Chapter One

Introduction

1.1 Background to the Study

Water is the primary component of the earth's hydrosphere and the fluid used by all known living things. Cells in both plants and people contain a large amount of water[1,2]. Water from the earth's hydrosphere in some way determines human habitation, life, and activities. The lack of access to clean water continues to be the biggest environmental problem confronting emerging nations[3].Groundwater contamination may cause it to become polluted without treatment or a cure. It could lead to the emergence of diseases like waterborne infections due to water contamination. Humans depend heavily on water as a resource to survive on earth. Being the primary constituent of plant and animal cells, it is the foundation of life, necessitating the development of resources as a crucial element in the comprehensive development of any area[4]. Water makes up a remarkable component of nature and covers 75% of the world[5]. Water is a resource that is crucial to every nation, community, and person. No person, culture, or nation can thrive without it, making it more necessary than other resources. The National Water Policy specifies that water should be distributed and allocated for the following needs: drinking, irrigation, hydropower, ecology, agro- and non-agricultural industries, navigation, and other uses. The polar ice caps and glaciers hold about 68.7% of the world's fresh water, while another 30.1% is found underground as groundwater, the majority of which is unusable[6]. Only 0.32% of the total is made up of rivers and lakes, 0.03% by atmospheric moisture, and 0.05% by soil moisture. Surface water (oceans, rivers, streams, seas, and brooks), lakes, ice, snow and groundwater are the main sources of water. However, depending on where they are found and how they are exploited, there are differences. The provision of water for urban and agricultural use depends heavily on groundwater. Its volume is about 6.73 × 10 km3, or about 0.5% of the entire hydrosphere. This happens in a porous geological formation called an aquifer, which has the ability to store and move water at rates quick enough to feed wells. It is the primary component of the earth's hydrological cycle[7,8].

The research work's primary focus, the dumpsite, is made up of deposits of wastes of various categories, primarily solid wastes. wastes of several kinds, mainly solid. Water travels from a higher level to a lower level according to hydrological analysis of groundwater, thus it is important to look at the degradable materials that leak into the groundwater and contaminate it. Dumpsite practises have been created by filling soil depressions with solid garbage. Due to their affordability and lack of awareness of such practises, humans create these dumpsites by situating abandoned fight sites or occasionally a chosen open space near residential and commercial areas in cities.Land filling of municipal solid waste has been the most popular waste management practise and the least expensive methods of waste management in many developing countries.Good and standardised dumpsites system must be in a selected places which is constructed and constantly maintained by some techniques, so as to minimised pollution of air, water, and soil, and poses a no risk to humans[10,11].

Surface or groundwater is used for direct or indirect daily water needs by residents around the dumpsites, to a greater or lesser extent.People who live in such an environment may experience negative effects and health risks from any interaction with these waters[12,13]. The following studies have reportedly shown the potential effects of residing near dumpsites: inhaling odours, being exposed to dust and smoke, being exposed through water sources, consuming plant and animal waste, being exposed through organisms (vectors), being exposed through dermal contacts to fire during incineration, and being exposed through domestic animals as potential routes of human exposure[14].

It has been amply demonstrated that all methods of trash disposal are harmful to the environment, people's health, and local economies. Waste disposal has resulted in soil, water, and air pollution, as well as temporary restrictions on people's ability to move around and blockages of streams and offensive odours in the area of the dumpsites[15]. Soil, which is the most readily available area to receive the wastes, can hold most of these solid wastes. Millions of tonnes of garbage are produced each year from a variety of sources, including industrial, home, and agricultural operations, and these wastes end up in the soil. It is well recognised that municipal solid wastes improve the recipient soil's organic matter, nitrogen concentration, pH, cation exchange capacity, and base saturation percentage[16]. Municipal waste dumps serve as major feeding grounds for pest species including rats, birds, and stray animals, which considerably aids in their survival and reproduction. Although metals are naturally occurring in the environment, particularly in soil, their constant addition raises serious concerns. One method of adding elements to the soil is by trash disposal[17]. The ecology is negatively impacted by this ongoing addition, particularly when potentially toxic elements (PTEs) are present at the dumpsite.

These metals are known to interact with soil components and bioaccumulate there over a long period of time. As a result, they enter the food chain through plants and animals[18]. Due to their negative effects on soil organisms, plants, animals, and people, potentially toxic elements (PTEs) as lead, cadmium, chromium, arsenic, nickel, cobalt, and mercury are a major issue.According to reports, potentially toxic elements (PTEs) in the soil can harm enzymes and cause chlorosis by preventing plant development, nutrient uptake, physiological, and metabolic activities. Additionally, the leachate from waste disposal sites is a source of PTE contamination for both the land and aquatic environments. Similar to other environmental stressors, potentially poisonous elements (PTEs) cause plants to produce more antioxidant enzymes[19].

In recent years, in Nigeria's major economic centres, the generation and disposal of solid waste by individuals and residents near the majority of dumpsites has caused severe health hazards[20]. The population of humans who rely directly on water for domestic purposes and the consumption of resident aquatic organisms face risks from dangerous natural and artificial radiation materials from dumpsites and landfills that are unregulated and poorly managed. Leachates, groundwater, and rivers have all been documented to contain radionuclides, and their known origins includeunregulated and poorly managed landfills human activity, including waste from abattoirs and dumpsites[21]. As a result, landfills and dumpsites could release radionuclides into inland surface and groundwaters. The aforementioned studies found radionuclides in the soils near the target dumpsites, confirming previous findings from time-lapsed vertical electrical sounding (VES) that substances were migrating from the dumpsites. This material movement into surface and ground waters will make it easier for residents and non-residents to come into contact with radioactive material, either directly or indirectly[22]. The necessity for urgent management measures for MSW in Nigeria has been further reinforced by the low cancer risks associated with chronic radiation exposure from Nigerian dumpsites[23,24].

1.2 Statement of the Problem

The study area (Ajakanga Municipal Solid Wastes Dumpsites) was in use prior to human habitation; it has since grown into a community and residential area, raising serious concerns about the health risks associated with exposure to pollution coming from the site. The amount of rubbish being produced has increased as a result of the nearby dumpsite's rapid residential expansion.The environment's increased garbage production and management have increased the amount of trash dumped there each day and increased its size compared to previous years, sometimes even extending to surrounding surface waters and major roads[25].

To address these issues, the dumpsite needs immediate and urgent action to minimise or reduce the amount of waste present, educate the locals on waste management, or find an alternative method of waste disposal. In order to determine the water quality of the water systems and the soil quality around the dumpsite, these study works have focused mostly on the current condition of the dumpsite and the health risk.

Waste decomposition is a result of physical, chemical, and biological processes that combine to break down municipal solid waste, industrial sewage, and hazardous wastes. The result of this process, leachate, is created by the action of rainfall during the decomposition process. Potentially toxic elements (PTEs), dissolved organic matter, inorganic macro components, and halogenated organic compounds are the main components of the leachate[26].

Leachates are hence persistent hazardous waste that is present in landfills or dump sites and that can contaminate groundwater, the water system, soil, plant and animal life, and people. Additionally, it harms the environment greatly and has negative effects on health. Surface water (stream water) and underground water are found at the ajakanga municipal solid waste site and are quite close to the dumpsite, where leachates migrate and contaminate the water. The user and the environment are seriously endangered by the poisoning of this groundwater supply[27,28].

The effect of leachate from the dumpsite on the soil composition, surface and ground water, and other variables has therefore sparked interest in these studies and research projects. Additionally, it is important to be aware of the water and soil quality in the area around this specific dumpsite (Ajakanga municipal solid wastes) [29,30].

1.3 Aim and Objectives of the Study

The primary objectives of this research are to assess the water quality near land that has been filled because of its proximity to a landfill and the quality of the soil composition around the landfill, which may be contaminated with heavy metals and organic compounds.

The specific objectives of the study include to:

i. carry out the physiochemical analysis of the Soil Sample, by evaluating the physical and chemical properties of the soil samples,(therein,pH,Temperature, Moisture content, Electrical conductivity,Chlorides,Sulphides,Nitrates,Magnesium,Calcium and ammonium will be determined.)

ii evaluate the presence and concentration of certain potentially toxic elements(PTEs)in thesoil samples using Atomic Absorption spectrophotometer.

ii. carry out the microbiological analysis of the soil samples by the determination of total heterotrophic bacteria,total coliform and Escherichia Coli.

iii. determine the physiochemical parameters of Water Samples, i.e. physical and chemical properties of water samples according to Association of Official Analytical chemist's standard methods.

iv. determine the presence and concentration of certain potentially toxic elements(PTEs) in the water samples using Atomic Absorption Spectrophotometer.

v. carry out the microbiological analysis of the water samples by the determination of total heterotrophic bacteria,total coliform and Escherichia Coli using Bergey's manual of classification.

1.4 Justification of the Study

There is no doubt that the reason for doing this investigation is the dumpsite's high rate and rising level of garbage. This site has been the subject of related studies in the past, however due to the presence and ongoing state of the dumpsite, this research work monitors the site to compare results across time. Additionally, to assess the quality of the nearby soil and water. In order to have a high concentration of the chosen variables to identify if present, this study was conducted between the middle of the rainy season and the beginning of the dry season. Since there is a tendency for these pollutants to spread from the dumpsite to the neighbouring water systems and soils, the chosen parameters are the typical pollutants inside the dumpsite. These specific contaminants have contributed to a number of health issues, are not biodegradable, and can build up in the food chain (which includes both plants and animals)[31,32].

Few households in the study region rely on bore holes for their water supply, while the bulk of those nearby uses dug wells, whose water is quickly contaminated by leachate through migration from the dumpsite. The study will recommend a course of action that both the government and the populace can take to lower the amount of pollution, which lowers the health risk associated with exposure to pollution.

1.5 Significance of the Study

This is done to make people aware of the health dangers associated with consuming water and food grown on soil near a dumpsite that has been contaminated by pollution from a dumpsite and also, to limit and reduce the amount of exposure to the pollution coming from the dumpsite; to evaluate the environment's water and soil quality.

1.6 Scope of the Study

The scope of these research work isto analyze the samples collected I:e water and soil samples from the vicinity of these dumpsite, the water samples are underground(well water and borehole) and surface water are the stream water. The physiochemical parameters of the water and soil were determined using standard method according to the Association of official analytical chemist. The assessed parameters are pH, Temperature, Moisture Content, Electrical Conductivity, Dissolved Oxygen, Total Hardness, COD, BOD, TDS, TSS, Chlorides, Sulphates, Nitrates, Nitrites, Magnesium, Potassium, Calcium, and Ammonium.

Moreso, Samples from the bulk water and soil samples were also subjected for further analysis to determine,identify, and quantify the concentration of potentially toxic elements (PTEs) using perchloric acid digestion and metal ion concentration were measured using an atomic absorption spectrophotometer (model Philips PU 9100) with a hollow cathode lamp and a fuel-rich flame (air acetylene).

Lastly, The samples collected were also subjected to microbial analysis to determine the microbial loads of the water and soil sample, the microbial parameters determined and identified were Total Heterotrophic bacteria, Total coliform and Escherichia Coli using Bergey's manual classification.

1.7 Limitation of the Study

Due to the current condition of the dumpsite, especially during wet seasons, reaching the dumpsite poses a significant problem and necessitates significant health and safety measures or approaches. One of the difficulties and health risks that were faced during the course of this research activity was the stink and unpleasant smell coming from the waste site.

Additionally, gathering soil samples and water samples from both surface-level (from streams) and subterranean sources (from wells and boreholes) needed a substantial commitment and was a challenging undertaking. However, due to unfulfilled promises from the Oyo state administration regarding the evacuation or effective monitoring of the dump, the locals in the area exhibit reluctance. The samples were analysed at the Federal College of Animal Health production & Technology's multipurpose chemical laboratory in Moor Plantation, Apata, Ibadan, Oyo state, after being transported over a long distance and in multiple steps.

1.8 Operational Definition of Terms

Landfill Site is an area of land that has been specifically engineered to allow for the deposition of waste onto and into it.

Dumpsite - This is a sites or places set aside or used to dispose of, solid wastes without environmental controls.

Waste Generation - These are process of producing or generating wastes been it human wastes, Agricultural waste and Industrial wastes, and also includes all materials discarded, whether or not they are later recycled or disposed in a landfill.

Environmental Management - means the rational and sustainable administration and utilisation of environmental elements,including the reuse,recycling,protection and conservation of these elements.

Environmental Pollution - is any addition of erroneous substance or energies to the environment, that causes a change to the composition of the environment. These variables can be air,water,soil,noise and light and changes to their natural values can profound consequences for ecosystem and human life.

Contamination - is the presence of a constituent,impurity or some other undesirable element that spoils,corrupt,infects,make unfit or makes inferior a material,physical body,natural environment,workplace.

Groundwater - is the water present beneath earth's surface in rock and soil pore spaces and in the fracture of rock formation.

Leachate - is defined as any contaminated liquid that is generated from water percolating through a solid waste disposal site,accumulating contaminants and moving into subsurface areas.

Surface water - is water located on top of land,forming terrestrial water bodies and may also be reffered to as blue water,opposed to the seawater and water bodies like ocean.

Potentially toxic elements - it is used as a group name for metals and semimetals(metalloids) that has been associated with contamination.

Physiochemical parameters - are important physical and chemical quality parameters of any variablesI:e air,water,soil. The parameters are pH,temperature, turbidity,conductivity,total dissolved solids,total suspended solids,total alkalinity,sulfate,nitrate,heavy metal and phosphate.

Endnotes

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Chapter Two

Literature Review

2.1 Sustainable Water Development

Water physically exists and manifests on Earth in a variety of locations and states, such as liquid, solid, and gas[1,2]. It has the physical ability to transform from a liquid to a solid through the freezing process, a liquid to a gas through the evaporation process, and a gas to a liquid through the condensation process. In the earth-atmosphere system, water naturally occurs in a variety of locations and forms, including liquid, solid, and gaseous states[3,4]. It mostly manifests as gaseous vapour in the atmosphere, as well as gas, solid, or liquid on and below the earth's surface. In all three states of matter, such as from liquid to solid (freezing), from liquid to gas (evaporation), and from gas to liquid (condensation process), it is always changing[5].

Water's economic significance has sped up global development and population increase. The desire for high-quality water has caused many people and businesses to look for alternative water sources, such as dug wells and bore holes. Urban areas with economic development are more likely to have high water demand than urban areas with low economic development and rural areas[6,7]. Population growth and economic development have an impact on how much water is needed for each home to consume in metropolitan areas.

Many different water management systems have been put into practise in both industrialised and developing nations. It has been sustainable to have good and quality drinking water by treating water from all sources. To have good portable water, the physical, chemical, and biological processes involved in water purification must all be completed. Groundwater and soil have been contaminated by domestic and industrial effluent, which has led to unfavourable environmental conditions and inefficient waste management[9,10,11].

Additionally, the predominant form of garbage disposal has been dumping, which is the most practical and accessible but poses a serious hazard to the soil, air, and groundwater systems. The primary environmental issues or threats were caused by the landfill's continual solid waste dumping, which led to ongoing contamination of the air, the composition of the soil bygroundwater through leachate discharges, and the leachate infiltration[12]. Due to the interdependence of groundwater and surface water, when groundwater is polluted, the risk of surface water contamination also increases. Leachate develops when wastes decompose simultaneously through biological, chemical, and physical processes. Leachate will thereafter, as a result of a rainstorm, travel to the surface and groundwater and contaminate the water supply.

However, the methods used to assess the quality of surface water have been natural processes and anthropogenic effects. These natural processes include precipitation rate, soil erosion, and weathering process, while the anthropogenic effects include urbanisation, agricultural, industrial, and human exploitation of water resources[13,14].

The level of pollution or the presence of contaminants in the landfill can be shown or identified using bio-indicators, such as plants and animals on the dumpsite or nearby. Additionally, bio-indicators can be used to detect the presence of pollutants, particularly potentially dangerous substances, close to a dump site. Due to its toxicity and risks to both the environment and human life, the presence of potentially harmful materials is of major concern[15].

2.2 Groundwater Supplies

Under the surface of the Earth, there is ground water that can be found in the pore spaces and fractures of rocks and sediments[16]. Snow or rain is its primary sources. The ground water system is reached once it percolates through the soil profile. The drilling of wells gradually makes its way back to surface rivers, seas, or lakes. Groundwater resources play a significant role in the world's water supply networks and are widely used for domestic, industrial, and agricultural reasons. The water supply has a broad distribution, is affordable, dependable, and has a lower chemical and microbiological quality than surface water. It also needs little to no treatment before use[17].

The supply of drinkable water is almost entirely dependent on groundwater for around half of the world's population[18]. About 75% of the people in Africa depend on groundwater for their water source. Groundwater is the only supply of drinkable water in several nations with little precipitation, such as Libya, Tunisia, Namibia, and Botswana[19].

2.2.1 Pollution of Groundwater and Surface Water

Groundwater's susceptibility to contamination shows that some combinations of geological and hydrological factors are more likely than others to increase the risk of groundwater pollution[20]. Through intertwined pore fringes, groundwater aquifers are hydraulically connected to the land surface above. This determines how susceptible an aquifer is to contamination. Groundwater is thought to be more sensitive than groundwater that gets water and impurities from the surface of the soil more gradually and in smaller amounts[20,21].

The ability of the geological system to attenuate impurities and the relative quantity of contaminants that enter the aquifer both affect the quality of groundwater. The type of soil, rock, pollutant, and associated activity all affect how much attenuation takes place[22]. A thorough grasp of the natural inherent characteristics of any targeted aquifer in terms of vulnerability to contamination and the history of the activities in the area in question are essential for any endeavour to manage or avoid surface and groundwater pollution in any area[23].

2.2.2 Groundwater Pollution from Heavy Metals, Nitrate and Iron

2.2.2.1 Heavy Metals

Individual metals and metal complexes known as heavy metals can have an effect on a person's health. Arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver are typical heavy metals with harmful consequences. They are naturally occurring compounds that are frequently only mildly present in the environment but are increased by human activity[24,25]. Humans often come into contact with these metals through ingestion (drinking and eating) or inhalation (breathing). According to their geochemical mobility, these metals may come from natural sources, leach from rocks and soils, or come from anthropogenic sources as a result of human land use and industrial activity. With the accumulation of metals in the biota and flora, the increase in industrial activity has exacerbated environmental pollution issues and the decline of various aquatic ecosystems. Due to their propensity to bio-accumulate, these trace metals are harmful and can induce heavy metal poisoning[26]. Research has been done in these areas due to the negative effects of heavy metals in drinking water.

In the Ojota neighborhood of the Lagos city, heavy metal contamination of groundwater resources was analyzed. It was discovered that hand-dug wells and boreholes close to the Olusosun dump were contaminated[27]. The comparatively high quantity of lead, copper, and iron in groundwater was likely produced by the improper disposal of batteries, lead and used petroleum products. The concentration level's regional and seasonal volatility points to point sources of pollution. In a separate investigation, Abuja FCT, Nigeria's water sources were discovered to have excessive concentrations of heavy metals[28].Concentrations of arsenic, lead, iron, and zinc were found to be notably high in both surface and groundwater sources. According to geochemical analysis, quartzite rocks in the Ibadan metropolitan have the greatest concentration of arsenic[29]. They came to the conclusion that Ibadan's water sources are vulnerable to arsenic pollution due to both the indiscriminate discharge of trash and industrial effluent and the leaching of weathered bedrock. The surface and subsurface areas of the Kaduna South Industrial Area were tested for trace metals[30]. Vanadium, chromium, iron, cobalt, nickel, gallium, arsenic, selenium, lead, strontium, zirconium, and molybdenum have amounts exceeding the WHO guideline for drinking water, accounting for 73.68% of the parameters evaluated. Investigations into the heavy metal contamination of the groundwater in the town of Yenegoa revealed quantities of iron, manganese, nickel, chromium, lead, arsenic, cadmium, mercury, and copper that were higher than the WHO's permissible level for drinking water[31]. They explained this by the presence of chemical injections and industrial discharges in an oil-producing region. When the heavy metal pollution in Makurdi's groundwater sources was analyzed, it was discovered that significant quantities of chromium, cadmium, iron, and copper were present, above the WHO's recommended level for drinking water[32]. They linked this to the mineralogy of the soil, the use of agrochemicals and artificial fertilizers, as well as other land uses. Lead has been considered to be present in water sources among the heavy metals researched because of its toxicity and availability due to industrial activity.

In the populated cities of Lagos and Ibadan, a study on lead pollution levels in indoor and outdoor environments was conducted[33]. In addition to soils, dust, and food, the degree of lead pollution in surface and groundwater was examined. The findings of tests of the levels of lead in various water sources show that the majority of the waters had levels of lead that were higher than those recommended by the WHO. Lead levels in Ibadan's low-density water were comparatively higher. However, the lead levels in the groundwater from elevated regions in both cities were noticeably greater.

The WHO acceptable limit for lead concentration in drinking water was exceeded in 91% of the wells studied in Zaria City when the lead level in wells and boreholes was assessed. Wells close to the city's industrial and automotive districts have higher lead levels than other wells[34].

In boreholes spanning different Benin Town formations, an undesirable level of iron was observed[35]. According to them, the geology of the ferrugated deposit, the drilling technique, the size of the submersible pumps, and the calibre of the distribution pipes could all be linked to the iron found in these boreholes.

2.2.3 Seasonal Effect on Groundwater Pollution

The level of physico-chemical and microbiological loading in water sources is thought to vary with the season. In Abraka town, seasonal variations in physico-chemical elements were examined[36]. The results indicate that during the dry season, total dissolved solids were lower. Eighty percent of the wells in Makurdi's city had nitrate contents that were higher than the WHO's permitted limit for drinking water during the wet season[37]. The concentrations of feacal coliform bacteria, turbidity, calcium, electrical conductivity, chromium, iron, biochemical oxygen demand, pH and chloride were also greater during the wet season. According to an analysis of the seasonal effects on the physico-chemical concentrations in hand-dug wells in Akure town, pH, total dissolved solids, total alkalinity, potassium, iron, and sulphate all had higher concentrations in the wet season. In contrast, the dry season has increased quantities of nitrates, magnesium, total hardness, turbidity, electrical conductivity, sodium, chloride, and temperature[38].

2.2.4 Groundwater Pollution Mitigation Measures in Nigeria

Physical processes and anthropogenic activities are the main causes of groundwater pollution in Nigerian cities[39,40]. It is commonly accepted that after groundwater has been contaminated, it is expensive or difficult to treat. Many times, preventive actions are advised. The following suggestions have been made in this regard:

i. To assess the quality of the urban groundwater in Nigeria, ongoing monitoring is necessary. This will serve as a guide for the general public and water managers regarding the necessary action plans.
ii. It is important to adequately control all land use activities that have the potential to contaminate surface and subterranean water sources to safeguard their quality.
iii. Water sources and water points need to be protected. It is important to prevent waste from being dumped carelessly into water sources, secure hand-dug wells with covers, and maintain a sanitary environment devoid of animal and human waste.
iv. Before being released, industrial effluents must undergo sufficient treatment to prevent contamination of water sources. Construction of sanitary landfills and other locations for the disposal of trash. Wastes produced should be collected and disposed of right away.
v. Only when a thorough sanitary inspection and a recommended location have been approved may groundwater exploitation systems, such as boreholes and hand-dug wells, be installed.
vi. To ensure safe drinking water quality, the water should be treated appropriately using boiling, filtration, and disinfection.
vii. Water source pollution should be strictly regulated by law. Consider adopting the polluter pays principle and good practises[41].

2.2.5 Urbanization and Groundwater Pollution

Surface and groundwater sources have traditionally provided water to African towns. Urban groundwater is seen as a preferable alternative, nevertheless, because surface water quality and quantity are declining due to increased urbanization and industrialization, as well as the costly expense of building new dams[42,43]. Despite this benefit, urbanization has significant long-term effects on how freshwater is used, how trash is managed, and how subsurface water is developed, protected, and managed in urban settings[44].

Groundwater quality in the southeast of Lagos from 1999 to 2001 on the effects of urbanization was thoroughly investigated, and it was discovered that all of the wells had amounts of sulphate, nitrate, and chloride that were undesirable[45,46,47]. Particularly high levels of nitrate were observed and are associated with human activity. Lagos' shallow depth and unconsolidated porous sand and gravel aquifer make the city's groundwater particularly susceptible to contamination.

In a related study, the effect of urbanization on the sub-surface water in Calabar Town was evaluated[48]. It was found that the water was acidic and that nitrate and faecal coliform had extremely high concentrations in the wells. Faecal coliform, pH, and chlorine exhibit a positive connection with urbanization, according to the results of multiple regressions. High faecal coliform is frequently linked to the wells' surrounding environment's hygienic state. The impact of urbanisation on the metropolis of Makurdi's groundwater quality was investigated[49]. Following analysis, it was discovered that samples of water taken close to a dumpsite had a low pH, higher concentrations of iron, manganese, calcium, total dissolved solids, and total coliform than samples taken farther away, indicating leachate influence. The well's cleanliness is the likely cause of the presence of coliform. $CaSO_4^-$ is the kind of groundwater.

The water quality of hand-dug wells in Makurdi town was examined in a similar study, which found that it was mildly acidic, fairly hard, and low in total dissolved solids50. In all the wells, there is a high concentration of coliform, while trace amounts of heavy metals like iron, zinc, copper, lead, and cadmium are also present.

2.3 Effects of Pollutants on Health

Under normal conditions, water naturally contains trace amounts of dissolved contaminants like silt, sand, and microorganisms as well as dissolved minerals like zinc, calcium, and magnesium. These concentrations are regarded as safe for human consumption, but the water becomes contaminated when they go above threshold levels[51]. Depending on the length of exposure and the surrounding temperature, metal ions and their complexes can be hazardous to organisms in a variety of ways, ranging from sub-lethal to deadly. For instance, even at low concentrations, the heavy metals Zn, Pb, As, Cd, Mn, Hg, and Ni are extremely hazardous[52]. Cadmium and lead both pose serious risks to human health. For example, prolonged exposure to lead can harm the kidneys, raise blood pressure, damage the brain, cause miscarriages, alter the neurological system, and harm male sperm. Damage to the brain, kidneys, neurological system, and haemoglobin regeneration can all trigger reactions in mercury[53]. The leachate produced when these contaminants are carelessly disposed in landfills makes its way into the groundwater or is washed into surface water and streams, causing water contamination.

Zn enters aquatic bodies via man-made channels, such as trash incineration, coal-fired power plants, and byproducts of steel production54. Zn can be found in trace amounts in fertilizers, mine leaching effluents, commercial industry effluents, and smelting processes.

Samples' measured pH values are merely indications of acidity; they do not represent actual hydrogen ion (H^+) activity levels. The pH scale ranges from 0 to 14, with 7.0 being regarded as neutral. pH values below 7.0 are regarded as acidic, whereas those above 7.0 are regarded as basic. As organisms depend on an appropriate range of acidity to live, pH values are indications of the health effects of a water supply. Any quantity of water acidity that comes into touch with a chemical or metal increases their noxiousness[55].

The quality of the water is also influenced by fertilizers and pathogens. Untreated sewage results in the development of pathogens like coli forms is a type of coliform bacteria that arises from the intestines of warm-blooded animals and serves as a sign of bacteriological contamination of drinking water. Many diseases have been linked to the presence of E. coli in portable water. On the other hand, the Environmental Protection Agency (EPA) claims that Total coliforms are markers of pathogens that require routine study even if they may not always be harmful to humans.

For healthy persons, coliform levels symptoms that fall under the heading of gastroenteritis may not be significant. However, those with weakened immune systems may experience major consequences as a result[56]. Biochemical indicators of the total coliforms are frequently used to detect the presence of Escherichia coli in drinking water. Escherichia coliform is a sign that there are germs in the water. The different diseases they may spread to people make their presence in drinking water a cause for concern. Similar to this, coliforms can affect newborns' red blood cells' ability to contain nitrogen, which can result in methemoglobinemia, sometimes known as "blue baby syndrome[57].

2.3.1 Potential Health Effects of Contaminated Surface Water Flow and Groundwater

Land filling, a controlled method of disposing of solid waste on land with the objectives of removing public health, environmental dangers, and minimizing annoyances without compromising surface or subsurface water resources, is widespread around the world. Despite this, many dump sites lack proper lining and building safeguards, which causes leachate from the decomposition of organic wastes to leak out[58,59]. Leachate continues to seep into the ground at certain disposal sites, where it may affect groundwater sources[60]. Groundwater resources that are gradually contaminated pose a threat to the environment and to the health of users, particularly young children and the elderly[61]. Drinking water with excessive nitrate levels can result in several water-borne illnesses, including, typhoid, baby blue syndrome, paratyphoid,diarrhea, enteric fever, hepatitis, dermatitis, and cholera. The petrol additive benzene is known to cause cancer in humans[61]. Significant health effects of lead, including hazards to unborn children, difficulties with the kidneys, nerves, and liver, and learning disabilities in youngsters. Preventing contaminants from getting into groundwater is the best strategy to lessen the health concerns related to bad drinking water quality.

2.4 Dumpsites

A dumpsite is a haphazard location where rubbish can be gathered. Construction of sanitary dumpsites and landfills typically takes place in areas where runoff and groundwater are not an issue. Local governments and citizens must be taken into account. Modern equipment, well-trained staff, and the prevention of burning must be offered. One of the largest issues facing the planet and its ecology is waste disposal. Wastes produced by daily human activities can cause environmental and health issues if they are not adequately managed. Finding the best waste management and disposal methods has been a challenge for governments. When the human population was not as numerous as it is today, a few decades ago, garbage disposal was readily controlled[62].

People deposited their rubbish in dumps, which are simply excavated areas of ground or pits. The majority of homes, particularly those in rural regions, have trash cans, whereas metropolitan communities have a shared trash can for inhabitants. Dumps lack processing control and are not governed by the government. They are everywhere, and they might or might not be covered in soil. They are also not monitored, which increases the likelihood that the liquid solid waste produces may contaminate the water supply. Open dumps can draw vermin like flies and rodents and release unsavoury scents that are dangerous to people. As a result, dumps are prohibited and have been substituted with dumpsites. Communal dumps have been transformed into government-regulated dumpsites[63].

The best dumpsite is one that is contained within a compact space and is shielded from view by many feet of soil. The bottom of the pit must also have a liner to stop leachate, or the liquid from solid waste, from seeping through and contaminating the water supply. A dumpsite must also have leachate treatment systems, groundwater testing, and be regularly covered with soil to prevent pest infestation and the release of offensive odours. A new dumpsite is made after the previous one is full. Due to the difficulty of waste items to decompose organically, old dump sites can be sources of poisons[64]. Dump sites attract scavengers because they are wonderful places to find recyclable goods, but if they are negligent, they run the risk of getting buried under the garbage. Although dumps and dumpsites are utilized to solve the waste issues, they eventually run the risk of becoming environmental and health risks. In conclusion, a dump is an area of land that has been excavated and used to store rubbish, whereas a dumpsite is an area of land that has been excavated and used to store waste but is subject to government regulation. While a dumpsite has leachate collection and treatment systems, dumps do not[65,66].

Dumpsites are scarcely covered, which hastens the decomposition process and causes hazardous fumes to be released into the atmosphere. Municipal solid waste, building debris, and possibly some types of agricultural and industrial garbage are all stored at a sanitary dumpsite or landfill[67]. Liners stop leachate from dripping from a well constructed dumpsite. Dumpsites are essentially created so that the trash can be stored without harming the environment. In contrast, a dumpsite or open dump is just a big hole in the earth where trash is dumped. The hole could be a former quarry, open-pit mine, or clay pit that is now used as a garbage dump.

2.5 Dumpsites Systems in the Developing World

Dumpsites have been characterized to as the poorest people's only means of life in developing nations, particularly in Africa[68]. The proverb "One man's meat is another's poison" has some truth to it because it also serves as a substitute supply of raw materials for recycling. These groups of people, referred to as scavengers, view waste differently from the majority. They understand that garbage is both money and the source of their ability to survive[69]. Competition among the scavengers is so intense, especially in Ibadan dumpsites that specific "payments" are provided to the dump management in order to gain entrance to the dumpsite for scavenging. There are many different dumpsite methods in use around the world, but when it comes to Africa as a continent, the open dump method is still the most common way to dispose of trash in the majority of African nations. Open dump, the standard method for managing municipal solid waste, entails the careless disposal of garbage and the use of few operational controls, particularly those that address the impact of dumpsites on the environment.

A country's initiative to improve dumpsites frequently starts with an operational or partially controlled dump. In controlled dumps, waste is extensively compacted, tipping front is controlled, and soil cover is applied. Incoming waste is also inspected and recorded in some way. However, operated landfills only take a few steps to lessen the effects on the environment. Operated dumps continue to use uncontrolled pollutant release and disregard environmental safety precautions like leachate and dumpsite gas management[70,71]. This is especially important in situations when leachate is generated and is not restrained by porous rock under the surface or fissured geology. In semi-arid and desert climates, where dumps do not produce substantial amounts of leachate, this problem might not be as serious. However, as cities expand, generate more waste, and improve the effectiveness of their solid waste collection system, the environmental damage caused by open dumps becomes unacceptable. To prevent future expenditures from existing mismanagement, open or managed dumps must be converted to engineered and sanitary dumpsites. Reducing annoyances like stink, dust, vermin, and birds is the first obstacle in converting open wastes to hygienic dumpsites[70]. A dumpsite that compacts garbage is typically referred to as a sanitary dumpsite.

Dumpsites and landfills, sometimes known as "open" or "polluting" dumps, contain rubbish below the surface that could allow a waste byproduct known as leachate to infiltrate and contaminate groundwater and other water sources. Additionally, they draw insects, rats, and other animals that spread disease. The production of potential fire hazards, the release of air pollution, and stench are additional detrimental effects of open dumps[72].

2.5 Dumpsite Pollution

The potential for groundwater contamination exists at any location where trash is concentrated, processed, and stored even temporarily. Depending on the types of trash deposited, leachate from waste deposits (dumpsites/landfills, refuse dumps) has a variety of contaminations[73]. Since the quality and concentration of the leachate produced is a function of the access of water to the waste, the likelihood of disposed wastes polluting groundwater depends on the unsaturated zone, the attenuation capacity of the underlying site, as well as the total and effective precipitation at the site.

In a chemical sense, water is naturally never pure. There are a variety of contaminants present in it, including gases (H_2S, CO_2, NH_3, H_2), dissolved minerals (Ca, Mg, Na, salt), suspended debris (clay, silt, sand), and microscopic plants and animals[74]. These are organic pollutants that come from the soil, catchment areas, and atmosphere. They naturally do not pollute water and are present in extremely small quantities. However, a number of variables, including the local geology, the time of year, and stream natural discharge, affect the quality of natural water.

It is generally recognized that traditional unlined sanitary dumpsites and open dumps discharge significant quantities of dangerous and other harmful substances into the air, groundwater, and soil nearby, as well as through leachate and dumpsite gas. However, there is little quantitative data on the overall risk that dumpsites provide to those who reside in or otherwise use properties nearby[75].

Groundwater pollution results from the presence of undesired, harmful materials and pathogens above a particular threshold. In general, anthropogenic activities including the discharge of sewage, effluents, and garbage from residential and commercial establishments produce water pollution. Additionally, due to the rate of leachate infiltration, percolation, and migration, the condition of groundwater pollution is more severe during the rainy season. One of the main dangers to groundwater resources has been identified as dumpsites. Open or covered dumps of waste are vulnerable to underflow or precipitation-induced infiltration. Due to the potential pollution source of leachate coming from the neighbouring site, areas next to dump sites have a high risk of groundwater contamination. Users of the local groundwater resource and the surrounding environment are at great danger from this kind of contamination[76].

2.6 Effects of Municipal Solid Waste on the Environment

Uncontrolled solid waste dumping exposes city dwellers to hazards from contaminated water, especially those who live close to dumpsites, unsafe food sources, and polluted air, land, and vegetation. Poor handling of and disposal of solid waste causes ecosystem destruction, public health hazards, and environmental deterioration. Such solid waste buildups pose a health risk to urban dwellers as well as a threat to the environment[77]. Environmental issues caused by solid waste include health risks, water and soil pollution, objectionable odours, and ugly sights. All of this contributes to the deterioration of our ecosystem.

The majority of dumpsites are located close to populated areas and wetlands. The dump sites are frequently not technologically positioned for harmful material adsorption. As a result, they are able to release contaminants into the air and neighbouring aquatic bodies through leachates or dumpsite gases, respectively. Many water sources have been designated as dangerous to people and other living things[78].

The majorities of abandoned landfills use improper waste disposal methods and date back many years. Such dumps have a big influence on the ecosystem. The potential health risks from solid waste to the terrestrial, marine, and aerial habitats are serious[79].

2.7 Challenges of Urban Solid Waste Management

The municipal solid waste management system is significantly impacted by attitudes regarding trash management and dumping locations. Public engagement and awareness are necessary for municipal solid waste management, which includes everything from domestic garbage storage to waste segregation, recycling, collection frequency, willingness to pay for waste management services, and opposition to the placement of waste treatment and disposal facilities. For the sake of the public's health and wellbeing, awareness of and participation in the management of dumping sites is just as important. This limits the use of social and communal methods to the management of SWM services[80].

2.8 Factors Affecting Groundwater Quality

Both natural and man-made factors affect groundwater quality. When it comes to anthropogenic factors, they include the nature of human activities, urbanisation, industrialization, and waste management disposal, among others. Groundwater is affected by the nature of bedrock geology, depth from surface soil, vegetation, climatic change, permeability of sediments, and terrain[81].

Leachate migration is consistent with the distance decay concept because concentrations of both reactive and conservative pollutants decline with increasing distance along the groundwater flow channel. It should be emphasised that seasonal influences on the recharging and release of the pollution, or reaction times controlled by variations in parameters like temperature, can cause the concentration of a pollutant at any point far from its source to vary throughout the year. As a result, seasonal fluctuation distinguishes the leachate concentration in groundwater[82]. The most prevalent natural solvent in the world is water. Minerals are thus dissolved when it permeates the ground. Total Dissolved Solids (TDS) are these minerals that are present in the water. Since the water in a shallow aquifer travels through the earth more quickly, it typically experiences less mineralization. On the other hand, deeper aquifers are more likely to be contaminated by nearby land use activities, including nitrate and microbiological contamination.

An key factor in determining the degree of groundwater mineralization is the volume of water that passes through the unsaturated zone[83]. Clay and silt are examples of sediments with low permeability, through which groundwater travels slowly. This gradual movement gives minerals more time to dissolve. On the other hand, high permeability sediments like sand and gravel enable groundwater to pass through them more quickly. As a result, the amount of dissolved minerals varies. The quality of groundwater can also be impacted by climatic changes like rainfall and evaporation[84].

The hydrological system that is currently in place is instantly affected by waste that is dumped in dumpsites or in refuse dumps. In addition to liquids produced by the waste itself through the processes of hydrolysis and solubilization, which are brought about by a whole series of complex biochemical reactions during the degradation of organic wastes, liquids derived from rainfall, snowmelt, and groundwater also percolate through the deposit and mobilise other components within the wastes. The generated leachate then migrates either directly on site or by infiltration of runoff containing leachate away. The leachate composition and its level of pollution are influenced by a variety of factors, including landfill hydraulics, dumpsite age, and waste component[85]. The composition of solid waste, cover design, compaction, interaction of leachate with environment, operation of dumpsites, particle size, degree of compaction, hydrology and hydrogeology of site, age of dumpsites, moisture and temperature conditions, and oxygen availability all affect the rate and characteristics of leachate production.

Depending on the local activities, the calibre, and the kind of items that communities consume, there are differences in the content and amount of discarded trash on a national and regional level trash from lower-income communities is often abundant in food-related trash, primarily organic materials[86]. The physico-chemical composition of groundwater can change due to the decomposition of organic waste, which can also increase the mobility of hazardous chemicals such as metals and solvents. Leachate from trash dumped from highly industrialized places may contain a wide variety of anthropogenic pollutants. trash output is a function of increased affluence and degree of industrialization[87].

As non-liquid and non-gaseous byproducts of human activity that are deemed to be wasteful and take the form of trash, refuse, or sludge, solid wastes can be classified as such. Solid wastes are categorised by Adedibu into eight categories: household, municipal, industrial, agricultural, pesticides, residential, and hazardous wastes[88]. But solid waste can be categorised as biodegradable or not, soluble or not, organic or not, liquid or solid, poisonous or not, etc. No matter how solid waste is classified, the majority of urban wastes are biodegradable, which speeds up leachate generation and migration compared to non-biodegradable wastes, which can persist for a long time without showing any signs of decomposition.Due to the make-up of the trash and the frequent infiltration of surface water from urban precipitation, there is the potential for leachate formation, plume expansion, and migration at the base of urban dumpsites[89].

2.8.1 Dumpsite Lifespan

The longevity of the dumpsite is directly correlated with groundwater contamination. Due to the length of time and age of the dumpsites, as well as the kind of the degraded waste, pollutants formed over years are quite varied in terms of physicochemical and potentially hazardous elements (PTEs) concentration. Kostova claims that the leachate ingredient concentration (mg/L) is divided into four phases: transition (0–5 years), acid production (5–10 years), methane fermentation (10–20 years), and final maturity (>20 years)[90]. When waste is first deposited in the dumpsite, groundwater may not already be contaminated. Between 1988 and 1993, more than 3400 Municipal Solid Waste Dumpsites across the United States were shut down or abandoned due to ageing. To assess the chance of soil and groundwater contamination and to gather data on leachate migration, these abandoned dumpsites must be monitored.The amount of leachate generated at a dumpsite is also greatly influenced by its age. A dumpsite ages together with an increase in leachate production.

Leachate produced during the first five years of waste deposition at dumpsites has a pH range of 3.7 to 6.5, indicating the presence of bicarbonate ions and carboxylic acids.Leachate's pH eventually reaches a neutral or mildly alkaline range between 7.0 and 7.6. Long-term dumpsite exploitation results in alkaline leachate with a pH range of 8.0 to 8.55[91].

2.8.2 Leachate Migration

Water that percolates through dumpsites/landfills that are not sealed frequently collects within or below the dumpsite.This is because, in addition to rainwater percolating, degradation processes that are active within the trash also produce leachate. Leachate from the landfill or dump flows outward and downward more as a result of the increased hydraulic head that was produced[92]. Groundwater resources below the surface are at risk from downward flow. When nearby wells or boreholes have low water quality, leachate is likely being migrated and produced. It's possible that the flow direction of groundwater differs from that of surface water. However, groundwater flows continually and slowly through the cracks in the rock and soil. Plumes of contamination will appear if a dumpsite contaminates the groundwater. While other wells, even those near the dumpsite, may not be harmed if they are not in the plume, those in the plume will be contaminated. Additionally, the fluctuation in leachate concentrations and groundwater flow directions affects how the leachate pollution plume behaves in the groundwater zone[93].

2.9 Characteristics of Leachate in Groundwater Quality

The leachate produced by the material, which frequently contains harmful compounds, especially when trashes with industrial origins are landfilled, is the main cause of groundwater contamination. It has been extensively noted, though, that leachates from non-hazardous waste dumps may also contain complex organic compounds, chlorinated hydrocarbons, and metals at levels that endanger both surface and groundwater[94]. Normal organic and inorganic components can be found in the generated leachate. Additionally, the created leachate seeps into the ground over time, changing the physical and chemical characteristics of the groundwater.According to reports, groundwater includes significant concentrations of potentially toxic elements (PTEs) like cadmium, arsenic, and chromium because of dumpsite operations[95].Leachate volume is primarily influenced by the dumpsite's size, weather and hydrogeological conditions, and capping efficiency. Therefore, it is anticipated that in humid areas with high rainfall, rapid runoff, and a shallow water table, the volume of leachate generated will be very significant. Thus, the degree of natural protection for groundwater from pollution by landfill leachate depends significantly on the geology and hydrogeology of any possible landfill site. According to earlier research, the majority of landfill leachate contains high concentrations of boron, ammonia, chloride, sodium, potassium, hardness, and the elements potassium, sodium, and hardness. As a dumpsite ages, its environment frequently changes from anaerobic to aerobic, allowing for a variety of chemical reactions to occur[96].

2.10 Nigerian Standard for Drinking Water Quality

In 2007, the Council of the Standards Organization of Nigeria approved the Nigerian Standard for Drinking Water Quality (NSDWQ), which establishes upper and lower limits of contaminants known to be dangerous to human health[97]. The Nigerian Standard for Drinking Water Quality (NSDWQ) and the World Health Organization (WHO) has different standards for determining the minimum and maximum concentration of water quality.

Water is an essential element for all life and is required for the majority of processes that are life-driven. It is a crucial resource required for the survival of all living things, including humans. It is also one of the most significant and prevalent substances on earth and is essential to the survival of all living things. Due to the lack of a reserve supply in human bodies, water is one of the most essential necessities for all living forms and is a necessity in man's everyday life[98]. As a result, water accounts for a sizable portion of man's daily food intake. In addition, it is a necessity for drinking, household, industrial, and agricultural usage. Quality water is tasteless, odourless, colourless, and free of any faecal contamination.

In addition to being necessary for maintaining personal hygiene, food production, and illness prevention, water is a crucial component of human nutrition. It makes up around 70% of the earth's crust and is the most prevalent component in the natural world. Water is regarded as a universal solvent due to its natural abundance, the fact that many living cells' protoplasm contains roughly 80% water, and the fact that most biochemical events that take place during the metabolism and proliferation of living cells include water medium. A biological medium that can be solid, liquid, or gas is water[99].

One of the natural resources that is essential to the existence and survival of every human being is fresh drinking water. Potable drinking water has been and continues to be a key pillar in the primary prevention of diseases as well as the prevention and management of water-borne illnesses. It is impossible to overstate the significance of water supply in a community's socioeconomic existence. As microbiological contamination of water is the main cause of illness outbreaks in many communities, particularly in many underdeveloped nations, the source and mobility of the water supply frequently reflect on the health status of communities[100]. Therefore, one of the main issues for a safe water supply is the spread of disease through drinking water. People are at risk of a variety of diarrheal and other illnesses, as well as chemical intoxication, when they drink contaminated water, which is a hazard to worldwide public health. When supply is frequently interrupted and shortages set in, the availability of drinkable water is a difficulty in many developing countries[101].

Unsafe drinking water poses a huge risk to health, and unsuitable water sources and unsanitary living circumstances can have a negative impact on people's wellbeing. The protection of public health, environmental preservation, and sustainable development all depend on the availability of clean drinking water. As a result, faecal oral pollution causes the transmission of numerous infectious diseases through water. Each year, illnesses brought on by drinking unclean water kill five million children and sicken 1/6 of the world's population[102].

The amount of assimilated organic carbon, limiting nutrients, disinfectant concentration, pipe type, packaging nylons, pH, temperature, hardness, and redox potential that regulates the growth of microorganisms on pipe surfaces are all factors that affect bacterial growth in drinking water. Numerous opportunistic pathogens have been found in water distribution networks as isolated microorganisms. High concentrations of opportunistic pathogens in drinking water are concerning because these germs have the potential to infect specific demographic groups[103].

Escherichia coli or thermotolerant coliform bacteria, giardia worms, viruses, *Cryptosporidium spp, Legionella pneumophila, Entamoeba hystolitical,* and other opportunistic pathogens like *Clostridium sp., Klebsiella sp.,* and Pseudomonas are prohibited from being present in high-quality drinking water, according to WHO guidelines. The recommendation also stated that the water should be tested for the presence of highly virulent pathogens like *Shigella dysenteriae, Salmonella typhi*, and *Vibrio cholerae,* which cause typhoid, bacillary dysentery, and cholera diseases, respectively, and are brought on by tropical waters' high levels of organic decay and fermentation[104].

The natural environment of the planet has been harmed by urbanisation and rising anthropogenic activity, which has also had a detrimental effect on human health. The scientific community is now concerned about water source contamination because it directly affects people's health. Water contamination has caused a number of common diseases like cholera, typhoid, diarrhoea, dysentery, and dysentery as well as regular deaths all across the world. Developing nations are on the worrying list because of the scarcity of clean, drinkable water and the poor quality of their health care[105].When people consume contaminated water, bacterial infections are the most common and are also getting more difficult to treat due to microorganisms' rising drug resistance. Depending on the host susceptibility, these diseases may be deadly or life-threatening.

The quality of the raw water at the source, the water purification process, and the water distribution system make up the three key links in the water system. The physicochemical properties as well as the microbiological composition are impacted by this three chain system. Numerous microbial communities exist in the water system, and given a good environment, they might start to expand and worsen the quality of the water. Worldwide, diarrhoea is now the fourth biggest cause of death, and in 2015, it is thought to have killed 1.3 million children under the age of five[106].

The population of the world is currently estimated to be over 7.6 billion people and is increasing by 83 million people annually, according to the United Nations in New York. In fact, the majority of the 8.6 billion and 8.9 billion anticipated population increases by 2030 and 2050, respectively, would be in low-income countries[107]. Population growth causes competition for freshwater to expand among agricultural, urban, and industrial sectors, putting pressure on both rural and urban locations. The primary sources of drinking water for the entire human population and other living things are surface water and groundwater. Groundwater is regarded as a dependable source of fresh water that is simple to get for a variety of uses, including irrigation, industry, and residential etc[108,109].

Around 1.5 billion people depend on groundwater for domestic and agricultural purposes on a global scale, either directly or indirectly. Groundwater chemistry is mostly governed by geochemical processes including oxidation-reduction and biological reactions, as well as dissolution, hydrolysis, precipitation, adsorption, and ion exchange. The majority of sewage and faecal sludge make their own way to the ground as a result of inadequate faecal sludge treatment, which increases the frequency of groundwater pollution and bacteriological contamination. The survey data states that approximately 24% of children in urban regions and 55% of children in rural areas are getting sick as a result of contaminated water[110]. Additionally, they stated that 23% of rural homes and 11% of urban households, respectively, have experienced baby deaths.

As a result of rapid population expansion, urbanization, and other anthropogenic influences, there is a growing need for water. Humans also need water since they require large daily water intakes to survive. In a perfect world, everyone should be able to drink water without fear. The World Health Organization (WHO) established guidelines for safe drinking water in terms of microbiological, chemical, and radionuclide content as well as physical characteristics[111].

Less than one-third of Nigerians living in urban and rural areas have access to piped water supply connections in their yards for drinking, and even those who have may still encounter unreliable, subpar service[112]. Public standpipes and unpiped water sources including hand-dug wells, boreholes, springs, and water vendors are used by the majority of families. All of these water sources are categorized as "improved drinking water sources." A source that is sufficiently built so that it is shielded, in particular, from faeces and other outside contaminants is considered to be an improved drinking water source[113]. Other sources, including bottled water and surface water from rivers, streams, lakes, and ponds, are categorized as unimproved drinking water sources.

Environmental contamination from discharges or effluents from abattoirs or sewage, especially downstream, and from industrial waste affect streams and rivers that have become significant sources of water for cooking and drinking in isolated communities and slums. Additionally, elements like iron, calcium, chromium, and aluminium have been identified in surface water, as well as groundwater that contain cadmium, lead, manganese, and nickel in excess of allowable limits for drinking water. In some areas of Nigeria, it has also been observed that groundwater contains amounts of other pollutants such fluoride and light polycyclic aromatic hydrocarbons that are higher than allowed limits[114]. Due to rising population densities, inadequate sanitation infrastructure, and poor hygiene, there is a substantial risk that these drinking water sources will become contaminated with pathogens and dangerous substances. According to estimates, 1.1 billion people lack proper access to water sources, which has caused an international outbreak of diarrhoea (approximately 4 billion cases) and deaths (about 5 million each year)[115].Studies throughout the years have demonstrated that inadequate management, worrying population expansion, negative policy implementation of water-related initiatives, and an increase in industrial activity are all linked to clean water shortages. The accessibility, availability, distribution, provision, and quality of water and related resources are also known to be adversely impacted by these dynamics. There is a need for immediate actions to avert water shortages, especially in developing nations like Nigeria where there have been numerous instances of cholera, typhoid, and other waterborne illnesses as a result of poor sanitation[116]. More than 66 million Nigerians live in urban and rural areas without access to a reliable supply of safe drinking water. As a result, more people are consuming tainted or polluted water, which could have a negative impact on public health.

Up to 10 water treatment techniques, including chlorination, activated carbon adsorption, chemical coagulation, filtration, aeration, ion exchange, chloramination, oxidation processes, and membrane, are recommended by the World Health Organization (WHO) in its guidelines for the quality of drinking water. For Nigeria's infrastructure development and management goals to be effectively guided, robust data on the current state of water services and water quality are required[117].

Since the majority of our body's organs and tissues depend on water for proper function and because 70% of our body's weight is made up of water, people who care about their health are more concerned with the quality of the water they consume. This means that good water is at least twice as important for supporting the body's metabolic processes as food. Our blood is actually 93 percent water, compared to 75 percent water in our muscles. Without food, we can go for weeks, but without water, we can only last for a few days[118].

2.11 Evaluation of Quality Water

A variety of techniques must be used to assess the quality of the water. However, the types of water pollutants cannot be expressed using these methods. In order to gather usable data, a research was carried out to create a programme that would be affordable for monitoring the quality of groundwater by sampling existing wells[119]. The mechanism for delivering a cumulatively determined numerical expression describing a certain level of water quality is provided by the Water Quality Index technique (WQI). One of the main benefits of WQI is that it combines data from several water quality metrics into a mathematical equation that assigns a numerical score to the condition of the water. Using ten (10) of the most often measured water quality indicators, including dissolved oxygen, pH, coliforms, specific conductance, alkalinity, and chloride, the Water Quality Index was initially created in the United States of America[120]. Horton's technique for evaluating the quality of the water is now widely utilized throughout Africa, Asia, and Europe. The Water Quality Index (WQI) technique employs a rating system to ascertain how each quality indicator affects the overall quality of the water. The following factors form the basis of a general WQI strategy;

i. Sub-indices aggregation with mathematical expression
ii. Determination of a Quality Function Curve
iii. Parameter selection

Different international organizations have developed a number of water quality indexes. According to studies, the Water Quality Index is one of the best instruments for informing users and decision-makers in each community about the general quality state of the water supply[121].

2.12 Review of Implications of the Physico-chemical Parameters on Health

The risk posed by dumpsites is significantly influenced by the presence of chemicals in drinking water and groundwater. The impact of consuming contaminated water on human health is not mentioned, if any. According to studies, drinking contaminated water can have a negative impact on one's health and shorten one's life expectancy or ability. Numerous environmental and health risks are produced by open landfills. Methane is produced during the degradation of materials, and it can cause fires and explosions as well as significant leachate, which contaminates groundwater and surface waters.Similarly, the smoke that results from the unchecked burning of solid waste during the dry season seriously pollutes the environment. When toxic and hazardous garbage is burned alongside other waste, such as asbestos fibre, it could release smoke that contains filaments that could cause cancer[122].Air pollution is further exacerbated during the dry season by the frequent occurrence of fires in open dumps. Burning garbage is another method of lowering the amount of rubbish at the disposal. Some cities' dump administrators willfully set rubbish on fire to prolong the life of the dumpsite. Landfill fires can start intentionally through arson, unintentionally by spontaneous combustion, the accumulation of heated wastes, or even accidentally by exposure to the sun's rays. However, these fires significantly alter the environment or have the capacity to do so. It is also known that the emissions from these flames can impair both human and animal respiration[122]. Numerous illnesses, including anaemia, brain damage, anorexia, mental deficiencies, vomiting, and even human death, have been linked to lead exposure. In addition, cadmium has been linked to both agonistic and antagonistic effects on hormones and enzymes, which can result in a variety of abnormalities including lung cancer, kidney and liver damage, bone loss or weakening, and kidney and liver damage. Infants younger than three to six months of age experience negative consequences from high nitrate concentration[123]. Nitrite, which nitrate converts to, can oxidise haemoglobin (Hb) to methaemoglobin (metHb), preventing the body from transporting oxygen.

The list below provides a succinct review of some of the most prevalent negative effects that are typically caused by particular pollutants.

2.12.1 Dissolved Oxygen

Dissolved Oxygen (DO) is the quantity of oxygen found or measured in a sample of freshwater or wastewater at the moment of collection. The dissolved oxygen level could possibly drop if the amount of oxygen taken exceeds the amount given out. This could cause some delicate animals to perish, become feeble, or leave their environment[124].The effects of pollution result in a decrease in the amount of dissolved oxygen in a body of water. Wrinkler's titration or the electrometric approach utilising oxygen-detecting electrodes are two ways to measure dissolved oxygen[125].

Higher concentrations of dissolved oxygen are associated with high productivity and low pollution, and they are used as a sign of a water body's health. A lake or stream's health or cleanliness, the quantity and type of biomass it can support, and the degree of decomposition taking place in the lake or stream may all be assessed by it analysis[125].

2.12.2 Oxygen Demand

Two categories or significant oxygen demand parameters are biochemical oxygen demand and chemical oxygen demand. The amount of oxygen or dissolved oxygen needed by bacteria or microorganisms to completely oxidise organic matter present in a sample of water or waste water into carbon dioxide and water, or the amount of oxygen needed for decomposable organic matter present in any water, waste water, to break down into simpler substances, is known as oxygen demand[126].

2.12.3 Chloride

Chloride is mainly found in salts, which are used to prepare a variety of dishes.It is moreover present in a number of chemicals and occasionally in compound compositions. Therefore, its inclusion in numerous chemical compounds has proved beneficial in the creation of foods and packaging. It is utilized in the production of synthetic rubber, PVC, and pesticide. After being used, all of these materials are brought to the dumpsite by human activity, where biodegradation or chemical decomposition occurs, and causing runoff into the neighboring stream or ground water, which results in pollution or contamination. Therefore, the chemicals' high concentration and bioaccumulation have a negative impact on human health[127].

2.12.4 Nitrates

The metabolic oxidation of the ammonia and nitrogen present in organic matter leads to the creation of nitrates from it. The primary method for determining the amount of organic matter is experimental nitrate determination. Nitrate from organic matter seeps through the soil's structure, runs off into the groundwater, and contaminates the water. When adults drink dirty water, the high nitrate concentration has a negative impact since it might cause stomach problems. It is possible for nitrates to be reduced to nitrite, which can then oxidise haemoglobin (HB) to methaemoglobin (methb), which prevents the body from transporting oxygen[128].

2.12.5 Total Hardness

The ability of water to precipitate soap was once thought to be measured by the water's hardness. The presence of calcium and magnesium ions in water is the main cause of soap precipitation. Other polyvalent metal ions, such as strontium, aluminium, iron, manganese, and zinc, as well as hydrogen ions, may also contribute to the precipitation of soap. Calcium and magnesium are only present in natural streams in substantial amounts[129].

Temporary hardness, which can be eliminated by boiling the water or adding lime, results from a high concentration of calcium and magnesium ions.However, if there are a lot of polyvalent metal ions in the water, an ion-exchange procedure can get rid of them. All of these substances or elements enter the groundwater from the landfill, particularly during the rainy season when they are likely to flow off into the local groundwater[128].

2.12.6 Potentially Toxic Elements(PTEs)

These are substances that may be present in water, particularly waste water, due to pollution or poisoning of the groundwater nearby landfills. They exist in water in three different phases: colloidal, particle, and dissolved. Their specific gravities are greater than 4.0 and their atomic weights range from 63.6 to 200.6. PTEs include arsenic, aluminium, bismuth, beryllium, chromium, cadmium, copper, cobalt, iron, lead, mercury, manganese, strontium, tin, titanium, and zinc, among other elements. They are essential metallic elements with varying economic value. The atoms of these elements are kept together by powerful metallic connections to form crystal lattices, which are solid at normal temperature[129].

PTEs, which do not degrade or decay like organic contaminants, provide a problem for cleanup. It's possible that the persistent presence of potentially harmful components will lead to bioaccumulation and biomagnification.

2.12.7 Iron

After aluminium, iron is the metal that is most prevalent in the crust of the earth.Except in meteorites, it cannot be found in the free metallic state. These elements have the qualities of being shiny, malleable, ductile, and silver-gay. Because it can form complexes and exist in various oxidation states, iron is essential in biological processes. Long-term exposure to high concentrations of these elements in the body can result in conditions like retinitis, choroditis, and conjunctivitis. The oxides of these specific elements can move from the dumpsite to the neighbouring ground water, changing the hue of the water system[130].

2.12.8 Copper

Copper is a soft, lustrous, red solid metal that is exceedingly malleable, ductile, and has a high tensile strength. There is copper and its compounds in many types of food, drink, and air.It is sprayed on vines, citrus trees, and potatoes as a fungicide. Some body areas, including the nose, mouth, and eyes, can become irritated by copper since it is a potentially hazardous element. When this metal is present in excessive concentrations or is exposed to illnesses like headaches, stomach pain, and other symptoms can occur[131].

2.12.9Turbidity

This procedure measures the loss in transmitted light intensity brought on by the scattering of the particles suspended in the medium. To assess the purity of water or water samples, turbidity is utilised. We refer to water as being turbid when it is not clear but contains suspended particles like clay, silt, finely split materials, organic matter, plankton, and other microorganisms.

By simply comparing the interference of light rays travelling through a sample (a water sample) with that in standard samples, turbidity can be determined[132].

The intensity of light dispersed increases with increasing turbidity. Turbidimetry is a technique or method used to assess the turbidity of water samples. Therefore, the water becomes dirtier or more cloudy the more suspended particles there are. Due to the dirtiness or high turbidity of the groundwater, this might absorb and promote the spread of waterborne diseases, which is extremely dangerous to the public's health. These diseases are caused by pathogenic microorganisms like viruses, parasites, and certain bacteria.

2.12.10 Electrical Conductivity (EC)

An indicator of an electrical conductor's capacity to carry electricity is its electrical conductivity. The main cause of the portable water's electrical conductivity is dissolved mineral water. Although free carbon(iv)oxide and ammonia also affect conductivity, their impact is minimal except in very low salinity conditions.Ionic solutes are responsible for the electrical conductivity of polluted water, treatment plant effluents, and industrial waste water. Therefore, the conductivity's magnitude provides a helpful indication of the amount of ionic solutes present[133].

Scm^{-1} or $UScm^{-1}$ is the unit used to measure electrical conductivity (S is used after Siemens). Due to the presence of dissolved ions in the water, electrical conductivity will increase if the temperature of water samples is high. This is an additional method for figuring out the ion content of our samples as well as the quality of the soil and water.

2.12.11 pH

The concentration of hydrogen ions in water is known as pH. With the use of a potentiometer or pH metre, the pH value of water is calculated as the reciprocal of the log of the hydrogen ion concentration. If the water's pH is below 7, it will be acidic, and if it is over 7, it will be alkaline. The pH level of pure water is 7. pH has additive effects; in stagnant water, pH is impacted by its age as well as the chemicals released by nearby neighbourhoods and businesses.Due to the fact that most biological life only survives in a very limited and important pH range, pH is a sign of biological life. Numerous harmful and beneficial substances' solubility is influenced by the pH of water. Most metals become more water soluble and poisonous as acidity rises. A reduction in pH (increase in acidity) also results in an increase in the toxicity of cyanides and sulphur compounds. However, even a small pH increase makes ammonia more hazardous[134].

2.12.12Calcium

One of the elements that is present in all water, whether it is pure, treated, polluted, etc., is calcium. Its richness and presence in the human body contribute to bone strength and growth. Calcium is necessary for human health and is advantageous. Calcium and magnesium salts are the main contributors to water hardness. The "curd" that forms when soap reacts with calcium and magnesium ions is one of the most typical signs of hard water. Mineral deposits were also created as a result of hard water[135].

2.13 Impact of Dumpsites on the Quality of Soil

Due to faulty management of the waste items dumped on it, the soil composition has been altered and is currently experiencing some difficulties. These waste materials result from human use of goods and services. Most of these waste materials come from businesses and individuals, primarily. Many businesses and citizens of developing nations are careless and unconcerned about the harm that inappropriate waste management does to humanity. These have been happening for a while. when governmental regulations are not followed and implemented[136].

Population growth has contributed to garbage production over time. Waste is often burned outside in these cities, and the ashes are dumped there. The hazardous effects of heat and ashes on soil composition have led to the destruction and reduction of soil nutrients and other soil constituents[137].

Inadequate waste management often poses a major threat to human health. The majority of people who live close to dumpsites are at risk for serious harm because they frequently come into contact with contaminated water, soil, air, and plants. The trash produced from various sources that ends up in the dumpsite fills up and creates these dumpsites.All of these pollutants pollute the soil, changing its makeup and causing it to lose nutrients. Additionally, there is a significant buildup of several organic compounds and potentially hazardous components[138].

It is risky for these non-biodegradable chemicals, elements, and organic materials to bioaccumulate. Potentially hazardous substances that are stable and simple to accumulate in soils are very difficult to remove, dangerous to organisms, and can influence the quality and characteristics of the soil system and the food chain for humans.Therefore, all of these indicate that it is impossible to disregard the possibility that open landfills or dump sites are a source of potentially dangerous element concentrations that cause environmental pollution. As a result, there has been much debate about the investigation of potentially harmful substances and other contaminants in landfills and open dumping grounds. Reviewing some of these studies reveals that the area around open dumps and landfills has been seriously affected by metals[139].

"Potentially toxic elements content of soils is a critical measurement for assessing the risks of refuse dumpsites and useful to assess pollution in the environment." In order to properly prescribe corrective actions, it is crucial to continuously monitor the soil quality in the area around dumpsites for the presence of potentially harmful components.

Leachate from landfills and dumps contributes to the chemical contamination of surface and ground waters. Organic materials, ammonium, magnesium, calcium, salt, sulphate, potassium, iron, PTEs (e.g., Cr, Cd, Cu, Pb, Ni, Zn), and other contaminants are known to be present in leachates.

2.14 Waste Disposal and Soil Degradation in Nigeria

The production of waste is an inevitable part of life; it cannot be stopped, but it may be controlled. Today, Port Harcourt in Rivers State is rapidly urbanizing as a result of rising economic growth and population growth[140]. Open dumpsites are typically unhygienic and smelly locations where disease-carrying rodents like rats and flies thrive. Commonly found in waste on dump sites are hazardous metals, which are dangerous to humans when they come into touch with poisoned plants or soil. Due to contamination, changes in the physical and chemical features of soil are frequently caused by the chemical composition of solid waste materials[140]. The heavy metals group is one of the most contaminated subgroups[141]. Hazardous substances that are dissolved in leachates from trash dumps, such as heavy metals, herbicides, and hydrocarbons, frequently contaminate soil and water.

Nigeria, a developing nation with inadequate waste disposal or recycling procedures, runs the risk of having its soil and surface water bodies contaminated by metals and organometallics, posing a health concern and degrading the land's suitability for agricultural use. One of the key factors influencing vegetation development at these dumpsites is the physicochemical composition of the degraded soils142. For instance, soil composition and acidity have a significant impact on how well plants absorb and store minerals, which has a direct impact on the establishment and growth of vegetation in such locations.

When toxic substances are dumped into landfills, they typically run off into groundwater and surface waters, where they eventually contaminate water due to leachate percolation[143]. Many workers have reported finding different heavy metals, including Mn, As, Cd, Ni, Co, Cu, and Fe in municipal solid waste dumpsites[144,145,146]. Monitoring of soil qualities and physicochemical characteristics, particularly heavy metal concentration in dumpsites, becomes vital since these contaminants have an impact on the environmental qualities in and around such dumpsites, which makes it easier to suggest appropriate remedial methods[146].

In addition to having decreased levels of their most crucial physical characteristics, such as structural stability and water retention, trash dumpsite soils are also deficient in organic matter and fertility[147]. These qualities eventually have a negative impact on the soil by either inhibiting plant growth or exposing the specific area to erosion processes.

2.15 Heavy Metals and Their Effect on Soil Physicochemical Characteristics.

Because of the negative consequences on food quality, crop development and production, and environmental health, heavy metal deposition in soils is a major concern in agricultural production[147].

The production and sustainability of crops may deteriorate as a result of contaminated soils. Because they are persistent in the environment, heavy metals have the potential to bioaccumulate. Their characteristics allow them to move up the food chain, even in little amounts. They build up over time and get bigger across the trophic levels, posing major health risks to tertiary consumers like humans[148].

The primary soil physicochemical characteristics that affect the solubility of metals include soil composition (organic or inorganic), pH, type, and density of charge on soil colloids, as well as reactive surface area. The nature and reactivity of hydrous oxide, particle size distribution, mineralogy, soil aeration, and microbial activity are all factors that will affect this phenomena. In contrast to the high capacity of the soil organic matter interaction, it has been observed that the mobility of heavy metals decreases in soils with inorganic matter[149]. The pH enhances the sorption. In other words, more metal may be discovered in solution and is subsequently mobilized the lower the pH value. Mobility is improved when pH is below 5 due to an increase in proton concentration. Some heavy metals have a tendency to form hydroxyl-complexes at pH levels higher than 7, which will boost the metal's solubility. At pH 6.5, adsorption is stronger than at pH 4.5[141]. The mobility sequence that was seen was Ni <Mn< Cr <Cu <Pb. Since their ability to bond to soil organic matter is trending in the other direction, there will be a decrease in mobility[149].

Heavy metal speciation and chemical form have a substantial impact on the fate and transport of the metals in soil. Heavy metals are re-distributed into several chemical forms with differing bioavailability, mobility, and toxicity once they have been absorbed by the soil through an initial rapid reaction, followed by a long adsorption reaction[143]. It is thought that soil-borne reactions involving heavy metals, such as mineral precipitation and dissolution, ion exchange, adsorption and desorption, aqueous complexation, biological immobilisation and mobilisation, and plant uptake, regulate this distribution[149].

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Chapter Three

Methodology

3.1 Samples Used

3.1.1 Soil Sample

To evaluate the quality of the soil and water in the area, samples of both were taken from the dumpsites and subjected to physicochemical examination, potentially hazardous element (PTE) content determination, and microbiological analysis.Transects were drawn at each sampling site along which soil samples were taken[1].Along each of the transect lines, four samples of the top soil were collected1. At the dumpsites and reference site, samples were taken within 500 mm of the surface and put in a black polythene bag. After being air dried, the soil samples were pulverized, put through a 2 mm filter, placed in clean polythene bags, and kept at room temperature for laboratory examination. The physiochemical characteristics of the soil samples were assessed using the recommended techniques by the Association of Official Analytical Chemists[2]. pH, temperature, moisture content, electrical conductivity, chlorides, sulphides, nitrates, magnesium, potassium, and calcium, as well as ammonium, were the characteristics that were determined.

Hydrochloric acid digestion was used to analyze the PTEs. Metal ion concentrations were measured using an atomic absorption spectrophotometer (model Philips PU 9100) with a hollow cathode lamp and a fuel-rich flame (air acetylene). Each sample was inhaled, and the mean signal response was recorded at the wavelength of the metal ion. The total heterotrophic bacteria, total coliform, and Escherichia coli were identified using the modified methods for the microbiological examination of the soil samples[3,4]. Bergey's handbook of classification was used to identify and categorize the isolated microorganisms[5].

3.1.2 Water Samples

Sixteen water samples were taken from water sources 20 metres distant from the chosen dumpsites, including eight samples from wells, four samples from streams, and four samples from boreholes. Then, a sizable number of representative samples were gathered into plastic bottles[6,7]. For the water sample collected at the reference site (acting as the control), the process was repeated. Upon arrival at the lab, water samples were preserved in 5% v/v nitric acid before being examined for the chosen physical, chemical, and biological characteristics.

The American Public Health Association's recommended methods were used to assess the physicochemical quality of the water samples (effluent from the dumpsites into the water source)[8].These variables included total suspended particles, electrical conductivity, nitrates, dissolved oxygen, chlorides, pH, biological oxygen demand, temperature, sulphates, and hardness, as well as magnesium, potassium, calcium, and ammonium.

Hydrochloric acid digestion was used to conduct the PTEs analysis. The concentrations of metal ions were measured using an atomic absorption spectrophotometer (model Philips PU 9100) with a hollow cathode lamp and an acetylene-rich flame. Each sample was inhaled, and the average signal response was recorded at the wavelength of the metal ion.

Escherichia coli, total coliform bacteria, and total heterotrophic bacteria were identified using modified methods for the microbiological examination of the water samples[9,10]. Bergey's classification handbook was used to identify and characterize the isolated bacteria[11].

3.2 Chemical/Reagents Used

Deionized water, sodium carbonate, conc. HCL, 2 ml NaCl mixture, Nitric acid solution, silver nitrate solution, potassium thiocyanate solution, trimethylhexan-1-ol, ferric alum indicator, Distilled water, phenolphthalein indicator, concentrated HCl, BaCl,0.5g Sulphanilic acid, 0.01m potassium chloride references solution, 0.1g naphthylamino, glacial acetic acid, Nitrite – free distilled water, Manganese(II)Sulphate solution, Alkali-iodide-azide reagent sodium thiosulphate solution, Concentrated H_2SO_4, starch, sodium acetate-acetic acid buffer, gum of Acacia and barium chloride Crystals, conc. HNO_3, conc. $HCLO_4$.

3.3 Instruments Used

Atomic absorption spectrophotometer (model Philips PU 9100), sample jar, beaker, whatman Filter Paper, Burette 50ml, weighing balance, stoppered conical flask, 500 ml plastic bottle, measuring cylinder, filter paper, medium grade filter funnel, mechanical shaker, filter paper, desiccator, lovibond nassleviser (BDH type), nassler tube (50ml), lovibond comparator permanent glass standard, conductivity meter and cell, shaking bottle, pH metre, standard buffer solutions of known PH value; standard used are pH 4.0, 7.0 and 10.0, water, glass stirring rod, Secchi disk, measuring cylinder, filter paper, drying oven, desiccator, wash bottle with D_1, thermometer, incubator, membrane filtration unit, sterile petric plate, biological safety cabinet, membrane filter, pipette, forceps, microwave oven, autoclave, Sintered-glass filter crucible having fine porosity with holder, volumetric flask.

3.4 Study Site

The dumpsite in Ajakanga is a significant open garbage disposal site in the metropolis of Ibadan that accepts household, business, and industrial wastes. Communities nearby face an environmental risk due to the dumpsites ongoing rubbish burning. Additionally, leachate from the landfill and runoff from rain at the trash disposal site contaminate the soil and water used for home, agricultural, and industrial purposes.

3.5 Description of Project Environment

3.5.1 Geographic Location

The Ajakanga dumpsite is situated along Odo Ona Elewe road near Arapaja in the Southwest of the Ibadan Metropolis between Latitudes 7018.90'N and 3050'E and 3051'E (Figure 1). It is reachable via a decent road and walking route network. The dumpsite is gradually becoming encircled by developed residential areas as a result of increased urbanization.

3.5.2 Geomorphology Climate and Drainage

The Ajakanga's topography is gently undulating with a few migmatite gneiss inselbergs scattered about. The dumpsite is located in a tropical climate zone, where the average temperature is 27°C from April to October during the wet season and 32°C from November to March during the dry season. 1300 mm of rain falls on average per year in the area. Tropical rain forest with dense undergrowth makes up the vegetation. River Ona and its tributaries drain the region around Ajakanga. Dendritic drainage is present.

3.5.3 The Local Geology

The Ajakanga Waste Dumpsite and its surroundings are primarily composed of quartzite, magmatite Genesis, and biotite-hornblende gneiss (Figure 2). The rock outcrops are mostly low lying, however along the Arapaja, Odo-ona route, in particular, inselbergs and isolated ridges of gneisses were found. They have thick foliage on these outcrops. N-S is the foliation's strike, while W is the direction of the dip.

3.6 Methods

3.6.1 Procedure of Analysis

The analysis was performed using a standard reagent, and all equipment was sterilized and washed with distilled water. Using the calibration curve approach, the atomic absorption spectrometer was calibrated by preparing standard solutions in at least four different concentrations, measuring the absorbance of this standard solution, and then creating a calibration curve based on the results.

The data acquired were shown to be as mentioned satisfactory and compared with the recommendation limit given by the World Health Organisation (WHO) and National Environmental Standard and Regulation Agency (NESREA).

3.6.2 Determination of Moisture Content (Soil Sample)

Procedure

Four soil samples were dried in an oven at 105°C overnight before being weighed. The samples were then reweighed after each had received 10 ml of deionized water. Once again, they were dried in the oven over night, and the following morning, as soon as they were taken out, they were weighed. From the equation below, the soil moisture content (Q) is computed.

$$Q = \frac{\text{wet weight} - \text{dry weight of soil sample}}{\text{Dry weight} - \text{jar weight}}$$

3.6.3 Procedure for the Determination of Nitration Soil Sample

Procedure

A 50 ml beaker was used to transfer 1.0 g of soil sample, which was then separated four times with 5 ml each of 0.5% sodium carbonate solution, filtered using Whatman filter paper, and weighed.

3.6.4 Procedure for the Determination of Chloride in Soil Sample

Principle

By dissolving dry soil samples in a mass of water that is twice as large as the sample, chloride is extracted, and the results are represented as chloride ion content.

Procedure

Standardization of thiocyanate solution involved transferring 25 ml of silver nitrate solution into a 250 ml conical flask, adding 5 ml of nitric acid solution with a pipette, 1 ml of ferric alum indicator solution, and then adding a thiocyanate solution from a burette until the first paramount colour, or a change from colourless to pink, appeared. The amount of thiocyanate injected was measured as V1 (m m/l), and by calculating the solution's concentration C (m mol/l), we have

$C=2.5/V_1$

- A small amount of soil was weighed into a bottle, and then twice as much distilled water was added, shaking the mixture to mix it. The suspension was then filtered through medium-grade filter paper into a clean beaker until at least 100ml of clear filtrate was collected.

3.6.5 Analysis of Extract

A 250ml conical flask is filled with 100ml of the filtered extract. The flask was first filled with 5ml of nitric acid solution, then with silver nitrate solution from a burette until all of the chloride had precipitated, and then with some extra silver nitrate.

Silver nitrate solution was measured as having a total volume of V (ml). In order to coagulate the precipitate, 2ml of 3,5,5-trimethylhexan-1-ol was added. The first lasting colour shift, from colourless to brick-red, was observed after the addition of 5ml of the ferric alum indicator solution and the standardized thiocyanate solution from a burette. The amount of thiocyanate solution that was added was measured, V_3(ml).

Calculation

Chloride content = 0.007092 (V_2- 10CV_3)

Where V_2 = volume of silver nitrate solution added

V_3 = volume of standardized potassium thiocyanate solution added.

C = concentration of standardized potassium thiocyanate solution.

3.6.6 Procedure for Determination of Sulphate in Soil Sample

Sodium sulphate, a kind of sulphate, is constantly present in soil. Climate change has an easy hydrating and dehydrating effect on salt.

Procedure

The soil sample is diluted to 25ml and placed in a beaker. A further 4ml of hydrochloric acid was added to the solution to make it acidic in order to test the solution's alkalinity using the phenolphthalein indicator. After the solution had boiled and cooled, heated barium chloride solution was added in a thin stream while being constantly stirred, until further additions did not cause precipitation. The precipitate was allowed to settle in the beaker while it was in a steam bath for at least four hours. To further the precipitation and remove the chloride ion, ashless filter paper wash was used. The paper was then dried. The precipitate was then ignited over a hob for 30 minutes using a low heat. Cool in a desiccator, weigh, and note the residue to find out how much barium sulphate is in it.

Calculation

a) Sulphate (SO_4) percent by mass = 41.15 W_1/W_2

b) Sodium Sulphate (Na_2SO_4) percent by mass = 60.85 W_1/W_2

Where, W_1=mass in mg of the precipitate

W_2 = mass of g of the dame contained in the solution taken for precipitation.

3.6.7 Electrical conductivity of the soil samples

This shows how many soluble (salt) ions are present in the soil.

Principle

A 1:5 suspension of soil and water is used to measure the electrical resistance and determine the electrical conductivity (EC).

Procedure

50ml of deionized water and 10g of air-dry soil were added to a bottle to create a 1:5 soil:water suspension. For one hour, it was mechanically agitated at 15 rpm to dissolve the soluble salts. The KCL reference solution was used to calibrate the conductivity in accordance with the manufacturer's instructions in order to determine the cell constant. After completely rinsing this cell, the electrical conductivity of 0.01 mKCL was measured at the same temperature as the soil samples. The soil suspension was used to rinse the conductivity cell. After that, the conductivity cell was recorded.

Calculations

$$Ec_{25}(ds/m) = \frac{S \times 1.414}{K}$$

Where S= measured resistance of suspension

K= measured resistance of Kcl solution

3.6.8 Procedure Used for Measuring pH in Soil Samples

Calibrate the PH master first using two buffer solutions, one with a neutral PH (7.0) and the other selected based on the range of PH in the soil. The two beakers containing the buffer solutions were filled with the buffer solution, the electrode was inserted into each beaker in turn, and then the PH as determined by the buffers was ready to test the samples. A 50 ml beaker containing 10.0 g of soil sample was filled with 20 ml of $CaCl_2$ solution.

Without stirring, the soil samples were allowed to absorb the CaCl2 solution before being thoroughly agitated with a glass rod for 10 seconds. After stirring the suspension for 30 minutes, the pH was measured using a calibrated pH.

3.6.9 Determination of Ammonium in Soil Sample

After the soil sample has been dissolved, the results are identical to those of water samples.

3.6.10 Microbiological Analysis of Soil Sample

The glassware was treated in a hot air oven at 160° C for 2 hours, while the polyethylene bags used to collect the samples were cold-sterilized in a UV radiation box for roughly 12 hours. Growth media were autoclaved at 121°C for 15 minutes along with diluents (distilled water).

Procedure

After mixing the soil sample, 1g (dry weight equivalent) of suspension was made in 10 ml of sterile water. The standard spread-plate dilution method outlined by Seeley and Vandenmark was used to estimate the presence of aerobic heterotrophic bacteria using 1 ml of the soil suspension that had been serially (10-fold) diluted[13]. To isolate the bacteria, nutrient agar containing 0.015% (w/v) nystatin (to prevent fungal growth) was employed, and it was cultured for 5 days.

On an agar slant at 4 oC, pure isolates of a representative community were kept. Based on cultural, microscopic and biochemical traits and with reference to Berey's manual of determinative bacteriology for bacterial, isolates were identified. Based on the applied dilution factor, the visible colonies on the plate were counted and documented[12].

$$\text{Number of organism} = \frac{numberofcolonies}{10ml} \text{ X } \frac{\text{dilution factor}}{1}$$

3.6.11 Procedure of Analysis of Water Samples

3.6.11.1 Procedure for the Determination of Nitrite from Water Samples

The diazotization method is used to determine nitrite levels. The process is based on combining the resultant diazonium molecule with alpha-naphthlyamino to produce a red azo-die after diazotizing Sulphanilic acid by nitrite in acid solution.

Solution A

At a temperature of 60 to 70 ◦C, 0.5g of sulphanilic acid was dissolved using consecutive portions of the mixture containing 30ml of glacial ethanoic (Acetic) acid and 120ml of nitrite-free distilled water.

Solution B

A mixture of 0.1g napthyl-amime and 30ml glacial ethanoic (acetic) acid was prepared, and 120ml nitrite-free distilled water was added.

Procedure

Following the addition of 2ml of solution A and 2ml of solution, 50ml of water sample was placed in a Nessler tube. In-depth mixing of the solutions was done before a 15-minute standing period. A Nessler tube was also filled with 50 ml of distilled water free of nitrites, 1 ml of diluted standard nitrite solution, and 50 ml of that mixture was then added. The mixture was then properly mixed. Readings were acquired from the Lovibond comparator permanent glass standards and the mixture's colour was matched in the Lovibond Nesslerizer.

3.6.11.2 Procedure for the Determination of Dissolved Oxygen of Water Samples

Winkler's titration is used to carry out the method of determination.Another method uses an oxygen-detection electrode and is electrometric.

Principle

Anhydrous DO in water is coupled with manganese(II) hydroxide in a solution to generate manganese(II) hydroxide, or Mn(OH)2, which oxidizes the metal's lower valency state Mn2+ to the higher valency state Mn^{4+}, which precipitates as brown hydrated oxide.

$Mn^{++} + 2OH = Mn(OH)_2$.

$2Mn(OH)_2 + O_2 = 2MnO_2 + 2H_2O$

Fixation of oxygen is another name for the process that produces MnO_2.

Procedure

A 300 ml bottle containing the water sample had 2 ml of $MnSO_4$ Solution and 2 ml of alkali-iodide-azide added to the liquid just below the surface. When adding conc. H_2SO_4, the acid was allowed to flow down the bottle's neck before the stopper was carefully employed to keep air bubbles out of the mixture and it was gently inverted many times until clear supernatant water was achieved. Conc. H_2SO_4 was then added.Before decanting the required amount for the titration, the iodine is then evenly distributed throughout the solution. To titrate, 100 ml of the solution were taken, and 0.0125 $Na_2SO_3.\ 5H_2O$ solution was added until the solution reached a pale straw hue. The titration was repeated by adding dropwise amounts of the thiosulphate solution after adding 1-2 ml of starch solution until the colour turned blue.

$$\text{Calculation}=\text{mg}/^{L}\ \text{DO} = \frac{16{,}000\times M\times V}{(V_1 - 2.0)}$$

Where M= Morality of the thiosulphate solution

V_1= Volume of the bottle, with stopper in place

V= volume of thiosulphate used for titration.

Procedure for BOD

The standard method for performing a BOD test is to measure the amount of dissolved oxygen in any sample both before and after it has been incubated for five days in the dark at 20 ◦C.

3.6.12 Procedure for Determination of Chloride in Water Sample

A 100 ml beaker containing 5 ml of the water samples was diluted to around 25 ml with distilled water. To the dark yellow solution, 5–6 drops of $K_2Cr_2O_4$ indicator were added. The mixture was then continuously stirred as it was titrated against the standard $AgNO_3$ solution until the first brick-red turge appeared. In order to prevent errors brought on by chemical impurities, a blank was run. The calculations is as follows:

Cl mg/litre of water=X x 1.755 x 1000ml of sample

Where:

- ml of water sample = 5
- X = ml of 0.05M $AgNO_3$. Consumed in titration
- 1.755 = factor representing mg of Cl in aliquot/sample as calculated below.

1ml of 1M $AgNO_3$ = 0.05M of cl = 35.5 x 0.05 = 1.775mg of Cl (in aliquot)..

3.6.13 Procedure for the Determination of Sulphate in Water Samples

Procedure

25ml of the volumetric flask held 5ml of the water sample (1mes/litre). To keep the PH at roughly 4.8, 10ml of sodium acetate-acetic acid buffer was also added. After thoroughly mixing 1ml of gum acacia and 1g of Bacl2 crystal, 25ml of distilled water was added. The flask was created multiple times to measure turbidity using a spectrophotometer and a blue filter at 440 nm. Following the preparation of the standard curves for 0, 1, 2, 3, 4, and 5, 2.5, 5, 7.5, 10, and 12.5 ml of a stock solution containing 10 m/litres were pipetted into 25 ml volumetric flasks.Then, for the water samples, its turbidity was generated and its intensity was measured. S concentration on the x-axis and absorbance on the y-axis were plotted on a curve. Using the standard curve and the free dilution factor (5ml made to 25ml), the S content of the water samples is determined and expressed as m/litres.

3.6.14 Procedure for Determination of Electrical Conductivity of Water

An aqueous solution's capacity to carry an electric current depends on the ions it contains, as well as their concentration and mobility.

$G \alpha (A/l)$ or $G= K (A/L)$

Where k is called conductivity or specific conductance and the unit of K is mho/cm

Procedure

Using standard solutions, the conductivity metre was calibrated in accordance with the instructions provided in the manufacturer's manual. The sample was rinsed with the cell, and the conductivity or resistance of the sample was then determined. Utilising the TDS mode, the total dissolved solids (TDS) were measured.

To calculate cell constant k (cm^{-1})

$K = R (KCL) \times ct\ cm^{-1}$

R (KCL) is the measured resistance of standard potassium chloride solution

Ct = conductivity ($uscm^{-1}$) of the standard potassium chloride solution at $t^{o}c$ (when $t = 25^{o}c$), ct = $0.0014135cm^{-1}$ or $1413uscm^{-1}$)

To calculate the conductivity Cs ($uscm^{-1}$) of the simple which is given by;

$Cs = K/RS = \underline{R(KCL) \times CT}\ uscm^{-1}$

Where; RS= measured resistance of water sample

3.6.15 Procedure for Determination of Nitrate in Water Sample

The distillation flask was filled with 50ml of the water sample. 0.2g of Devarda's Alloy and 0.5 g of MgO were added. A conical flask that is attached to the distillation equipment was then filled with the NH_4 (NO_3 transformed into NH_4 by reducing agent Devarda's alloy) after the mixture had been heated. About 35 to 40 ml of distillate were obtained after further distillation. The heating system was turned off before the distillate was removed. The distillate was titrated against 0.02M H_2SO_4 after that till the pink colour appeared. At the same time, a black titration was performed. The calculation:-

$$NO_3 = N\ (\text{mg/litre}) = \frac{(X - Y) \times 0.56 \times 1000}{50\text{ml of sample}}$$

Where:

- X = Volume (ml) of 0.02m H_2S0_4 consumed in sample titration.
- Y = Volume (ml) of 0.02m H_2S0_4 consumed in blank titration.

- 0.56 = Factor ; 1 litre 1M H_2S0_4 = 28g N;

- therefore 1ml 0.02m $H_2S0_4 = \frac{28 \times 0.02 \times 1000}{1000}$ mgN

= 0.56mgN

3.6.16 Procedure for Determination of pH Value Of Water Sample

Procedure

Using a clean glass stirring rod, the water samples were thoroughly swirled before the 40ml + 5ml sample was added to the glass beaker and covered with watch glass. In order to allow the temperature to stabilize, the sample was left standing for an hour while being stirred now and then. The sample's temperature was measured, and the PH meter's temperature controller was set to match the sample's temperature. Following standardization of the PH metre, the electrode was inserted into water samples, and the beaker was rotated just enough to ensure good contact between the water and the electrode(s). The PH value is read and recorded after the PH metre has stabilized.

3.6.16 Procedure for the Determination of Temperature of Water Samples

For an accurate reading, the thermometer was properly inserted into the sample. Prior to removal, the temperatures were then recorded to the nearest fraction of a degree Celsius. At various depths and intervals, the temperature of the water samples was noted.

3.6.17 Procedure for Determination of Total Dissolved Solid in Water Samples

A 150ml clear, dry glass beaker with the proper identification mark was used. It had been kept in an oven at 1030°C for an hour. Weighing the beaker. The filtrates were called after 100 ml of the water sample had been filtered through two layers of filter paper. The beaker was kept in an oven set at 1030°C for 24 hours before being allowed to cool and weighed.

Total Dissolved solids, TDS (mg/l)

$$= \text{mg of solids in the beaker} \times \frac{1000}{\text{Volume of sample}}$$

Also, Total Suspended solids

TSS (mg/l) = TSS (mg/l) =TS (mg/l) – TDS (mg/l)

3.6.19 Determination of BOD in Water Samples

BOD, is a measure of how much oxygen is used by microbes in stream water to break down organic materials. Two samples must be taken at each site (Sample site) in order to assess BOD. One is checked right away for the presence of dissolved oxygen, while the other is incubated for five days in the dark at 20°C before being checked again for the presence of dissolved oxygen. The amount of BOD is the difference in oxygen levels between the first and second tests, expressed in mg per litres (mg/l). This reflects the amount of oxygen that microorganisms used to decompose the organic material in the sample bottle while it was incubating.

3.6.20 Determination of Chemical Oxygen Demand (COD) in Water Samples

An indirect way to gauge the amount of organic material present is to use COD. The COD test is based on the fact that almost all organic compounds can fully oxidise to carbon dioxide when exposed to an aggressive oxidising agent in an acidic environment. The comparable amount of oxygen is then compared to the quantity of oxidising agent required to thoroughly oxidise the organic substance.

When dichromate, $Cr_2O_7^{2-}$, was utilised, each chromium atom changed from an oxidation state of +6 to +3 in the liberated ion Cr3+ during the oxidation-reduction reaction. The excess dichromate ion is added, and COD is calculated. Following the procedure, the excess amount of dichromate is determined by ferrous ammonium sulphate titration.In milligrammes per litre (mg/l), COD is measured.

3.6.21 Determination of Ammonium in Water Sample

Ammonium in the water was determined using capillary zone electrophoresis and direct UV detection. During migration, some of the ammonium in the samples was transformed into ammonia in the alkaline background electrolyte (BGE), and this was picked up by molecular absorption of ammonia at 190nm in a 7mm region. At a signal-to-noise ratio of three, the ammonium limit of detection (LOD) was 0.24 mg/l (as nitrogen). After that, the appropriate value was recorded.

3.6.22 Microbiological Analysis of the Water Sample

To identify E. coil, total coliform, and total heterotrophic bacteria in a water sample.**Process and Procedure**

In sterile polypropylene sample containers with leak-proof lids, water samples were obtained. We used a sterilised glass or plastic container, like a Whirl-Pak bag filled with sodium thiosulfate. The water flow should be moderate for two to three minutes before a portable water sample is taken. Hold the container below the water's surface in a river, lake, or reservoir to collect a non-potable sample before removing the cap. To avoid collecting water sample scum, take off the cap and lower the container so that the mouth is below the water's surface. Submerged, completely fill the container. Take a sample of at least 100 ml. Maintain an air space inside the container of no less than 2.5 cm (1 inch). As quickly as feasible, begin the analysis after writing the sample information on the container. Keep the sample at or below 10 °C (50 °F) for a maximum of 8 hours if immediate analysis is not possible. Keep the sample from freezing.

Culture Media Preparation

Chromocult coliform Agar

Put 2.25g in 100ml of distilled water and stir. To fully dissolve it, heat the medium for two minutes at boiling point. Place 15 ml into a sterile petri plate, and then let it cool.

Filtration Unit Preparation

Aluminium foil should be wrapped around each membrane filtering component (glass) before placing them in an autoclave to sterilise them. In the Biosafety cabinet, remove the sterile membrane filtration component. Establish the membrane filtering system. First, join the lower part (collector flask) with the middle part (Base). Second, properly position the filter paper on the middle portion. Thirdly, put the upper portion (funnel) correctly above the filter paper. Finally, secure the components using a clamp or locker clip. Each stage needs to be carried out aseptically. Homogenize the water sample by shaking or spinning it. Utilizing a sterile measuring cylinder, measure 100ml of the water sample. Place the water sample in the filter unit's upper section. Connect the hoover pump to the filtration unit, and then turn it on. By doing this, water filtering continues even after the hoover pump is turned off. Detach the set from the vacuum pump and take out the locker clip or clamp once the water has been filtered. After that, take the filtration unit's top portion out. In the centre of the chromocult coliform agar for E. coli and coliform, place the filter paper. Place the filter paper so that there is no air trapped behind it. When moving the filter paper to the agar plate, keep the upper side up so that it doesn't touch the media.

The plate with a lid was covered. Label the plate with the sample name and incubate it for 24 hours at 35 °C. Avoid inverting the plate while maintaining Incubate the plate, and then remove it. The after-incubation colour shifts the quantity of pink and blue colonies on filter paper. E. coli blue colonies Colonies that are blue and pink are coliform. Count the amount of blue colonies of Coliform and E. coli bacteria on filter paper.

(N1)=70 CFU

Number of pink/purple colonies on filter paper (N2)=120 cfu

Total coliform =N1+N2

3.6.22 Determination of PTEs

Elements classified as potentially hazardous are those with densities more than 5gcm^{-3} (or 5kgm^{-3}).These are typically found in the periodic table's group III-V. Atomic Absorption Spectroscopy or a colorimeter can successfully identify how much of these elements are present in any type of water. It moves quickly and doesn't call for complicated separation methods.

Atomic absorption spectroscopy is employed in this study to identify the presence and quantities of potentially harmful components in soil and water sampled. wherein the flame vaporised and atomized the atoms of an element. The light at the characteristic wavelength was then absorbed by the atoms. A hollow cathode lamp, which was built of the same unidentified element, served as the light source. The lamp generated radiation with the right wavelength, which was absorbed by the sample's free atoms as it passed through the flame. A photo-detector read-out device calculated the amount of energy that was absorbed. The concentration of the element in the sample determines how much energy is absorbed. Before and throughout the determination, the equipment was tested for standard solutions of each element to ensure that it was functioning properly.

All subsequent analyses use an aliquot of the sample that has been digested.

Procedure

To get an aliquot of the samples (water or soil), the samples were digested. Digestion procedure: To evaporate the sample, 5 ml of concentrated HNO3 was added to 100 ml of the acidified sample in a 250 ml conical flask. The sample was then heated on a hot plate to roughly 60 °C for 15 minutes. The sample that had evaporated was then placed in a 125 ml conical flask, allowed to cool, and then 5 ml of concentrated HNO_3 and 10 ml of 70 oC $HClO_4$ were added. A dense, white $HClO_4$ fume appeared after carefully and gently adding a few glass beads. The clarity of the solution was checked. 10ml of concentrated HNO_3 was added, a watch glass was placed on the mouth of the flask, and the mixture was gradually heated on a hot plate while maintaining a very low boil until a clear solution was generated.

The mixture was cooled, diluted with 50ml of distilled water, then heated to remove any chlorine or nitrogen oxides that might have been present before being filtered through sintered glass crucible and placed in a clean flask. The 100 ml volumetric flask containing the filtrate was then filled with the filtrate after the filtrate had been transferred from the filter.After cooling, the solution was poured into the volumetric flask until it reached the 100ml mark. The mixture was then vigorously stirred to combine. About 0.8M HCLO4 was used as the solution.The solution was then divided into aliquots for use with an Atomic Absorption Spectrometer (AAS) to identify the metals.

N.B: To check for PTE presence and metal concentrations, the same process was applied to soil samples.

Calculation

M_W(mg/l)=Absorbency(mg/l)×D(L)/weight of sample.

D=Volume of Digest,Absorbency=Instrument reading.

Note: Dilution factor for potassium was 2500,and for other elements including calcium,iron,sodium and magnesium was 100

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Chapter Four

Results and Discussion of Findings

4.1 Results

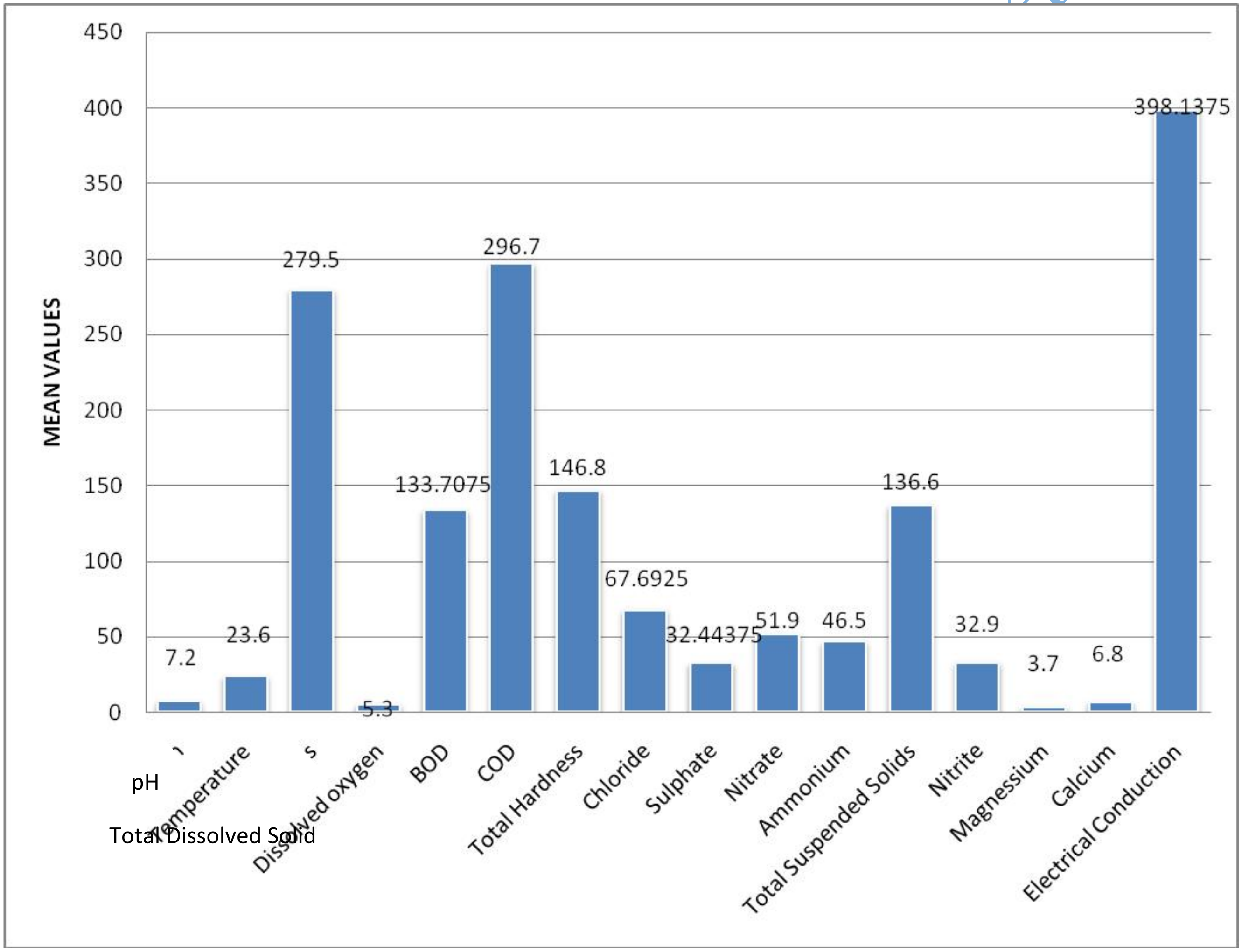

Figure 4.1: Mean Values of Physiochemical Parameter of Water Samples

Source: Field Work, 2022.

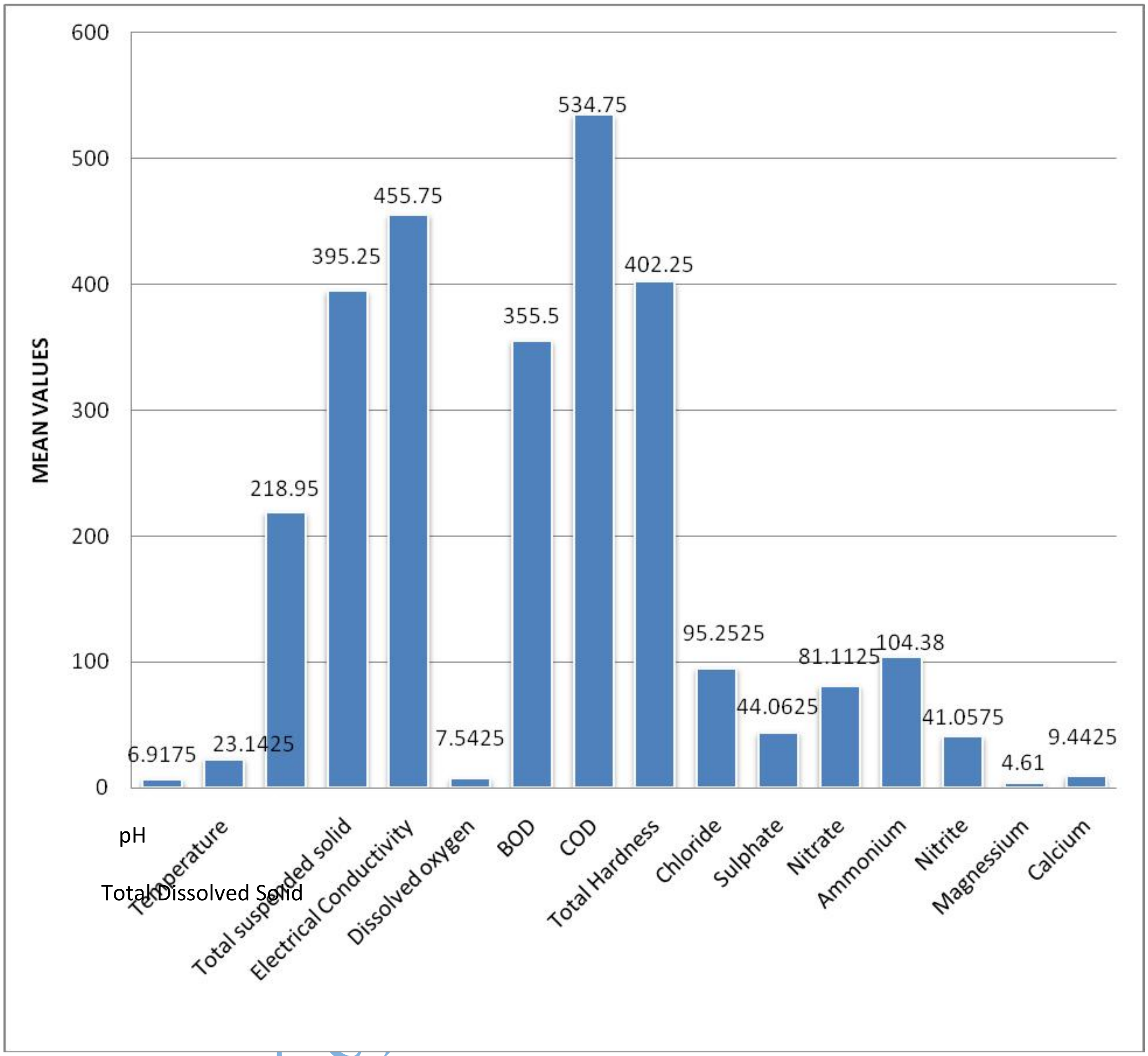

Figure 4.2: Mean values of Physiochemical Parameter of Stream

Source: Field work, 2022.

Table 4.1: Mean Values &Standard Deviation of Physiochemical Parameter of Borehole Water

Parameters	Mean value	Std. dev	Min	Max	NESREA	WHO limit
pH	6.91	0.233381	6.58	7.12	6-9	6.5-8.5
Temperature	23.415	0.491155	22.9	24.01	<40	Nil
Total Dissolved Solids	503	78.12383	420	604		5000
Total suspended solid	36.4175	8.405809	28.34	47.01	28	25
Electrical Conductivity	1141.5	160.5771	957	1323		
Dissolved oxygen	2.4175	0.472326	1.98	3.02		7.5
BOD	3.4125	0.463995	2.98	4.01		
COD	8.825	2.288005	7.22	12.15		
Total Hardness	13.52	3.789837	9.81	18.14	Nil	100-300
Chloride	27.49	4.092782	21.82	31.09	600	250
Sulphate	7.8925	2.38479	4.71	10.14		2000
Nitrate	1.635	0.684324	0.95	2.54	20	45
Ammonium	0.375	0.284546	0.15	0.76		NS
Nitrite	0.3675	0.313409	0.1	0.82		0.20
Magnesium	0.16	0.060553	0.1	0.24		0.5
Calcium	2.12	0.439848	1.67	2.71		75

Source: Field work, 2022.

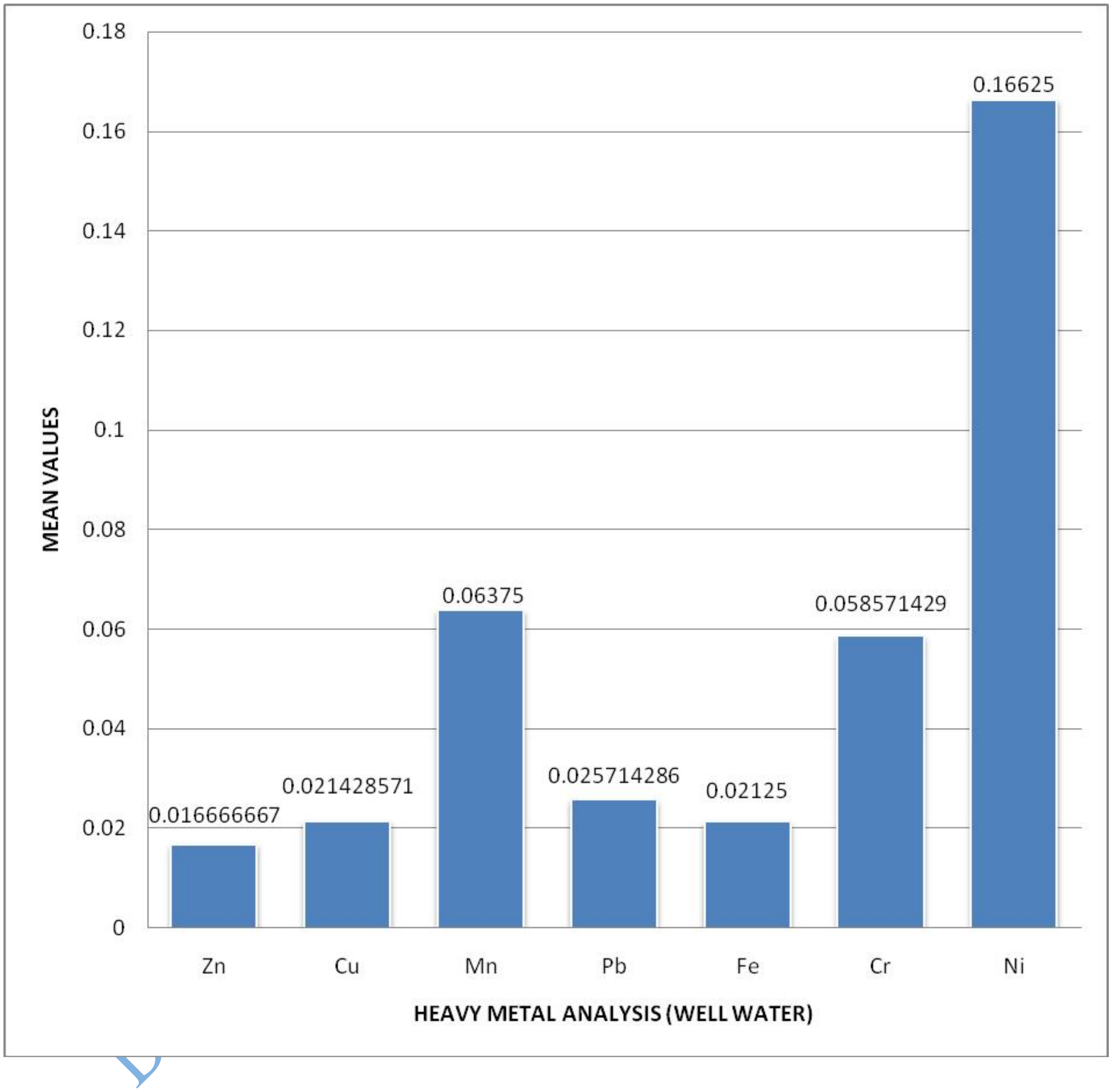

Figure 4.3: Mean Values of PotentiallyToxic ElementsAnalysis (Well Water)

Source: Field work, 2022.

Table 4.2: Mean Values &Standard Deviation of PotentiallyToxic ElementsAnalysis (Stream Water)

Parameters	Mean value	Std. dev	Min	Max	WHO limit
Zn	0.0015	0.000707	0.001	0.002	1.5
Cu	0.02525	0.006397	0.017	0.032	0.1
Mn	0.04925	0.017481	0.037	0.075	0.2
Pb	0.08375	0.01967	0.056	0.1	1.0
Fe	0.05225	0.015521	0.031	0.068	1.5
Cr	0.0475	0.009678	0.034	0.055	0.1
Ni	0.188	0.085717	0.112	0.301	<1

Source: Field work, 2022.

Table 4.3: Mean Values &Standard Deviation of PotentiallyToxic ElementsAnalysis (Borehole Water)

Parameters	**Mean value**	**Std. dev.**	**Min**	**Max**	**WHO limit**
Zn	0.001	0	0.001	0.001	1.5
Cu	0.003333333	0.003215	0.001	0.007	0.1
Mn	0.03425	0.008694	0.025	0.045	0.2
Pb					1.0
Fe					1.5
Cr	0.089333333	0.019088	0.075	0.111	0.1
Ni	0.04625	0.024459	0.021	0.078	<1

Source: Field work, 2022.

Table 4.4: Mean Values &Standard Deviation of Microbial Analysis of Water Sample (Well Water)

Parameters	**Mean value**	**Std. dev.**	**Min**	**Max**	**WHO limit**
***E. coli* Bacteria**	2.7375	1.276085	0.7	5	0
Total Coliform (cfu/ml)	6800	5486.347	2100	17300	0
Total Heterotrophic Bacteria	185.75	133.9198	21	410	$1.1\text{x}10^2$

Source: Field work, 2022.

Table 4.5: Mean Values &Standard Deviation of Microbial Analysis of Water Sample (Stream Water)

Parameters	**Mean value**	**Std dev**	**Min**	**Max**	**WHO limit**
***E. coli* Bacteria**	4.3	2.821347	1	7.2	0
Total Coliform (cfu/ml)	28275	12750.26	12000	43100	0
Total Heterotrophic Bacteria	322.5	97.76673	190	410	$1.1x10^2$

Source: Field work, 2022.

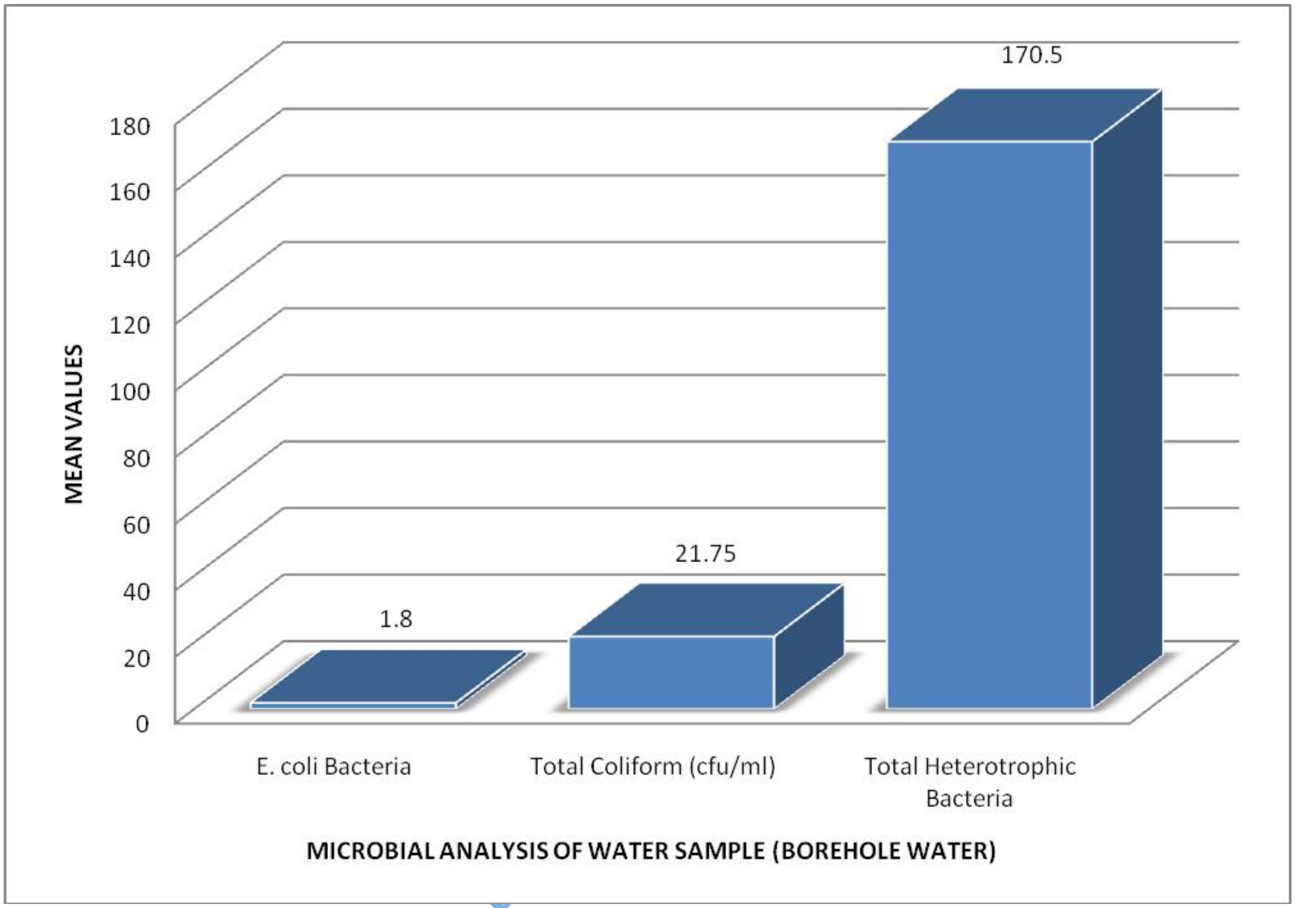

Figure 4.4: Mean Values of Microbial Analysis of Water Sample (Borehole Water)

Source: Field work, 2022.

Table 4.6: Mean Values &Standard Deviation of Physiochemical Parameter of Soil samples

Parameters	**Mean value**	**Std dev**	**Min**	**Max**	**NESREA**	**WHO limit**
Temperature (^{O}C)	26.425	0.25	26.1	26.7	6-9	6.5-8.5
Ph	8.195	0.08346656	8.12	8.31	<40	Nil
Electrical Conductivity Scm^{-1}	125.605	19.13600707	98.2	141.12		5000
Moisture content %	7.835	1.270944531	6.5	9.12	28	25
Total Hardness (Mg/L)	204.1	21.80003823	178.25	230.2		
Chloride	26.43	4.328702654	21.27	31.64		7.5
Sulphate	143.925	30.91165746	110.5	173.4		
Nitrates	65.045	7.206508632	58.34	74.85		
Ammonium	133.9575	19.36546131	109.56	151.12	Nil	100-300
Magnesium	5.1	1.52094269	3.04	6.57	600	250
Calcium	10.91	2.118033679	8.31	13.01		2000

Source: Field work, 2022.

Table 4.7: Mean Values &Standard Deviation of PotentiallyToxic ElementsAnalysis of the Soil Samples

	Potentially toxic elements analysis of the soil samples						
Soil samples	**Zn (mg/l)**	**Cu**	**Mn**	**Pb**	**Fe**	**Cr**	**Ni**
Mean value	0.2715	0.21325	1.639	0.2715	0.8095	0.19475	0.25
Std dev	0.068889	0.070505	0.329415	0.182677	0.183306	0.113535	0.047434
Min	0.195	0.145	1.21	0.107	0.65	0.093	0.193
Max	0.36	0.311	2.01	0.512	1.01	0.312	0.301

Source: Field work, 2022.

Table 4.8: Mean Values &Standard Deviation of Microbial Analysis of Soil Samples

	microbial analysis of soil samples		
Soil samples	**E. Coli**	**Total Coliform**	**Total heterotrophic**
Mean value	46.5	195	5475
Std dev	15.86401	106.6145706	1717.313794
Min	25	70	3100
Max	63	330	7200

Source: Field work, 2022.

4.2 Discussion of Findings

In accordance with Table 4.1, the physiochemical parameters of the dug-well water sample range from pH values of 7.1 to 7.31, temperature values of 22.05 to 28, DO values of 4.1 to 6.2, COD concentrations of 195.6 mg/l to 402.0 mg/l with a mean value of 296.74 ±68.55 mg/l, and BOD values that range from 98.5 mg/l to 156.84 mg/l with a mean value of 133.This result is consistent with the figures provided by Osakwe and Otuya[1].Conductivity measurements ranged from 130 to 836 s/cm, which may be due to ions present from leachate and soluble salt migration from the dumpsite. Other physiochemical values, including those for chloride, sulphate, total dissolved solids, total hardness, nitrate, ammonium, total suspended solids, nitrite, magnesium, and calcium, are below WHO and NASREA-permitted levels.

The pH value of stream water, which is a little lower than that of dug-well water, ranges from 6.75 to 7.11, according to Table 4.2.The conductivity value, which ranged from 327 to 612 s/cm with a mean value of 455.75 + 125 s/cm, was lower than that of dug-well water. This difference may be due to the run-off of soluble salts and other compounds from the dumpsite to the river.Electrical conductivity readings range from 327.0 mg/l to 612.0 mg/l with a mean value of 455.75 ±125.14 mg/l, whereas total dissolved solids concentrations range from 161.1 mg/l to 314.0 mg/l on average. The BOD value was between 295.0 and 401.0 mg/l.As a result, the stream water's ability to decompose organic matter required a larger oxygen demand, which in turn increased the biochemical oxygen demand value. This indicates that the stream water contained a bigger amount of decomposable matter. The quality of fresh water is impacted, aquatic life, particularly fish downstream, may be harmed, and the survival of the aquatic biota in the receiving stream is put at risk by the continuous discharge of effluent with a high biochemical oxygen demand into rivers.The physiochemical characteristics of stream water are below WHO and NASREA-permissible standards.

Due to higher concentrations and the presence of ions, borehole water's electrical conductivity concentrations range from 957 s/cm to 1323 s/cm with a mean value of 1141.5 ±160.57 s/cm, which is higher than that of dug-well and stream water. While the average result for total suspended solids is 36.41 ±8.405 mg/l, values range from 28.34 to 47.01 mg/l. The findings demonstrated that the physiochemical parameters of borehole water are below WHO and NASREA permitted levels.

According to Table 4.4, nickel concentrations in well water range from 0.07 mg/l to 0.31 mg/l, with a mean value of 0.166± 0.095 mg/l, whereas manganese concentrations range from 0.02 mg/l to 0.15 mg/l, with a mean value of 0.063 ±0.044 mg/l. The results were consistent with those of a study that examined potentially hazardous components in the wastewater from an acid battery recycling facility[2].However, bioaccumulation of these potentially hazardous components can be harmful to health even though the results are below WHO-permissible levels.

According to Table 4.5, Nickel concentrations in stream water range from 0.12 mg/l to 0.301 mg/l with a mean value of 0.188± 0.085 mg/l, while metal lead concentrations range from 0.056 mg/l to 0.1 mg/l with a mean value of 0.083 ±0.019 mg/l. The bioaccumulation and biomagnification of some Potentially Toxic materials in the environment can result in major environmental health issues[3].

Chromium concentrations range from 0.075 mg/l to 0.111 mg/l with a mean value of 0.089 ±0.019 mg/l in the probable hazardous element analysis of borehole water, whereas manganese levels range from 0.025 mg/l to 0.045 mg/l with a mean value of 0.034 ±0.008 mg/l. Chromium can cause cancer when exposed, endangering the general public's health[4]. The amounts of potentially harmful elements were below the WHO's allowed limit, according to the data.

According to Table 4.7, total coliform concentrations in well water range from 2100.0 to 17300 cfu/ml with a mean value of 6800.0 ±5486.34 cfu/ml, while total heterotrophic bacteria values range from 21.0 to 410.0 cfu/ml with a mean value of 185.75 ±133.919 cfu/ml. This conclusion is consistent with the findings that the levels of Escherichia coli, total heterotrophic bacteria, and total coliform count in water samples taken from wells close to the designated dumpsites were greater than those found in reference samples from the control site and WHO limits[5]. These results, which went beyond WHO guidelines, showed that the water samples may contain bacteria that render them dangerous for drinking and domestic use.It might have happened because the well was in a stagnant condition and wasn't treated.

According to Table 4.8, total coliform concentrations in stream water range from 12000.0 to 43100 cfu/ml with a mean value of 28275.0 ±12750.26 cfu/ml, while total heterotrophic bacteria values range from 190.0 to 410.0 cfu/ml with a mean value of 322.5± 97.766 cfu/ml. The results revealed that the stream's bacteria levels were higher than those recommended by the WHO. The high value obtained may have been caused by the stream's proximity to a dumpsite, where germs can grow and then be carried to the stream nearby.As a result, there is a risk to public health because of the propensity of bacteria to cause illness.

According to Table 4.9, total coliform counts in borehole water range from 19.0 cfu/ml to 25.0 cfu/ml, with a mean value of 21.75.0 ± 2.75378 cfu/ml. Total heterotrophic bacteria counts, meanwhile, range from 109.0 cfu/ml to 250 cfu/ml, with a mean value of 170.5 ± 60.213 cfu/ml.The high value might have been caused by the borehole's surrounding stagnant water, which serves as a perfect environment for bacterial growth.The results showed that the bacteria counts were higher than the WHO's recommended levels, which is not hygienic and unsafe for drinking water.

According to Table 4.10, the pH values of the soil sample's physiochemical parameter ranged from 8.12 to 8.31, which indicates that the dumpsite is naturally alkaline.The presence of more soluble salts and metal scraps may be the cause of the soil's electrical conductivity, which ranges from 98.2 to 141.12 S/cm.The range of the soil's moisture content, or its ability to store water, was 6.5% to 9.12%.Ammonium concentrations range from 109.56 mg/l to 151.12 mg/l with a mean value of 133.95 19.365 mg/l, whereas total hardness concentrations range from 178.25 mg/l to 230.2 mg/l. With the exception of chloride (CL-), whose levels are higher than those allowed by WHO and NASREA, the physiochemical parameters of the soil samples are all within acceptable ranges. These suggest that the soil at the dumpsite contains higher soluble salts and chloride compounds. The soil of the dumpsite contains nitrogen compounds, ammonium, calcium, magnesium, and sulphate, which helped the plants grow well there. Nitrate leachate has a tendency to pollute surface and ground water systems during the rainy season as it is run off from the dumpsite since it is particularly soluble in the soil and does not retain anions.

Iron concentrations range from 0.65 mg/l to 1.01 mg/l with a mean value of 0.809± 0.183 mg/l in Table 4.11's possibly harmful elements analysis of soil sample, whereas Manganese values range from 1.21 mg/l to 2.01 mg/l with a mean value of 1.63 ±0.329 mg/l.With the exception of manganese, whose high content varied from 1.21 mg/l to 2.01 mg/l, the value of potentially harmful elements examined were below allowed limits of WHO and NASREA. These could have formed as the dumpsite deteriorated and amorphous manganese hydrous oxides precipitated.Due to their organic compound complexes' high formation constants, all of these potentially hazardous components are present.

Table 4.12 showed that the microbial analysis of soil sample which has total coliform concentrations ranging from 70.0 cfu/ml to 330.0 cfu/ml with mean value of 195.0 ± 106.61 cfu/ml, while the total heterotrophic bacteria values vary from 3100.0cfu/ml to 7200.0 cfu/ml with a mean value of 5475.0 ± 1717.31 cfu/ml, which is due to constant and continuous biodegradation and decomposition of solid and food wastes on the dumpsite. High bacterial numbers, which can behave as human pathogens linked to numerous infectious diseases, are evident in the results.

Endnotes

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3. V.P. Ulniković, & S.M. Kurilić. *Heavy metal and metalloid contamination and health risk assessment in spring water on the territory of Belgrade City, Serbia.* **Environ. Geochem**.42, 2020, 3731–3751.

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Chapter Five

Conclusion

5.1 Summary of Findings

The findings on the determination of water and soil quality in the vicinity of a selected dumpsite in Ibadan(Ajakanga Municipal solid waste dumpsite) in Oyo state gives a concern result on the quality of water and soil in these environment, as these shows the present of determined variables in water and the soil but below the standard limit. Therefore, biomagnification and bioaccumulation of these parameters can poses a high health risk and dangerous environment for life in the vicinity.

5.2 Conclusion

The results of the physiochemical quality check on water and soil samples indicates that there is presence and high value of these physiochemical parameters and this shows the greater activities of decomposable matter present and happening on the dumpsite at this time of this research work, further activities and continuous dispose of wastes can result to a value above standard limit which then dangerous to the environment and life.

Furthermore, the potentially toxic elements on these samples indicates the presence of these toxic elements with the values below permissible levels and standard limits but inasmuch as continuous activities of waste dumping is happening on these dumpsite, thers is tendency for extreme high value of these toxic elements which are treats to life. Also, bioaccummulation and biomagnification of these elements can cause cancer and other dangerous diseases. The results of this research work justify the occurrence of microbial activities on the dumpsites. Microbial analysis was carried out and this shows the presence and significance quantities of E. Coli, Total Coliform, Total

Heterotrophic bacteria in the selected samples. As this occur as a result of biodegradation and decomposition of organic and biological wastes.

5.3 Recommendation

Based on the study carried out, there is need for standard and proper waste management policies in this area and generally in the state. It is also necessary to make a guideline so as to sensitizes and makes awareness to industries and residents dumping their wastes products to the dumpsite on how to handle these wastes.

In addition,there's also need for adequate orientations about the danger and health problems of exposing to environmental pollution which might comes from Air,water,soil,plant and animals.

This study also recommend and suggest an urgent evacuation of the waste in this particular area if possible because of the level of dirtiness, litters on roads and the stench odours emanating from the dumpsite is unbearable. For the safety and health of people aboding close to the dumpsite.

This studied research suggested that a further research work should be carried out on Air pollution in the area so as to determine or detect the possibility of airborne diseases that might be evolving from the dumpsite.

5.4 Contribution to Knowledge

This research work carried out the physiochemical quality check on water and soil samples in the vicinity of the dumpsite. The physiochemical check was successfully analyzed using the standard procedures and data were provided. The potentially toxic elements of the samples were analyzed and data were provided which indicates the presence of these determined elements. Based on the stench odour and dirtiness of the environment, microbial analysis were also carried out and data were established.

5.5 Suggested Areas for Further Studies

Further research should be carried out on air pollution based on quality of air and other gases evolving from the dumpsite using standard procedures and the results be compared to standard limits.

Further studies should be aimed using bio-indicators such as plants and animals so also evaluate the rate and concentration of possible metals uptake by this factors or indicators. Based on the result from microbial analysis, this research work suggested a further work on other microbial activities such as fungi, viruses and other bacteria organisms

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Appendices

APPENDIX 1: Ajakanga solid waste municipal dumpsite

APPENDIX 2: Atomic Absorption Spectrometer


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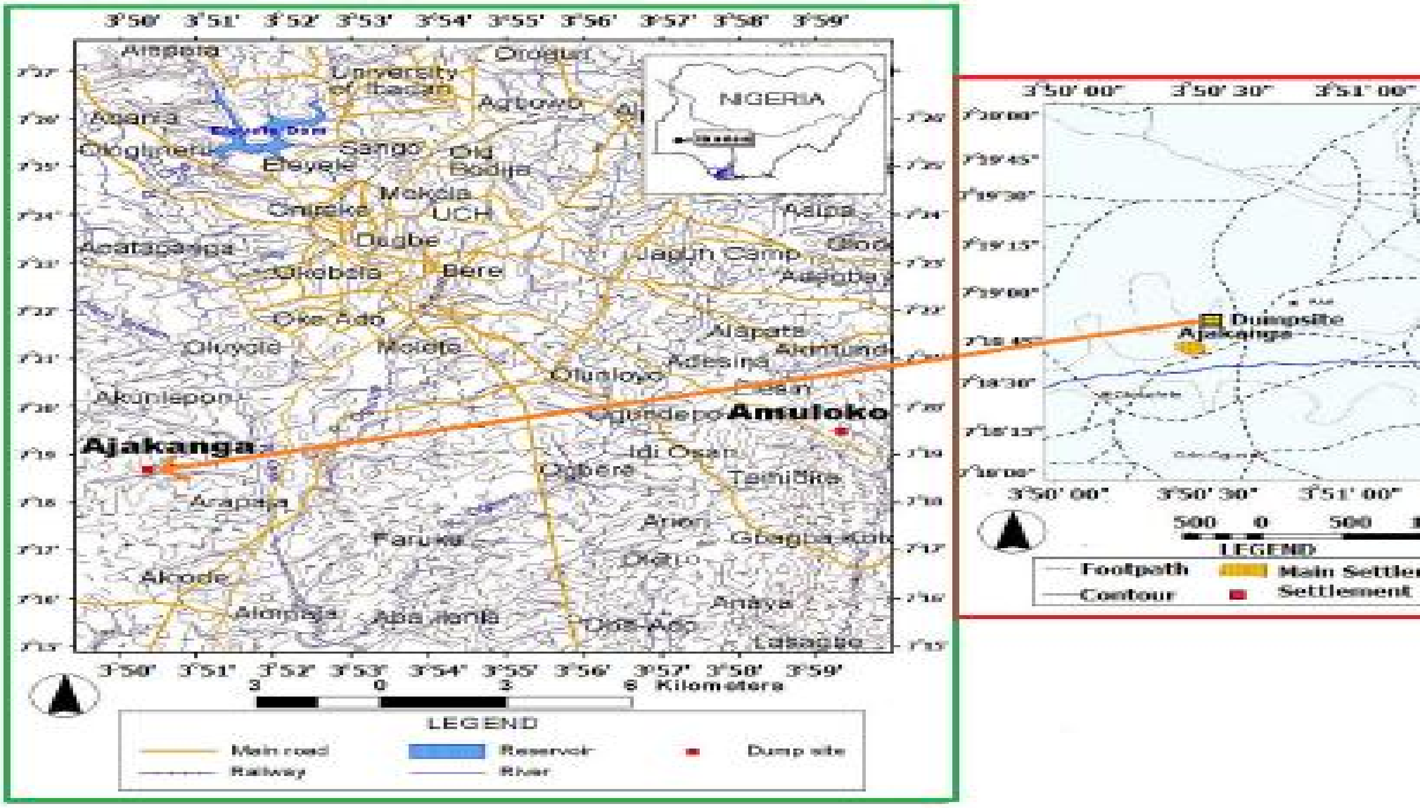
Diagram of pH Meter

Diagram of Electrical Conductivity Meter



APPENDIX 3: Topographical Map of Part of Ibadan Showing Ajakanga Area (Extracted from

Nigerian Geological

Survey Agency, Ibadan Sheet No.59, (1980)

APPENDIX 4: Physiochemical Parameters of Well-Water Samples

Parameters & Units	S1	S2	S3	S4	S5	S6	S7	S8	Control value
pH	7.31	7.10	7.12	7.23	7.15	7.25	7.30	7.19	7.20
Temperature °C	23.5	22.5	22.7	23.1	22.9	23.3	23.4	23.40	23.55
TDS (mg/l)	409	205	275	95	320	383	460	89	115
DO (mg/l)	4.1	5.5	6.0	4.5	5.2	4.7	6.2	6.1	6.3
BOD (mg/l)	156.84	148.1	132.00	141.22	113.5	127.3	152.2	98.5	112.7
COD (mg/l)	342.67	321.3	278.4	195.6	301.7	208.5	402.0	323.8	215.3
Total Hardness(mg/l)	142.67	141.71	136.23	210.70	97.83	114.3	188.2	142.4	140.5
Chloride (mg/l)	57.22	56.1	76.90	81.5	51.42	92.5	60.1	65.8	57.30
Sulphate (mg/l)	47.39	64.5	39.2	15.01	31.12	9.30	40.72	12.31	16.70
Nitrate (mg/l)	62.11	45.02	51.15	61.09	54.21	42.40	35.11	64.70	47.2
Ammonium (mg/l)	86.89	42.01	46.15	71.32	10.43	37.20	56.40	21.60	33.1
TSS (mg/l)	228.14	117.40	203.0	89.7	105.7	150.1	125.2	73.9	93.2
Nitrite (mg/l)	38.45	31.40	32.7	29.70	35.20	40.2	36.51	19.30	22.7
Magnesium (mg/l)	2.04	2.51	2.33	3.05	2.41	5.12	9.12	2.72	3.6
Calcium (mg/l)	5.59	7.14	8.20	13.50	14.5	2.01	0.72	3.25	10.2
Electrical conductivity (Us/cm)	836	510	149.5	420	130.1	715	244.5	180	215

APPENDIX 5: Stream Water

Parameter	Unit	S1	S2	S3	S4	Control
PH		6.80	7.01	6.75	7.11	7.2
Temperature	^{O}C	23.4	23.01	22.95	23.21	23.2
Total dissolved solids	Mg/l	161.10	204	196.7	314	251
Total suspended solids	Mg/l	472	401	317	391	301
Electrical conductivity	Mg/l	327	612	495	389	351
Dissolved oxygen	Mg/l	7.4	8.10	7.87	6.8	6.9
Bod	Mg/l	372	295	401	354	278
Cod	Mg/l	702	412	441	584	391
Total hardness	Mg/l	352	433	709	115	221
Chloride	Mg/l	98.15	115.0	85.70	82.16	96.1
Sulphate	Mg/l	50.10	42.70	53.80	29.65	39.6
Nitrate	Mg/l	73.5	81.01	102.34	67.60	77.4
Ammonium	Mg/l	95.2	110.6	120.42	91.30	96.8
Nitrite	Mg/l	38.21	40.12	46.80	39.10	41.5
Magnesium	Mg/l	4.60	5.13	4.91	3.80	4.2
Calcium	Us/cm	7.13	10.52	11.71	8.41	8.39

APPENDIX 6: Physiochemical Analysis of Borehole Water

Parameter	Unit	S1	S2	S3	S4	Control
PH		6.58	7.01	7.12	6.93	6.92
Temperature		23.6	22.9	24.01	23.15	23.4
Total dissolved solids		604	517	471	420	451
Total suspended solids		47.01	39.12	31.20	28.34	33.2
Electrical conductivity		1215	1071	1323	957	905
Dissolved oxygen		2.56	1.89	3.02	2.11	3.01
Bod		3.54	4.01	2.98	3.12	3.15
Cod		7.42	12.15	8.51	7.22	12.5
Total hardness		15.01	11.12	18.14	9.81	13.1
Chloride		31.09	29.75	21.82	27.3	28.6
Sulphate		10.14	7.51	9.21	4.71	8.2
Nitrate		1.74	2.54	1.31	0.95	1.25
Ammonium		0.76	0.42	0.15	0.17	0.41
Nitrite		0.82	0.3	0.25	0.1	0.13
Magnesium		0.24	0.17	0.13	0.10	0.21
Calcium		2.15	2.71	1.95	1.67	1.81

APPENDIX 7: Potentially Toxic Element in Well Water

Parameter	S1	S2	S3	S4	S5	S6	S7	S8	control
Zn	0.01	ND	0.01	0.02	0.03	0.02	ND	0.01	0.01
Cu	0.02	0.01	0.03	0.01	0.02	ND	0.02	0.04	0.01
Mn	0.03	0.06	0.10	0.04	0.0	0.03	0.02	0.15	0.12
Pb	0.02	0.01	0.05	0.06	ND	0.01	0.01	0.02	0.02
Fe	0.03	0.01	0.02	0.04	0.01	0.03	0.02	0.01	0.1
Cr	ND	0.01	0.2	0.15	0.01	0.02	0.01	0.01	0.03
Ni	0.2	0.15	0.31	0.08	0.10	0.12	0.07	0.30	0.02

APPENDIX 8: Potentially Toxic Element (PTEs) in Stream Water

Parameter	S1	S2	S3	S4	Control
Zn	ND	0.01	ND	0.002	0.01
Cu	0.024	0.032	0.017	0.028	0.02
Mn	0.045	0.040	0.037	0.075	0.013
Pb	0.084	0.095	0.056	0.10	0.01
Fe	0.053	0.031	0.057	0.068	0.032
Cr	0.054	0.047	0.034	0.055	0.014
Ni	0.207	0.112	0.031	0.132	0.130

APPENDIX 9: Potentially Toxic Elements inBorehole

Parameter	S1	S2	S3	S4	control
Zn	ND	ND	0.001	0.001	0.001
Cu	0.007	0.001	ND	0.002	0.001
Mn	0.045	0.03	0,025	0.037	0.025
Pb	ND	ND	ND	ND	0.01
Fe	ND	ND	ND	ND	0.01
Cr	0.111	ND	0.082	0.075	0.121
Ni	0.078	0.035	0.051	0.021	0.035

APPENDIX 10: Microbial Analysis of Well Water Sample

Parameter	S1	S2	S3	S4	S5	S6	S7	S8	control
E.Coli Bacteria	3.0	204	5	5	0.7	3.5	2.7	1.6	1.8
Totl(Cfu/Ml) Caliform	2.3 x 10^3	4.1 x 10^3	1.27 x 10^4	1.73 x 10^3	3.2 x 10^3	2.1 x10^3	7.5 x10^3	5.2 x10^3	2.3x10^3
Total Hetera Thropic Bacteria	3.2 x 10^2	1.3 x 10^2	1.8 x 10^2	2.1 x 10^1	2.4 x 10^2	3.5 x 10^1	4.1 x 10^2	1.5 x 10^2	1.7x10^2

APPENDIX 11: Stream Water

Parameter	S1	S2	S3	S4	Control
E.Coli Bacteria	6	7.2	3	1	3.5
Totl(Cfu/Ml) Caliform	3.00 x 10^4	4.31 x 10^4	1.2 x 10^4	2.8 x 10^4	1.56x10^3
Total Hetera Thropic Bacteria	4.1 x 10^2	3.8 x 10^2	3.1 x 10^2	1.9 x 10^2	2.8x10^3

APPENDIX 12: Borehole Water

Parameter	S1	S2	S3	S4	Control
E.Coli Bacteria	1.2	2	1	3	1.5
Totl(Cfu/Ml) Caliform	19	23	25	20	21
Total Hetero Thropic Bacteria	1.89 x 10^2	1.44 x 10^2	2.5 x 10^2	1.09 x 10^2	2.3x10^2

APPENDIX 13: Physicochemical Analysis of Soil Samples

Parameters	S1	S2	S3	S4	control
Temperature ^{0}c	26.1	26.4	26.7	26.5	26.4
Ph	8.12	8.20	8.31	8.15	8.12
Electrical Conductivity	135.8	127.3	98.20	141.12	100.1
Moisture Content %	8.70	9.12	6.50	7.02	7.5
Total Hardness	178.25	210.15	197.8	230.2	198.7
Chloride	31.64	27.51	21.27	25.30	24.8
Sulpahte	166.79	125.01	173.40	110.50	133.2
Nitrates	74.85	61.27	65.72	58.34	68.4
Ammonium	109.56	127.35	151.12	147.8	141.1
Magnesium	3.04	5.82	4.97	6.57	5.2
Calcium	10.12	12.20	13.01	8.31	9.7

APPENDIX 14: Potentially Toxic Element (PTEs) Analysis of the Soil Samples

Soil Samples	Zn(Mg/C)	Cu	Mn	Pb	Fc	Cr	Ni	control
S1	0.36	0.21	1.701	0.155	0.658	0.093	0.301	0.27
S2	0.281	0.311	2.01	0.512	0.92	0.102	0.193	0.31
S3	0.195	0.45	1.635	0.107	0.65	0.272	0.232	0.27
S4	0.25	0.187	1.21	0.312	1.01	0.312	0.274	0.31

APPENDIX 15: Microbial Analysis of Soil Samples

Soil Samples	E.Coli	Total Calform	Total Hetero Thropic	Control
S1	5.10×10^1	3.3×10^2	7.2×10^3	6.1×10^3
S2	6.3×10^1	2.0×10^2	5.7×10^3	4.1×10^3
S3	4.7×10^1	0.7×10^2	5.9×10^3	2.8×10^3
S4	2.5×10^1	1.8×10^2	3.1×10^3	2.1×10^3

APPENDIX 16: Mean values & standard deviation of Physiochemical parameter of water samples
N = 16 samples

Parameters	Mean value	Std. dev	Min	Max	NESREA	WHO limit
pH	7.20625	0.079451	7.1	7.31	6-9	6.5-8.5
Temperature (^{O}C)	23.61875	1.830288	22.05	28	<40	Nil
Total Dissolved Solids (mg/L)	279.5	140.206	89	460		5000
Dissolved oxygen (mg/L)	5.2875	0.795411	4.1	6.2	28	25
BOD (mg/L)	133.7075	20.11591	98.5	156.84		
COD (mg/L)	296.74625	68.55782	195.6	402		7.5
1Total Hardness (mg/L)	146.755	36.69471	97.83	210.7		
Chloride	67.6925	14.44654	51.42	92.5		
Sulphate	32.44375	19.31626	9.3	64.5	Nil	100-300
Nitrate	51.97375	10.54164	35.11	64.7	600	250
Ammonium	46.5	24.99492	10.43	86.89		2000
Total Suspended Solids (mg/L)	136.6425	54.18893	73.9	228.14	20	45
Nitrite	32.9325	6.545404	19.3	40.2		NS
Magnesium	3.6625	2.404673	2.04	9.12		0.20
Calcium	6.8175	5.002947	0.7	14.15		0.5
Electrical Conductivity (Scm^{-1})	398.1375	269.9126	130.1	836		

APPENDIX 17: Mean values & standard deviation of Physiochemical parameter of Stream water

Parameters	Mean value	Std. dev	Min	Max	NESREA	WHO limit
pH	6.9175	0.170758	6.75	7.11	6-9	6.5-8.5
Temperature (^{O}C)	23.1425	0.204512	22.95	23.4	<40	Nil
Total Dissolved Solids (mg/L)	218.95	66.07998	161.1	314		5000
Total suspended solid (mg/L)	395.25	63.41595	317	472	28	25
Electrical Conductivity (mg/L)	455.75	125.1489	327	612		
Dissolved oxygen(mg/L)	7.5425	0.574362	6.8	8.1		7.5
BOD (mg/L)	355.5	44.73999	295	401		
COD (mg/L)	534.75	134.4802	412	702		
Total Hardness (mg/L)	402.25	245.0026	115	709	Nil	100-300
Chloride	95.2525	14.84389	82.16	115	600	250
Sulphate	44.0625	10.65906	29.65	53.8		2000
Nitrate	81.1125	15.17844	67.6	102.34	20	45
Ammonium	104.38	13.55641	91.3	120.42		NS
Nitrite	41.0575	3.907057	38.21	46.8		0.20
Magnesium	4.61	0.582123	3.8	5.13		0.5
Calcium	9.4425	2.058825	7.13	11.71		75

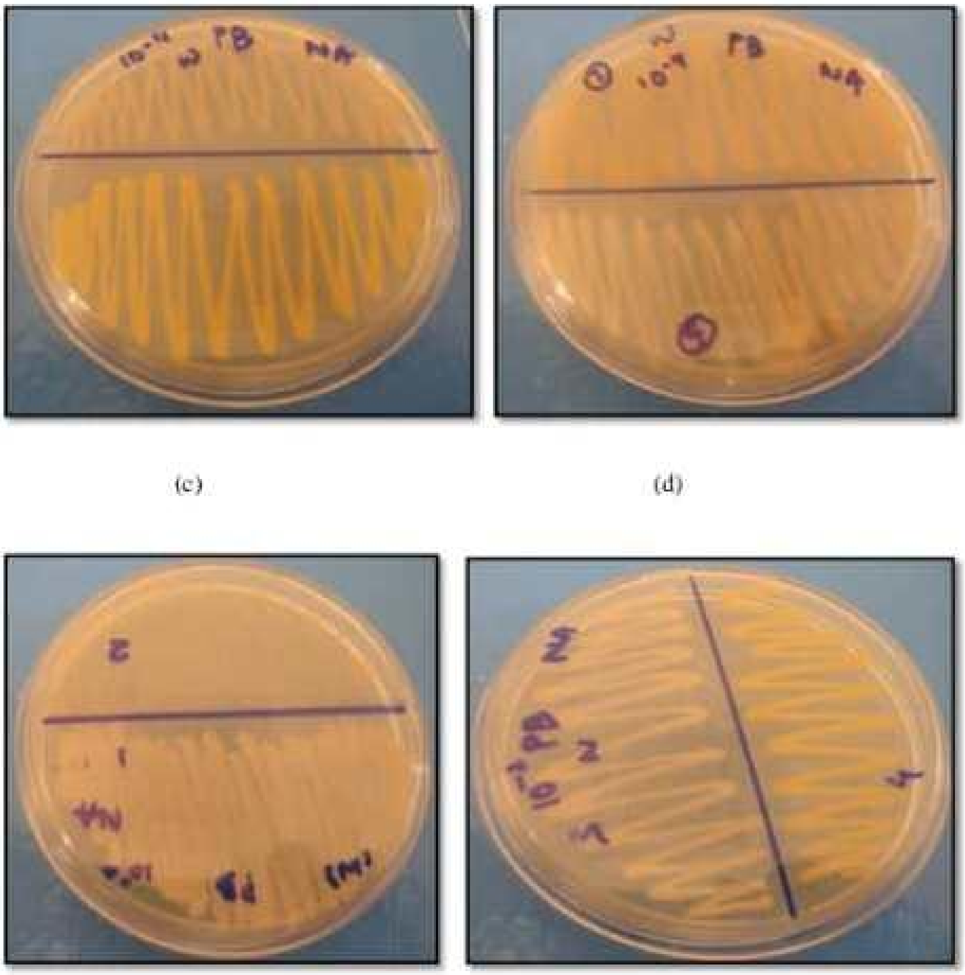
APPENDIX 18: Mean values & standard deviation of potentially toxic element analysis (well water)

Parameters	Mean value	Std. dev	Min	Max	WHO limit
Zn	0.016666667	0.008165	0.01	0.03	1.5
Cu	0.021428571	0.01069	0.01	0.04	0.1
Mn	0.06375	0.044381	0.02	0.15	0.2
Pb	0.025714286	0.020702	0.01	0.06	1.0
Fe	0.02125	0.01126	0.01	0.04	1.5
Cr	0.058571429	0.080917	0.01	0.2	0.1
Ni	0.16625	0.095009	0.07	0.31	<1

APPENDIX 19: Mean values & standard deviation of microbial analysis of water sample (borehole water)

Parameters	Mean value	Std dev	Min	Max	WHO limit
E. coli Bacteria	1.8	0.909212	1	3	0
Total Coliform (cfu/ml)	21.75	2.753785	19	25	0
Total Heterotrophic Bacteria	170.5	60.21351	109	250	$1.1x10^2$

APPENDIX 20: Picture of Plates for Water Sample



(c) (d)

(e) (f)

APPENDIX 21: Picture of Microbial Plate for Soil Sample

APPENDIX 22: Statistical Approach

Mean/ Mean Deviation

If n measurement are made in a series of tests viz: x_1, x_2, x_3,……………..x_{n-1},x_n, the arithmetic mean is reffered to as the mean which is given by x = $\frac{x1,x2,x3,\ldots\ldots\ldots xn-1,xn}{\square}$.

The deviation of each of the following measurements from X are obtained were sum up (regardless of sign) and divided by the number of measurement made, the result gives the mean deviation.

Standard Deviation

For a series of measurement, the means as X=$\frac{x1,x2,x3,\ldots\ldots\ldots xn-1,xn}{\square}$

The mean defined above can now be put mathematically as: $[(x1-X)^2 + (x2-X)^2 + \ldots\ldots\ldots + (Xn-x)^2]$.

The standard deviation, S, kis defined as:

$$S=\sqrt{\frac{(x1-X)2 + (x2-X)2 + \ldots\ldots\ldots + (Xn-x)2}{\square - 1}}$$

$$S= \sqrt{\frac{\sum_{1-1}^{\square}(\square 1-\square)2}{\square-1}}.$$

Bio-data

A. Personal Data

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Nationality:	Nigerian
Next of Kin:	Mrs. Olatise Oluwakemi Adesola

B. Education Background

Educational Institutions Attended with Dates and Qualifications

• Lead City University, {MSc. Environmental and Analytical Chemistry}	2020 – till date
• University of Ilorin, {BSc. in Industrial Chemistry}	2002-2006
• Abbey Technical Secondary School, Challenge Ibadan, Oyo State (Senior Secondary School Certificate)	1991-1997

C. Work Experience with Dates

a.	Boklad Oil And Gas Limited	December, 2012 – May, 2014.
b.	Bentos Pharmaceutical Products Limited	July, 2009 – May, 2012
c.	Joycrown Investment Limited	June, 2014 –2018.
d.	Federal College of Animal Health and Production	January, 2018 – Till date

D. Publication: Thesis and Dissertation

1. *Determination of Selected Metal Levels in Commonly Consumed Cooking Oil in Ibadan Metropolis.* **International Journal of Forensic Medical Investigation.** Publishers: Dr. O.J. Ojezele, Adijat. Y Shorinmade, Olatise Olaoluwa A., Mujitaba Mohammed A.

2. *Evaluation of Selected Antioxidants and Vitamins in Honey, in Ibadan, Oyo State.* **Annals of Research Journal (ARJ).** Journal Publication FCAH & PT, Ibadan, Oyo State

E. Conferences/Seminar & Workshop Attended with Dates

1. Professional In-House Training on Wholesome Academic Delivery Organised by Science Laboratory Technology Department, FCAH & PT, Moor Plantation, Ibadan, Oyo State. Date: 14th January 2021

2. Manpower Development and Job enhancement Training Programme, organized by Toplink – Empire Multipurpose Concept in Collaboration with Federal College of Animal Health and Production Technology, Moor Plantation, Ibadan, Oyo State.
   Date: 17 & 18 December, 2020

3. Capacity Building Workshop on Modern Trends in Scientific Data Analysis, Sourcing, Writing and Publication of Academic Journals. Organized by Science Laboratory Technology Department, Moor Plantation, Ibadan, Oyo State.
   Date: 11th September, 2019

4. Workshop on Grantsmanship and Capacity Building in Higher Education Institution in Nigeria. Organized by Research and Development Committee, FCAH & PT, Moor Plantation, Ibadan, Oyo State. Date: 1st August, 2019.

F. Referees

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- Dr. A. C. Tella
  Department of Chemistry
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Signature **Date**

The University Compliance Certification

This is to certify that this Thesis written by Olaoluwa Akintunde OLATISE with matriculation number LCU/PG/001414 in the Department of Chemical Science, Faculty of Applied Sciences, Lead City University, Ibadan, Oyo State is in full compliance with approved University format and style.

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Signature **Date**