Assessment of Wastewater from Different Point Sources in a Nigerian University Using Water Quality Index

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Abstract
Civil and environmental engineers have copious assignments to do to ensure a hygienic and greener environment that is void of contamination of the environment and various point sources. This research examined wastewater from different point sources (hostels, colleges, laundry, cafeterias and bakery) in a Nigerian University. Wastewater from different point sources was monitored for six months and various laboratory tests were carried out. The physicochemical characteristics of the wastewater were determined following standard procedure and their qualities were assessed using the Water Quality Index (WQI). Ammonia, dissolved oxygen and turbidity were 0.52 mg/L, 7.78 mg/L and 38.62 NTU making the wastewater moderately polluted according to WQI. Wastewater from selected sources was within acceptable limits specified by the Environmental Protection Agency (EPA). The bacterial composition of lake water, in particular, may alter as a result of contamination coming from the point sources within the watershed Quality Index limit of the wastewater provided substantiates the fact that there are environmental issues and contamination of water bodies traceable to improper wastewater management from various point sources in developing countries. Wastewater may become a point source of pollution if it is not managed properly, which might be dangerous for both the environment and human populations' health. Periodic assessment of wastewater will assist decision-making regarding public health and environmental sustainability in communities and institutions of developed and developing nations of the world.

Keywords: Environmental engineers, Point sources, Water Quality Index, Physicochemical characteristics, Wastewater management

Introduction

Wastewater management requires interdisciplinary strategies and multifaceted approaches for global impact, public health, a cleaner environment and sustainable development. Contributions from industries and academia from various disciplines such as engineering, environmental health, sciences and medical fields are essential for its effectiveness, efficiency and sustainability [1]. Wastewater requires appropriate management for health and wealth in all nations of the world. Water resources and environmental engineers are concerned with some of the most demanding problems of our world, including public infrastructure regeneration, sustainable water sector development, and access to potable water, environmental remediation and sustainable resolutions to energy needs. This can be ascribed to the general public's wastewater management receiving low attention from governments, institutions, and the corporate sector. The improvement of Nigeria's wastewater management issues may be facilitated by it [2]

Wastewater is divided into three categories. They are domestic wastewater, industrial wastewater and stormwater wastewater. Figure 1 describes various types of wastewater.

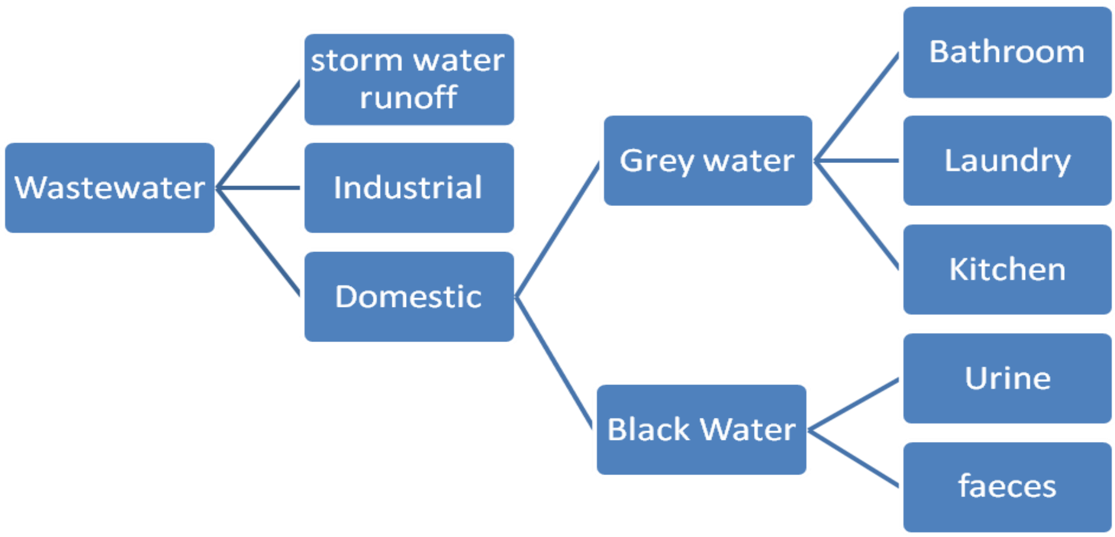

Figure 1: Types of Wastewater [23]

Wastewater is any water that has had its quality degraded due to anthropogenic factors. Access to improved sanitation also decreased in many regions in Nigeria because of a lack of priority and inadequate attention to wastewater management. However, we are keeping our fingers crossed that this is not just another cynical measure to give the impression that something is being done even though the issue still exists. The availability of clean and safe drinking water is a major concern worldwide. A major issue that needs to be addressed in developing countries in Africa is the lack of access to clean water supplies and potable water. Greywater filtration is possible in rural regions using Horizontal Sub Surface Flow Built Wetlands (HSSFCW). The intricacy of the interactions between solids, contaminants, bacteria, and plants is typically avoided in the design of such facilities [3]. Water quality control involves decreasing nutrient levels in wastewater because they frequently impede water bodies from serving their intended uses [4]. The spatiotemporal features of the greywater footprint, as well as natural and human influences, all affect the extent of water pollution [20]. Triclosan, a commonly used antiseptic that promotes the growth of germ resistance, is frequently found in wastewater and is hence detectable [5]. Microplastics (MiP) release is poorly predicted in developing nations, although sewage treatment plants (WWTPs) are substantial point producers of MiP in the receiving waters [6]. In their watersheds, lakes serve as sentinels for environmental changes brought on by anthropogenic sources and a changing climate. The bacterial composition of lake water, in particular, may alter as a result of contamination coming from the point or non-point sources within the watershed [7].

The health of a population is greatly influenced by the environment. The seventh of the eight Millennium Development Goals set forth by the United Nations emphasizes the necessity of protecting the environment and averting further degradation in acknowledgement of the significance of the environment [8]. Table 1 provides guidelines on permissible limits for wastewater discharge.

Table 1: Guidelines on Permissible Limits for Wastewater Discharge to the Environment

Characteristics	Tolerance / Limit
pH value	6.5-8.5
Dissolved Oxygen	4
Biochemical oxygen demand (5 days at 20° C)	3
Total Coli form Organisms, MPN/100 ml,	1000
Colour, Hazen	300
Fluorides (F),	1.5
Cadmium (Cd),	0.01
Chlorides (Cl),	600
Chromium (Cr^{6+}),	0.05
Cyanides (CN),	0.05
TDS	1500
Selenium (Se),	0.05
Sulphates (SO_4),	400
Lead (Pb),	0.1
Copper (Cu),	1.5
Arsenic (As),	0.2
Iron (Fe),	50
Phenolic Compounds (C_6H_5OH),	0.005
Zinc (Zn),	15
Anionic detergents (MBAS),	1
Oils and grease,	0.1
Nitrates (as NO_3^-),	50
Alpha emitters, µc/ml, Max	10^{-9}
Beta emitters, µc/ml, Max	10^{-8}

Source: [9]

Waste Stabilization Ponds (WSPs) are a practical substitute for traditional wastewater treatment in undeveloped nations like Nigeria where sunlight is abundant because of their inexpensive initial, ongoing, and maintenance expenses. They are also entirely natural, easy to build, very effective at purifying wastewater and operate without the aid of technological expertise. Whether in wealthy or underdeveloped nations, many current efforts to protect and maintain human development, gratify human desires, and accomplish human ambitions are simply unsustainable. This cross-sectional study can be used to assess drinking water and wastewater management facilities to reduce the health risks brought on by heavy metal pollution of available water sources [10].

Due to the propensity of government-treated water to transmit diseases among a large population, it is therefore of particular relevance that this public water delivery system conforms to internationally recognized microbiological criteria. Surface runoffs and untreated wastewater from many developing countries severely degrade impoundment water bodies. Several of these sources of water that are used for domestic water needs can have detrimental effects on the human population. As an alternative, institutional wastewater can be treated utilizing water hyacinth technology. After the plant was put into operation, the number of students increased, and no plans were made to account for population changes. There was a lot of silting, and it collects in the tanks because there is no system in place to remove it. Awba Lake generally receives significant amounts of pollution from various point sources [11].

Engineers seek solutions to problems and often compare an idea's technical merits to its commercial viability. Sustainable development implies development that does not hurt anyone. It is essential to use non-renewable resources wisely neither too swiftly nor too slowly to ensure that the natural riches they represent are progressively transformed into long-term wealth. To address healthcare difficulties and water challenges and achieve Nigeria's infrastructure development, enough attention should be paid to the water sector's strategic management [12]. The majority of the world's countries are currently experiencing an energy crisis and environmental problems as a result of improper growth of techniques and goods utilizing sustainable and non-renewable resources. Engineering life cycle management is crucial for the health and prosperity of industrialized and developing countries [13].

Making smart investments in wastewater management will pay off handsomely because treating wastewater is an essential step in eradicating poverty and maintaining natural services. If wastewater is managed properly, rather than creating issues, the ecology will benefit. Building water infrastructure and encouraging improved wastewater management are two examples if there are any. These investments in integrated planning may sustainably result in more benefits for a variety of industries [14]. The effectiveness of wastewater reuse projects depends critically on the perception of the community toward the usage of recycled water. Public support for the reuse of treated wastewater is known to be significantly influenced by political issues, perceived health risks, and the amount of human contact with treated wastewater [15].

There have been numerous big initiatives throughout the years to ensure that everyone on the planet has access to services for water supply and sanitization. During the so-called Water Decade (1980-1990), by the end of which an increasing number of people lacked access to basic sanitary facilities, the goal of providing water and sanitation for everyone could not be realized. Based on the criteria of the year 2000 used by the Clean Water 2000 program, achieving 100% coverage seemed to be impossible. The recently formed Global Water Vision has again set full coverage of these services as its objective in its section on water supply and sanitation. The target year this time is 2025. The Millennium Development Goals, adopted at the Johannesburg Global Conference on Sustainable Development in 2002, set an aim for 2015 to reduce by half the amount of people without water that is safe to drink and in sanitary conditions. This indicates that every day, 310,000 people globally might need improved sources of water and 460,000 people would need proper sanitation [16].

Environmental sustainability includes factors such as carbon footprint, water footprint, air footprint, and land footprint. Figure 2 illustrates sustainability's primary focus.

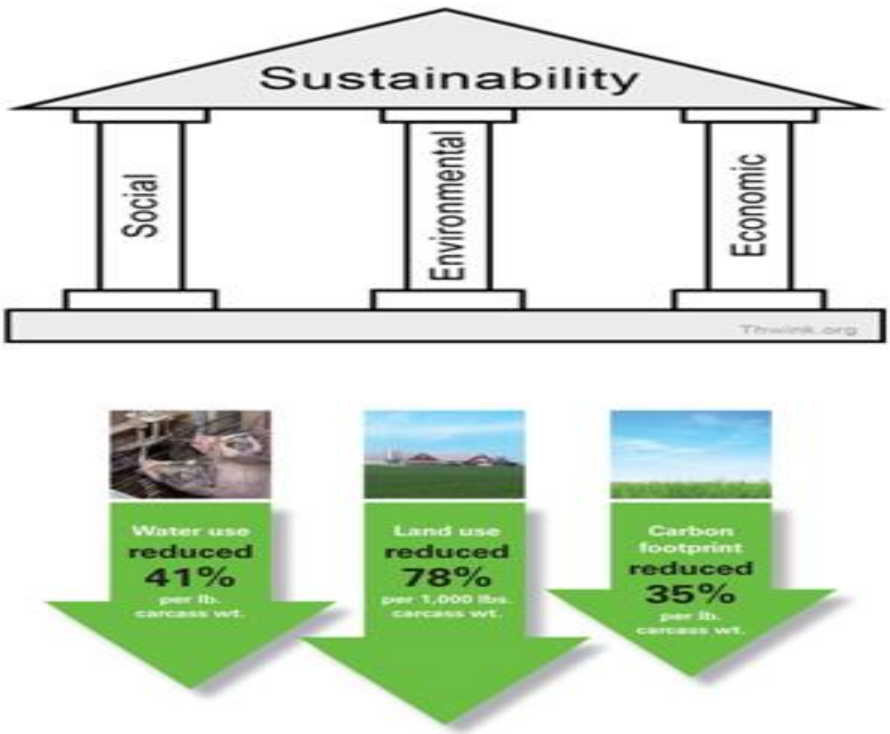

Figure 2: Three Aspects and Focus of Sustainability
Source: [17]

Any organized, governmental or private, efforts to promote health, prevent sickness, and lengthen life are considered public health activities. It directs its efforts toward entire communities as opposed to specific individuals or illnesses to promote healthy living circumstances. Public health has a different meaning for each person [18].

Methodology

The methodology employed includes the determination of the wastewater's physicochemical parameters using a set procedure. Wastewater samples were collected from different point sources and monitored for six months and various laboratory tests were carried out. The physicochemical characteristics of the wastewater were determined following standard procedure and their qualities were assessed using the Water Quality Index (WQI). Ammonia, dissolved oxygen and turbidity. The efficacy and limitations of the system were determined by analyzing the influent and effluent characteristics of wastewater samples from the current WTP treatment facility within the research region.

Sources of Wastewater in the Community

The sources of potentially treatable wastewater in the University community for design were narrowed down to the three male hostels, the three female hostels, Cafeteria 1, Cafeteria 2, and the Talent Discovery Centre Six (6) communities are situated around the project influence zone. The demographic characteristics, an economic structure including livelihoods, and socio-cultural infrastructure led to environmental problems and development challenges.

Preliminary Investigation

A campaign to acquire information through fieldwork, data analysis and interpretation, reporting, stakeholder and expert evaluations, and planning and review processes were all finished before. Initial investigations established the foundation for more in-depth enquiries. The following inquiries should be made at this time:

i. What are the specific historical facts of the place in question?
ii. At this point, how reliable is the regional clean water?
iii. What are the current and foreseeable costs of local freshwater?
iv. How may wastewater reuse in the area affect the environment?
v. What issues with reuse are related to public health, and how may these issues be resolved?
vi. Which reuse initiatives are most likely to garner the support and interest of the general public?
vii. What rules and regulations—current or forthcoming—could have an impact on reuse in the region?
viii. Which regional, federal, or municipal organizations must examine and authorize the implementation of the reuse program?
ix. What are a reclaimed water user's legal obligations?

Laboratory Test

The preservation of samples was done by refrigeration to safeguard and guarantee that the samples that were analyzed in a laboratory had an original quality that was, in any case, extremely comparable to the site for the duration prescribed by the standard. Several tests, including those for turbidity, hardness, DO, pH, BOD, and TDS, were carried out in the laboratory while adhering to all applicable laws, rules, and safety precautions.

Dissolved Oxygen (DO)

Before a laboratory test, samples from the wastewater treatment plant's influent and effluent were collected. The DO meter was activated and given 15–20 minutes to warm up to avoid errors. Using the meter's instruction manual, the instrument was then accurately calibrated before my sample was placed into a 300-mL container and the laboratory electrode was inserted, all while making sure that no air was caught against the membrane. The following parameters were measured with Hanna portable digital meters: pH, temperature, dissolved oxygen, conductivity and total dissolved solids. The dissolved oxygen level in the water was also determined on-site with Hanna's dissolved oxygen test kit. Table 2 presents the test methods for water physicochemical parameters. Figure 3 presented samples collected at point sources (blue cover) and surface water area (Red cover). Figure 4 also presents the Microbial Incubator, Resistivity meter, Atomic Absorption Spectrophotometer and Ph meter used in the wastewater Laboratory.

Figure 3: Samples collected at point sources (blue cover) and surface water area (Red cover)

Figure 4: Microbial Incubator, Resistivity meter, Atomic Absorption Spectrophotometer and Ph meter used in the wastewater Laboratory

Table 2: Test methods for water physicochemical parameters

Parameter	Method/Instrument
Temperature (°C)	Hanna portable digital meter
pH	Hanna portable digital meter
Conductivity (µS/cm)	Hanna portable digital meter
TDS (mg/L)	Hanna portable digital meter
TSS (mg/L)	Gravimetry
Turbidity (NTU)	Turbidity meter
DO (mg/L)	Hanna DO Test Kit
BOD_5 (mg/L)	DO measurement after 5 days
COD (mg/L)	Dichromate/titrimetry
Alkalinity ($mgCaCO_3$/L)	Titrimetry
Salinity as chloride (mg/L)	Titrimetry
Total hardness ($mgCaCO_3$/L)	Titrimetry using EDTA
Sulphate (mg/L)	Turbidimetry
Phosphate (mg/L)	Spectrophotometry
Nitrate (mg/L)	Spectrophotometry
Ammonia (mg/L)	Nesslerisation
E. Coli and Aerobic count	ColiMinder
Calcium (mg/L)	Titrimetry using EDTA
Magnesium (mg/L)	Titrimetry using EDTA
Cadmium (mg/L)	Atomic Absorption Spectrophotometer (AAS)
Chromium (mg/L)	AAS
Copper (mg/L)	AAS
iron (mg/L)	AAS
Lead (mg/L)	AAS

Determination of Alkalinity

20 ml of each sample should be prepared, and 2 drops of the methyl orange indicator should be added before stirring. Then, pour the acid into the burette while keeping track of the burette's original value. Titrate until you reach the endpoint, and then take the final reading.

Turbidity

The Hach 2100Q turbidity meter is used to conduct this experiment. Use the manufacturer's standards to calibrate the device before use. Make sure the battery is fully charged before moving on to the three standards (20 NTU, 100 NTU, and 800 NTU), gently stirring them by turning them upside down three times to prevent bubbles from interfering with the calibration. The following materials were used: The wastewater that was used in this study was collected from the student Boys' hostel, the Student's Girls hostel, the Student's Cafeteria 1 Kitchen, and the Printing press of the University Ado-Ekiti Nigeria. Silica Oil, (Formazin) standard, Water distiller, Eriochrome black T, EDTA (Ethylene diamine Tetra-acetic acid), and Ammonia buffer were used. Equipment used includes a beaker (600mm), pH meter, Tissue paper, Power supply, Turbidity meter, sample cell, Battery for the turbidity meter, Cleaner, Conical flask, Burette, Retort stand, Funnel, Pipette. To ensure appropriateness, each body of water needs to undergo frequent analysis. From straightforward field testing for a single analysis to laboratory-based multiple-component instrument analysis, various sorts of analysis may be used. The quantity of a particle substance suspended in water is known as turbidity. The scattering of light by suspended solids is measured by turbidity. The turbidity increases with the intensity of scattered light.

Determination of Total Hardness

Following the preliminary testing, it was found that the effluent from the investigated treatment plant had a hardness that was equal to that of hard water (350–550 mg $CaCO_3$/L), as defined by the conventional water hardness classification. Reverse osmosis and membrane filtration can both be used to lessen the hardness of wastewater effluent. The dissolved calcium, magnesium, and iron salts—calculated as parts of $CaCO_3$ equivalent per million parts of water—are a practical way to quantify the hardness of water (ppm). A sample of water has a certain degree of hardness if it includes parts of calcium carbonate equivalent per 10,000 parts. One toughness level is consequently the hardness brought on by a million times the concentration of $CaCO_3$ (or its equivalent) in water.

Procedures

An uncontaminated conical flask was filled with a 100 mL wastewater sample. The pH of the wastewater sample was maintained between 9 and 10 by adding 1.0 mL of ammonia buffer solution, and the sample wine was turned red by adding three drops of the Erichrome black T indicator to the conical flask. The burette was then adjusted to zero after receiving 0.02 mL of the regular EDTA solution. The burette was used to titrate the sample against the EDTA solution (Ethylene diamine tetra-acetic acid).

Wastewater	**Measured value**
Sample 1: Wastewater from the boy's hostel	151 FNU
Sample 2: Wastewater from the Girl's hostel	170 FNU
Sample 3: Wastewater from the Kitchen	Over range FNU
Sample 4: Wastewater from the printing press.	Out-of-range FNU

pH Value test

The pH scale measures the number of hydrogen ions present in wastewater and indicates whether it is acidic or alkaline. Because aquatic life, including most fish, can only exist in a constrained pH range between pH 6.5-8, this value is crucial.

Wastewater	**Temperature**	**Measured value**
Sample 1: Wastewater from the boy's hostel	25°C	7.02 pH
Sample 2: Wastewater from the Girls' hostel	25°C	6.94 pH
Sample 3: Wastewater from the Kitchen	25°C	5.55 pH
Sample 4: Wastewater from the printing press.	25°C	10.40 pH

3.6.1 Alkalinity Test Table

S/N	Samples	Value of sample	Burette Readings		Volume of HLC
			Initial reading	Final reading	
1	A	200ml	50.00ml	38.2ml	382ml
2	B	100ml	50.00ml	11.6	232ml

RESULTS

pH value before titration for sample A = 7.02 pH
pH value after titration for sample A = 3.38 pH
pH value before titration for sample B = 6.94 pH
pH value after titration for sample B = 3.25 pH

Calculations

$$\text{Total Alkalinity} = \frac{B \times N \times 50000}{ml\ sample} \times D \quad (3.1)$$

Where; B = ml titration for sample
N = Normality of acid
D = Dilution factor which is constant
sample A is wastewater from the boy's hostel
Sample B is wastewater from the girl's hostel

$$\text{Dilution factor (D)} = \frac{1000ml}{500ml} = 2$$

N= 0.02
ml= Volume of HCL for each sample

$$\text{Total Alkalinity for sample A} = \frac{38.2 \times 0.02 \times 50000}{200} \times 2 = 382mg/l$$

$$\text{Total Alkalinity for sample B} = \frac{11.6 \times 0.02 \times 50000}{100} \times 2 = 232mg/l$$

3.7 Hardness Test

Hard water is defined as having a high mineral concentration. Bicarbonate, chlorides, and calcium and magnesium sulfate are all present in hard water. The amount of calcium and magnesium ions in the water, given as calcium carbonate, is a measurement of the hardness of the water.

S/N	Samples	Burette Readings		Volume of EDTA
		Initial reading	Final reading	
1	Sample A	50.00ml	43.00ml	07.00ml
2	Boiled sample A	29.90ml	12.7ml	17.20ml
3	Sample B	41.00ml	20.10ml	20.90ml
4	Boiled sample B	09.80ml	00.00ml	09.80ml

Calculations

$$\text{Total Hardness} = \frac{ml\ of\ EDTA \times 1000}{ml\ sample}$$

Where; ml of sample $= 100mg/l$

Sample A is wastewater from the boy's hostel
Sample B is wastewater from the girl's hostel
For sample A

Total Hardness mg/L $CaCO_3$ =

$$\frac{07.00 \times 1000}{100} = 70mg/l$$

For sample B

Total hardness mg/L $CaCO_3$ =

$$\frac{20.90 \times 1000}{100} = 209mg/l$$

For sample A

$$\text{Non-carbonate hardness} = \frac{ml\ of\ EDTA\ (boiled) \times 1000}{ml\ sample}$$

$$= \frac{17.20 \times 1000}{100} = 172mg/l$$

For sample B

Non-carbonate hardness =

$$\frac{ml\ of\ EDTA\ (boiled) \times 1000}{ml\ sample}$$

$$= \frac{09.80 \times 1000}{100} = 98mg/l$$

For sample A

Carbonate hardness= Total hardness – non-carbonate hardness

$= (70-172) = -102 mg/l$

For sample B

Carbonate hardness= Total hardness – non-carbonate hardness

$= (209-98) = 111 mg/l$

Project Design Life

Finding out not only the total annual water demand but also the necessary average flow rates and changes in these rates is important when constructing a wastewater treatment plant. Determining the design capacity is a crucial step before designing water delivery infrastructure can start. Before it needs to be upgraded or redesigned, the wastewater treatment plant's design is intended to last for roughly twenty (20) years. The planning considerations for this project were restricted to the design life, which is 20 years.

3.9 Population projection

The population is dynamic, the population of the University in 2015 was estimated to be 6992 and in 2017 it is estimated to be 7760.

There is a need to do a population forecast for the 20-year design life of the Wastewater Treatment Plant project.

The arithmetic increase method is the most preferred method for this forecast;

$F = P+ni$

Where; F: Projected population

P: Population in 2017

R: Population in 2015

n: Term in years

i: Population increment every year.(i= P-R÷2)

Water Use Projections

As the population increases in the case study University, there will be a need to match the increasing water demand. The demand for water can be determined using the formula below; $W= FA$

Where; W is the Water use projection, and F is the Projected population

A: Average litres of water required per head according to WHO (World Health Organization) standards.

Water quality index calculation

The Water Quality Index (WQI) is a useful and distinctive rating that summarizes the current state of water quality in a single phrase and aids in the selection of the most effective treatment methods to address the relevant problems. A single figure, the Water Quality Index (WQI), based on a few water quality boundaries, expresses the total water quality at a certain location and time. The Water Quality Index is determined by the following five steps:

i. Selecting the elements to gauge the water quality.

ii. Designing a scoring mechanism to establish the rating (Vr).

iii. One can calculate the unit weight of each indicator parameter (Wi) by taking into consideration the weightage of each parameter.

Finding the sub-index value, which is (WiVr), is step four Combining the sub-indices to get the total WQI.

WQI is calculated by the following equation:

$$WQI = \sum_{n=1}^{n} q_n w_n / \sum_{n=1}^{n} w_n$$

Where W_n = unit weight for nth parameter

$W_n = k/s_n$, sn = standard permissible value for nth parameter

k = proportionality constant, qn values are given by the relationship.

$q_n=100 (v_n-v_i) / (v_s-v_i)$

Vs = Standard value, Vn = observed value, Vi = ideal value

To determine the value of the final water quality index, the Horton model suggests the following five water quality classes (Table 3).

Table 3: Water Quality Rating as per Weight Arithmetic Water Quality Index Method

WQI Value	Rating of Water Quality	Grading
0-25	Very Bad water quality	E
26-50	Bad water quality	D
51-70	Medium water quality	C
71-90	Good water quality	B
91- 100	Excellent water quality	A

Source: Uddin et al., (2021)

Results

Physicochemical parameters include pH, Conductivity in μs/cm, Total Suspended Solids (TSS) in mg/*l*, Biological Oxygen Demand (BOD) in mg/*l*, Chemical Oxygen Demand (COD) in mg/*l*) and other important parameters. Physicochemical parameters from buildings in the university were categorized into 6 groups according to the zoning of the university. Table 4 presents the results of Water Demand by University Staff and Students. Table 5 presents the physicochemical characteristics of wastewater from the university buildings.

Table 4: Results of Water Demand by University Staff and Students

Status	College	Duration of stay (year)	avg demand estimate (l)	Avg water received estimate	Remarks (satisfied?)
STAFF	ENGINEERING	0-2	45-75	45-75	YES
		03-Apr	45-75	45-75	YES
		5 and above	-	-	-
	LAW	0-2	90-150	90-150	YES
		03-Apr	90-150	90-150	YES
		5 and above	-	-	-
	SOCIAL AND MANAGEMENT SCIENCES	0-2	45-75	45-75	YES
		03-Apr	45-75	45-75	YES
		5 and above	45-75	45-75	YES
	SCIENCES	0-2	90-150	90-150	YES
		03-Apr	45-75	45-75	YES
		5 and above	-	-	-
	MEDICINE	0-2	45-75	90-150	YES
		03-Apr	45-75	45-75	YES
		5 and above	-	-	-
STUDENTS	ENGINEERING	0-2	45-75	15-30	NO
		03-Apr	45-75	15-30	NO
		5 and above	45-75	15-30	NO
	LAW	0-2	15-30	15-30	YES
		03-Apr	45-75	15-30	NO
		5 and above	45-75	15-30	NO
	SOCIAL AND MANAGEMENT SCIENCES	0-2	45-75	15-30	NO
		03-Apr	45-75	15-30	NO
		5 and above	15-30	15-30	YES
	SCIENCES	0-2	45-75	15-30	NO
		03-Apr	45-75	15-30	NO
		5 and above	-	-	-
	MEDICINE	0-2	15-30	15-30	YES
		03-Apr	45-75	45-75	YES
		5 and above	-	-	-

Table 5: Physicochemical Characteristics of Wastewater from the University Buildings

Parameter	SW 1	SW 2	SW3	SW4	SW5	SW6	NESREA
pH	7.24	7.5	7.53	7.84	7.6	7.56	6.5 – 8.5
E. C. (mS/cm)	138	149	151	280	153	151	-
Temp. ^{o}C	36	8.39	20	7.74	7.96	8	40.0
TDS (mg/L)	69	74.5	75.5	122	76.5	75.5	500
TSS (mg/L)	8.32	6.6	6.43	4.2	6.48	9.22	25
Turbidity (NTU)	27.5	25.3	23.6	8.8	26.2	23.7	5.0
CO_3^{2-} (mg/L)	ND	ND	ND	ND	ND	ND	30
Alkalinity ($mgCaCO_3/L$)	18.33	21.33	23.67	37.67	31.33	27.33	60
Hardness $CaCO_3/L$)	45.47	45.47	53.73	96.8	54.27	36.67	-
Ca^{2+} (mg/L)	4	4.5	5.76	11.27	5.34	4.2	75
Mg^{2+} (mg/L)	8.51	8.76	9.44	16.47	9.6	9.28	0.2
DO (mg/L)	3.8	4.1	4	3.7	4.1	4	ND
BOD_5 (mg/L)	2.2	2.6	1.8	2.2	2.6	2	3.0
COD (mg/L)	5.2	5.65	4.72	3.6	4.9	5.4	30.0
Cl^- (mg/L)	19.44	27.29	27.29	34.01	24.58	34.3	300
SO_4^{2-} (mg/L)	3.58	2.84	3.83	1.76	3.2	4.27	100
NO_3^- (mg/L)	10.5	12.6	13.3	15.35	13	14.4	10
PO_4^{3-} (mg/L)	4.51	3.67	5.21	3.56	7.64	11	3.5
S^{2-} (mg/L)	ND	ND	ND	ND	ND	ND	ND
Oil and Grease	ND	ND	ND	ND	ND	ND	ND
THC (mg/L)	ND	ND	ND	ND	ND	ND	ND

Note: SW – Sample of wastewater at locations 1 to 6, ND – Not Detected

From other experiments conducted in the laboratory on wastewater from various point sources, Figure 4.1 presented a Chart of Calcium Hardness Representation, Figure 4.2 presented Dissolved Oxygen.

Discussion of Results of Wastewater Quality from different point sources

The total volume of wastewater generated is 1,419,200. The majority of this wastewater was generated from hostels and ventures. 80% of the water from different buildings finally becomes wastewater. This is in line with the statistic that roughly 75% of domestic wastewater is produced by homes or residential buildings, with the remaining 25% coming from businesses, public buildings, and other sources [19,20]. The average Nigerian uses 9 litres of water daily, which is less than the 12 to 16 litres per day acknowledged as the minimal guidelines at the national level, according to research by the Federal Ministry of Water Resources of Nigeria and UNICEF. the calibre of wastewater discharged from other facilities and wastewater treatment plants. According to the World Health Organization [21], these values are within the permitted range based on an evaluation of the wastewater produced by various point sources (hotels, colleges, laundries, cafeterias, and bakeries) in the university.
The WQI results from the various point sources ranged from 28 to 70. According to the findings, all samples with a WQI of 45.7 had satisfactory water quality, but samples 2 and 3 with WQIs of 78.72 and 114.2, respectively, were deemed to have very low water quality and to be unfit for drinking purposes. The wastewater was significantly polluted by ammonia, dissolved oxygen, and turbidity at 0.52 mg/L, 7.78 mg/L, and 38.62 NTU, respectively, according to the Water Quality Index. Public sewage infrastructure includes wastewater treatment facilities, sewerage and collection systems, as well as the cost of maintaining the collecting systems and pumping facilities [22]. Other works investigated the spatiotemporal characteristics of the greywater footprint, as well as external factors like weather and anthropogenic activities, all have an impact on how polluted the water [20].
It is possible to conclude that all of the samples are fine because they fall within the acceptable limit for effluent based on the laboratory experiment that was conducted and the results shown above. The amount of suspended particle matter in water is measured as turbidity. Measured by turbidity, suspended particles' impact on light scattering is quantified. The turbidity increases in direct proportion to the intensity of scattered light.
The total amount of water supplied to the University campus is obtained from the sum of the estimated average volume received (daily use) by the occupants as indicated in distributed questionnaires and the total volume of water stored in all tanks per day. The research assessed wastewater from different point sources (hostels, colleges, laundry, cafeteria and bakery) in the study area. Bakery has the highest calcium hardness of 537.5, total hardness of 468 and total dissolved solids of 2500 while Laundry has a calcium hardness of 330. The kitchen has the highest value of dissolved oxygen, ammonia, alkalinity and biochemical oxygen demand. Laundry has the highest value of Ph and turbidity. Figure 5 presents the variation in the concentration of calcium hardness across selected point sources. Figure 6 presents dissolved oxygen across selected point sources.

Figure 5: Variation in Concentration of Calcium Hardness across Selected Point Sources

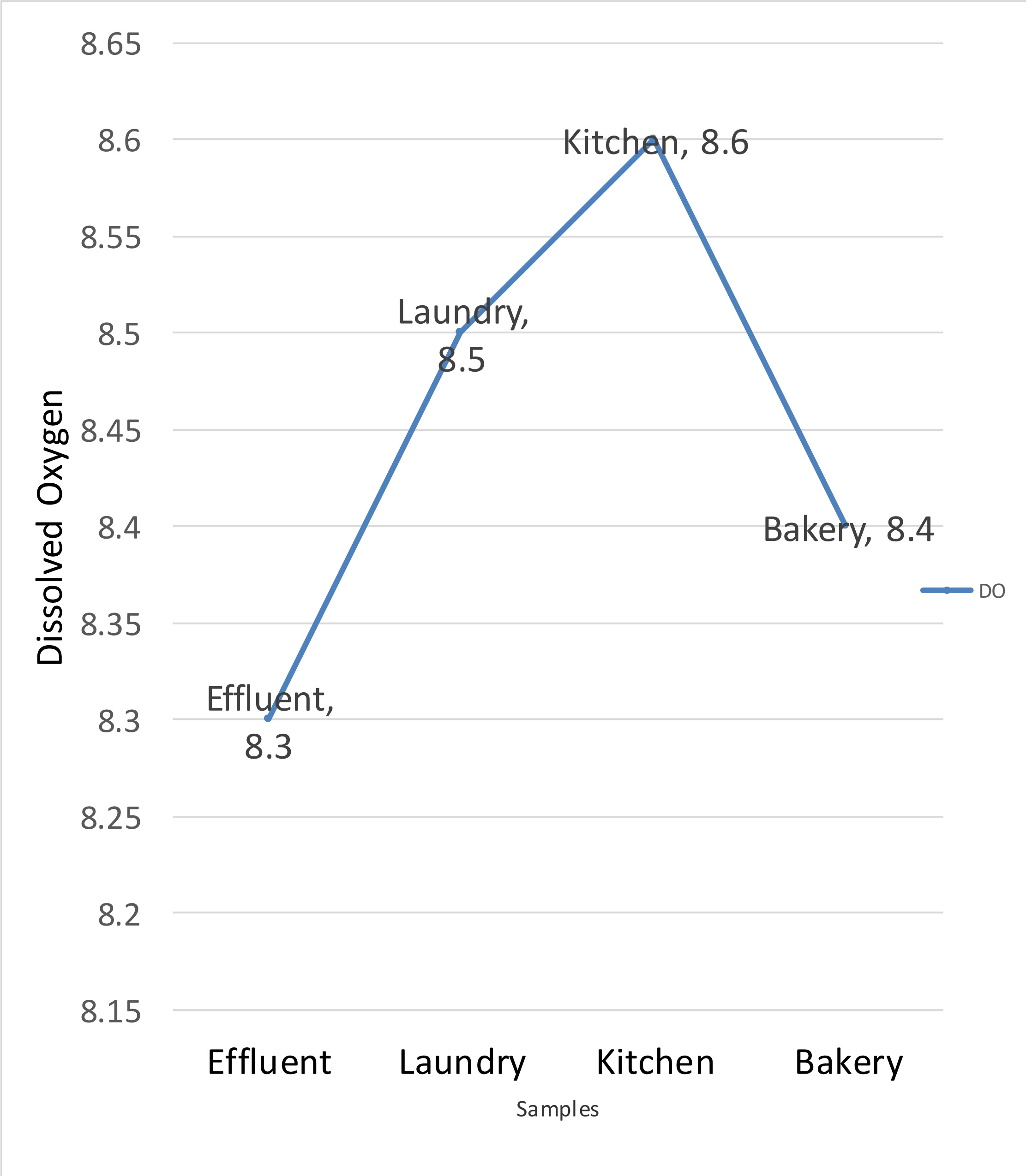

Figure 6: Dissolved Oxygen across Selected Point Sources

Conclusion

The following significant conclusions may be derived from this study based on the findings and analysis of the research:

i. The volume of wastewater generated in the university was 772,000 litres per day. The pilot scale WTP was designed with special consideration for parameters such as dissolved oxygen, recirculation ratio, water quality modelling tools and hydraulic loading for the enhancement of wastewater treatment facilities.
ii. The study also sheds light on how this technology might be used to remediate wastewater in the future. It also provided baseline information on the nature and characteristics of wastewater generated in Ado-Ekiti and its environs. This can be replicated in other areas to address environmental issues and contamination of water bodies.

Recommendations

It is recommended that a particular goal be set for controlling the contamination level of wastewater from various point sources, but the pollution reduction must be measurable, proven and done as early as possible. it is required to make the following suggestions to improve the best practices for managing the institution's wastewater. More research should be deployed on wastewater treatment and surface water quality monitoring regarding regulations and standards.

List of abbreviations

BOD_5	Biological oxygen demand (5-Day)
CO_2	Carbon Dioxide
COD	Chemical Oxygen Demand
DO	Dissolved Oxygen
FEPA	Federal Environmental Protection Agency
HSSFCW	Horizontal Sub Surface Flow Built Wetlands
pH	Negative Logarithm of Hydrogen Ion Concentration
TDS	Total Dissolved Solids
TH	Total Hardness
TS	Total Solids
TSS	Total Suspended Solids
UNICEF	United Nations International Children's Emergency Fund
WHO	World Health Organization
WQI	Water Quality Index

DECLARATIONS

Availability of data and materials
The data used to support the findings of this study are included within the article and are available from the corresponding author upon request.

Competing interests
The authors declare that there is not any conflict of interest.

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Authors' Contributions
OJ worked on the literature review and results compilation and he is a major contributor in writing the manuscript. OJ conceived the idea and intensified work on the realization of the research work. AK supervised the methodology, collection of materials and implementation of the research work. EO and JO proofread and made notable contributions. All authors read and approved the final manuscript.

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