COMPARATIVE ANALYSIS OF DRINKING WATER QUALITY AT THE UNIVERSITY OF BENIN, BENIN CITY (UGBOWO CAMPUS)

BY

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PLAGIARISM

This work "**Comparative Analysis of Drinking Water Quality at the University of Benin, Benin City (Ugbowo Campus)"** by **EKWU Emmanuel,** with matriculation number **ENG1810271** of the Department of Civil Engineering, Faculty of Engineering, University of Benin, Edo State, Nigeria has passed the plagiarism test.

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CERTIFICATION

This is to certify that this work was carried out by **EKWU Emmanuel with matriculation number ENG1810271**, of the department of Civil Engineering, University of Benin, Benin City, Edo State, Nigeria.

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DEDICATION

I dedicate this work to almighty God my creator, the pillar of all knowledge and understanding, for encouraging, leading and inspiring me all through this research work. I also in a special way dedicate this work to my parents, Mr. and Mrs. Ekwu, for their enormous support and assistance all through my research work. Thank you all and God bless.

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ABSTRACT

The aim of this study was to evaluate and compare the drinking water quality for four residential locations at the University of Benin, Benin City, Ugbowo Campus by carrying out physical and chemical analysis on water samples and access their safety by calculating their water quality index values and comparing with those of the Nigerian Standard of Drinking Water Quality (NSDWQ), and World Health Organization (WHO).

A comprehensive physical and chemical assessment was conducted on water samples collected from four residential areas within the University of Benin: Senior Staff Quarters (SSQ), NDDC Quarters, Junior Staff Quarters (JSQ), and Hall 4 Hostel. Key water quality parameters analyzed included pH, turbidity, electrical conductivity, Total Dissolved Solids (TDS), biochemical oxygen demand (BOD), mineral content, and the presence of heavy metals. Heavy metal analysis was performed using an air-acetylene flame atomic absorption spectrophotometer.

Water samples from the Junior Staff Quarters had better physical parameters while water samples at the hall 4 residence had the least quality in comparison to SON and WHO standard. However, all water samples were found to be acidic according to their pH values of 5.1 5.2, 5.4 and 5.3 for SSQ, NDDC, JSQ, Hall 4 Hostel respectively. The result gotten from water quality index calculation was 68.076, 97.10, 97.59, 94.60 for SSQ, NDDC, JSQ, Hall 4 hostel respectively. The water sample for SSQ is poor, for NDDC is bad, for JSQ is bad and that for Hall 4 Hostel is very bad

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ACRONYMNS

TDS: Total dissolved solids

BOD: Biological oxygen demand

TSS: Total suspended solids

WHO: World Health Organization

SON: Standard organization of Nigeria

EC: Electrical conductivity

ND: Not detected

SSQ: Senior staff quarters

JSQ: Junior staff quarters

NDDC: Niger delta development council

H4: Hall 4

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

Water is one of the most abundant and essential resources of man and it occupy about 70% of the earth's surface. About 97% of this volume of earth's surface water is contained in the oceans, 21% in polar ice and glaciers, 0.3 - 0.8% underground, 0.009% in inland fresh waters such as lakes, while 0.00009% is contained in rivers (Ekhosuehi, Akharame & Obayuwana, 2018). Water has been regarded as a universal solvent that can dissolve many chemicals which may or may not be beneficial to man and his environment. It is however essential to all living things and its environment. Ground water is the water beneath the earth's surface where all the voids in the rocks and soil are filled. It is a source of water for wells, boreholes and springs. A borehole is a hydraulic structure which when properly designed and constructed, permits the economic withdrawal of water from an aquifer (Roozbahani & Boldaji, 2013). It is a narrow well drilled with machine. Apart from the essential role played by water in supporting human life, if polluted, it also has a great potential for transmitting a wide variety of disease. Portable water for human consumption does not always occur in nature because of the presence of impurities in most natural water bodies, and this has been attributed to its high solvating capacity. Water in its pure state is acclaimed key to health and the general contention is that water is more basic than all other essential thing in life (Byjus, 2024).

Access to safe and clean drinking water is a fundamental human right and a crucial determinant of public health. However, the quality of drinking water can vary significantly depending on the source, treatment methods, and environmental factors (Badamisi, Yaro & Bashir, 2019). Contaminated drinking water poses a substantial threat to human health, leading to various waterborne diseases and long-term health complications. Numerous studies have highlighted the global challenge of ensuring access to safe drinking water, particularly in developing countries. (Omorogieva et al., 2018). These studies have revealed that a significant proportion of the world's population lacks access to improved water sources, relying on untreated or inadequately treated water, which can be contaminated with harmful pathogens and chemicals (Badamisi, Yaro & Bashir, 2019).

In many regions, rapid urbanization, industrialization, and agricultural activities have further exacerbated the problem of water pollution, leading to the contamination of both surface and groundwater sources. This contamination can arise from various sources, including industrial effluents, agricultural runoff, and inadequate sanitation systems. To assess the safety and portability of drinking water, various physicochemical and microbiological parameters are routinely analyzed. Some of these parameters include pH, turbidity, electrical conductivity, total dissolved solids, and the presence of coliform bacteria, including Escherichia coli (Coli, 2022).

A numerical representation used to assess the quality of water in different situations is the Water Quality Index (WQI). It makes it simpler to comprehend and evaluate the general health of water bodies by combining several water quality measures into a single score

The WQI's primary goal is to make it easier for the general public and decision-makers to understand water quality data. It raises public awareness of water quality issues by converting complex facts on water quality into a format that is simple for the average person to understand. (Cordy & Gail, 2010).

1.2 Statement of the Problem

While the University of Benin has several locations where water can be obtained and utilized for drinking, there is a significant lack of readily accessible and comprehensive information regarding the comparative quality of these different sources of water. This lack of information creates a gap that makes it difficult for the university community to make informed decisions about drinking water, raising concerns about potential health risks and the long-term sustainability of water resources in the campus. This study aims to address this critical need by conducting a comparative analysis of drinking water quality from various locations where water is utilized for drinking within the University of Benin, providing data-driven insights to empower informed choices.

1.3 Aim and Objectives

The aim of this study is to evaluate and compare the drinking water quality for four residential locations at the University of Benin, Benin City, Ugbowo Campus. The objectives are to:

I. Carry out physical and chemical analysis on water samples collected from all four locations.

II. Compute the water quality index values for all locations.

III. Compare experimental and numerical results with those of regulatory bodies i.e. World Health organization, European Union and Nigerian standards.

1.4 Scope of the study

This research focuses on evaluating the quality the quality of drinking water in selected locations within the University of Benin, specifically at Senior Staff Quarters, NDCC, Junior Staff Quarters and Hall 4 hostel .This Study encompasses various aspects, including collection of water samples from these locations, water quality analysis on the collected water samples, water quality index analysis. It is confined to these four specific locations to ensure a direct comparative analysis. The scope extends from the assessment of parameters such as PH, turbidity, total dissolve solids, total suspended solid, etc to the quantification of heavy metals, providing a comprehensive understanding of the potential health implications and quality variations across these different areas.

1.5 Justification of the Study

This study holds significant importance in providing a rationale for the comparative analysis of drinking water quality by addressing health implications. The study's relevance lies in its potential to guide public health policy and water management strategies, offering advantages in identifying high- risk sources, ensuring compliance with established safety standard, and providing reliable information for consumers choice. This claim aligns with the broader goal of advancing public health and promoting responsible stewardship of water resources.

CHAPTER TWO

LITERATURE REVIEW

2.1 Water

H_2O is the chemical formula for water, which is an inorganic compound. It is a clear, practically colorless, tasteless, and odorless chemical compound. It is the primary component of the hydrosphere on Earth and the fluids found in all known living things, where it functions as a solvent (Gleick, 2023). Even though it doesn't include organic micro-nutrients or dietary energy, it is essential for all known forms of existence. Water occurs on Earth as a result of the planet's environment being very close to the triple point of water, i.e a gas, a liquid, and a solid. (Buttler, 2023). It creates aerosols in the form of fog and precipitation in the form of rain.

2.2 Uses of water

Water being the most abundant resource finds useful applications in agriculture, human consumption, cleaning, transportation, industrial use etc (Badamasi, Ibrahim & Bashir, 2019).

2.2.1 Agriculture

Biofuels or other water-intensive businesses, there will probably be new water concerns. Up to 80–90% of all human water consumption is used for agriculture, including irrigated agriculture, making this the most common use of water by humans (Buttler, 2023). The majority of water that is "consumed" is used and not returned to the environment goes to agriculture. With growing economies and populations, consumption of as the demand for meat that is thirsty for water increases and for

2.2.2 Human Consumption

Depending on body size, the human body can contain anywhere between 55% and 78% water. The body needs one to seven liters (0.22 to 1.54 imp gal; 0.26 to 1.85 US gal) of at water each day to function effectively and prevent dehydration; the exact amount varies depending on temperature, humidity, activity level, and other factors (Maton, 2019).

2.2.3 Cleaning

Cleaning is done through washing, which is often done with water and soap or detergent. Keeping one's body and clothes clean by regular washing and rinsing is crucial for maintaining excellent health and hygiene (Maton, 2019). To help emulsify oils and dirt particles so they can be rinsed away, people frequently use soaps and detergents. You can apply the soap directly, with the help of a washcloth, or with the help of sponges or other similar cleaning instruments (Buttler, 2023).

2.2.4 Transportation

Whether across lakes and oceans, through canals or along rivers, maritime transportation can be accomplished over any distance by boat, ship, sailboat, or barge. Shipping can be done for business, pleasure, or even for the military (Cordy & Gail, 2010). Even if vast inland transportation is no longer as crucial, the world's major waterways, including several canals, continue to be vital to global economies.

2.2.4 Industrial Use

The water industry supplies homes and businesses with potable water as well as wastewater services, such as sewage treatment. Water wells, rainwater collecting cisterns, water supply networks, water purification systems, water tanks, water towers, and water pipes, including historic aqueducts, are examples of water supply facilities. Researchers are working on atmospheric water generators. (Lindsey et al., 2020).

2.3 Sources of water

Water can be gotten from two main sources i.e. rivers and rainfall.

2.3.1 Surface water

As opposed to seawater and water bodies like the ocean, surface water is the water that sits on top of land and forms terrestrial (surrounded by land on all sides) water bodies. Surface water comes in three main categories (Cordy & Gail, 2010).

There are lakes, rivers, and wetlands (marshes and swamps) that are permanent (perennial) surface waters that are present all year round. Surface water that is only present occasionally during the year is referred to as permanent (ephemeral). This includes seasonally dry channels like streams, lagoons, and waterholes. Surface water that has been produced by humans is defined as water that can be sustained by human-built infrastructure. This would include constructed ponds (such as garden ponds), canals, dammed lakes, and wetlands. Hydro power is one renewable energy source that can be produced from the surface water that dams store. The process of forcing surface water from rivers and streams to create energy is known as hydropower (Lindsey et al., 2020).

2.3.2 Ground water

The water found in the pore spaces of rocks, soil, and rock formation fissures beneath the surface of the Earth is known as groundwater. Groundwater makes up around 30% of the freshwater that is readily available worldwide. (Ludwig et al., 2023). An aquifer is an unconsolidated deposit or unit of rock that can provide a useful amount of water. The water table is the depth at which the pore spaces in soil or the cracks and gaps in rock are totally saturated with water.

Groundwater receives its replenishment from the surface; it can naturally seep and burst out of the ground, creating oases and wetlands. Groundwater is also frequently extracted through the construction and maintenance of extraction wells for use in industry, agriculture, and cities. The analysis of mobility and distribution hydro geology, often known as groundwater hydrology, is the study of groundwater.

2.4 Water Quality Standards by W.H.O

a) To preserve the public's health, the World Health Organization (WHO) has set thorough Standards for drinking water quality.

The following are some salient features of these guidelines:

b) **Health Targets:** By guaranteeing that drinking water is free of dangerously high levels of pollutants, these targets are intended to safeguard human health for both chemical and microbiological parameters.

Plans for Water Safety (WSPs)

The whole water supply system, from catchment to customer, is covered by these plans, which constitute a preventive risk management strategy.

At every point of the supply chain WSPs seek to detect and control water quality hazards.

c) **Microbiological Quality:** According to the recommendations, drinking water must be free of pathogens such viruses, bacteria and protozoa.

It is advised to conduct routine testing and monitoring to guarantee microbiological safety.

d) **Chemical Quality**: The standards set limits for a number of chemical pollutants, such as pesticides, disinfection byproducts, and heavy metals (such as lead and arsenic). Health risk assessments provide the basis of these limitations (WHO, 2017).

e) **Radiological Quality:** Limits to guard against radiological dangers are established in the standards, which also cover the presence of radioactive materials in drinking water.

f) **Operational Monitoring:** To guarantee adherence to the regulations, routine monitoring of water quality parameters is necessary. These include assessing the pH, turbidity, and amounts of residual disinfectant.

g) **Public Health Surveillance:** To ensure that water safety strategies are working and that water quality criteria are being fulfilled, independent surveillance is advised (W.H.O, 2017).

2.4.1 Physical Aspects of Palatable Water (W.H.O Guidelines)

Physical aspects of drinking water as propounded by the world health organization are based on taste, odour, colour, turbidity and temperature.

2.4.1.1 Taste Requirements

Taste requirements refer to the acceptable levels of substances in drinking water that affect its palatability, or how pleasant it is to drink. Even when water is safe, certain chemical components can make it taste salty, bitter, or otherwise unpleasant. Maintaining proper taste ensures that water is both safe and enjoyable for consumers.

Chloride

Water and drinks with high chloride concentrations taste salty.

For sodium, potassium, and calcium chloride, the taste thresholds for the chloride anion range from 200 to 300 mg/l, depending on the related caution.Although some consumers may grow acclimated to modest levels of chloride induced taste, concentrations above 250mg/l are more likely to be noticed by taste. Chloride in drinking water has no suggested health-base guideline value.

Chlorine

Chlorine in drinking water can be tasted or smelled by most people at concentrations considerably below 5 mg/l, and some at as little as 0.3 mg/l.Chlorine's taste threshold is less than the 5 mg/l health based recommended value.

2.4.1.2 Colour requirements

The optimum drinking water should be colorless. The presence of colored organic materials, mainly fulvic and humic acids, linked to the humus component of soil is often what gives drinking water its color. The presence of iron and other metals, either as naturally occurring contaminants or as byproducts of corrosion, also has a significant impact on color.

It may also result from the contamination of the water source with industrial effluents and may be the first indication of a hazardous situation. It is important to look into the cause of color in a drinking water supply, especially if there has been a significant change (W.H.O, 2017).

2.4.1.3 Turbidity requirements

Colloidal matter or suspended particles that block light from passing through the water are the source of turbidity. It could be brought on by organic or inorganic materials, or both. The elimination of turbidity through filtration will significantly lower microbial contamination in treated water since microorganisms (bacteria, viruses, and protozoa) are usually connected to particles. Nephelometric turbidity units (NTU) are used to measure turbidity, and above about 4.0 NTU, turbidity is first visible to the unaided eye. However, turbidity should be at least 1 NTU and ideally considerably lower to guarantee disinfection efficacy. Before disinfection, large, efficiently operated municipal supplies should always be able to attain less than 0.5 NTU and should be able to average 0.2 NTU or less (Dash & Payyappilli, 2016).

2.4.1.4 Temperature requirements

In general, cold water is more palatable than warm water, and temperature will alter the acceptability of several additional chemical pollutants and inorganic elements that might affect flavor. High water temperatures encourage the growth of microorganisms and can exacerbate corrosion, color, taste, and odor issues (Ramakrishnaiah, Sadashivaiah & Ranganna 2019).

2.4.2 Chemical aspects of palatable water (W.H.O guidelines)

Chemical aspects of drinking water as provided by W.H.O are based on parameters such as water PH, total dissolved solids, concentration of heavy metals or other organic compounds (Ramakrishnaiah, Sadashivaiah & Ranganna 2019).

2.4.2.1 Total amount of dissolved solids

A total dissolved solids (TDS) level of less than 600 mg/l is typically regarded as good for palatability; at TDS levels more than 1000 mg/l, drinking water becomes significantly and progressively less pleasant. Due to excessive scaling in water pipes, boilers, heaters, and domestic appliances, customers may find high TDS levels to be bothersome. There is currently no proposed health-based guideline value for TDS (Oputu & Akharame, 2022).

2.4.2.2 pH Requirements

Permissible limits for certain physicochemical characteristics of drinking water, including pH, have been established by the World Health Organization (WHO). The recommended pH range is from **5.9 ± 0.001 to 6.8 ± 0.002**. pH is an important parameter because it reflects the acid–alkali balance of water and provides an indication of its pollution level. A pH value of **7** is considered neutral, values **less than 7** indicate acidity, and values **greater than 7** indicate alkalinity (Ologbosere et al., 2016).

2.4.3 Microbial Aspects of Palatable Water (WHO Guidelines)

The most frequent and widespread health risk associated with drinking water is the occurrence of infectious disorders caused by pathogenic bacteria, viruses, and parasites such as helminths and protozoa. The public health burden of water-related infections depends on several factors, including the severity and frequency of the diseases, their level of contagiousness, and the size of the population exposed. Disease outcomes are often more serious in susceptible subgroups such as children, the elderly, and immune compromised individuals. A breakdown in the safety of the water supply system—whether at the source, during treatment, or throughout distribution—can result in large-scale contamination and potentially detectable disease outbreaks (Ekhator, Akhere & Okosun, 2022).

In many situations, public health surveillance is unlikely to identify contaminated drinking water as the direct source of infection. Nevertheless, low-level or recurrent pollution may occasionally contribute to significant, though relatively rare, illnesses.

Table 2.1: Drinking water pathogens

Pathogen	Persistence and Future Characteristic		Resistance to Chlorine	Relative Infectivity	Important Animal Source
Bacteria *Burkholderia pseudomallei*	High	May multiply	Low	Low	No
Campylobacter jejuni, *C. coli*	High	Moderate	Low	Moderate	Yes
Escherichia coli – Pathogenic	High	Moderate	Low	Low	Yes
E. coli – Enterohaemorrhagic	High	Moderate	Low	High	Yes
Francisella tularensis	High	Long	Moderate	High	Yes
Legionella spp.	High	May multiply	Low	Moderate	No
Leptospira	High	Long	Low	High	Yes
Mycobacteria (nontuberculous)	Low	May multiply	High	Low	No
Salmonella Typhi	High	Moderate	Low	Low	No
Other salmonellae	High	May multiply	Low	Low	Yes
Shigella spp.	High	Short	Low	High	No
Vibrio cholerae	High	Short to long	Low	Low	No
Viruses Adenoviruses	Moderate	Long	Moderate	High	No
Astroviruses	Moderate	Long	Moderate	High	No
Enteroviruses	High	Long	Moderate	High	No
Hepatitis A virus	High	Long	Moderate	High	No

Hepatitis E virus	High	Long	Moderate	High	Potentially
Noroviruses	High	Long	Moderate	High	Potentially
Rotaviruses	High	Long	Moderate	High	No
Sapoviruses	High	Long	Moderate	High	Potentially

Source: W.H.O, 2017

2.5 European water quality standards

Three directives largely codify the water quality regulations of the European Union: Directive on Urban Wastewater Treatment: This 1991 directive addresses the release of specific municipal and industrial wastewaters (European Union, 2023).

The 1998 Drinking Water Directive addresses the quality of drinkable water. The 2000 Water Framework Directive addresses the management of water resources. Standards for water meant for human consumption are established by the Drinking Water Directive. Nitrate: 50 mg/L, Nitrite: 0.50 mg/L, Total pesticides: 0.50 µg/L, and Individual pesticides: 0.10 µg/L are a few instances of these requirements.

Establishing the necessary policing measures to guarantee that the legislation is carried out is the responsibility of each member state. The Drinking Water Inspectorate, for instance, oversees the water providers in the United Kingdom (Cordy & Gail, 2021).

Below are the numerical limits for both microbiological and physio chemical parameters for pumped and pipped water supplies for domestic use (Gupta, Chaudhary & Yadav, 2023).

Table 2.2: Microbial parameters limits for ground water supplies

Parameter	**Parametric value**	**Unit**
Intestinal enterococci	0	number/100 ml
Escherichia coli (E.coli)	0	number/100 ml

Source: European Union, 2023

Table 2.3: Chemical parameters limits for ground water supplies

Parameter	Parametric value	Unit
Cadmium	5.0	µg/l
Chlorate	0.25	mg/l
Chlorite	0.25	mg/l
Chromium	25	µg/l
Copper	2.0	mg/l
Cyanide	50	µg/l
1,2-dichloroethane	3.0	µg/l
Epichlorohydrin	0.10	µg/l
Fluoride	1.5	mg/l
Haloacetic acids (HAAs)	60	µg/l
Lead	5	µg/l
Mercury	1.0	µg/l
Microcystin-LR	1.0	µg/l
Nickel	20	µg/l
Nitrate	50	mg/l
Nitrite	0.50	mg/l
Pesticides	0.10	µg/l
Pesticides — Total	0.50	µg/l
PFAS Total	0.50	µg/l
Sum of PFAS	0.10	µg/l
Polycyclic aromatic	0.10	µg/l
hydrocarbonsSelenium	20	µg/l
Tetrachloroethene and Trichloroethene	10	µg/l

Trihalomethanes Total	100	µg/l
Uranium	30	µg/l
Vinyl chloride	0.50	µg/l

Source: (European Union water Quality Standard, 2023)

2.6 Nigerian standard for drinking water quality

Public health and the safety of drinking water sources are protected by drinking water quality standards. Consumer protection will be guaranteed by the creation of the Nigerian Standard for Drinking Water Quality (NSDQW). The Nigerian Standard for Drinking Water Quality is anticipated to improve the management of all drinking water systems in the nation and expedite the process of updating unprotected water systems (Uddin et al., 2022).

After lengthy consultations with all stakeholders, including development partners responsible for water quality management, a consensus was established on the substance of the Nigerian Standard for Drinking Water Quality. Therefore, the broad ideas of a collaborative, integrated, and preventive multi-agency approach form the basis of this standard. This standard establishes guidelines and upper limits for drinking-water (Akharame & Nneoma, 2024).

Table 2.4: Tolerable limits for physical characteristics of drinking water

Parameter	Unit	Maximum Permitted Levels	Health Impact
Colour	TCU	15	None
Odour	-	Unobjectionable	None
Taste	-	Unobjectionable	None
Temperature	^{0} Celsius	Ambient	None
Turbidity	NTU	5	None

Source: Nigerian standards for drinking water quality, (2007)

Table 2.5: Tolerable limits for chemical water contaminants

Parameter	Unit	Maximum Permitted	Health Impact
Aluminum (Al)	mg/L	0.2	Potential Neuro-degenerative disorders
Arsenic (As)	mg/L	0.01	Cancer,
Barium	mg/L	0.7	Hypertension
Cadmium (Cd)	mg/L	0.003	Toxic to the kidney
Chloride (Cl)	mg/L	250	None
Chromium (Cr^{6+})	mg/L	0.05	Cancer
Conductivity	μS/cm	1000	None
Copper (Cu^{+2})	mg/L	1	Gastrointestinal disorder,
Cyanide (CN^{-})	mg/L	0.01	Very toxic to the thyroid and the nervous system
Fluoride (F^{-})	mg/L	1.5	Fluorosis, Skeletal tissue (bones and teeth) morbidity
Hardness (as $CaCO_3$)	mg/L	150	None
Hydrogen Sulphide (H_2S)	mg/L	0.05	None
Iron (Fe^{+2})	mg/L	0.3	None
Lead (Pb)	mg/L	0.01	Cancer, interference with Vitamin D metabolism, affect mental development in infants, toxic to the central and peripheral nervous systems
Magnesium (Mg^{+2})	mg/L	0.20	Consumer acceptability
Manganese (Mn^{+2})	mg/L	0.2	Neurological disorder

Source: Nigerian standards for drinking water quality, (2007)

Table 2.6: Tolerable limits for Microbial water contaminants

Parameter	Unit	Maximum Permitted Levels	Health Impact
Total Coliform count	cfu/mL	10	Indication of faecal contamination
Thermo tolerant Coliform or *E.coli*	cfu/100mL	0	Urinary track infections, bacteraemia, meningitis, diarrhea, (one of the main cause of morbidity and mortality among children), acute renal failure and haemolytic anaemia
Faecal streptococcus	cfu/100mL	0	Indication of recent faecal contamination
Clostridium perfringens spore	cfu/100mL	0	Index of intermittent faecal contamination

Source: Nigerian standards for drinking water quality, (2007)

2.7 Comprehensive Assessment of Water Quality in Benin City Residential Areas.

During six months of the 2015 wet season, from April to September, the water quality index (WQI) of five rivers in Edo State, Southern Nigeria, was examined. pH, turbidity, total dissolved solids (TDS), conductive properties, total hardness, magnesium, calcium, sulfate, phosphate, and dissolved oxygen are among the physicochemical characteristics that are examined. The phycology lab in the Department of Plant Biology and Biotechnolog, University of Benin, Benin City, analyzed river water samples for the parameters (Akharame & Ajayi, 2022). According to WQI values, none of the rivers under study were appropriate for household use and did not fall within the acceptable pollution range.

This was linked to a lot of anthropogenic activities in the surrounding watershed of the research sites as well as flooding related with the wet season which brought in allochthonous materials into the rivers (Ekhator et al., 2022).

In light of the fact that 73% of people in developing nations lack access to sanitary facilities and that approximately half of them lack safe drinking water, this study was conducted in two suburbs of Benin City, Edo state, Nigeria, to investigate the hydrogeology and water quality of these communities. Three boreholes were drilled to depths of 57.60, 60.3, and 45.68 meters, respectively, and soil samples were taken at intervals of 4.57 meters to ascertain the subsurface geology, aquifer geometry, and soil properties. Water samples were collected from these wells, in addition to two other existing boreholes and a sample from a nearby river (Omorogieva et al., 2016). The water quality index (WQI) is used to assess the quality of the water. (Akharame & Obianke, 2024).

Standard laboratory techniques were used to analyze the water samples for physicochemical parameters such as; TDS, pH, TH, EC, NO3, SO4, and Mg2+. The Atomic Absorption Spectrometer (AAS) model 969 unicam series with air acetylene flame was used to analyze the heavy metals. Three wells were found to be highly contaminated two to be of good quality, and one to be of poor quality, according to the results of the physicochemical analysis that was used to calculate the values for the water quality index (Gleick, 2023).

The aquifer geometry is essentially made up of fine to coarse sand grains with high porosity and permeability, which improve water percolation, according to the hydrogeological study. The groundwater flows toward the southeast from the northwest; and in the study area, it was found that the water quality improved from the nearby landfill to the river. This suggests that the leachate from the unprotected landfill, along with the topography geology of the area, is a significant contributing factor to the poor water quality. To stop the problem, the authors suggest a suitable legislature and the application of current environmental rules (European Union, 2023).

The lack of drinkable water leads to reliance on river water for household and drinking needs. Solid waste disposal and effluent discharge are two easy ways to contaminate river water. Assessing the quality of river water is essential for both environmental sustainability and public health. The Ikpoba River in Benin City, Nigeria, was evaluated for quality using the National Sanitation Foundation Water Quality Index (NSFWQI) model (European Union, 2023).

In accordance with conventional protocols, nine physicochemical and microbiological parameters were examined for NSFWQI assessment (Okonofua, Nwadialo & Ekun, 2019).

These consist of temperature, pH, turbidity, phosphate, nitrate, total dissolved solids (TDS), dissolved oxygen (DO), biochemical oxygen demand (BOD), and total coliforms. For the samples, the NSFWQI values fell between 35.97 and 50.59, which is within the river water's average quality status is bad, with scores ranging from bad to medium. BOD, TDS, turbidity, and total coliform were the main parameters that did not meet the standards set by national and international regulatory bodies (Dybka-Stępień & Leszczewicz, 2019).

Past studies in Edo State have examined river and borehole water quality but were often limited to only basic physicochemical parameters (Akharame & Ajayi, 2022; Omorogieva et al., 2016; Ekhator, Akhere & Okosun, 2022). Most did not consider palatability factors such as turbidity, TDS, or dissolved gases (Okonofua, Nwadialo & Ekun, 2019; Dybka-Stępień & Leszczewicz, 2019), and few used Water Quality Index (WQI) to compare multiple locations (Akharame & Obianke, 2024; Gleick, 2023).

2.8 Previous Work done

Comparative studies on drinking water quality within universities have increasingly emphasized chemical contaminants, heavy metals, student perceptions, and the use of Water Quality Indices (WQI) as tools for assessment. These works provide valuable insights into how infrastructure, environmental factors, and behavioral responses shape the safety and sustainability of drinking water in academic environments.

Pieper etal (2017) conducted a research at the University of North Carolina at Chapel Hill (USA), the research detected lead contamination in some campus drinking water outlets. Comparative sampling across different buildings revealed that contamination levels were higher in older infrastructure, underscoring the role of plumbing materials and pipe age in determining water safety. The study prompted remediation measures, including fixture replacement and increased monitoring.

At the University of Illinois Urbana-Champaign (USA), a student-led project compared water quality from different types of drinking fountains (glass fillers, bottle fillers, filtered stations). Although most samples met safety standards, distrust among students led to increase bottled water use, raising sustainability concerns due to plastic waste. It implies that comparative perception studies reveal that even when water is technically safe, student distrust can drive unhealthy or unsustainable behaviors. This underscores the importance of transparent communication and trust-building in water management within universities.

In Nigeria, Akharame & Ajayi (2022) assessed groundwater quality around the University of Benin using the Water Quality Index (WQI). Their comparative analysis showed that while some sources were within acceptable limits, others were classified as poor or very poor, indicating contamination from anthropogenic activities such as waste disposal and industrial runoff. It implies that the comparative analyses demonstrate that both infrastructure age and environmental pollution strongly influence water safety in universities. They highlight the need for targeted remediation, especially in campuses with aging distribution systems or vulnerable aquifers.

Study by Okoro et al. (University of Nigeria, Nsukka); conducted a comparative analysis of three borehole water sources in Nsukka urban area, where the university was located. The Parameters assessed were pH, hardness, total solids, alkalinity, turbidity, sulphate, phosphate, silica; copper (Cu), lead (Pb), iron (Fe), residual chlorine, and chloride. From the Findings; pH values ranged between 6.29–6.43, within acceptable limits. Hardness varied widely (15–483 mg/L), with some samples exceeding WHO limits. Lead and iron concentrations were detected in certain boreholes, raising concerns about long-term health risks. Comparative analysis showed significant variation between borehole sources, reflecting differences in aquifer protection and local geology. It implies that Borehole water quality in Nsukka is inconsistent, with some sources safe and others requiring treatment before consumption.

In India, comparative WQI studies across multiple campuses revealed significant variations in water quality linked to local pollution sources and treatment practices, Hota R. N. et al (2025). Campuses located near industrial zones reported higher levels of contaminants such as nitrates and fluoride, while those with better treatment infrastructure scored higher on WQI. It implies that WQI provides a standardized framework for comparing water quality across different university sites. It allows administrators and policymakers to identify unsafe sources quickly an prioritize intervention.

CHAPTER THREE

METHODOLOGY

3.1 Study Area

The study was carried out at the University of Benin, Benin City, Edo State, focusing on four residential locations: Senior Staff Quarters (SSQ), Junior Staff Quarters (JSQ), Niger Delta Development Council (NDDC) Hall, and Hall 4 Hostel. The University has an estimated total population of 60,000 students across Ugowo and Ekenwan Campuses.

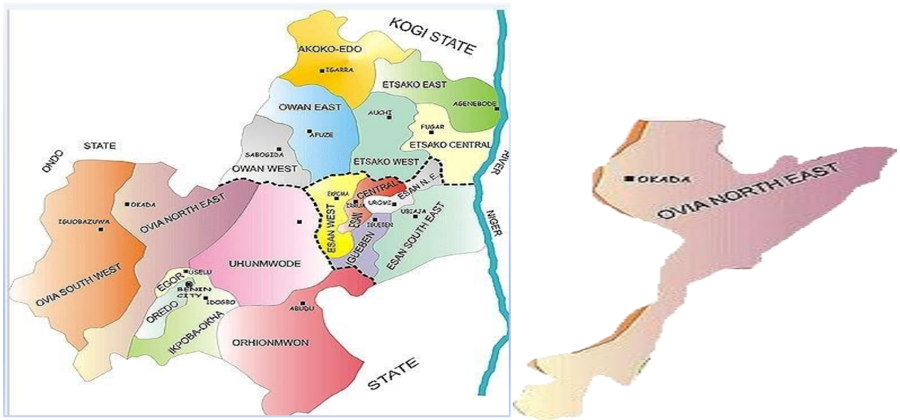

Figure 3.1: Map of study area (GIS Satellite, 2018)

3.1.1 Senior staff quarters (SSQ)

The SSQ is a residential area occupied mainly by teaching staff. The land is relatively flat, and the environment is generally conducive, being free from nearby dump sites, major roads, and industrial activities. The main source of water for inhabitants is publicly supplied pumped groundwater from University-managed boreholes, stored in private storage tanks.

3.1.2 Junior Staff Quarters

The JSQ is inhabited by both teaching and non-teaching staff. The area has less favorable environmental conditions due to inadequate waste management, and its water supply also originates from University-managed pumped boreholes, stored in storage tanks for individual units.

3.1.3 Niger Delta Development Council and Hall 4 hall of Residence

The NDDC Hall and Hall 4 Hostel are student residences. Water for these locations is primarily publicly supplied pumped groundwater from University boreholes, with storage tanks available at various points. The Hall 4 storage tanks are located near waste disposal areas, which may affect water quality.

3.2 Samples Collection

Water samples were collected in 1-liter sterile containers, sealed and stored at room temperature. Replicate samples were collected from each location to. The study focused on physicochemical parameters, specifically: pH, turbidity, total suspended solids (TSS), total dissolved solids (TDS), and heavy metals. These parameters were selected to evaluate both water safety and potability.

3.3 Experimental procedures

The water quality of the four locations was assessed through physico-chemical. All procedures were conducted according to standard laboratory protocols.

3.3.1 Physical analysis of ground water at the four locations

The physical properties measured included turbidity, temperature, dissolved oxygen (DO), pH. Turbidity and DO were measured using calibrated meters, while pH was determined using a standard pH meter. Temperature and taste were recorded according to laboratory observation procedures.

3.3.1.1 Turbidity Test

a) First, the turbidity meter will be calibrated using standard solutions like Formazin, which have known turbidity values.

b) Water samples will be collected in clean, turbidity-free containers

c) The sample would be inserted into the turbidity meter and the reading will be recorded. It is ensured that the sample be free from bubbles and particles that could affect the measurement.

d) The sample cell would be cleaned thoroughly between measurements to avoid contamination.

3.3.1.2 Dissolved Oxygen (DO) Test

a) The DO meter would be calibrated using air-saturated water or a zero-oxygen

b) Water samples would then be collected in airtight containers to prevent oxygen from exchanging with the atmosphere.

c) Following this, the DO probe would be inserted into the sample, allowed to stabilize, and the DO concentration would be recorded.

d) It will also note that the DO probe would be regularly cleaned and maintained to ensure accurate readings.

3.3.1.3 pH Test

a) The pH meter is calibrated using standard buffer solutions, such as those with pH 4, 7, and 10

b) Water samples would then be collected in clean containers, with a warning to avoid contamination.

c) After this, the pH probe would be inserted into the sample and allowed to stabilize before the pH value was recorded

d) Finally, the probe would be rinsed with distilled water between measurements to prevent cross-contamination

3.3.2 Chemical analysis of ground water at the four locations

Chemical analysis involved determining TDS, TSS, and heavy metals (Na, K, Ca, Mg, Cl, Fe, Mn, Zn, Cu, Cr, Cd). TDS was measured by evaporating filtered water samples and weighing the residual solids. Heavy metals were quantified using **Atomic Absorption Spectrometry (AAS)** or **Inductively Coupled Plasma Mass Spectrometry (ICP-MS)** after appropriate acid digestion of samples.

3.3.2.1 Total dissolved solids (TDS) Test

Testing for Total Dissolved Solids (TDS) in water involves measuring the combined content of all inorganic and organic substances dissolved in the water.

a) **Sample Collection:**

   The water sample is collected in a clean, contamination-free container and ensured that it is well-mixed before testing.

b) **Preparation:**

   The water sample is filtered through a Whatman filter paper to remove any suspended solids and the filtrate is collected in a clean container.

c) **Weighing**:

   A clean, dry evaporating dish would be weighed, and its weight would be recorded as (W1). A measured volume of the filtrate would then be poured into the dish.

d) **Evaporation:**

   The evaporating dish would be placed in an oven set to 103-105°C and allowed to remain there until all of the water had evaporated, leaving only the dissolved solids. This process typically takes 24 hours.

e) **Cooling and Weighing:**

   After evaporation, the evaporating dish would be cooled in a desiccator to prevent it from absorbing moisture. Following this, the dish with the dried residue would be weighed, and its weight would be recorded as (W2).

   TDS (mg/L) = (W2-W1) X 1000 / Volume of samples (mL)……… Eqn (3.1)

Where W2 = Weigh the dish with the dried residue

W1 = Weight of dry evaporating dish

3.3.2.2 Heavy metals test

Testing for heavy metals in water samples is crucial for assessing water quality and ensuring it is safe for consumption and other uses. The test procedures are listed below.

a) Clean hands/dirty hands (CH/DH) techniques are applied to avoid contamination. Wearing of gloves and usage of clean, acid-washed containers is employed.

b) Few drops of nitric acid (HNO_3) are added to the sample to preserve it and prevent metal precipitation.

c) Samples would be then stored in a cool, dark place until analysis.

Analytical Methods

Inductively Coupled Plasma Mass Spectrometry (ICP-MS):

a) The sample is digested with acids (e.g., HNO_3 and HCl) to break down organic matter and release metals.

b) The digested sample would be injected into the ICP-MS, which ionizes the sample and measures the mass-to-charge ratio of the ions to identify and quantify metals.

3.3.3 Water Quality Index (WQI) for the four locations

The WQI would be calculated to provide a composite measure of overall water quality. The method employed for this study is as described by Ahmed et al (2023) which involves first calculating the quality of parameters, Qp as presented in the equation. Below;

$$Qp = \sum_{p=1}^{n} \frac{(Vn - In)}{(Sn - In)} X\ 100 \quad \text{.............................(Eqn 3.2)}$$

Vn is the average values of the parameters determined under laboratory conditions. S is the standard permissible values obtained from WHO and In is the ideal values for the parameters. All ideal values (In) are taken to be zero except that of PH=7, and Dissolve Oxygen (DO) = 14.6mg/l. The unit weight (Wn) is calculated by taking the inverse variation of the standard permissible value Sn For the parameter considered. I.e Wn $\propto \frac{1}{\mathrm{Sn}}$,

$$\mathrm{Wn} = \frac{\mathrm{K}}{\mathrm{Sn}} \quad \text{.............................(Eqn 3.3)}$$

$$\text{But } \mathrm{K} = \frac{1}{\sum(\frac{1}{\mathrm{Sn}})} \quad \text{.............................(Eqn 3.4)}$$

The water quality index therefore is determined by aggregating the product of the parameter qualities and the unit weights and dividing by aggregate of the unit weights.

$$\mathrm{WQI} = \frac{\sum \mathrm{QnWn}}{\sum Wn} \quad \text{...(Eqn3.5)}$$

TABLE 3.1 Water Quality Index and Water Quality Status

Water Quality Index	Water Quality Status
0-25	Excellent
26-50	Good
56-75	Bad
76-100	Very bad
>100	Unfit for drinking

Source: Chatterji and Razuiddin(2002)

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.1 Physio properties of water samples

The physical parameters values of water samples from the four locations are presented in **Table 4.1**. Properties measured included electrical conductivity (EC), Salinity, turbidity, total dissolved solids (TDS), and total suspended solids (TSS).

Table 4.1: Physical Properties of Water Samples at the Four Locations

S/N	Location	Sample ID	EC dc(µS/cm)	Salinity (g/L)	Turbidity (NTU)	TSS (mg/L)	TDS (mg/L)
1	Senior Staff Quarters	SSQ	285	0.130	ND	ND	143
2	NDDC Hall	NDDC	98	0.044	ND	ND	49
3	Junior Staff Quarters	JSQ	84	0.038	ND	ND	42
4	Hall 4 Hostel	H4	120	0.054	ND	ND	61

It was observed that the water samples from Junior Staff Quarters had better physical quality, with lower EC and TDS, while Hall 4 showed comparatively poorer quality. The water sample in SSQ had the highest TDS .The high TDS at SSQ could have resulted from intrusions into water pipelines, human activities, or natural sources. Low dissolved oxygen was attributed to temperature fluctuations and the presence of organic matter, potentially increasing ammonia levels over time.

4.2 Chemical Properties of Water Samples

The chemical parameters values of water samples from the four locations are presented in the following tables. Parameters measured included PH, Dissolved Gases/ion (DO, HCO_3-, NH_4^+,

NO_2^-, etc) indicators, (BOD, COD), Mineral Concentrations (Na ,k Ca Mg, Cl, P) , Heavy Metal(Fe, Zn, Cu, Cd) etc.

Table 4.2: Concentration of Dissolved Gases/ion, indicators (mg/L) and PH

S/N	Location	Sample ID	HCO_3-	NH_4^+	NO_2^-	NO_3^-	SO_4^{2-}	PH	BOD	COD	DO
1	SSQ	SSQ	33.3	0.041	0.005	0.035	0.017	5.1	1.3	11.0	0.8
2	NDDC	NDDC	17.4	0.020	0.002	0.011	0.007	5.2	1.0	9.2	1.2
3	JSQ	JSQ	15.0	0.015	0.001	0.009	0.004	5.4	1.0	7.4	1.4
4	H4	H4	28.0	0.033	0.003	0.027	0.011	5.3	1.1	10.4	0.9

It was found that trioxocarbonate (HCO_3^-) had the highest concentration at SSQ, while tetraoxosulphate (SO_4^{2-}) was the lowest across all locations. Values were below SON and WHO limits, indicating low risk to water safety.

The above table shows the concentration of dissolved gases in the water samples from the four different locations measured in milligrams per liter. Low dissolved oxygen was attributed to temperature fluctuations and the presence of organic matter, potentially increasing ammonia levels over time. Trioxocarbonate gas had the highest concentration at the SSQ location, while the least dissolved gas was tetraoxosulphate. The recorded values posed least risk to water safety as values were far lower than those recommended by the SON and WHO. These values may be due to increased water temperatures, pollution and decaying organic matter (Atlas, 2018). Increased values may however lead to increased corrosion capacity of water, altered taste and odor.

Table 4.3: Mineral Concentrations (mg/L)

S/N	Location	Na	K	Ca	Mg	Cl	P
1	SSQ	0.74	0.28	5.10	3.12	30.7	0.014
2	NDDC	0.41	0.11	2.91	1.45	18.7	0.008
3	JSQ	0.28	0.09	2.15	1.10	15.0	0.006
4	H4	0.55	0.18	3.38	2.01	25.6	0.011

From the table above it shows that SSQ had the highest mineral concentration while JSQ had the least concentration. It was observed that Calcium and Magnesium concentrations were low, indicating that all the water samples were seen to be free from hardness.

Table 4.4: Heavy Metal Concentrations (mg/L)

Location	Fe	Mn	Zn	Cu	Cr	Cd	Ni	Pb	V
SSQ	0.221	0.094	0.174	0.027	0.021	0.002	ND	0.008	ND
NDDC	0.303	0.112	0.191	0.033	0.027	0.003	ND	0.010	ND
JSQ	0.312	0.123	0.204	0.041	0.030	0.003	ND	0.010	ND
H4	0.258	0.102	0.181	0.030	0.025	0.003	ND	0.009	ND

All locations show trace amounts of various heavy metals, with Iron (Fe) being the most prevalent and Cadmium (Cd) is being the least common. The NDDC and JSQ locations generally exhibit higher concentrations of most metals compared to the SSQ and H4 locations. Overall, the results suggest that the water from all sites contains heavy metals, necessitating further analysis to determine if the concentrations exceed safety limits.

4.3 Water Quality Index (WQI) of All Locations

Water quality index was calculated for all parameters for all four locations and results were tabulated as follows in table 4.5.

Table 4.5: WQI Values for the Four Locations

S/N	**Location**	**SAMPLE ID**	**WQI**
1	SSQ	SSQ	68.076
2	NDDC	NDDC	97.10
3	JSQ	JSQ	97.59
4	H4	H4	94.60

The Water quality index values obtained for the four sampled locations indicate varying levels of water quality. SSQ falls within the Bad category, suggesting the water is unsafe for direct consumption without treatment. In contrast, NDDC, JSQ, and H4 all fall within the *very bad* category, reflecting severe contamination likely linked to anthropogenic activities and aging infrastructure. These results show that while SSQ is relatively better, none of the locations provide water of acceptable drinking quality.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The study investigated the physico-chemical quality of water samples from four selected locations within the University of Benin campus: Senior Staff Quarters (SSQ), Junior Staff Quarters (JSQ), Niger Delta Development Council Hall (NDDC), and Hall 4 Hostel (H4). Analysis of physico-chemical parameters revealed that all water samples were free from hardness, with Calcium and Magnesium concentrations well below recommended limits. Among minerals, Sodium showed the lowest concentration, while Chlorine had the highest, which may pose potential health risks over time if not monitored.

Heavy metal concentrations across all locations were generally low, likely due to the absence of industrial and significant agricultural activities within the campus. The lowest heavy metal concentration was recorded at SSQ, while the highest was at Hall 4. Total Dissolved Solids (TDS) and Sodium content were lowest at JSQ, but its iron content was relatively higher than at other locations. Hall 4 recorded the highest Water Quality Index (WQI) and the lowest TDS compared to SON and WHO standards.

Overall, the water quality across the four locations is bad for drinking and variations in physico-chemical parameters underscore the importance of regular monitoring.

5.2 Recommendations

Based on the findings, the following recommendations are proposed to ensure safe and high-quality water for campus residents:

1. Regular monitoring of Chlorine levels to ensure they remain within safe limits (≤ 5 mg/L) according to WHO guidelines.
2. Implementation of water treatment methods such as activated carbon filtration, chlorination, or reverse osmosis to reduce chemical and microbial contamination.
3. Continuous microbial and physico-chemical testing to detect and address contamination promptly.
4. Regular monitoring of TDS and mineral concentrations to ensure they remain within safe limits.
5. Educate campus residents and staff on safe water handling, storage, and hygiene practices to prevent contamination.
6. Adopt a holistic water quality management approach, considering all physico-chemical and microbial parameters to improve the overall WQI.
7. Periodically compare water quality data with SON and WHO standards to identify deviations early.
8. Develop campus-specific guidelines and policies for safe water collection, storage, and distribution.

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APPENDIX

Martlet Environmental Research Laboratory Limited
(A DIVISION OF MACGILL ENGINEERING & TECHNICAL SERVICES LIMITED)
(Environmental Consultancy and Biophysicochemical Analyses)
237, 3rd East Circular Road, Benin City, NIGERIA

RESULTS OF CHEMICAL ANALYSIS

Name of Client: Mr. Ekwu Emmanuel
Type of Sample: Water Sample
Date Received: 15th February, 2025

Code	pH	EC	Sal.	Col.	Turb.	TSS	TDS	DO	BOD	COD	HCO_3	Na	K	Ca	Mg	Cl	P	NH_4N	NO_2	NO_3	SO_4
		µS/cm	g/l	Pt.Co	NTU			mg/l													
Senior Staff Quarters	5.1	285	0.130	ND	ND	ND	143	0.8	1.3	11.0	33.3	0.74	0.28	5.10	3.12	30.7	0.014	0.041	0.005	0.035	0.017
NDDC Hostel	5.2	98	0.044	ND	ND	ND	49	1.2	1.0	9.2	17.4	0.41	0.11	2.91	1.45	18.7	0.008	0.020	0.002	0.011	0.007
Junior Staff Quarters	5.4	84	0.038	ND	ND	ND	42	1.4	1.0	7.4	15.0	0.28	0.09	2.15	1.10	15.0	0.006	0.015	0.001	0.009	0.004
Hall 4 Hotel	5.3	120	0.054	ND	ND	ND	61	0.9	1.1	10.4	28.0	0.55	0.18	3.38	2.01	25.6	0.011	0.033	0.003	0.027	0.011
NAFDAC LIMIT	6.5 – 8.5	1000	N.S	3.0	5.0	1.0	500	<10	5	N.S	100	N.S	10	75	20	100	N.S	N.S	0.02	10.0	100
SON LIMIT	6.5 – 8.5	1000	N.S	3.0	5.0	1.5	500	<10	5	N.S	100	N.S	10	75	20	100	N.S	N.S	0.02	10	100
WHO LIMIT	7.0 – 8.9	1000	N.S	3.0	5.0	1.0	500	<10	5	N.S	100	N.S	N.S	N.S	20	200	N.S	N.S	0.2	10	250

Code	Fe	Mn	Zn	Cu	Cr	Cd	Ni	Pb	V	THC
	mg/l									
Senior Staff Quarters	0.221	0.094	0.174	0.027	0.021	0.002	ND	0.008	ND	ND
NDDC Hostel	0.303	0.112	0.191	0.033	0.027	0.003	ND	0.010	ND	ND
Junior Staff Quarters	0.312	0.123	0.204	0.041	0.030	0.003	ND	0.010	ND	ND
Hall 4 Hotel	0.258	0.102	0.181	0.030	0.025	0.003	ND	0.009	ND	ND
NAFDAC LIMIT	0.3	2.0	5.0	1.0	0.05	0.003	N.S	0.01	N.S	N.S
SON LIMIT	0.3	0.05	5.0	1.0	0.05	0.003	N.S	0.01	N.S	N.S
WHO LIMIT	1	0.1	0.01	0.5	0.05	0.003	N.S	0.01	N.S	N.S

AAS MODEL-SOLAAR 969 UNICAM SERIES
FLAME USED – AIR ACETYLENE FLAME

Approved by………………………………………………………
(Prof. R. O. Onyeonwu)
Date: 17th February, 2025

APPendix 1a : Computed Water Quality Index (Senior Staff Quarters)

S/ No	Parameters	WHO Limits (Sn)	Test Result (Vn)	Ideal values (In)	$(Sn)^{-1}$	K	Weightage(Wn)	Quality Ratings (qn)	(Wn*qn)
1	PH	8.9	5.1	7.0	0.1124		0.000238	100	0.0238
2	EC	1000	285	0.0	0.001		0.000002118	28.5	0.000060363
3	TDS	500	143	0.0	0.002		0.000004236	28.6	0.000124696
4	DO	9.5	0.8	14.6	0.1053		0.0002229	270.588	0.060314
5	BOD	5	1.3	0.0	0.2		0.0004236	26	0.0110136
6	HCO_3	100	33.3	0.0	0.01		0.00002118	33.3	0.000705294
7	K	10	0.28	0.0	0.1		0.0002118	2.8	0.00059304
8	Ca	75	5.10	0.0	0.013		0.00002824	6.8	0.000192032
9	Mg	20	3.12	0.0	0.05		0.0001059	15.6	0.00165204
10	Cl	200	30.7	0.0	0.005	0.002118	0.00001059	15.35	0.00016256
11	NO_2	0.2	0.005	0.0	5		0.01059	2.5	0.026475
12	NO_3	10	0.035	0.0	0.1		0.0002118	0.35	0.00007413
13	SO_4	250	0.017	0.0	0.004		0.000008472	0.0068	0.00576096
14	Fe	1	0.221	0.0	1		0.0002118	22.1	0.000468078
15	Mn	0.1	0.094	0.0	10		0.02118	94	1.99092
16	Zn	5	0.174	0.0	0.2		0.0004236	3.48	0.001474
17	Cu	0.5	0.027	0.0	2		0.004236	5.4	0.02287
18	Cr	0.05	0.021	0.0	20		0.04236	42	1.77912
19	Cd	0.003	0.002	0.0	333.33		0.706	66.7	47.0902
20	Pb	0.01	0.008	0.0	100		0.2118	80	16.944
							∑(Wn) =0.99829		∑(Wn*qn) = 67.95998
							WQI=∑(Wn*qn) /∑(Wn) =68.076		

APPendix 1b: Computed Water Quality Index (NDCC Hostel)

S/ N	Parameters	WHO Limits (Sn)	Test Result (Vn)	$(Sn)^{-1}$	Ideal values (In)	Weightage (Wn)	K	Qualiy Ratins (qn)	(Wn*qn)
1	PH	8.9	5.2	0.1124	7.0	0.000238		94.74	0.022548
2	EC	1000	98	0.001	0.0	0.000002118		9.8	0.0000207564
3	TDS	500	49	0.002	0.0	0.000004236		98	0.00041513
4	DO	9.5	1.2	0.1053	14.6	0.0002229		262.7451	0.05857
5	BOD	5	1.0	0.2	0.0	0.0004236		20	0.0008472
6	HCO_3	100	17.4	0.01	0.0	0.00002118		17.4	0.000368532
7	K	10	0.11	0.1	0.0	0.0002118		1.1	0.00023298
8	Ca	75	2.91	0.013	0.0	0.00002824	0.002811	3.88	0.00010957
9	Mg	20	1.45	0.05	0.0	0.0001059		7.25	0.000099017
10	Cl	200	18.7	0.005	0.0	0.00001059		9.35	
11	NO_2	0.2	0.002	5	0.0	0.01059		1	0.01059
12	NO_3	10	0.011	0.1	0.0	0.0002118		0.11	0.000023298
13	SO_4	250	0.007	0.004	0.0	0.000008472		0.0028	0.0023722
14	Fe	1	0.303	1	0.0	0.0002118		30.3	0.000641754
15	Mn	0.1	0.112	10	0.0	0.02118		112	2.37216
16	Zn	5	0.191	0.2	0.0	0.0004236		3.82	0.0016182
17	Cu	0.5	0.033	2	0.0	0.004236		6.6	0.0279576
18	Cr	0.05	0.027	20	0.0	0.04236		54	2.28744
19	Cd	0.003	0.003	333.33	0.0	0.706		100	70.6
20	Pb	0.01	0.010	100	0.0	0.2118		100	21.18
						∑(Wn) =0.994478			∑(Wn*qn) =96.56601
						WQI=∑(Wn* qn) /∑(Wn)= 97.10			

APPendix 1c : Computed Water Quality Index (Junior Staff Quaters)

S/No	paramaters	WHO limits (Sn)	Test Results (vn)	Ideal vaues (In)	Sn^{-1}	K	Weightage (Wn)	Quality Rating (qn)	(Wn*qn)
1	PH	8.9	5.4	7.0	0.1124	0.002118	0.000238	84.21	0.02004198
2	EC	1000	84	0.0	0.001		0.000002118	8.4	0.000017712
3	TDS	500	42	0.0	0.002		0.000004236	8.4	0.0000355824
4	DO	9.5	1.4	14.6	0.1053		0.0002229	258.823	0.05857
5	BOD	5	1.0	0.0	0.2		0.0004236	20	0.0008472
6	HCO_3	100	15.0	0.0	0.01		0.00002118	15.0	0.0003177
7	K	10	0.09	0.0	0.1		0.0002118	0.9	0.00019062
8	Ca	75	2.15	0.0	0.013		0.00002824	2.87	0.0000810488
9	Mg	20	1.1	0.0	0.05		0.0001059	5.5	0.00058245
10	Cl	200	15.0	0.0	0.005		0.00001059	7.5	0.000079425
11	NO_2	0.2	0.001	0.0	5		0.01059	0.5	0.005295
12	NO_3	10	0.009	0.0	0.1		0.0002118	0.09	0.000019062
13	SO_4	250	0.004	0.0	0.004		0.000008472	0.0016	0.00000001355 2
14	Fe	1	0.312	0.0	1		0.0002118	31.2	0.000660816
15	Mn	0.1	0.123	0.0	10		0.02118	123	2.60514
16	Zn	5	0.204	0.0	0.2		0.0004236	4.08	0.0017283
17	Cu	0.5	0.041	0.0	2		0.004236	8.2	0.0347352
18	Cr	0.05	0.030	0.0	20		0.04236	60	2.5416
19	Cd	0.003	0.003	0.0	333.3		0.706	100	70.6
20	Pb	0.01	0.010	0.0	100		0.2118	100	21.18
							∑(Wn) = 0.994478		∑(Wn*qn) = 97.04994219
							WQI=∑(Wn* qn)/∑(Wn) =97.59		

APPendix 1d: Computed Water Quality Index (Hall 4 Hostel)

S/N	Parameters	WHO Limits (Sn)	Test Result (Vn)	Ideal Values (In)	$(Sn)^{-1}$	K	Weightage (Wn)	Quality Ratings (qn)	(Wn*qn)
1	PH	8.9	5.3	7.0	0.1124		0.000238	89.47	0.0213
2	EC	1000	120	0.0	0.001		0.000002118	12	0.000025416
3	TDS	500	61	0.0	0.002		0.000004236	12.2	0.0000516792
4	DO	9.5	0.9	14.6	0.1053		0.0002229	268.627	0.0599
5	BOD	5	1.1	0.0	0.2		0.0004236	22	0.0093192
6	HCO_3	100	28.0	0.0	0.01		0.00002118	28	0.00059304
7	K	10	0.18	0.0	0.1		0,0002118	1.8	0.00038124
8	Ca	75	3.38	0.0	0.013		0.00002824	4.507	0.00012728
9	Mg	20	2.01	0.0	0.05		0.0001059	10.05	0.001064295
10	Cl	200	25.6	0.0	0.005		0.00001059	12.8	0.00013552
11	NO_2	0.2	0.003	0.0	5	0.002118	0.01059	1.5	0.015885
12	NO_3	10	0.027	0.0	0.1		0.0002118	0.0027	0.00000057186
13	SO_4	250	0.011	0.0	0.004		0.000008472	0.0044	0.0000000372768
14	Fe	1	0.258	0.0	1		0.0002118	25.8	0.00546444
15	Mn	0.1	0.102	0.0	10		0.02118	102	2.16036
16	Zn	5	0.181	0.0	0.2		0.0004236	3.62	0.001533432
17	Cu	0.5	0.030	0.0	2		0:004236	6	0.025416
18	Cr	0.05	0.025	0.0	20		0.04236	50	2.118
19	Cd	0.003	0.003	0.0	333.33		0.706	100	70.6
20	Pb	0.01	0.009	0.0	100		0.2118	90	19.062
							∑(Wn) =0.994478		∑(Wn*qn) = 94.0815572
							WQI=∑(Wn* qn) /∑(Wn) =94.60		