

**ENVIRONMENTAL QUALITY ASSESSMENT ON HOSTELS IN A  
TERTIARY INSTITUTION**

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**UNIVERSITY OF BENIN, BENIN CITY**

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**A PROJECT WORK SUBMITTED TO THE DEPARTMENT OF ANIMAL  
AND ENVIRONMENTAL BIOLOGY, FACULTY OF LIFE SCIENCES,  
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THE AWARD OF BACHELOR OF SCIENCE (B.Sc. HONOURS) DEGREE  
IN ANIMAL AND ENVIRONMENTAL BIOLOGY**

**FEBRUARY, 2025**

## CERTIFICATION

This is to certify that this project work titled **Environmental Quality Assessment on Hostels in Tertiary Institution** was carried out by **OMOGO DIVINE OGHENEFEJIRO** Matriculation Number **LSC2010054** under the supervision of Prof Evelyn Uwa Edosomwan.

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Prof E.U. Edosomwan

Date

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Prof M.O. Omoigberale

Date

## **DEDICATION**

This project is dedicated to Almighty God, for his divine protection, guidance, and resources throughout the course to this program. All the glory and honour are to him, and to my late sister Precious Jonathan for the support while she was alive.

## **ACKNOWLEDGEMENT**

My appreciation goes to God Almighty for his grace and mercies toward me, throughout the periods of my study.

I am grateful to my project supervisor Prof Evelyn Uwa Edosomwan for her patience, understanding and guidance during field works and report writing, and also to the Head of Department Prof M.O. Omoigberale.

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## ABSTRACT

Tertiary institutions, which provide education and temporary housing for thousands of students, face environmental challenges. This study analyzed water samples from five hostels for microbiological contamination and physicochemical parameters. Bacterial counts ranged from  $2 \times 10^1$  to  $1.3 \times 10^3$  CFU/ml, with no coliform or *E. coli* detected. *Proteus* was found in samples 1 and 2, while *Pseudomonas* was present in samples 3 and 4. The analysis revealed acidic pH values between 4.77 and 5.33 and low total dissolved solids (TDS) from 13 to 37 mg/l. Iron concentrations were the highest, ranging from 62.32 to 154.70 mg/kg. Manganese peaked in sample 3 (0 to 15 cm depth) with 34.46 mg/kg. Lead levels ranged from 1.25 to 3.09 mg/kg, and copper levels varied from 4.36 to 11.05 mg/kg. Cadmium levels were stable at 0.01 to 0.02 mg/kg, while arsenic and mercury were not detected. Waste characterization showed that plastics and food constitute a significant portion of hostel waste. Regular monitoring of water quality and maintenance of storage systems can enhance drinking water in student hostels. Improving waste disposal and implementing better waste segregation are also essential to minimize metal accumulation. These actions will significantly enhance waste management and drinking water quality.

# CHAPTER ONE

## INTRODUCTION

### BACKGROUND OF THE STUDY

Environmental assessment has emerged as a crucial tool for evaluating and managing the environmental impacts of institutional operations, particularly in academic settings (Vykydal *et al.*, 2020). Tertiary institutions which serve as centres of learning and temporary homes for thousands of students face unique environmental challenges that require careful examination and management (Ralph and Stubbs, 2014). These challenges are especially pronounced in developing nations like Nigeria, where rapid urbanization and increasing student populations place significant pressure on institutional infrastructure and environmental resources (Imo *et al.*, 2024).

This study undertakes a comprehensive environmental assessment focusing on three critical aspects: the quality of drinking water sources in student hostels, the characterization and heavy metal content of refuse dumps and the assessment of pest population in waste disposal areas. These components are interconnected and directly impact the health, safety and well-being of the student population.

## **WATER QUALITY IN HOSTELS**

Having access to clean drinking water is essential for human health and welfare. The majority of living things can only endure brief periods without water, which is a necessary component for the sustenance of all life forms (Oparaocha *et al.*, 2010). Providing a sufficient quantity of drinkable water is one of the biggest concerns of our time because of industrialization and the resulting pollution issues in water bodies. Nonetheless, it is necessary for all living creatures and their surroundings (Agbaire *et al.*, 2014). In actuality, it is among life's most fundamental needs. One could say that water is a substance that all living things rely on to survive. But in many developing areas, including some parts of Nigeria, the quality of the water is still a serious issue as a result of improperly maintained sanitation infrastructure, insufficient water treatment, and contamination from human activity (Nwachukwu and Onyenechere, 2023).

For many higher education institutions in Nigeria, the drinking water quality in hostels is a serious public health issue. Students depend on a variety of water sources, such as public water delivery systems, wells, and boreholes (Adeleke *et al.*, 2023). Because of their proximity to waste disposal sites, leaking sewage systems, and inadequate water storage methods, these sources are frequently vulnerable to contamination by microbial diseases, heavy metals, and chemical

contaminants. Physical, chemical, and microbial characteristics all affect drinking water quality. Important markers of water safety include factors like pH, turbidity, dissolved solids, heavy metals (including lead, arsenic, and cadmium), and microbiological content (like coliform bacteria).

Waterborne illnesses including cholera, typhoid fever, and diarrhea can be brought on by contaminated water, and they represent serious public health hazards in hostel settings where sanitation standards may be inadequate. Different degrees of physical, chemical, and biological contamination in drinking water sources have been found in earlier research conducted in Nigerian institutions, underscoring the necessity of routine evaluation and monitoring.

## **HEAVY METAL ASSESSMENT IN REFUSE DUMPS AND SOLID WASTE CHARACTERIZATION**

According to (Mathuitha *et al.* 2021), heavy metals are defined as metals with a high specific weight of more than  $5\text{g.cm}^{-3}$ , while (Mishra *et al.* 2018) found that heavy metals are naturally occurring in soil, depending on regional conditions. According to (Goodwill *et al.* 2019), metals can accumulate in biological species such as plants and animals and are present in the atmosphere, the earth crust, and water bodies. These metals enter the environment through human activities like mining, agriculture, transportation, and industrial production (Husejnovic *et al.*,

2021) as well as natural processes like volcanic eruptions. The metals that are most frequently found in soil are lead, cadmium, zinc, copper, chromium, and arsenic.

An important environmental and public health concern in urban areas, particularly in developing nations like Nigeria, is the management of solid waste and refuse dumps. Significant volumes of solid waste are produced by tertiary institutions, like those in Edo State, as a result of their academic facilities, administrative operations, and dorms. These wastes, which frequently build up in poorly maintained dumpsites, include hazardous compounds, plastics, metals, and organic materials. If these pollutants are not disposed of properly, they can pollute the land and water, endangering human health and local ecosystems.

The possible heavy metal contamination of waste disposal sites is one urgent worry. Batteries, industrial chemicals, electronic debris, and other discarded objects can release heavy metals including lead (Pb), cadmium (Cd), zinc (Zn), chromium (Cr), and copper (Cu) into the soil and water systems. Numerous health concerns, including as cancer, neurological impairment, and reproductive disorders, have been connected to heavy metal exposure (Soleimani *et al.*, 2022).

In higher education, hostel dumpsites are frequently not adequately supervised, which results in inappropriate waste disposal and segregation procedures. In order to comprehend the makeup of the waste produced, solid waste categorization becomes crucial. This gives information for creating efficient waste management

systems and aids in locating possible sources of contaminants, especially heavy metals.

## **PESTS IN HOSTEL REFUSE DUMPS**

Hostel refuse dumps with pests pose a serious threat to cleanliness and public health. Considering that hostels usually accommodate a large number of students, they generate a lot of waste (Ifegbesan *et al.*, 2017). Unmanaged waste can attract pests and act as a breeding ground for them.

Pests pose a serious threat to the environment and public health, the risk of pest infestation is considerably increased when waste disposal sites are located near residential areas, especially hostel settings (Abdul, 2010). Given that pests are known to spread several infectious diseases, the proximity of these dumps near student housing raises the possibility of disease transmission (Krystosik *et al.*, 2020). Inadequate waste management in these locations provides a haven for a variety of pests such as cockroaches, flies and rodents (Omoda and Akosu, 2013). Numerous diseases that are harmful to human health are known to be spread by pests. For example, the droppings, urine and bites of rodents can spread disease such as salmonellosis, hantavirus and leptospirosis (Meerburg *et al.*, 2009).

Bacteria that can cause foodborne infections, such as Salmonella and E. coli, are spread by cockroaches. Additionally, flies especially houseflies can spread diseases

that cause cholera, diarrhea, and dysentery (Sarwar,2015). Disease outbreaks are more likely to occur when these pests are present near hostels for students, particularly when appropriate waste disposal practices are not followed (Wondimu,2020).

The welfare of students is significantly impacted by pest infestations in hostel settings. The psychological and emotional strain that comes with living in unhygienic surroundings can have a detrimental effect on students' academic performance and general well-being in addition to the health hazards that pests bring (Wada *et al.*,2022). Infested hostels can cause anxiety, discomfort, and a lower quality of life for students, which can lead to absenteeism and poor academic performance (Azil *et al.*,2021).

Understanding the type and population of pests associated with refuse dumps is essential for implementing effective pest control measures and improving waste management practices.

### **AIM OF THE STUDY**

To carry out a thorough environmental evaluation of the hostel facilities at a university in Benin City, with an emphasis on the characterization of solid waste, water quality, heavy metal assessment, and pest infestation in hostels and waste dumps.

## **OBJECTIVES OF THE STUDY**

1. To analyze the physio chemical parameters and microbial content of drinking water sources in student hostels.
2. To determine the heavy metal content of soil in refuse dumpsites and characterize solid waste generated in student hostels.
3. To identify common pest found in refuse dump in student hostels and the factors contributing to the prevalence.

## **SIGNIFICANCE OF THE STUDY**

This thorough evaluation will make a substantial contribution to better environmental management in higher educational institutions. Additionally, it will add to the body of knowledge on institutional environmental assessment by generating opportunities for additional study and acting as a reference for future studies.

## **CHAPTER TWO**

### **LITERATURE REVIEW**

#### **WATER QUALITY**

Access to good quality water is essential for ensuring public health, environmental protection, and sustainable development (Rajini et al., 2010). It plays a fundamental role in human physiology, and our continued existence heavily relies on the availability of clean water (Ishola et al., 2018). Water is vital for sustaining life, and a reliable supply must be provided to consumers.

Potable water is defined as water that is pure enough to be consumed or utilized with a low risk of immediate or long-term harm. In Nigeria, similar to many other developing countries, access to potable water is a critical issue. Approximately 48% of the population (around 67 million Nigerians) rely on surface water for domestic use. Additionally, 57% (79 million Nigerians) depend on hand-dug wells, 20% (27.8 million) harvest rainwater, 14% (19.5 million) have access to piped water, and another 14% rely on borehole water sources (Owolabi et al., 2014).

Water that is unsafe to drink can carry pathogenic microbes and heavy metals. Globally, approximately 80% of all diseases and deaths in developing countries are related to water issues. Access to good quality water is essential for ensuring public health, environmental protection, and sustainable development (Rajini et al., 2010). Water plays a fundamental role in human physiology, and our continued

existence heavily relies on the availability of clean water (Ishola et al., 2018). Therefore, it is crucial to provide a reliable supply of clean water to consumers.

Potable water is defined as water that is pure enough to be consumed or utilized with a low risk of immediate or long-term harm. In Nigeria, as in many other developing countries, access to potable water is a critical issue. Approximately 48% of the population (around 67 million Nigerians) relies on surface water for domestic use. Additionally, 57% (approximately 79 million Nigerians) depend on hand-dug wells, 20% (27.8 million) harvest rainwater, 14% (19.5 million) have access to piped water, and another 14% rely on borehole water sources (Owolabi et al., 2014). The results of polluted water sources have significant health implications (Ayeni et al., 2011).

The number of reported waterborne disease outbreaks in Nigeria highlights that the transmission of pathogens through drinking water remains a significant cause of illness (Owolabi et al., 2014). Although the symptoms of gastrointestinal disorders (such as nausea, diarrhea, vomiting, and abdominal pain) are usually mild and generally last a few days to a week, only a small percentage of those affected seek treatment at health facilities. However, the impact of these illnesses on human productivity is substantial.

Several researchers in Nigeria have examined the water quality of groundwater used by undergraduate and postgraduate students living in various university hostels. Owolabi et al. (2014) conducted a study on the bacteriological and physicochemical assessment of water in student hostels at Osun State University, Main Campus, Osogbo, Southwest Nigeria. The results indicated that all samples of sachet water met the physical/organoleptic parameters, inorganic constituents, and mean coliform and *E. coli* counts per 100 ml set by the WHO/SON maximum permissible levels, making them safe for drinking. However, slightly elevated levels of iron were found in water samples from borehole sources BH2 and BH3, although these levels pose no known health risks, as iron is an essential nutrient in human nutrition. Taste is usually not noticeable at iron concentrations below 0.3 mg/l, and while concentrations of 1–3 mg/l can be acceptable for individuals consuming well water, no health-based guideline value for iron has been established.

Conversely, the study found slightly elevated nitrate levels in samples from hand-dug wells HD1 and HD3, suggesting that these sources are unsafe for consumption, particularly for infants under three months old. Additionally, the presence of fecal coliform in water samples from hand-dug wells HD1 and HD2 indicates that these sources are not safe for human consumption. It is recommended that water from hand-dug wells be boiled before consumption to ensure public health and safety.

Ezugwu and Eze (2019) investigated the quality of drinking water sources in Igbinedion University Okada and its surroundings. Their laboratory results regarding the physicochemical properties of the drinking water sources revealed similar concerns. The analysis based on WHO standards showed that the levels of pH, dissolved oxygen (DO), biochemical oxygen demand (BOD), iron, magnesium, manganese, and cadmium did not meet the recommended limits in some drinking water sources. Additionally, the assessment of biological parameters indicated that all sources were highly polluted and contaminated, posing a health risk to individuals who consume this water without treatment.

A separate study by Ibanga et al. (2020) examined the drinking water quality in hostels around the University of Benin. This study found unacceptable levels of water pollution and quality indicators, particularly concerning copper, cadmium, iron, and coliform bacteria, across the sampled private hostels. While some water quality parameters met WHO limits, making the water relatively suitable for consumption, there was no observed variation in pollution indicators among the sampled hostels.

## **FACTORS AFFECTING THE QUALITY OF DRINKING WATER**

Deteriorating water quality may be caused by sediment buildup inside pipelines. Research by Jachimowski et al. (2017) indicates that iron sediments can

accumulate in water supply pipelines, sometimes reaching an iron concentration of 0.05 mg/dm<sup>3</sup>. This sediment buildup leads to increased iron concentration, even when the chemical composition of the pumped water is good. The release of these sediments occurs due to changes in water flow direction or speed within the distribution system, which causes iron to dissolve and enter the water.

The quality of treated water is significantly influenced by factors related to the technical condition and age of the water supply network (Jachimowski, 2017). Pipe age, in particular, plays a crucial role in determining failure rates. Extended use of pipes accelerates the wear of materials (Bergel et al., 2013), increasing the risk of failures in the water supply system (Tchórzowska-Cieślak, 2010). Hydraulic conditions in the water supply network—such as flow velocity, water pressure, excessive water age, and prolonged supply outages—also greatly impact the quality of the water delivered to consumers (Świdarska-Bróż and Wolska, 2006).

Corrosion processes in both outdoor and indoor water pipes contribute to the deterioration of water quality. The presence of aggressive carbon dioxide in water can damage protective oxide coatings, accelerating corrosion. The corrosion rate is influenced not only by the materials used for the pipelines but also by the physicochemical properties of the water itself. The consequences of corrosion include the degradation of water supply materials and the enrichment of delivered water with dissolved metals. Ultimately, the quality of water received by

consumers largely depends on the processes occurring within the water distribution system. Deteriorating water quality may be caused by sediment buildup inside pipelines. Research by Jachimowski et al. (2017) indicates that iron sediments can accumulate in water supply pipelines, sometimes reaching an iron concentration of  $0.05 \text{ mg/dm}^3$ . This sediment buildup leads to increased iron concentration, even when the chemical composition of the pumped water is good. The release of these sediments occurs due to changes in water flow direction or speed within the distribution system, which causes iron to dissolve and enter the water.

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### **PHYSIO-CHEMICAL AND BIOLOGICAL PARAMETERS**

In chemical analysis, substances that make water unpalatable at concentrations higher than the existing standards for proper health or that affect the look, smell, taste and that are of health concern, are investigated. These investigations help to establish health-based summary statements and guideline values. These summary statements and guideline values for each substance, upon adoption by water authorities, aid in the provision and usage of water which is satisfactory aesthetically and has uniform quality (WHO, 2011).

Bacteriological analysis investigates microbiologically, both quantitatively and qualitatively, microbial contaminants in the water. The importance of bacteriological analysis of drinking water helps to determine the presence of potential water-borne pathogens. In chemical analysis, substances that make water unpalatable at concentrations exceeding the established health standards, or that

affect its appearance, smell, and taste, are investigated due to health concerns. These investigations help establish health-based summary statements and guideline values. Once adopted by water authorities, these summary statements and guideline values assist in providing water that meets aesthetic and quality standards (WHO, 2011).

Bacteriological analysis examines microbial contaminants in water both quantitatively and qualitatively. The significance of bacteriological analysis lies in its ability to identify the presence of potential waterborne pathogens. Therefore, bacteriological analysis serves as one of the most sensitive indicators of water quality. To say the bacteriological analysis of water provides the most sensitive quality parameter.

#### **WATER QUALITY INDICATOR**

Water quality is determined by the concentrations of various chemicals present in the water. To evaluate water quality, it typically involves comparing the measured concentrations of these chemicals to natural background levels, as well as to guidelines established to protect human health and ecological communities. (RAMP, 2007; 2008).

## **pH**

pH (pondus Hydrogenium), is the degree of the basicity or acidity of a water solution or simply as the measure of hydrogen ion concentration of a water solution  $[H]^+$ . pH has no unit of measurement, since it is a dimensionless quantity, by virtue of its logarithmic nature. It is a parameter that determines the quality of all water, which also affects most physical, biological and chemical processes in water supply treatment (WHO, 2007). Water in its pure state, for example has a pH of 7 (neutral); the exact value depends on temperature. For most natural waters, the pH ranges from 6 to 8.5, values below 7 (acidic water) in waters that are high in organic content and values above 7 (alkaline waters) in eutrophic waters, ground water brines and salt lakes (Ohrel and Register, 2006).

## **Chlorides**

Chlorides are soluble in water are unaffected by biological processes, hence, reducible by dilution. They are compounds of chlorine which occur as chloride ions ( $Cl^-$ ) in solution. The concentrations of chloride ions depend on the composition of the geologic make up in any given area. The presence of chlorides is common in most natural waters (Edori,2020). Small quantities of chlorides of calcium and magnesium are found in many waters. This characteristic adds palatability to the water thus is desirable for consumption. Chloride concentration

in natural waters is usually below 10 mg/l in areas with high humidity and in isolated fresh water bodies. Tidal streams contain increasing amounts of chlorides (as much as 19,000 mg/l) as the bay or ocean is approached.

Chloride is introduced in water through the leaching process of chlorides from sedimentary rocks (e.g., rock salt deposits) and soils (Hinga,2016). Higher concentrations of chloride can be found near salt water intrusions, wet coastal areas, irrigation drains, in sewage and other waste outlets. Chlorides in large amounts (above 100mg/l) affect the taste, making it salty and unfit for humans and animals.

High level of chloride is catastrophic to individuals and increases the risk of rectal and bladder cancer (Maju-Oyovwikowhe 2021). The removal of chloride in water is not done by conventional treatment. Levels of chlorides in water, however, can be lowered by the process of dichlorination which is achieved by the use of agents like activated carbon, aluminum ammonium sulphate, ion-exchange resins, sodium bi-sulphite (sodium pyrosulphate), sodium sulphite and Sulphur dioxide. Pollution control and dilution can also be used to reduce chloride concentration. The actual removal of chloride, however, can be accomplished through a demineralization process, which includes reverse osmosis or electrodialysis (Hinga,2016).

Domestic effluents have a higher concentration of chlorides than in natural water, and therefore acts as a suitable pollution tracer for borehole contamination. The

methods used was a rapid determination by titration with  $\text{AgNO}_3$  solution, using  $\text{K}_2\text{CrO}_4$  as an indicator. The end-point was indicated by the appearance of a permanent reddish tinge (Mohr's method).

## **Turbidity**

Turbidity is defined as the dispersion and interference of light passage that is caused by the organic matter like silt, clay and other finely divided organic or inorganic particles suspended in water (WHO, 2007). The surface characteristics and size of the suspended matter has an influence on the scattering and absorption of light. It is caused by colloids in suspension, which are mainly clay particles, microorganisms and vegetation. Colloidal matter harbors microorganisms and chemicals that affect the quality of water and hinder disinfection during treatment (Sosbey, 2002). The degree of turbidity of water is often taken as an approximate measure of the extent of pollution. However, it is not the only measure when determining presence or absence of pollution. This is because water may be clear but is contaminated by acids, toxic metals or other substances that do not cause turbidity. Following rainfall, variation in colour of water may indicate contamination due to surface runoff and may lead to the need of treatment prior to use, especially for public supplies (Sosbey, 2002). The KS and WHO guidelines value for turbidity is 5 NTU and above this value, water can be objected for

aesthetic value. A value of turbidity that is higher than 5 NTU may be repulsive to consumers.

## **Sodium**

Sodium salts are highly soluble and naturally occur in ground water from sodium bearing rock minerals. At levels of above 200 mg/litre, sodium salt can be tasted by most people (Alhajjar et al., 1990).

## **Nitrates and Nitrites**

Natural unpolluted water, practically, does not contain Nitrites. Nitrites are the first product of oxidation of free ammonia by biochemical activity. The nitrite concentration present is due to the organic matter in the soils. Concentrations that are higher than the very low value of 0.001 mg/l are of sanitary significance (Kaplan, 1987). Nitrates represent the mineralization of nitrogen from organic matter and can also occur in a well-oxygenated environment. High nitrate concentration in water *has* been linked to causing methemoglobinemia in infants (Fewtrell, 2004).

Nitrates generally occur in trace amounts in freshwater bodies on land, however, the concentration could be much higher in some groundwater (Ayejoto and Egbueri, 2024). Nitrates are reduced to  $\text{NH}_3$  by Devarda's alloy (containing 50%

Cu, 45% Al, 5% Zn) in strongly alkaline solutions; the  $\text{NH}_3$  is distilled into excess standard acid and finally estimated titrimetrically.

Nitrites are an intermediate product, both in the oxidation of  $\text{NH}_3$  to  $\text{NO}_2$  and in the reduction of  $\text{NH}_3$  which occurs in natural waters, water distribution systems and waste-water treatment plants. A method based on the diazotization reaction was used and a reddish-purple azo-dye color was formed at pH 2.0 – 2.5 by the bonding of diazotized-sulphanilamide with N-(1-naphthyl) ethylenediamine dihydrochloride.

### **Sulphate**

Sulphate occurs in natural waters and is considered not toxic when presented in low concentration. However, the presence of large amounts of sulphate induces sour taste in household water and scaling in pipelines (Chatla *et al.*, 2023)

### **Phosphate**

Phosphate occurs in waste waters and natural waters as inorganic and organically bound phosphate since they are mainly used for laundry purposes. Primarily, they are naturally produced in biochemical processes and are also constituents of domestic sewage (APHA, 1994). The phosphate concentration in water comprises; ortho-phosphates and condensed phosphates, both soluble and insoluble organic species. A digestion method is necessary to oxidise organic-bound phosphate by

rupturing both the condensed-phosphate and condensed-ortho-phosphate bonds and releasing phosphate as soluble  $\text{PO}_4$ .  $\text{HNO}_3 - \text{H}_2\text{SO}_4$ , digestion shall be used for these samples. In dilute ortho-phosphate solution, ammonium molybdate reacts in acidic medium to form molybdophosphoric acid which is measured at 460 nm (APHA, 1994).

### **Coliform and Total Bacteria**

A group of bacteria called coliform are a microbiological measure that is most important in drinking water quality (WHO, 2008) Coliform, if found present in water, act as a sign for contamination by microbial pollutants and as measure of the biological quality, easily. The coliform count thus reflects the chance of pathogens being present; the lower the coliform count, the less likely it is that pathogens are in the water. Biological contaminants constitute water quality parameters, since their presence or absence maybe an indication of the attributes of the water source. Pathogens are of primary importance to water specialists, they include bacteria, viruses, protozoa and parasitic worms. They infest their host for a part of their life cycle and also thrive in water systems (Chahal *et al.*,2016). Autotrophic bacteria require carbon dioxide to multiply by binary fission while heterotrophic bacteria require organic compounds.

Total coliform bacteria include a wide range of aerobic and facultatively anaerobic, Gram-negative, non-spore-forming bacilli capable of growing in the presence of relatively high concentrations of bile salts with the fermentation of lactose and production of acid or aldehyde within 24 hours at 35-37°C. *Escherichia coli* is a subset of the coliform group that can ferment lactose at higher temperatures. As part of lactose fermentation, total coliforms produce the enzyme  $\beta$ -galactosidase. Traditionally, coliform bacteria were regarded as belonging to the genera *Escherichia*, *Citrobacter*, *Klebsiella* and *Enterobacter*, but the group is more heterogeneous and includes a wider range of genera, such as *Serratia* and *Hafnia*. The total coliform group includes both faecal and environmental species.

Photosynthetic bacteria get their energy from sunlight, whereas chemosynthetic bacteria from chemical reactions. They are very adaptive and can be found in almost any environment (Spellman, 2003). Faecal waste is the main source of bacterial contamination in water, especially through waste discharge from septic tanks and sewage treatment facilities. Bacteria from these sources can enter wells that are either open at the land surface or do not have watertight casings or caps (Abd Alrazig et al., 2024).

Total coliforms are a large group of different types of bacteria that share several characteristics. They are commonly found in the environment, such as in soil, and in the intestines of animals, including humans. The main sources of total coliforms

in water are contamination from human and animal waste. Total coliforms are used as an indicator of the cleanliness of a water source. Although total coliform bacteria themselves do not necessarily cause harmful illness, their presence indicates that water will likely contain other more harmful pathogens. In drinking water, total coliform testing can be used to monitor the effectiveness of the disinfection processes. Coliforms present in drinking water indicate there could be pathogens present in the water that cause serious diseases.

Total coliforms can enter the water through environmental contamination such as waste from mammals or birds, agricultural runoff, and untreated human sewage. The World Health Organisation state that total coliform bacteria must not be detectable in any 100mL sample of water. Similarly, the Drinking Water Inspectorate state total coliform bacteria should not be detectable in any 100mL sample of water taken at consumers taps.

### **Faecal coliform**

A faecal coliform is a rod-shaped, gram-negative, non-sporulating bacteria that is facultatively anaerobic. The majority of coliform bacteria are found in the intestines of warm-blooded animals. Faecal coliforms are oxidase-negative, may develop in the presence of bile salts or other comparable surface agents, and can break down lactose into acid and gas in less than 48 hours at a temperature of

44.5°C (Doyle *et al.*, 2006). The phrase “thermotolerant coliform” is used over “faecal coliform” since it is more accurate (Paruch, and Mæhlum, 2012).

Coliform bacteria comprise both genera with faecal origins (such as *Escherichia*) and genera without faecal origin (e.g., *Enterobacter*, *Klebsiella*, *Citrobacter*). The test is designed to be a faecal contamination indicator, more especially for *E. coli*, a bacterium that serves as a marker for other pathogens that may be present in faeces. Faecal coliforms in water may not always indicate the presence of faeces and may not even be physically hazardous (Doyle *et al.*, 2006).

### ***Escherichia coli***

*Escherichia coli* are faecal coliforms and are a subset of the total coliform family. *Escherichia coli* (*E. coli*) is a species of thermotolerant coliform distinguished by producing indole from tryptophan, and it also possess  $\beta$  -galactosidase and  $\beta$  -glucuronidase enzymes. The distinction in the laboratory is their ability to produce the enzyme glucuronidase and their ability to grow at elevated temperature (44.5). under the total coliform rule, specimen that test positive for total coliform are supposed to be further tested for confirmation of faecal coliform or *E. coli*. *E. coli* and faecal coliform do not distinguish between human and animal contamination. However, they are better indicators for the presence of recent faecal contamination than total coliform. Their densities are much lower than those for total coliform,

and thus are not used as an indicator for treatment effectiveness and post-treatment contamination. *E. coli* confirmation test gives better sign to show faecal pollution than test for faecal coliform group (Sililo *et al.*, 2001).

Nevertheless, some findings show that *E. coli* can also be found, multiply and persist in the environment especially in tropical soils, climates and waters rich with organic matter (Kenea,2016). The majority of *E. coli* strains are non-pathogenic, even though some serotypes, like *E. coli* 0157:H7, can cause serious illnesses (Wilson *et al.*, 2011). The use of *E. coli* as an indicator organism of water quality dates back to the late of 18<sup>th</sup> century. However, the procedures were not suitable for periodic detection of *E. coli*. Due to these surrogates for *E. coli* like coliforms were used to detect faecal contamination (Edberg *et al.*, 2000). Multiple tube fermentation and membrane filter methods are most commonly used techniques detect indicator organisms of faecal contamination in water. The detection of *E. coli* shows recent faecal contamination of water sources as the bacteria is sensitive to environmental factors due to this, the indicator bacteria is widely used to monitor the quality of water. The detection of *E. coli* in water samples does not prove that pathogenic organisms are present, instead it shows a risk of faecal contamination, and therefore the possible presence of pathogenic microorganisms of faecal origin (Brüssow *et al.*, 2004). As a result, the detection and enumeration

of *E. coli* is broadly used to monitor water samples for faecal contamination (Atlas *et al.*, 1993).

## **Water Treatment**

The most serious threat to the safety of a water supply is contamination by feces. Water should only be treated to the extent necessary. Different types of water treatment include chemical disinfection, boiling, filtration, and sedimentation.

Treatment of water to remove disease-causing organisms is of vital importance. Disease causing agents such as suspended solids, bacteria, algae, viruses, fungi, minerals like iron and manganese, and fertilizers are generally removed during water treatment. Different methods of water treatment are broadly grouped into filtration and disinfection methods for application at the household and community level. Filtration method involves trapping of tiny particles, including pathogenic microorganisms and other impurities present in water, whereas in disinfection methods, contaminants are removed by the use of various chemicals. (Sarma,2020).

## **A REVIEW ON PESTS AND REFUSE DUMPS**

### **THE CONCEPT OF PEST**

The Latin word "Pestis," which means "plague or contagious disease or devastating infectious disease," is the root of the English term "pest." Any living thing whose population grows to such an extent is considered a pest. For this study, we shall be looking at pests as any organisms that cause nuisance or pose a significant health risk to man, or one that damages properties (Kumar *et al.*, 2023).

Pests could also be seen as organisms occupying space, eating food, and or carrying out other biological functions in places where they are not wanted (Flint and Van den bosch,2012). Numerous creatures, ranging from weeds and fungus to insects and rodents, can be considered pests. These organisms can flourish in a variety of settings, such as houses, industrial sites, and agricultural fields. Depending on their characteristics and the environment they live in, their effects may be health, economic, or physical.

Invertebrates, which include protozoa, flatworms, nematodes, snails, slugs, insects, and mites, as well as various rodents among the vertebrates make up the majority of animal pests.

Serious pests include insect pests, they are the primary global factors limiting agricultural productivity and production; they harm crop plants directly by feeding

on them and indirectly by spreading plant viruses, which results in significant yield losses as well, particularly those that spread illness. (Britannica, 2024).

## **2.2 ROLES OF REFUSE DUMPS IN PEST PROLIFERATION**

A refuse dump, often referred to as a landfill or waste dump, is a specifically designated location where waste materials, including organic materials, commercial waste, and home waste materials, are temporarily or permanently kept (Qasim *et al.*,2020). Refuse dumps can be official, well-run establishments or unofficial, unregulated locations where rubbish is dumped (Njagi *et al.*,2016). Vegetative waste, paper, plastics, metals, construction trash, and toxic materials are just a few of the materials that can build up in these dumps (Abdel-Shafy and Mansour, 2018). Pests are often attracted to these dumps because they act as source of food for many pests, in addition they provide shelter and suitable conditions breeding (Zuberi and Ali,2015). Additionally, the warm, humid, and nutrient-rich atmosphere of a rubbish dump speeds up the decomposition process, which encourages reproduction. Again, the unpleasant smell of decomposition processes draws pests, especially insects that consume decomposing materials (Qasim *et al.*,2020), and heat is created during the process, which can intensify pest activity.

Based on the kind of garbage they receive and the manner of disposal, refuse dumps can be broadly classified as follows:

**Open Dumps:** These are uncontrolled locations where trash is just dumped on the ground without any protections for the environment (Tse and Adamu,2012). Since open dumps frequently cause serious health and environmental issues, they are prohibited in many places (Ayilara *et al.*,2020).

**Sanitary landfills:** They are meticulously planned locations created to avoid contaminating the environment. To lessen the chance of pollution, they have liners, drainage systems, and layers of compacted soil (Britannica,2024).

**Controlled dumps:** In between sanitary landfills and open dumping are controlled dumps. They frequently lack an appropriate liner system, are only minimally managed, and have few environmental controls (Wee *et al.*,2021).

### **2.3 COMMON PESTS ASSOCIATED WITH REFUSE DUMPS**

The presence of refuse dumps in hostel environments creates ideal conditions for various pest populations to thrive. A lot of studies have documented the categories of pests usually found in refuse dumps.

In Taraba State University dorms, research conducted by (Binga *et al.* 2024) revealed that insect pests predominated. A total of 901 insects were examined for this investigation, with the highest number being 242 *Musca domestica*, and the mosquitoes occurring as 217 numbers from the culicine and anopheles' group. The majority of the 134 insects discovered were *Periplaneta americana* cockroaches, with spiders and millipedes making up the minority. The prevalence of each of these pests in hostels was the subject of some other research. The number of mosquito species present in hostels was recorded in the study conducted by (Shehu *et al.*, 2023). In the female hostels, *Aedes* sp. was more prevalent (50.9%) than *Culex* sp. (42.9%), while *Anopheles* sp. was the least prevalent (6.11%). On the other hand, *Culex* sp. predominated in male hostels with 186 (50.2%), followed by *Aedes* sp. (48.3%), and *Anopheles* sp. (1.35%). The abundance of mosquito species in hostels was therefore the subject of a distinct study conducted by (Ombugadu *et al.* 2022) at the University of Lafia in Nasarawa state. *Anopheles gambiae*, *Anopheles squamosus*, *Anopheles coustani*, *Culex quinquefasciatus*, *Aedes aegypti*, and *Mansonia uniformis* are the six species of anopheline and culicine mosquitoes that were found to have been captured in total. There were more participants in the culicine group (62.3%) than in the anopheline group (37.7%). *Rattus rattus* was the predominant species in a different study

(Bamidele and Kowobari, 2019), with a total of 236 found in both male and female hostels. From these we can therefore categorize them.

## **CLASSIFICATION OF PESTS FOUND IN REFUSE DUMPS**

**INSECTA:** Members of these groups commonly found in refuse dumps are cockroaches, mosquitoes, houseflies, ants and termites.

**COCKROACHES:** Cockroaches are insects that dwell in any place where food and shelter are available, particularly in warm and moist regions (Abudin *et al.*,2023). Members of these groups include those from the Blattidae family, American cockroach (*Periplaneta americana* L.), and Blattellidae family which includes the German cockroach (*Blattella germanica* L.), brown -banded cockroach (*Supella longipalpis* F.), and field cockroach (*Blattella vaga* Hebard). Their biology—including their unclean habits, indifferent food, feeding behaviors, and morphology—makes them capable of acquiring, mechanically transporting, and dispersing diseases. Because they mostly feed on human feces, they contaminate food by leaving behind an oily lipid with an unpleasant odor or by harboring bacteria that can cause food poisoning. They are pests of medical and public health importance (Sosan *et al.*,2019).

**HOUSEFLY:** The housefly with scientific name (*Musca domestica*) belongs to the family Muscidae, there are about 170 genera and 4200 species in this family, some of which are of medical importance like *Musca domestica*. It is the most frequent and widespread species of flies in the world (Hassan *et al.*, 2021).

They are also common pests associated with refuse dumps. They are attracted by the strong, disagreeable smells released by decaying organic stuff, such as food scraps, excrement, and rotting meat, attract houseflies. Potential food sources and breeding grounds are indicated by these odors.

**MOSQUITOES:** Mosquitoes belong to a group of insects called Culicidae. There are over 3500 species of mosquitoes, some of which are of importance to public health because of their ability to transmit disease (Britannica, 2024). Refuse dumps, especially those with poor waste management and improper drainage, create favorable conditions for mosquitoes, since they are known to breed in areas with standing waters such as gutters, trash cans containing water, inside buckets or an old tire. Some of the species commonly found in refuse dumps include *Culex quinquefasciatus*, *Aedes albopictus*, *Aedes aegypti*, *Anopheles gambiae* (Ebuka *et al.*, 2017).

**RODENTIA:** They belong to the class Mammalia and the order Rodentia, common members of these groups associated with refuse dumps are the *Rattus norvegicus* (Norway rat), *Rattus rattus* (Black rat), *Mus musculus* (House mouse). In addition to providing ideal conditions that make it an ideal breeding habitat for rats and mice, the presence of food waste draws rodents to trash dumps.

### **IMPACTS OF PEST INFESTATION ON PUBLIC HEALTH**

The spread of illnesses including leptospirosis, salmonellosis, cholera, and malaria are among the health effects linked to pests in waste disposal sites. These illnesses are frequently contracted by direct contact with tainted food or drink, insect bites, or airborne particles. Apart from the obvious health hazards, insect infestations at landfills lead to environmental deterioration and unhygienic living circumstances, which worsen public health issues.

### **RODENTS**

Several diseases are carried by rodents, either directly through bites and food contamination or indirectly as carriers of diseases spread by mites, fleas, and ticks. They carry several zoonotic illnesses, such as According to a study on rats by (Ayinmode and Agbajelola, 2019), rodents commonly contaminate food sources with their droppings, urine, and saliva, introducing parasites, bacteria, and

pathogens that can cause gastrointestinal sickness. *Rattus norvegicus* had an 86 percent prevalence rate of gastrointestinal illnesses.

The pathogens that cause salmonellosis, plague, leptospirosis, leishmaniasis, toxoplasmosis, hantavirus, rat-bit fever, taeniasis, zoonotic babesiosis, Lassa fever, and hemorrhagic fever are said to be carried by rats, in a study (Dahmana *et al.*, 2020).

## **INSECTS**

There is substantial evidence that insect pests are the cause of several of the deadliest illnesses in the world, including cholera, yellow fever, and malaria (CDC, 2021). Certain insects are recognized as disease carriers. Mosquitoes are one type of insect that can spread illness. The parasitic disease malaria is caused by Plasmodium parasites, which are spread by the bites of female Anopheles mosquitoes, which are mostly active between dusk and dawn. Malaria causes fever, chills, and a flu-like condition. Human malaria is caused by five parasite species, with Plasmodium falciparum and P. vivax being the most prevalent. The deadliest is P. falciparum, which has the highest fatality and complications rates (WHO,2014). This fatal type of malaria poses a major threat to public health. Other types of mosquitoes known to transmit disease are the *Aedes aegypti* and *Aedes albopictus* known to cause dengue fever. Dengue is a mosquito-borne viral

infection that causes a severe flu-like illness and sometimes a potentially lethal complication called severe dengue. The incidence of dengue has increased 30-fold over the last 50 years. Up to 50–100 million infections are now estimated to occur annually in over 100 endemic countries, putting almost 4 billion people at risk (WHO,2024).

In addition to mosquitoes, cockroaches are another insect that spreads disease. Human contact with food and house dust contaminated with the faeces of cockroaches causes allergic reaction especially those with asthma (Mawak *et al.*, 2005).

Because of their feeding habits and unclean breeding practices, cockroaches are the most likely mechanical carriers of a variety of intestinal infections that affect humans (fungi, bacteria, viruses, and parasites). Numerous harmful microbes, including bacteria (like *Enterobacter*, *Pseudomonas* sp., *Staphylococcus* sp., and *Enterococcus* sp.), viruses (like Rotavirus and Enterovirus), and fungi (like *Candida* spp., *Penicillium* spp., and *Aspergillus* spp.), have been isolated from cockroaches, as well as other parasites.

In research by (Liu *et al.* 2024), 128 cockroaches were sampled, and 36 of them tested positive for pathogens, further confirming the pathogenic nature of

cockroaches. Of these 36 cockroaches, 44.4% tested positive for different viruses, and 13.9 tested positive for intestinal pathogens at different stages of life.

*E. coli*, *Salmonella sp.*, *Balantidium coli*, larvae of *Strongyloides stercoralis*, and *Ascaris lumbricoides* eggs were among the fungal, bacterial, and parasitic isolates found in 234 cockroaches that were examined for another study (Tatfeng *et al.*, 2005).

A mechanical vector of pathogens (bacteria, fungi, viruses, and parasites), some of which cause significant diseases in humans, is the house fly, *Musca domestica*. More than 130 pathogens, including bacteria (including some dangerous and life-threatening species), were found in house flies, according to a study (Khamesipour *et al.*, 2018). Also, another study, *Musca domestica* is known to be a vector of both zoonotic and non-zoonotic protozoan parasites such as *Sarcocystis* spp, *Toxoplasma gondii*, *Isospora* spp, *Giardia* spp, *Entamoeba coli* and *E. histolytica* (Ahmed,2011). further demonstrating the pathogenic nature of pests.

# **FACTORS CONTRIBUTING TO THE PREVALENCE OF PEST INFESTATION**

## **1. Food Source Availability**

Pests like rats, flies, cockroaches, and ants find a lot of food in refuse dumps because they contain a range of organic waste, including food scraps, fruits, and vegetables

## **2. Humidity and Moisture**

Because these conditions facilitate their reproduction cycles, pests like flies, mosquitoes, and other insects are drawn to damp or moist places in dumps. Rain, waste leaks, or inadequate drainage in the area can all cause moisture to build up.

## **3. Harborage and Shelter**

Waste buildup, particularly large things like cardboard, plastic, and old furniture, provides pests like cockroaches and rats with places to hide and build their nests. They can procreate and evade predators in these protected areas.

## **4. Organic Matter Decomposition**

Methane and other gases are released along with heat as organic waste breaks down. Because they are attracted to the smell of decomposing waste, pests like flies and beetles are drawn to this. Additionally, mold and

bacteria are produced throughout the breakdown process.

**5. Poor Handling of Waste:** Waste becomes more accessible to pests if it is not routinely collected or if it is left uncontained. Increased infestations result from poorly maintained landfills or open dumps, which give pests easy access to food and shelter.

**6. Inadequate Pest Management Strategies:** Refuse dumps turn into havens for a range of pests in places without routine pest treatment. Rat, fly, and mosquito populations will increase in the absence of adequate sanitation and control measures.

## **EFFECTIVE STRATEGIES FOR CONTROLLING PESTS**

**1. Mosquito Control:** Eliminating breeding grounds, erecting physical barriers, and utilizing chemical treatments—of which organochlorines and organophosphates are the most often used—are the main strategies for controlling mosquitoes. The main methods for reducing mosquito populations are preventative measures, such eliminating standing water, applying insect repellents, mosquito nets, and insecticides. Plant-based extracts are another helpful technique (Chaudhry et al, 2019). Their numbers can also be decreased by biological management techniques, such

as introducing natural predators like larvivorous fish, which eat mosquito larvae.

2. Sanitation, exclusion, and targeted chemical treatments are all necessary for effective cockroach control. Infestations can be avoided by keeping living areas tidy, caulking crevices, and removing sources of food and water. Effective housefly control measures include utilizing flytraps or flypaper, keeping living spaces clean, and managing trash properly. Insecticidal baits and gels are also available. Insecticide sprays and baits are examples of chemical control methods that can be employed, but they must be handled cautiously to avoid resistance. Long-term cockroach control is provided by integrated pest management (IPM) strategies, which combine several methods, in addition to the widely used sprays and trapping devices (Gondhalekar et al., 2021).
3. Using flytraps or flypaper, keeping living spaces clean, and managing trash are all important components of an efficient housefly control strategy. Insecticide sprays and baits are examples of chemical control methods. Chemicals derived from plants are thought to be more environmentally friendly and effective at suppressing pests (Abbas et al., 2013). However, in order to avoid resistance, it is crucial to carefully control them.

#### **4. RATS AND MICE**

utilizing bait stations and sticky traps. Sanitation is essential because it deters infestations by limiting the availability of food. For severe infestations, chemical techniques such as the use of rodenticides and fumigants can be employed.

### **A REVIEW ON HEAVY METALS AND SOLID WASTE CHARACTERIZATION**

#### **Heavy Metal Contamination**

Heavy metal contamination is an increasingly pressing issue worldwide, and Nigeria is no exception. This contamination poses significant environmental and public health concerns, particularly in areas experiencing industrialization, urbanization, and improper waste management. Tertiary institutions in Nigeria can be affected by heavy metal contamination due to several factors, including pollution from nearby industrial activities, the improper disposal of electronic waste, and agricultural practices that use fertilizers or pesticides containing heavy metals.

In recent years, there has been growing concern about the presence of heavy metals in the environment, especially around educational institutions. Heavy metals are

particularly problematic due to their toxicity, persistence in the environment, and potential for bioaccumulation. Common heavy metals such as lead (Pb), cadmium (Cd), and mercury (Hg) often come from electronic waste, lead-acid batteries, and other hazardous materials typically found in refuse dumps (Olayanju et al., 2019). The leaching of these metals from solid waste into surrounding soil and water systems can pose serious health risks to students and the surrounding community.

### **Assessment of Heavy Metal Concentrations**

Several studies have evaluated heavy metal concentrations in waste dumps across Nigeria, including those near educational institutions. For example, Odebunmi et al. (2021) measured heavy metal levels in solid waste from various urban centers and found concerning concentrations of lead and cadmium, especially in waste sites close to schools. These findings highlight the need for localized studies to assess heavy metal contamination in refuse dumps within specific institutions.

### **Previous reviews on heavy metal assessment**

A study conducted by Etsakku et al. (2003) examines the trace metal content in the fine fraction of municipal solid waste (MSW) collected from various depth levels at the Perungudi dumping ground (PDG) near Chennai. Leachates were also collected and analyzed from the same sampling area. The concentrations of heavy

metals, including arsenic (As), mercury (Hg), chromium (Cr), cadmium (Cd), copper (Cu), lead (Pb), nickel (Ni), and zinc (Zn), were measured in milligrams per kilogram (mg/kg) in the MSW samples. In contrast, the leachates and water extracts were analyzed in micrograms per liter ( $\mu\text{g/L}$ ). In some instances, the metal concentrations exceeded the limits established for compost by the Central Pollution Control Board (CPCB). Nevertheless, all values remained within the acceptable limits set by the United States Environmental Protection Agency (USEPA) standards.

A study conducted by Sanni et al. examined the concentrations of heavy metals—specifically copper (Cu), chromium (Cr), lead (Pb), nickel (Ni), and cadmium (Cd)—in soils surrounding a refuse dumpsite in Jattu, Edo State, Nigeria. Soil samples were collected from the center of the dumpsite and at 50m and 100m lateral intervals towards the North, East, and West directions. Samples were also taken from two vertical depths: 0-15 cm and 15-30 cm.

Analysis using Atomic Absorption Spectrometry (AAS) revealed significant decreases in heavy metal concentrations from the topsoil to the subsoil, both within the dumpsite and at each sampling point. The results showed that the concentration of heavy metals in the soils followed this order: Ni (3.76-8.54 mg/kg) > Cu (0.70-1.78 mg/kg) > Pb (0.08-0.90 mg/kg) > Cr (0.11-0.42 mg/kg) > Cd (0.07-0.19 mg/kg). A comparison with the Department of Petroleum Resources (DPR) target

and intervention values (2002) guidelines indicated that all concentration values obtained in this study were below the recommended levels.

Statistical analysis using one-way ANOVA ( $P < 0.05$ , 95% confidence level) revealed significant differences in heavy metal concentrations. Correlation analysis suggested that the metals were not dependent on the specific site, indicating a common origin. The study concluded that the soils were contaminated with heavy metals, particularly at the dumpsite, as evidenced by the positive relative pollution potential values at all sampled points.

In research conducted by Abdus-Salam, eight strategically located dumpsites in the Ilorin metropolis, an average-growing city and state capital, were selected for a study on the characteristics of dumpsite soil. The estimated total and potentially available metals were analyzed using specific methods. It was observed that the groundwater is vulnerable to contamination, as there is no treated basement to absorb toxic metals at these sites. Approximately 70% of manganese (Mn), iron (Fe), zinc (Zn), cadmium (Cd), and lead (Pb) were found in the exchangeable fraction and those bound to carbonate and iron/manganese oxide fractions. These fractions represent the mobile and potentially harmful portion of the total metals in the ecosystem. The metal enrichment factor indicated that Zn, Cd, and Pb originated from anthropogenic sources, while Fe had both natural and

anthropogenic sources. Therefore, the dumpsites in Ilorin pose negative consequences for the soil and groundwater environment.

### **Environmental and Health Implications**

Heavy metal contamination has broad implications, impacting both environmental and human health. Prolonged exposure to heavy metals can result in neurological damage, developmental disorders, and various chronic health issues (Khan et al., 2018). This is especially concerning in an academic setting, where young adults are still in their developmental stages, highlighting the need for immediate attention to these risks.

### **Management Strategies**

Effective management strategies are crucial for mitigating the risks associated with solid waste and heavy metal contamination. Various studies, including those by Ifeanyi et al. (2020), highlight the importance of implementing recycling programs and public awareness campaigns aimed at educating students about waste segregation and reduction. Additionally, incorporating environmentally friendly practices into institutional policies can promote a culture of sustainability and decrease reliance on landfills.

## **Solid Waste Management in Educational Institutions**

Waste management involves the collection, transportation, processing, disposal, management, and monitoring of waste materials. It treats all types of waste—solid, liquid, gas, or radioactive—as a single category and aims to reduce the harmful environmental impacts associated with each type by using the most appropriate methods. The measures adopted for waste management depend on the waste's sources, as its characteristics and composition vary accordingly (Tchobanoglous et al., 1993).

Solid waste management is an essential public health service, but many developing countries fail to meet residents' needs adequately (Addo-Yobo and Ali, 2003). Educational institutions, particularly tertiary institutions, generate substantial amounts of solid waste, including food waste, plastics, paper, and hazardous materials. According to Adeogun et al. (2020), the student population typically produces organic and inorganic waste in varying proportions, which necessitates effective management strategies. Improper handling of this waste leads to serious environmental issues, especially when waste is deposited in landfill sites that can leach toxins into the soil and groundwater.

## **Characteristics of Solid Waste**

The composition and characteristics of solid waste are crucial for developing effective management strategies. According to (Ezeah *et al.* 2013), solid waste characterization typically involves categorizing waste into organic, recyclable, and hazardous materials. Studies conducted in various tertiary institutions in Nigeria reveal that a significant percentage of waste consists of organic materials; however, the presence of plastics and other non-biodegradable items complicates waste management efforts (Ogunwande *et al.*, 2017).

(Amijo de Vege *et al.* 2008) emphasized that waste characterization is the first step toward any successful waste management policy. This process allows for estimating potential material recovery, identifying sources of waste generation, designing processing equipment, estimating the physical, chemical, and thermal properties of the waste, and ensuring compliance with regulations.

The composition of generated waste can vary due to seasonal changes, lifestyle factors, demographic differences, geographic locations, and local legislation (Hockett *et al.*, 1995; Irwan *et al.*, 2011; AbdAlqader and Hamad, 2012).

### **Previous reviews on waste characterization**

Research was carried out by (Salamatu *et al.*,) at Bayero University, Kano State. Solid waste samples were collected and analysed from the four major dumpsites in

Kano metropolis during the months of September, 2016- January, 2017. The results showed that light plastic had the highest mean values of 8.63kg/50kg sample, Organics 7.22kg/50kg, Heavy plastic 4.15kg/50kg, Fabric 3.91kg/50kg, paper 2.70kg/50kg, metal 2.05kg/50kg, glass 1.89kg/50kg, Bone 1.47kg/50kg, styrofoam 0.19kg/50kg, others 1.06kg/50kg and wood -0.25kg/50kg. There was significant correlation between estimated population and volume of trash collected.

This study presents the findings of a waste characterization analysis conducted at the Campus Mexicali I of the Autonomous University of Baja California (UABC). The primary objective was to lay the groundwork for implementing a waste management program focused on recovery, reduction, and recycling. The results revealed that the campus generates approximately 1 ton of solid waste daily, with over 65% being recyclable or potentially recyclable. This suggests that a segregation and recycling program is viable on the university campus. Furthermore, the local market can absorb these recyclable materials under current conditions. The study also explores alternatives for managing potentially recyclable waste and discusses strategies for reducing waste at its source.

## **CHAPTER THREE**

### **RESEARCH METHODOLOGY**

#### **STUDY AREA**

This study was conducted in Benin City, Edo State, Nigeria, at the University of Benin (UNIBEN). Located in latitude 6°20.022'N and longitude 5°36.009'E in the Ovia North-East Local Government Area of Edo state, South-South, Nigeria, the University of Benin was founded in 1970 and is owned by the Federal Government. There are an estimated 77,000 students enrolled at the college at the moment. The student residences, which include Tetfund, NDDC, Hall 1, Hall 3, and Hall 4, were used for the study.

#### **Climatic Condition of the Study Area**

Benin City's climate is characterized by a humid tropical wet and dry climate with an abundance of rainfall. There are two separate seasons: the dry season starts in November and ends in April, while the rainy season persists for from March to October.

#### **RESEARCH DESIGN**

Given the variety of methods of data collecting, a mixed method research design was employed for this study. Three categories were included in the study: all operational water sources in the University of Benin's student residence halls; all official and unofficial waste disposal sites on the campus of the residence halls; and some students living there who make use of the facilities.

## **SAMPLE AND SAMPLING TECHNIQUE**

For the study five student hostels were randomly selected for the study. water and soil samples were collected and waste characterization was done.

## **METHOD OF DATA COLLECTION**

Water samples from tap outlets in the five hostels that were chosen were collected using transparent glass bottles; the bottles were cleaned before collection and then brought to the laboratory for analysis. For the five hostels that were chosen, soil samples were collected using a hand auger to check for the presence of heavy metals. Each sample was taken in a black polythene bag, with top soil being taken from a depth of 0 to 15 cm and bottom soil at a depth of 15 to 30 cm. The samples were transferred to the lab for additional analysis after the coordinates were recorded at the location of each collection using a mobile compass. Direct visual inspection of the waste materials was used to characterize the waste.

## **USE OF QUESTIONNAIRES**

Electronic questionnaires were shared to students in hostels to gather statistical information about the quality of drinking water, pest prevalence in hostels, the factors that might be responsible for their prevalence.

## **METHOD OF DATA ANALYSIS**

The physiochemical characteristics of water samples, including pH, temperature, total dissolved solids, turbidity, chloride, acidity, nitrate, sulphate, and phosphate, were determined through laboratory examination.

**Determination of pH:** An electrode that had been calibrated and standardized using three sets of buffer solutions with pH values of 4.0, 6.8, and 9.2 was used. To find the pH, it was first rinsed with distilled water before being dipped into the sample. For all five samples, this procedure was carried out repeatedly.

**Determination of temperature:** A digital thermometer was dipped in each water sample and allowed to sit in the sample for five minutes before reading the temperature.

**Determination of total dissolved solids:** Total dissolved solids was measured with the use of a TDS meter.

**Determination of turbidity:** Turbidity was measured using a Hach turbidimeter to get a calibration curve, the value was then estimated from the curve.

**Determination of chloride:** Mohr's method also called precipitation titration was used to determine the chloride ion concentration in water, by titrating with a 0.02N of silver nitrate and with the use of a potassium chromate indicator. Chloride was then calculated using the formula:

$$\text{Chloride Mg/L} = \frac{V_1 - V_2 \times N \times 35.5 \times 1000}{V}$$

Where:  $V_1$  is initial volume,  $V_2$  is final volume,  $N$  means normality for silver nitrate solution, 35.5 is the molecular weight of chlorine and  $V$  is the volume of water sample used.

**Determination of acidity:** Acidity was determined by adding three drops of phenolphthalein indicator to 50ml of the sample in a conical flask and titrating with standard 0.03M of sodium hydroxide until it turns to a faint pink colour. It is then calculated using the formula:

$$\text{Acidity as Mg/L of calcium carbonate} = A \times M \times V$$

Where  $A$  represents the milliliter titration of the sample,  $M$  represents the molarity of sodium hydroxide and  $V$  represents the volume of sample used.

**Determination of sulphate:** Turbidimetric determination of sulphate in water samples was carried out by pipetting 10ml of the sample into a conical flask and adding distilled water to make it 20ml, 1ml of gelatine barium chloride reagent was added. Distilled water was added to make up volume, the content was mixed thoroughly and left to stand for 30 minutes. A spectrometer was then used to determine the absorbance values at wavelength of 420nm. It is then calculated as:

$$\text{Concentration in Mg/L} = \frac{AC \times DF \times EV}{V}$$

Where AC represents the analytical concentration in milligrams per litre, DF represents the dilution factor, EV represents total volume and V represents the volume of water samples in litre.

**Determination of nitrate:** Nitrate concentration was carried out using a UV/VIS spectrophotometer. 2ml of brucine agent was added to 10ml of the sample, 10ml of concentrated tetraoxosulphate (VI) was added rapidly and mixed for 30 seconds and left to stand for five minutes, cooled for twenty minutes and mark up volume with distilled water. Absorbance values of the coloured solution at 470nm with thirty minutes was determined using a UV/Visible spectrophotometer.

Concentration of nitrate in Mg/L =  $AC \times DF \times EV \div V$ .

Where AC represents the analytical concentration in milligrams per litre, DF represents the dilution factor, EV represents total volume and V represents the volume of water samples in litre.

**Determination of phosphate:** Phosphate was determined using the UV/VIS spectrophotometer test method. 5ml of sample was pipetted into a conical flask and 15ml of distilled water was added. 8ml of a reagent containing (ascorbic acid, ammonium molybdate, antimony potassium tartrate and tetraoxosulphate (VI) acid). Distilled water was added to mark up volume, it was mixed thoroughly and

absorbance values were determined at 660nm with thirty minutes on a spectrometer.

Concentration of phosphate in Mg/L =  $AC \times DF \times EV \div V$

Where AC represents the analytical concentration in milligrams per litre, DF represents the dilution factor, EV represents total volume and V represents the volume of water samples in litre.

The microbial content of the water samples was carried out as follows:

### **Standard plate count method**

A dilution of one was used. Sterile petri plates were filled with 1 ml of the first tube, which contained 9 ml. Eosin Methylene Blue agar (EMB) for E. coli, Macconkey agar for coliform, and molten nutrient agar for bacteria were then added to a petri plate and left to harden. To ensure that the bacteria were distributed evenly, each dish was rotated. All of the petri dishes were incubated for 24 hours at 30°C after solidification. The colony forming unit per millimeter was computed and recorded after counting each emergent colony.

### **IDENTIFICATION OF BACTERIA ISOLATES**

Bacteria identification was carried out based on the cultural gram stain and biochemical test. Bergeys manual for bacterial identification was used to identify the bacterial isolates. (Cheesbrough, 2005).

## **Analysis of heavy metals in soil**

Laboratory analysis was carried out on soil to determine the concentration of heavy metals manganese, iron, lead, copper, cadmium, arsenic, and mercury

**Determination of trace metals (Mn, Fe, Pb, Cu, Cd):** The twofold acid extraction procedure was used to extract the material after it had been treated. The soil samples were processed by placing them on a petri dish and drying them in an oven set to 35°C. Any lumps that remained were then broken up with a glass rod to reveal the interiors for drying. After another twenty-four hours of drying, it was crushed and put through a 2 mm sieve.

## **Extraction procedures**

Ten grams of the dehydrated soil sample were put into a 250 ml plastic bottle that had been acid-washed. 10 milliliters of extraction solution with 0.0125 milliliters of HNO<sub>3</sub> and 0.05 milliliters of HCl. Filter the suspension using Whatman No. 42 filter paper after shaking the mixture for an hour in a mechanical shaker. Use flame atomic absorption spectroscopy to examine the filtrate. The concentration of each metal in the sample was determined using the following formula: Each metal absorbed light at a different wavelength and produced a different color.

$$\text{Conc of element(X)Mg/Kg} = A \times B \times 100 \times DF \div 1000$$

**Determination of mercury:** Weighing a dry, clean beaker and recording the weight allowed us to ascertain each sample's moisture level prior to starting the mercury analysis. The beaker was filled with 10 grams of wet sediment, which was then weighed. The beaker and the dried sediment were weighed after the sediment was dried for 24 hours at 105°C in an oven. The sample's wet sediment was weighed and put in a 100 ml volumetric flask. 100 ml of double-distilled water (DDW) was then used to rinse the sediments in the flask's neck. 15 milliliters of sulphuric The sample was mixed with nitric acid and left to cool. After adding 2 ml of HCl in 0.5 increments, the foaming was allowed to go down before adding more. Following two hours of drying in a shaking water bath set at 60°C, the flask was taken out and allowed to cool for half an hour in a fumehood. After adding 15 milliliters of KMnO<sub>4</sub> in 5 ml increments, the foam was let to cool and subside in between additions, and the flask was chilled for half an hour. When 10 milliliters of potassium persulphate solution were added, a purple tint appeared. After letting it stand overnight, combine in 5 milliliters of hydroxylamine hydrochloric-sodium solution. Use distilled water to dilute to volume. A 25 ml portion of each flask's contents should be centrifuged for 15 minutes at 2500 revolutions per minute.

## CHAPTER FOUR

### RESULTS

**TABLE 1: physiochemical composition of water samples.**

Parameters	Units	Standard Values (WHO)	Water 1 (Hall1)	Water 2 (Hall3)	Water 3 (Hall4)	Water 4 (NDDC)	Water 5 (Tetfund)
pH		6.5- 8.5	5.53	5.23	5.27	5.23	4.77
Temp	°C		32.4	32.6	32.3	32.2	32.5
TDS	Mg/L	< 500	13	14	14	19	37
Turbidity	NTU	< 5	1.08	4.3	4.09	1.94	1.51
Chloride	Mg/L	250	5.67	5.67	7.09	9.60	16.31
Acidity	Mg/L	6-7	12.0	6.0	7.0	7.0	12.0
Nitrate	Mg/L	50	13.68	12.38	15.66	18.98	29.82
Sulphate	Mg/L	250	8.16	4.39	10.04	3.77	9.1
Phosphate	Mg/L	1	0.005	0.004	0.007	0.007	0.008

Table 1 shows the parametric values for the five water samples taken from Hall1, Hall3, Hall4, NDDC and Tetfund hostels respectively. All five samples are below the acceptable pH range of 6.5 to 8.5 recommended by WHO, indicating high acidity. From the table all water samples are within the acceptable temperature

range of < 35 °C . Total dissolved solids for all water samples fall within the acceptable limits of less than 500mg/l recommended by WHO. Turbidity for water samples 1,4, and 5 are within the acceptable range of <5NTU recommended by WHO with sample 2 and sample 3 being slightly elevated. The chloride concentration of all five samples falls within the limit of 250mg\l recommended by WHO. Acidity levels are at its highest in samples 1 and 5 while others fall within 6 to 7mg/l. The nitrate concentration for the samples ranges from 12.38 to 29.82mg/l which is within the WHO safe limit of 50mg/l. Sulphate concentration in all five water samples range from 3.77 to 10.04mg/l which falls significantly below the limit of 250mg/l recommended by WHO. Phosphate values are very low ranging from 0.004 to 0.008mg/l which fall below WHO’s recommended standard of 1mg/l.

#### **BACTERIAL ANALYSIS OF WATER SAMPLE**

**Table 2: concentration of bacteria in water samples expressed as CFU/ml**

Samples	Dilution	Bacteria count (CFU/ml)	Coliform count	<i>E.coli</i> count
1(Hall1)	10 <sup>1</sup>	1.3× 10 <sup>3</sup>	0	0
2(Hall3)	10 <sup>1</sup>	5× 10 <sup>1</sup>	0	0
3(Hall4)	10 <sup>1</sup>	4× 10 <sup>1</sup>	0	0
4(NDDC)	10 <sup>1</sup>	2× 10 <sup>1</sup>	0	0

5(Tetfund)	10 <sup>1</sup>	2×10 <sup>1</sup>	0	0
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Table 2 shows the total bacterial count for the five water samples, samples 2,3,4, and 5 all fall within the total bacterial count of <100CFU/ml recommended by WHO. sample 1 slightly exceeds this at 1.3× 10<sup>3</sup>CFU/ml. From the table there was no coliform bacteria in any of the five water samples, therefore all water samples meet the standard of 0CFU/100ml recommended by WHO. Also, from the table there was no E. coli bacteria in any of the water samples so also all water samples meet the required standard of 0CFU/100ml recommended by WHO.

### Bacteria Isolates Occurrence

**Table 3: Bacteria isolate of water samples.**

Samples	CFU/ml	<i>Proteus</i>	<i>Pseudomonas</i>	<i>Kleb</i>	<i>E. coli</i>
1 (Hall1)	1.3× 10 <sup>3</sup>	+	–	–	–
2 (Hall 3)	5× 10 <sup>1</sup>	+	–	–	–
3 (Hall 4)	4× 10 <sup>1</sup>	–	+	–	–
4 (NDDC)	2× 10 <sup>1</sup>	–	+	–	–
5 (Tetfund)	2×10 <sup>1</sup>	–	–	–	–

Key + = present

– = absent

Table 3 shows the presence of other types of bacteria apart from coliform and E. coli. In sample1 and sample 2 *proteus* bacteria was detected while in that of sample

3 and sample 4 a *pseudomonas* bacterium was detected. Bacteria in sample 5 was not specifically identified. No *E. coli* or *Klebsiella* were found in any samples.

### Heavy Metals Concentration in Soil Samples

**Table 4: Values of heavy metal concentrations across different sampling stations.**

	Standard values (WHO)	2000	50000	85	36	0.8		
S/N	Sample details	Mn mg/kg	Fe mg/kg	Pb mg/kg	Cu mg/kg	Cd mg/kg	As mg/kg	Hg mg/kg
1	SS1 0-15cm	14.39	138.07	2.76	11.05	0.02	0.00	0.00
2	SS1 15-30cm	11.67	140.76	2.82	10.56	0.01	0.00	0.00
3	SS2 0-15cm	17.09	151.61	3.03	7.58	0.02	0.00	0.00
4	SS2 15-30cm	25.33	62.32	1.25	4.36	0.00	0.00	0.00
5	SS3 0-15cm	34.46	126.82	2.54	8.88	0.00	0.00	0.00
6	SS3 15-30cm	33.95	154.70	3.09	10.83	0.02	0.00	0.00
7	SS4	8.96	130.18	2.60	9.11	0.00	0.00	0.00

	0-15cm							
8	SS4 15-30cm	9.06	145.80	2.92	10.21	0.01	0.00	0.00
9	SS5 0-15cm	10.97	139.08	2.78	9.74	0.00	0.00	0.00
10	SS5 15-30cm	8.66	141.43	2.83	9.90	0.01	0.00	0.00

Table 4 shows the measurements for seven (7) heavy metals (manganese, iron, lead, copper, cadmium, arsenic, and mercury) across five sampling stations (ss1 to ss5) at two different depths of 0 to 15cm and 15 to 30cm. The concentrations of manganese in all soil samples fall below the permissible limit of 2000mg/kg as recommended by WHO, though its concentrations varied across sampling points with the highest value seen at SS3 (0-15 cm) at 34.46 mg/kg and the lowest at SS4 (0-15 cm) at 8.96 mg/kg. The concentrations of iron in all sampling stations fall below the permissible limit of 50,000mg/kg by WHO standard, there was significant variations ranging from 62.32 mg/kg (SS2, 15-30 cm) to 154.70 mg/kg (SS3, 15-30 cm). In most locations, Fe concentrations were higher at greater depths, except for SS2, where a notable decrease was observed. Lead concentrations in all samples did not exceed the permissible limit of 85mg/kg standard of the WHO. Its concentration remained relatively stable across depths, with values ranging from 1.25 mg/kg (SS2, 15-30 cm) to 3.09 mg/kg (SS3, 15-30 cm). A sharp decline in Pb concentration was noted at SS2 (15-30 cm). Copper concentrations across all

sampling stations fall within the acceptable limit of 36mg/kg by WHO, there were variations ranging from values of 4.36 mg/kg (SS2, 15-30 cm) and 11.05 mg/kg (SS1, 0-15 cm). The data indicate slightly higher Cu concentrations in surface samples compared to deeper layers. Trace amounts of cadmium was found at SS1(0-15 cm), and (15-30 cm), at concentrations of 0.02mg/kg and 0.01mg/kg. SS2 (0-15 cm), at a concentration of 0.02mg/kg, SS3 (15-30 cm), at a concentration of 0.02mg/kg. SS4 and SS5 both had a concentration of 0.01mg/kg at (15-30 cm) depth. Concentrations at these sampling stations all fall within the permissible limit of 0.8mg/kg standard of WHO. Both arsenic and mercury were undetectable in all samples (0.00 mg/kg), indicating no significant contamination from these toxic elements.

### **Waste Characterization in Hostels**

**Table 5: composition of waste generated in hostels.**

<b>Category</b>	<b>Examples</b>	<b>Characteristics</b>
Plastics	Pure water bags, plastic bottles, disposable cups, straws, polythene bags.	Non-biodegradable
Food waste	Orange peels, corn cobs, other food leftovers.	Highly biodegradable

Paper and cardboard	Carton boxes and papers	Non-biodegradable
Synthetic materials	Styrofoam, foam, and hair attachments	Biodegradable
Glass	Glass bottles	Non-biodegradable
Wood	Furniture parts	Biodegradable
Others	Vehicle tyre, and fabrics	Non-biodegradable

From the table, waste from plastics form a significant portion of hostel waste with six different types of plastic items listed. Food waste represents the second most common type of waste generated in hostels, paper, cardboard synthetic materials, glass, wood and others form the minor sources of waste generated in hostels.

## CHAPTER FIVE

### DISCUSSION

#### Water quality analysis

pH of water samples shows high acidity, which could make the water corrosive, resulting in leaching of metals from the pipe. The temperature of the water samples is slightly elevated, this could promote microbial growth and reduce dissolved oxygen levels, the turbidity of samples 2 and 3 indicates the presence of suspended particles. Total dissolved solids in the samples suggest low mineral content which may influence taste but poses no health concern. Chloride levels are within the permissible limit and pose no significant health or taste issues, though the nitrate levels in the samples are within the acceptable limit, nitrate concentration above 10mg/l can pose a risk to individual populations leading to methemoglobinemia. Precautionary measures are needed to prevent further accumulation of nitrate. Acidity levels in sample 1 and 5 show the presence of acidic compound, the sulphate and phosphate are below the permissible limit, therefore no immediate concern arises from its values. For the microbial content, the total bacterial count in sample 1 exceeds the acceptable limit at  $1.3 \times 10^3$ CFU/ml and requires further investigation due to its high bacterial count. The presence of *proteus* in water sample 1 and sample 2 suggests potential fecal contamination of water source

either from sewage or animal waste. *Pseudomonas* in water indicates biofilm formation in pipes or water storage systems.

### **Heavy metal contamination in soil**

The concentrations of lead are below typical concern threshold for residential areas, Copper, and Cadmium are within acceptable limits, suggesting minimal contamination concerns. The absence of arsenic and mercury is encouraging since these metals are highly toxic. However, the elevated levels of Mn and Fe in certain locations may warrant further assessment, depending on land use requirements. The accumulation of these metals from dumpsites may result in leaching of the metals into groundwater, and potential health implications to humans (Shittu *et al.*,2021).

### **Waste characterization in hostels**

The results suggest that hostel waste is primarily organic and plastic-based, necessitating strategies such as composting, plastic recycling programs, and awareness campaigns to minimize waste generation. The presence of wood, glass, synthetic materials, fabrics, and vehicle tyres also indicates a need for proper segregation and potential recycling opportunities.

## **RECOMMENDATIONS**

### **Water quality improvement**

Water quality can be tracked and improved by routinely checking and maintaining water storage systems, as well as by putting water treatment techniques like filtration and disinfection before consumption into practice.

### **Soil quality improvement**

Monitoring the soil regularly to monitor the levels of heavy metals. ensuring appropriate land-use planning in order to reduce the danger of pollution. To reduce the amount of metal that accumulates in dumpsites, waste disposal procedures must also be reviewed and adjusted.

### **Waste Management Strategies**

Priority should be given to composting organic waste and improving waste segregation in hostels. These measures can significantly enhance waste management, water quality, and environmental conditions for students.

## **CONCLUSION**

By enhancing water quality, monitoring soil, and improving waste management practices, we can create healthier living conditions for students and promote

environmental sustainability. Collaboration among students, management, and local authorities is essential to implement these recommendations effectively.

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