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Article

Assessment of Physiochemical Parameters of Waste Water in Tertiary Hospital in Port Harcourt, Rivers State

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Abstract: This study evaluates the physicochemical characteristics of wastewater generated from a tertiary hospital in Port Harcourt, Rivers State, Nigeria. Wastewater samples were collected from six hospital wards: kitchen, laundry, theatre, paediatric ward, surgery ward, and laboratory. Standard analytical methods were employed to determine temperature, pH, dissolved oxygen (DO), electrical conductivity, total dissolved solids (TDS), and turbidity. Data were analyzed using descriptive statistics and one-way analysis of variance to assess variations among sampling locations. Temperature values were relatively uniform across all wards, ranging from 29.03 ± 0.31 °C to 29.60 ± 0.54 °C, with no significant difference observed ($p > 0.05$). In contrast, pH values varied widely, with acidic conditions recorded in kitchen wastewater (4.48 ± 0.09) and strongly alkaline conditions observed in theatre and paediatric effluents (10.18 ± 0.61 and 10.38 ± 0.38, respectively). Dissolved oxygen concentrations were low in kitchen, laundry, and laboratory wastewater (1.16–1.62 mg/L), indicating high organic load, while higher DO levels were recorded in theatre and paediatric wards (6.69–7.34 mg/L). Electrical conductivity ranged from 301.3 ± 29.26 µS/cm in laundry wastewater to 4858 ± 96.65 µS/cm in paediatric effluent, reflecting elevated ionic content. Similarly, TDS values varied considerably, from 59.00 ± 6.63 mg/L in kitchen wastewater to 3191 ± 160.4 mg/L in theatre wastewater. Turbidity levels were extremely high in kitchen and laundry wastewater (122.2–125.8 NTU) but low in theatre, paediatric, and surgery effluents (<3 NTU). Significant differences ($p < 0.0001$) were observed across wards for all parameters except temperature. The findings demonstrate that wastewater generated from tertiary hospitals contains variable and elevated physicochemical pollutant loads that may pose environmental risks if discharged without adequate treatment.

Keywords: Hospital Wastewater, Physicochemical Parameters, Tertiary Hospitals, Water Quality, Port Harcourt.

1. Introduction

Hospitals are major consumers of water and, consequently, significant generators of wastewater containing a complex mixture of chemical, biological, and pharmaceutical contaminants. Hospital wastewater is distinct from domestic wastewater due to its heterogeneous composition, which includes disinfectants, detergents, pharmaceuticals, laboratory reagents, and other chemical residues arising from clinical, diagnostic, and housekeeping activities [1], [2]. When inadequately treated or discharged into the environment, such wastewater can pose serious risks to aquatic ecosystems and human health [3].

In many developing countries, including Nigeria, hospital wastewater is often discharged into municipal drainage systems without specialized treatment. This practice raises concerns because conventional wastewater treatment plants are not designed to remove many hospital-derived contaminants effectively [4], [5]. Physicochemical parameters such as pH, temperature, dissolved oxygen (DO), electrical conductivity, total dissolved solids (TDS), and turbidity are widely used indicators for assessing wastewater quality and environmental impact. These parameters influence chemical reactions, microbial activity, and the ecological balance of receiving water bodies, making them critical in wastewater characterization studies [6], [7].

The physicochemical characteristics of hospital wastewater may vary significantly within the same facility due to the nature of activities carried out in different hospital wards. Units such as theatres, laboratories, laundries, and kitchens generate effluents with different chemical loads owing to variable use of disinfectants, detergents, reagents, and organic materials [8], [9]. As a result, wastewater quality assessments should consider ward-level variation to accurately determine pollution sources and risks.

Port Harcourt, a major urban and industrial city in Rivers State, Nigeria, faces increasing pressure on its surface water and drainage systems due to rapid urbanization and inadequate wastewater management infrastructure [10], [11]. Despite the potential environmental implications, limited information is available on the physicochemical quality of wastewater generated by tertiary hospitals in the city. This study therefore seeks to fill this gap by assessing the physicochemical parameters of wastewater from different wards of a tertiary hospital in Port Harcourt, providing baseline data to support effective wastewater management, environmental protection, and regulatory enforcement.

Aim of the Study

The aim of this study was to assess the physicochemical characteristics of wastewater generated from different wards of a tertiary hospital in Port Harcourt, Rivers State, Nigeria.

Objectives of the Study

The specific objectives of the study were to:

1. Determine the physicochemical parameters (temperature, pH, dissolved oxygen, electrical conductivity, total dissolved solids, and turbidity) of wastewater from selected hospital wards;
2. Compare the physicochemical characteristics of wastewater across different wards within the tertiary hospital;
3. Evaluate the variation in wastewater quality in relation to ward-specific activities and potential environmental and health implications.

2. Materials and Methods

Study Area

The study was carried out in a tertiary hospital located in Port Harcourt, Rivers State, Nigeria. The hospital serves as a major referral center and generates wastewater from multiple functional units, including the kitchen, laundry, theatre, paediatric ward, surgery ward, and laboratory. Wastewater from these units is discharged through internal drainage channels, making them suitable sampling points for assessing physicochemical characteristics.

Sample Collection

Wastewater samples were collected from six hospital units: kitchen, laundry, theatre, paediatric ward, surgery ward, and laboratory. Sampling was conducted using sterile plastic containers that were rinsed with the wastewater prior to collection to avoid contamination. Samples were collected in the morning hours to ensure uniformity and were transported immediately to the laboratory in an ice-packed container for analysis. All analyses were carried out within 24 hours of sample collection.

Determination of Physicochemical Parameters

Physicochemical parameters were determined using standard analytical procedures. Temperature was measured in situ using a calibrated mercury-in-glass thermometer. The pH of the wastewater samples was measured using a digital pH meter after calibration with standard buffer solutions. Dissolved oxygen was determined using the Winkler titration method.

Electrical conductivity was measured using a conductivity meter, while total dissolved solids were determined using a TDS meter, both instruments calibrated according to manufacturer specifications. Turbidity was measured using a turbidimeter and recorded in nephelometric turbidity units (NTU).

Quality Control

All instruments were calibrated prior to use to ensure the accuracy and reliability of measurements. Analyses were performed in triplicate, and results were expressed as mean values with corresponding standard deviations.

Statistical Analysis

The data obtained were analyzed using statistical software. Results were presented as mean ± standard deviation. One-way analysis of variance (ANOVA) was used to determine significant differences in physicochemical parameters across wastewater samples from different hospital units. Statistical significance was set at $p < 0.05$. Post hoc multiple comparison tests were applied where significant differences were observed.

3. Results

Assessment of Physicochemical Parameters of Wastewater from a Tertiary Hospital in Port Harcourt, Rivers State

The physicochemical characteristics of wastewater samples collected from different wards of the tertiary hospital were analyzed to determine variations in water quality across hospital units. The parameters assessed included temperature, pH, dissolved oxygen, electrical conductivity, total dissolved solids, and turbidity. The results are presented in Table 1

Table 1. Physicochemical Parameters of Wastewater Samples from Different Wards in the Hospital.

Variables	Temperature (°C)	pH	DO (mg/L)	Conductivity (μS/cm)	TDS (mg/L)	Turbidity (NTU)
Kitchen	29.23±0.33	4.48±0.09	1.62±0.40	1046±38.33	59.00±6.63	125.8±0.91
Laundry	29.03±0.31	5.86±0.07	1.16±0.08	301.3±29.26	144.2±1.58	122.2±1.33
Theatre	29.60±0.54	10.18±0.61	7.34±0.44	4563±351.6	3191±160.4	0.58±0.25

Paediatric	29.50±0.37	10.38±0.38	6.69±0.21	4858±96.65	2630±46.34	2.60±0.37
Surgery	29.32±0.33	7.45±0.30	6.45±0.18	651.3±49.22	336.0±24.39	0.73±0.17
Laboratory	29.33±0.56	9.11±0.63	1.57±0.30	2229±8.29	1117±6.03	22.28±0.64
P-value	0.4563	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
F-value	0.9804	135.5	394.9	695.0	1540	27820

Values are presented as mean ± standard deviation. Superscripts indicate significant differences between wards.

Temperature values across all wards were similar, with no statistically significant difference observed ($p > 0.05$), indicating uniform thermal conditions of wastewater generation within the hospital. In contrast, significant differences were observed for pH, dissolved oxygen, electrical conductivity, total dissolved solids, and turbidity across wards ($p < 0.0001$). The kitchen and laundry effluents were acidic, while theatre and paediatric wards recorded strongly alkaline pH values. Electrical conductivity and total dissolved solids were markedly higher in theatre and paediatric wastewater, suggesting elevated levels of dissolved ions and chemical residues. Turbidity was highest in kitchen and laundry effluents, reflecting high particulate and organic matter load.

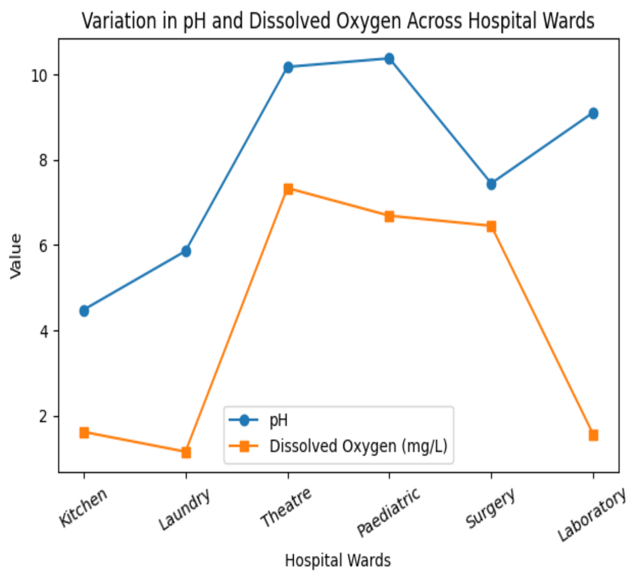

Figure 1. Variation in pH and Dissolved Oxygen Levels of Wastewater across Hospital Wards.

This figure presents the distribution of pH and dissolved oxygen levels in wastewater samples collected from different wards of the tertiary hospital. Marked variation in pH and dissolved oxygen was observed across hospital wards. Theatre and paediatric wastewater recorded strongly alkaline pH values and higher dissolved oxygen levels, while kitchen, laundry, and laboratory effluents exhibited acidic to moderately alkaline pH with low dissolved oxygen concentrations. Reduced dissolved oxygen in these units suggests a high organic load and increased biochemical oxygen demand, which may negatively affect receiving water bodies if discharged untreated.

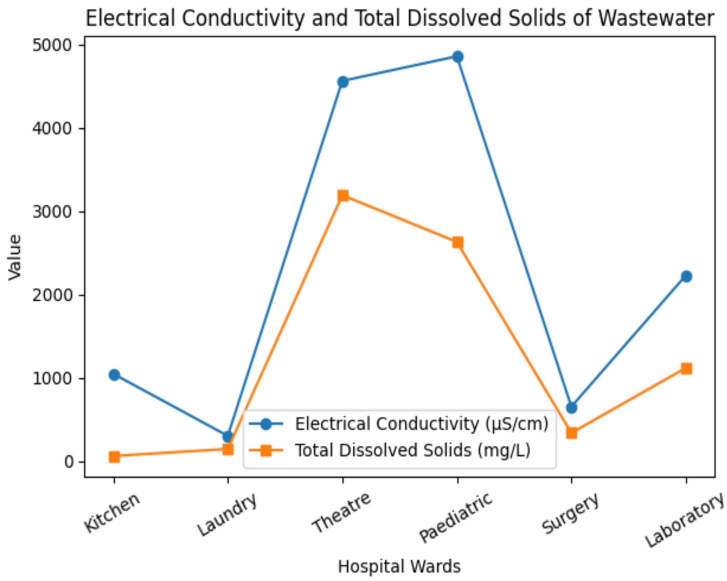

Figure 2. Electrical Conductivity and Total Dissolved Solids of Wastewater from Different Hospital Pharmaceuticals Wards.

This figure compares electrical conductivity and total dissolved solids concentrations across wastewater samples from the hospital wards. Electrical conductivity and total dissolved solids were substantially higher in theatre, paediatric, and laboratory wastewater compared to kitchen, laundry, and surgery effluents. This indicates elevated concentrations of dissolved ions and chemical residues, likely originating from disinfectants, , and laboratory reagents. High conductivity and TDS values reflect poor wastewater quality and pose potential risks to aquatic ecosystems.

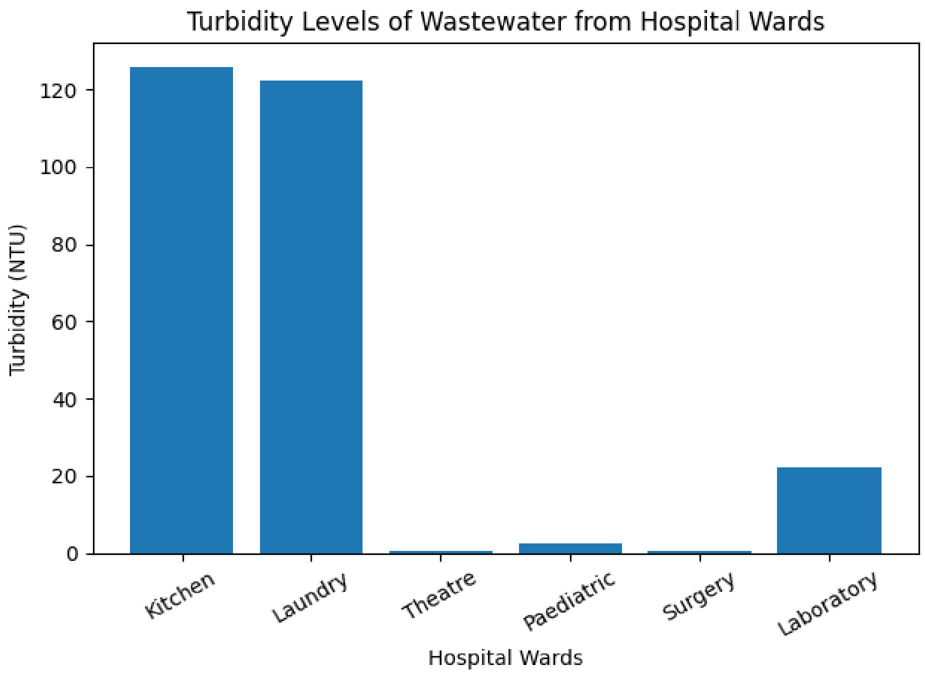

Figure 3. Turbidity Levels of Wastewater from Different Hospital Wards.

This figure illustrates the turbidity levels of wastewater samples obtained from different hospital wards. Turbidity was extremely high in kitchen and laundry wastewater, while theatre, paediatric, and surgery effluents recorded very low turbidity values. The elevated turbidity in kitchen and laundry units reflects the presence of suspended organic matter, food residues, and detergents. High turbidity can reduce light penetration in aquatic environments and contribute to ecological imbalance when such wastewater is discharged without adequate treatment.

4. Discussion

The physicochemical characteristics of wastewater from different wards of the tertiary hospital showed marked variation, reflecting the influence of ward-specific activities on wastewater composition. Temperature values were relatively uniform across all sampling points and did not differ significantly, indicating that wastewater discharge within the hospital does not contribute to thermal pollution. Similar observations have been reported in hospital wastewater studies where temperature remained close to ambient conditions and was not considered a major pollutant indicator [12], [13]. However, the determined values of the physiochemical parameters of the waste water as shown in Table 4.1 is indicating the temperature as 29.031+_ 0.3096 degrees Celsius at the laundry to 29.60+_ 0.5416 degrees Celsius at the theater and showed that there was no significant difference with p - values of greater than 0.05. This value when compared with the Federal Ministry of Environment (FME) standard value of 20 - 33 degrees Celsius shows a normal value. It shows that the waste water could support the growth of normal bacteria which could pose health risks to patients and workers.

The pH values varied significantly among the wards, with kitchen and laundry wastewater exhibiting acidic conditions, while theatre and paediatric effluents were strongly alkaline. This wide pH range is characteristic of hospital wastewater and is often attributed to the use of detergents, disinfectants, pharmaceuticals, and chemical reagents in clinical and cleaning activities. Comparable pH variability has been reported in hospital wastewater studies in Nigeria and other developing countries, where extreme pH values were linked to intensive chemical usage in specialized hospital units [13], [14].

Dissolved oxygen concentrations were notably low in wastewater from the kitchen, laundry, and laboratory wards, suggesting a high organic load and increased oxygen demand. Low dissolved oxygen levels in hospital wastewater have been widely reported and are associated with the presence of organic matter, food residues, and biodegradable pollutants that rapidly consume oxygen during microbial decomposition [12], [15]. In contrast, higher dissolved oxygen values observed in theatre and paediatric wards may reflect lower organic contamination or recent water use.

Electrical conductivity and total dissolved solids were significantly elevated in theatre, paediatric, and laboratory wastewater. High conductivity and TDS values indicate increased concentrations of dissolved ions, salts, and chemical substances commonly used in medical procedures and laboratory analyses. Similar findings have been documented in hospital wastewater studies, where elevated conductivity and TDS were attributed to disinfectants, pharmaceuticals, and chemical reagents discharged into hospital effluents [13], [14].

Turbidity levels were exceptionally high in kitchen and laundry wastewater, reflecting the presence of suspended solids such as food particles, organic debris, and detergents. Elevated turbidity in hospital wastewater has been reported by several authors and is considered an indicator of poor wastewater quality that can impair light penetration and disrupt aquatic ecosystems if discharged untreated [12], [16], [17]. The comparatively low turbidity observed in theatre and paediatric wards suggests lower particulate discharge from these units.

Overall, the significant differences observed in physicochemical parameters across hospital wards highlight the complex and heterogeneous nature of hospital wastewater. The findings of this study are consistent with previous reports indicating that untreated hospital effluents contain high pollutant loads and pose environmental and public health risks. These results reinforce the need for effective wastewater treatment and regular monitoring of hospital effluents before discharge into the environment.

5. Conclusion

The assessment of physicochemical parameters of wastewater generated from a tertiary hospital in Port Harcourt revealed marked variations across hospital wards, reflecting the influence of ward-specific activities on wastewater quality. While temperature values were relatively uniform and showed no significant variation though the values when compared with the Federal Ministry of Environment standard value of 20 - 33 degrees Celsius shows a normal value which shows that waste water could support the growth of bacteria which could pose health risks to patients and workers, other parameters including pH, dissolved oxygen, electrical conductivity, total dissolved solids, and turbidity differed significantly among the wards. Acidic wastewater was observed in the kitchen and laundry units, whereas strongly alkaline conditions characterized theatre and paediatric effluents. Elevated electrical conductivity and total dissolved solids in theatre, paediatric, and laboratory wastewater indicated high concentrations of dissolved chemical substances, while excessive turbidity in kitchen and laundry wastewater suggested a high load of suspended and organic matter. These findings indicate that untreated hospital wastewater contains substantial pollutant loads that may pose environmental and public health risks if discharged into receiving water bodies without adequate treatment.

Recommendations

1. There is a need for the installation and proper operation of effective wastewater treatment facilities in tertiary hospitals to ensure that physicochemical parameters are reduced to acceptable levels before discharge into the environment.
2. Routine monitoring of hospital wastewater quality should be institutionalized to detect changes in physicochemical characteristics and guide timely intervention.
3. Regulatory agencies should enforce compliance with wastewater discharge standards and promote best practices in hospital effluent management to minimize environmental contamination.

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