wastewater samples, and the readings were recorded in micro-Siemens per centimetre (µS/cm).

Temperature, turbidity, and total dissolved solids were measured using a multi-parameter 600 series meter. Dissolved oxygen was determined using a DO meter (HANNA Instrument Model DI 9146). The instrument was calibrated before use, and the probe was immersed into the sample for approximately two minutes before the readings were recorded in milligrams per litre (mg/L). Biochemical oxygen demand was determined following standard APHA laboratory procedures.

### 2.6 Data Analysis

The data obtained from laboratory analyses were subjected to statistical analysis using descriptive and inferential statistical techniques. Descriptive statistics such as mean and standard deviation were computed to summarize the physicochemical characteristics of the wastewater samples. A paired sample t-test was used to compare wastewater quality parameters between the wet and dry seasons across the sampling sites. Analysis of Variance (ANOVA) was applied to determine spatial variations in physicochemical parameters among the different sampling locations. In addition, Spearman's correlation analysis was used to examine the relationships among the selected physicochemical parameters. The results obtained were compared with guideline values recommended by the World Health Organization (WHO, 2017) and National Environmental Standards and Regulations Enforcement Agency (NESREA).



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## 3. Result and Discussion

### 3.1 Physicochemical Parameters Mean Concentration Comparison Across all the Study Location

**Table 1: Mean values of Physicochemical Parameters of Hospital, domestic and Agricultural Wastewater Effluents in Kano Metropolis.**

| Source | Sampling Sites | Temperature (°c) | pH | DO(mg/) | Ec (us/c) | TDS (mg/l) | BOD(mg/) | Turbidity (NTU) |
|---|---|---|---|---|---|---|---|---|
| Hospital | MMSH | 28.50 | 6.7 | 4.2 | 3.23 | 1057 | 1.85 | 31.33 |
| | MAWTH | 28.45 | 6.3 | 3.8 | 2.0 | 905 | 2.05 | 20.10 |
| Domestic | Jakara | 28.55 | 6.9 | 2.9 | 3.10 | 1673 | 1.8 | 16.42 |
| | Danagundi | 28.65 | 6.6 | 3.7 | 2.17 | 1369 | 1.85 | 20.5 |
| Agriculture | Vegetable Farm | 27.55 | 6.7 | 3.9 | 1.68 | 766 | 1.85 | 8.82 |
| | Livestock farm | 27.40 | 6.4 | 4.5 | 2.23 | 1036 | 2.1 | 10.41 |
| Overall Mean | | 28.2 | 6.5 | 3.7 | 2.40 | 1038 | 1.92 | 14.59 |
| WHO Guidelines | | ≤35 | 6.5-8.5 | ≥4 | ≥ 1ooo | ≤1500 | ≤ 20 | ≤ 5 – 10 |
| NESREA Guidelines | | ≤ 40 | 6-9 | ≥2.0 | 1500 | ≤2000 | ≤50 | 8.0 |

**Key:** Temperature, Dissolved oxygen (DO), Electrical conductivity (EC), Total dissolved solids (TDS), Biochemical oxygen demand (BOD), MMSH = Murtala Muhammad Specialist Hospital, MAWTH= Muhammad Abdullahi Wase Teaching Hospital.
**Source: Fild Survey (2025)**

### Temperature

The recorded temperatures ranged between 27.40°C and 28.65°C across all sampling sites, with an overall mean of 28.2°C (Table 1). These values fall within the permissible limits set by WHO (≤35°C) and NESREA (≤40°C). Wastewater temperature is influenced by climatic conditions, industrial processes, and microbial activity. Elevated temperatures can reduce dissolved oxygen solubility and disrupt aquatic ecosystems (Echioda *et al,* 2024; Abdel-Shafy & Mansour, 2015). However, the relatively moderate temperatures observed in this study indicate minimal thermal pollution and are unlikely to cause ecological imbalance. Similar results of temperature not exceeding WHO limit were reported by Mshelia and Ejeh., (2024); Ambrose *et al;* (2019); Sani *et al;* (2013); Agoro *et al;* 2018; Abubakar, 2015; Omotoshi *et al*; (2019) and Abdullahi *et al*, (2022)

### pH

The pH values ranged from 6.3 (MAWTH Hospital) to 6.9 (Jakara Domestic), with an overall mean of 6.5 (Table 1). These results fall within the acceptable range of 6.5 – 8.5 (WHO) and 6.0 – 9.0 (NESREA). Slightly acidic pH in the hospital effluent (MAWTH) may be attributed to the use of cleaning agents, disinfectants, and acidic pharmaceutical residues. The pH of wastewater affects the solubility of heavy metals and the survival of aquatic organisms, while a neutral to slightly alkaline pH is generally considered optimal. The result of this study is lower than 12.0 observed by Mshelia and Ejeh. (2024). However, the findings are in line with the result reported by Aziz *et al*., (2018).


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**Dissolved Oxygen (DO)**

DO concentrations range from 2.9 mg/L (Jakara) to 4.5 mg/L (livestock Farm), with an overall mean of 3.7 mg/L. Only the livestock farm sample met the WHO minimum requirement of ≥4 mg/L. though all samples exceeded the NESREA minimum of ≥2 mg/L. Low DO levels in hospital and domestic effluents suggest high organic and microbial loads, potentially leading to oxygen depletion in receiving water bodies. Such conditions can negatively impact aquatic life and promote the proliferation of anaerobic bacteria (Singh *et al*, 2020). Similar ranges were also observed by Oladeji (2019); Mshelia and Ejeh, 2024).

**Electrical Conductivity (EC)**

Electrical conductivity varied from1.68 µS/cm (Vegetable Farm) to 3.23 µS/cm (MMSH Hospital), with a mean of 2.4 µS/cm. It serves as an important indicator of ionic content and salinity. The higher EC values in hospital effluents reflect the presence of ions from pharmaceuticals, disinfectants, and laboratory reagents, while the lower values in agricultural effluent suggest dilution or reduced use of chemical inputs.

**Total Dissolved Solids (TDS)**

TDS levels ranged from 766 mg/L (Vegetable Farm) to 1673 mg/L (Jakara), with an overall mean of 1038 mg/L (Table 1). Even though NESREA's upper limit of 2000 mg/L was not exceeded, Jakara domestic effluent surpassed the WHO maximum of 1000 mg/L. High TDS in domestic and hospital wastewater can be attributed to household waste, detergents, salts, and human excreta. Elevated TDS impairs water clarity, affects aquatic life, and may increase the cost of treatment for reuse (Obaid *et al*., 2022; Mshelia and Ejeh, 2024). Higher values of TDS were reported by Shawai *et al*., (2019); Mshelia *et al.*, (2023) and Omotosho *et al,* (2023).

**Biological Oxygen Demand (BOD)**

BOD values ranged from 1.80 mg/L to 2.10 mg/L, with a mean of 1.92 mg/L. all well below WHO (30 mg/L) and NESREA (50 mg/L) limits (Table 1). Low BOD suggests moderate levels of biodegradable organic matter, possibly due to partial microbial degradation during retention in open drains. However, slightly elevated BOD in the livestock farm effluent is consistent with organic loading from feed and waste (FAO, 2017). The result of this study were similar to the findings of Omitoyin *et al*. (2017) who reported BOD value of 32.80 mg/L and Egekwu (2017) who recorded DO (0.82mg/L) but was in disagreement with the findings of Azeez (2017) and Ezeonuegbu, (2021) who reported BOD values of 130mg/L and 145.3mg/L respectively. The differences in results could be due to differences in sampling season as well as land use.

**Turbidity**

Turbidity levels varied largely from 8.82 NTU (Vegetable Farm) to 31.33 NTU (MMSH Hospital), with an overall mean of 14.59 NTU (Table 1). Only agricultural mean value sources met WHO recommended range of 5–10 NTU. High turbidity in hospital and domestic effluents is likely due to suspended solids, colloids, and microbial load. Similar findings were reported by Nwoko *et al*, (2025) Turbidity impairs light penetration, inhibits photosynthesis in aquatic systems, and can harbor pathogens (Echioda *et al*, 2020). Elevated turbidity also increases the cost and complexity of wastewater treatment.



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### 3.2 Physicochemical Parameters Seasonal Variation Across All Study Sites

The paired t-test results comparing wastewater quality parameters between the wet and dry seasons across six sites are summarized in Table 2. The analysis revealed significant seasonal differences in several parameters. A slight variation was observed in the pH between the wet and dry season. A similar result of slightly higher pH in the dry season was reported by Muhammad, 2013 and Abdullahi *et al*, (2022).

Temperature showed a significant increase during the dry season (M = 30.63°C, SD = 0.81) compared to the wet season (M = 25.73°C, SD = 0.47), t (5) = -16.46, $p < 0.001$, indicating higher temperatures during the dry period as a result of increase solar radiation and less moisture in the atmosphere during the dry period. Electrical conductivity (EC) was also significantly higher in the dry season (M = 2.76, SD = 0.94) than in the wet season (M = 1.90, SD = 0.64), t (5) = -2.58, p = 0.049. This may be due to high temperature which result in increased evaporation and concentration of dissolve pollutant. Obaid *et al,* 2022 reported higher EC value during dry season and reduced with increase concentration of water and rainfall. Dissolved oxygen (DO) levels were significantly lower during the dry season (M = 3.25 mg/L, SD = 0.44) than in the wet season (M = 4.15 mg/L, SD = 0.55), t (5) = 5.09, p = 0.004. High DO in the wet season may be due to increase aeration because of rainfall and water temperature decreases in contrast decrease in oxygen during the dry season may be attributed to increase temperature leading to decrease in dissolve oxygen concentration, furthermore high organic matter content resulting from anthropogenic activities may result in reduce concentration of DO as a result of enhance microbial activity to the increased requirement of BOD (Echioda *et al,* 2025). The findings of the current study are in line with the report of Aziz *et al*., (2015); Doudu *et al*, 2021 and Obaid *et al*, (2022).

No significant difference was observed in total dissolved solids (TDS) between seasons (p = 0.435), with means of approximately 1027.33 mg/L (wet) and 1241.17 mg/L (dry). However, Abubakar, (2015) reported higher TDS value in wet season. Biological oxygen demand (BOD) was significantly higher in the wet season (M = 2.48 mg/L, SD = 0.29) compared to the dry season (M = 1.35 mg/L, SD = 0.14), t (5) = 7.25, p = 0.001, which may be due to increase in water concentration, run off and high level of organic matter content in the dry season. The result is in line with the findings reported by Abdullahi *et al*., (2022). Turbidity was also significantly higher during the dry season (M = 19.20 NTU, SD = 8.43) than in the wet season (M = 10.27 NTU, SD = 4.35), t (5) = -2.68, p = 0.044, which is above the WHO permissible limit.

**Table 2: Temporal variability of physicochemical parameters of wastewater Effluent Using Paired t-Test: Wet vs. Dry Season (n = 6 Sites)**

| Parameter | Wet Season Mean ±SD | Dry Season Mean ± SD | t-value | Df | p-value |
|---|---|---|---|---|---|
| Ph | 6.57 ± 0.49 | 6.50 ± 0.25 | 0.33 | 5 | 0.750 |
| Temp | 25.73 ± 0.47 | 30.63 ± 0.81 | -16.46 | 5 | <0.001** |
| EC | 1.90 ± 0.64 | 2.76 ± 0.94 | -2.58 | 5 | 0.049* |
| DO | 4.15 ± 0.55 | 3.25 ± 0.44 | 5.09 | 5 | 0.004** |
| TDS | 1027.33 ± 560.47 | 1241.17 ± 312.86 | -0.85 | 5 | 0.435 |
| BOD | 2.48 ± 0.29 | 1.35 ± 0.14 | 7.25 | 5 | 0.001** |
| Turbidity | 10.27 ± 4.35 | 19.20 ± 8.43 | -2.68 | 5 | 0.044* |

Key: Temperature, Dissolved oxygen (DO), Electrical conductivity (EC), Total dissolved solids (TDS), Biochemical oxygen demand (BOD).

**Source: Fild Survey (2025)**



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### 3.3 Physicochemical Parameters Mean Correlation Across All Study Sites

Table 3 presents the Pearson's correlation coefficients among various physicochemical parameters of waste water effluent in Kano Metropolis. Temperature shows significant positive correlation with EC ($r = 0.65$, $p < 0.05$) suggesting that higher temperatures increase ionic activity and conductivity. Its strong negative correlation with DO ($r = –0.72$, $p < 0.05$) confirms the inverse relationship between temperature and oxygen solubility. The positive correlation with TDS ($r = 0.55$, $p < 0.05$) indicates that warmer conditions enhance solid dissolution. Temperature also correlates negatively with BOD ($r = –0.68$, $p < 0.05$), likely due to faster microbial oxygen consumption at higher temperatures. A moderate positive relationship with turbidity ($r = 0.45$) shows that heat may promote particle resuspension.

EC correlates strongly and significantly with several parameters. The negative relationship with DO ($r = –0.58$, $p < 0.05$) indicates that ionic strength adversely affects oxygen levels, possibly through oxidation processes. The very strong positive correlation with TDS ($r = 0.92$, $p < 0.05$) confirms that both parameters measure ionic concentration. The strong negative correlation with BOD ($r = –0.75$, $p < 0.05$) shows that increased ionic pollution may limit microbial oxygen availability. Its positive correlation with turbidity ($r = 0.68$*) suggests that ionic load is associated with suspended particulate matter. Dissolved oxygen DO show negative correlation with TDS ($r = –0.62$, $p < 0.05$) indicating that high solid concentrations reduce oxygen solubility. The negative relationship with turbidity ($r = –0.55$, $p < 0.05$) indicates that suspended particles hinder oxygen diffusion. Dissolved oxygen demonstrated significant negative correlations with Temperature ($r = -0.72$, $p < 0.05$) and BOD ($r = -0.85$, $p < 0.05$), indicating that higher temperature and BOD levels are associated with lower DO.

Total Dissolved Solid (TDS) exhibited strong correlations with multiple variables. The negative correlation with BOD ($r = –0.80$*) suggests that high dissolved solids hinder microbial decomposition, possibly due to osmotic stress. A strong positive relationship with turbidity ($r = 0.75$, $p < 0.05$) indicates that sites with high TDS also experience high particulate matter, signaling poor sedimentation or filtration efficiency. Biochemical Oxygen Demand (BOD) exhibited a strong negative correlation with turbidity ($r = –0.65$, $p < 0.05$), implying that high turbidity may reduce microbial efficiency in breaking down organic matter, possibly due to the dominance of non-biodegradable suspended solids.

The correlation matrix reveals significant interdependence among physicochemical parameters in the wastewater effluents of Kano Metropolis. Electrical conductivity, TDS, and temperature emerge as critical factors influencing oxygen dynamics. Strong negative correlations between EC, TDS, and DO indicate that ionic and particulate pollution adversely affect water quality. Conversely, positive associations between EC and turbidity confirm that areas with high ionic pollution also exhibit high suspended solids. Overall, the results suggest that elevated conductivity and solid content in wastewater impair oxygen availability and biological activity, reflecting high pollution loads and inefficient treatment processes.



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**Table 3: Pearson's correlation matrix for the physicochemical parameters of waste water effluent in Kano Metropolis**

| Parameter | Ph | Temp | EC | DO | TDS | BOD | Turbidity |
|---|---|---|---|---|---|---|---|
| Ph | 1.00 | | | | | | |
| Temp | 0.18 | 1.00 | | | | | |
| EC | -0.35 | 0.65* | 1.00 | | | | |
| DO | 0.42 | -0.72* | -0.58* | 1.00 | | | |
| TDS | -0.21 | 0.55* | 0.92* | -0.62* | 1.00 | | |
| BOD | -0.15 | -0.68* | -0.75* | -0.85* | -0.80* | 1.00 | |
| Turbidity | -0.08 | 0.45 | 0.68* | -0.55* | 0.75* | -0.65* | 1.00 |

**Source: Fild Survey (2025)**

## 4. Conclusion

This study comparatively assessed the physicochemical characteristics of hospital, domestic, and agricultural wastewater effluents in Kano using parameters such as temperature, pH, dissolved oxygen (DO), electrical conductivity (EC), total dissolved solids (TDS), biochemical oxygen demand (BOD), and turbidity. The findings showed variations in wastewater quality across the different sampling sites and seasons. Temperature and pH values were generally within permissible limits recommended by the World Health Organization and National Environmental Standards and Regulations Enforcement Agency. However, low dissolved oxygen levels and high turbidity observed in some hospital and domestic wastewater sources indicate poor water quality and possible environmental contamination. Electrical conductivity and total dissolved solids were also higher in hospital and domestic wastewater sources, reflecting increased concentrations of dissolved pollutants associated with human activities. Seasonal variations significantly influenced several physicochemical parameters across the study locations. Overall, the study revealed the presence of physicochemical pollution in wastewater effluents within Kano Metropolis and highlighted the need for effective wastewater management and continuous environmental monitoring to protect public and environmental health.

## 5. Recommendations

**i.** The Kano State Ministry of Environment should establish and strengthen decentralized wastewater treatment systems in hospitals, residential areas, and agricultural zones in order to reduce the discharge of untreated wastewater into the environment.

**ii.** The National Environmental Standards and Regulations Enforcement Agency (NESREA) should intensify routine monitoring and enforcement of wastewater discharge standards among hospitals, residential communities, and agricultural facilities within Kano Metropolis to ensure compliance with environmental regulations.

**iii.** Management authorities of Murtala Muhammad Specialist Hospital and Muhammad Abdullahi Wase Teaching Hospital should implement effective wastewater treatment and disinfection measures before effluent discharge in order to minimize microbial and chemical contamination of surrounding water bodies.



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**iv.** The Kano State Environmental Protection Agency should conduct regular environmental surveillance and physicochemical assessment of wastewater sources across the metropolis to identify pollution hotspots and prevent environmental degradation.

**v.** Urban planning and sanitation authorities in Kano should improve drainage systems and sanitation infrastructure within densely populated residential areas such as Jakara and Danagundi to reduce indiscriminate wastewater disposal and environmental contamination.

**vi.** Agricultural extension agencies and environmental health officers should educate farmers on the proper use of fertilizers, pesticides, and livestock waste management practices in order to minimize agrochemical runoff and agricultural wastewater pollution.

**vii.** The Bayero University Kano and other research institutions should promote further studies on microbiological and heavy metal contamination of wastewater within Kano Metropolis to provide comprehensive information for environmental management and public health protection.

**viii.** Public health authorities and environmental agencies should intensify public awareness campaigns on the environmental and health implications of improper wastewater disposal and encourage community participation in environmental sanitation and pollution control programs.

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