

## Assessment of Water Quality in Slum Area Ibadan

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### Abstract

The quantity of water is as important as the quality, since these affect the quantity and the quality of available water, water quality is used to express the suitability of water and sustainable to various uses or processes. It is affected by a wide range of natural and human influences, the most important of the natural influences is hydrological influence. The water qualities study was carried out in Ibadan using three landuse (urban, peri urban and rural) in slum areas of Ibadan were evaluated for these physicochemical parameters: temperature, total dissolved solid (TDS), pH, and dissolved oxygen (DO), from well, borehole, water from vendor or pipeborne, from 8 localities and 3 LGA in Ibadan. The results showed variations in the water quality parameters the slum areas. Water pH is lowest in Awotan and Apete of Ido LGA water source which makeup rural slums landuse. with water pH of 5.7 well and 5.8 borehole which is acidic, there is highest value of conc of Lead in these areas of (0.259 mg/l) compared to other landuse and locality, water is of best quality among water from vendors. Using the sig value of 0.05, that is no sig difference between the water quality in slum areas and WHO standards. Using Anova with physico-chemical parameters of water temperature, pH, dissolved oxygen, total dissolved solids, conc of zinc, and iron also having no significant. But a significant spatial variation of water quality of Lead concentration with the sig value of 0.033 and F value of 2.983. There is significant variation in different water source of water pH, total dissolved solid and dissolved oxygen. a sig value of 0.028, 0.031, and 0.000 respectively.

**Keywords:** Water quality; WHO standards; Physico-chemical parameters

### Introduction

#### Background to the study

Slums have been conceptualized as a group of buildings or an area characterized by overcrowding, deterioration, insanitary conditions, or absence of basic and essential facilities like potable water, drainage system, schools, health facilities, recreational grounds, post office, among others [1].

Slums generate spontaneously and are in some cases, a direct result of the prevalence of poverty experienced by the inhabitants of cities. Slums, which are regarded as an element of urban decay, also result from congestion in overcrowded cities where poor immigrants seek to settle for just any available accommodation irrespective of quality.

In 2012, UN-Habitat stated that around 33% of the urban population in the developing world, or about 863 million people, lived in slums. The proportion of urban population living in slums was highest in Sub-Saharan Africa (61.7%), followed by South Asia (35%), Southeast Asia (31%), East Asia (28.2%), West Asia (24.6%), Oceania (24.1%), Latin America and the Caribbean (23.5%), and North Africa (13.3%).

Also, among individual countries, the proportion of urban residents living in slum areas in 2009 was highest in the Central African Republic (95.9%). Between 1990 and 2010 the percentage of people living in slums dropped, even as the total urban population increased. The world's largest slum city is found in the Neza-ChalcoIxtapaluca area, located in the State of Mexico.

The United Nation (2002) has estimated that a third of world's urban population today does not have access to adequate housing, and lack access to safe water and sanitation. These people live in overcrowded and serviced slums, often situated on marginal and dangerous land. In Lagos State, 42 of such slum areas were identified in a research carried out by the University of Lagos Consult in 1997 as they put the figure at over 100 in 2006. Almost 70 percent of the slums in Nigerian cities were found within a radius of 1 km from the city centre of South West of Nigeria (with Lagos and Ibadan in particular) [2,3]. The Chairman of Ibadan South East Local Government stated that about 60 percent of his local government area is a slum covering a big part of the southern inner city [4].

The situation is being exacerbated by two factors, almost complete lack of planning or preparation for urban growth and management in most parts of the world, and a rapid increase in both inequality and poverty, which is compounded by policies intended to improve growth, but which have mostly not done so because they have tried to fight the key urbanization dynamics rather than working with it. The areas are also loaded with scarcity of electricity and water, deterioration of housing conditions as well as overcrowding [4].

Urban slum is of global concern according to the UN-Habitat (2001), 31.6% of the world's urban population lived in slums as far back as 2001. It is worse in developing regions, where 43% of the urban population, compared to 6% of the urban population in developed regions lived in slum. It was projected in 2001 that in the next 30 years, the number of slum dwellers worldwide will increase to 2 billion if no firm or concrete action is taken to arrest the situation (UN-Habitat, 2001). This has informed the inclusion of "Cities without Slums" target, also known as Target 11, in the Millennium Declaration adopted by Member States of the United Nations in September 2000.

Water is the most abundant substance found on the surface of the earth, covering roughly three quarters of the earth's surface and it plays a very vital role in existence as well as maintenance of life of organisms, Water in its pure state is acclaimed key to health and the general contention is that water is more basic than all other essential things to life [5].

Groundwater can be defined as water that occurs below the surface of the Earth, occupying some or all the voids and spaces in soils or any geologic strata. It can also be called subsurface water to distinguish it from surface water which is found in large water bodies like the oceans, seas or lakes, or water which flows overland in streams and rivers [6].

In 2015 the World Health Organization (WHO) estimates that still 2.5 billion people more than one third of the global population live without basic sanitation facilities, while 750 million people still lacks access to safe and clean drinking water. Due to poor water quality, there is lack of proper sanitation which contributes approximately 700,000 child deaths every year due to diarrhoea. Chronic diarrhoea can have a negative effect on child development both physical and cognitive.

There is standard that guard the quality of water and sanitation in an area. The most common standards used to assess water quality relate to health of ecosystems, safety of human contact, and drinking water, which is made by Environmental lawyers and policymakers. According to United States Environmental Protection Agency [7] primary standards regulate substances that potentially affect human health; secondary standards prescribe aesthetic qualities affect taste, odour, or appearance (ibid).

### Statement of problem

Rapid progress in industrialization and urbanization has resulted in creation of more slums, with dilapidated facilities, which is prevalent in the developing and urban area without exclusion to water facilities. The provision of sanitary tools and infrastructures are overwhelmingly deficient as most residents of Ibadan do not have access to a hygienic toilet. Also slum houses in the urban blighted zones lack toilet provisions and structures, resulting in indiscriminate littering of streams with human faecal materials and other wastes [8].

The faecal wastes and other solid wastes are discharged to the environment without adequate treatment, while liquid wastes from sewage is being released into rivers and ponds untreated. Therefore, the quality of water affected has significant impact on the spread of infectious disease and quality of life. This can therefore be accessed using the biological water parameters in bacterial analysis. The contaminants will be identified to quantify the sanitation of the slum area. Most slum areas are noted for lack of reliable sanitation services, supply of clean water, reliable electricity, law enforcement and other basic services. The major features of slum are known with poor housing and planning systems, which can be seen in the water quality and sanitary facility [9].

### Aim and objectives

The aim of the study is to assess water quality of slum areas in Ibadan.

The objectives of the study are to;

1. Determine the physico-chemical properties of water from different sources within the study area.
2. Assess the level of concentration of heavy metals in the water from different sources within the study area.
3. Compare the quality of water over space within the study area.
4. Compare the quality of water from different water sources within the study area.

### Research hypothesis

The following research hypotheses will be tested

There is no significant variation in the quality of water in different source within the study areas.

There is no significant spatial variation in water quality within the study area.

There is no significant difference between the water quality in this region and WHO standards.

### Justification of study

Water is an invaluable resource to man, essential for sustenance of life. It is a basic human need to have good water quality. Traditionally hydrology has been interested purely in the amount of water in an area: water quantity, however, an important challenge to hydrology is the availability of water for human consumption, and domestic uses. Therefore, the research study of water quality of slum areas in Ibadan is important as the availability of water in slum areas of Ibadan.

### Significance of study

Much work has been done on housing, hygiene and water quantity in slum area of Ibadan, with a little focus on water quality of these areas. It is of importance to the health of the people as some of the heavy metals are toxic and injurious to human health. The significance of the research is to institutions for better government policies and the residents cannot be underrated (consisting human consumption and domestic use). The study will benefit the county government and improve its rating among the residents since water service provision and supply is one of their functions.

### Study area

The study area is in Ibadan metropolis which comprises of five local government area (LGA) of Oyo state as shown in Figure 1 showing map of Ibadan. Ibadan is an urban city with eleven (11) Local Governments in Ibadan region consisting of five urban local governments in the city and six semi-urban local governments in the less city [10].

The town (Ibadan) falls between latitude 3°49'E and 3°57'E and longitude 7°20'N and 7°27'N. Which is located in south-western Nigeria in the south-eastern part of Oyo State at about 119 kilometres (74 miles) northeast of Lagos and 120 kilometres (75 miles) east of the Nigerian international border with the Republic of Benin. It lies completely within the tropical forest zone but close to the boundary between the forest and the derived savannah [11].

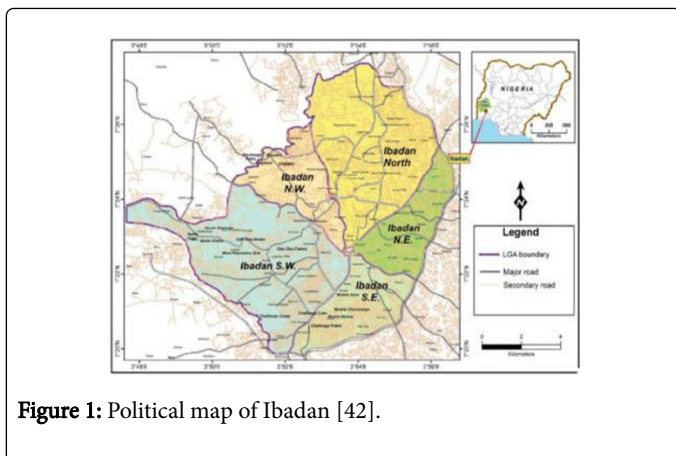


Figure 1: Political map of Ibadan [42].

## Climate and geology

Ibadan a climate with Mean temperature in the area ranges from 21.42°C-26.42°C yearly with average relative humidity of 74.55% and mean annual rainfall of approximately 1,420 mm [10].

Rainfall plays a vital role with respect to flood threat within this area and with most threatening events from June to September, because over 60% of the annual rain falls during these months and the average elevation of 239 metres above sea level. The general geology of the area is made up two types of underlying rock which are old crystalline rock known as basement complex rock and sedimentary rock, with rock types consist of quartzes of metasedimentary series and migmatites complex consisting of branded gneiss and auger gneiss. The minor rock type is pegmatite. The gneiss in Ibadan is strongly foliated into a general strike of NNW-SSW [12].

The city of Ibadan is naturally drained by four rivers with many tributaries: Ona River in the North and West; Ogbere River towards the East; Ogunpa River flowing through the city and Kudeti River in the Central part of the metropolis. Ogunpa River, a third-order stream with a channel length of 12.76 km and a catchment area of 54.92 km<sup>2</sup>. Lake Eleyele is located at the north-western part of the city, while the Osun River and the Asejire Lake bounds the city to the east [8].

## Conceptual Framework

### Theory of slum and housing

Turner was amongst the first to formulate a theory on the phenomenon of slums and squatter settlements drawing inferences from Latin America [13]. Turner describes two ways to define housing:

1. Housing as a noun
2. Housing as a verb

Housing as a noun refers to the physical structure: The house as a product or commodity. Housing as a verb focuses on the universal activity of housing. Housing primarily as a noun focuses on physical housing units. whilst housing as a verb sees housing as an on-going process and concentrate on the role of housing within the context of the household's broader livelihood. Turner lays emphasis on the functional side of housing rather than on the material side. He observed that a squatter can be considered as housing not in terms of what it is but in terms of what it does. This observation becomes

relevant in developing countries where resources, especially financial, are extremely limited and the dwellers are in dire poverty.

Turner argues that the important thing about housing is not “what it is but what it does in people’s lives and advocates that the value of slums be measured not in terms of how well it conforms to the image of the dwellers standards, but rather it be measured in terms of how well the structure serves its inhabitants [13].

Tisong citing Turner noted that for slum households whose building activities are not regulated by exogenous criteria, the proposition such that, households if given the autonomy to design, build, and manage the maintenance process; prospective households will be able to make their own arrangements for accommodation by supplementing their respective means of income by personal and local monetary resources such as their imagination, intuitiveness and capacity to use irregular sites, locally available building materials and tools, organizational capacities through self-help initiatives [13,14].

Turner derives his theory contrasting housing that emanate from a decentralized decision process where the occupants have the authority and that which results from a process where a large centralized authority controls major decisions. Turner substantiate his theory by observing the self-help housing process in slums and squatter settlements and that of public housing programmes which produce large scale standardization [13].

In conclusion, turner points out that, when tenure of property is secured and individual households have the authority to control major decisions regards their accommodation arrangements with respect to standards, location and tenure, both the process and the environment produced are economically viable as well as will stimulate the wellbeing of the residents which are necessary conditions to propel an orderly urban growth [15].

In line with Turner’s approach the researcher is of the view that the successful provision of infrastructural services in slums is relevant to urban development. It is in seeking to address this, that the researcher takes a look at the challenges of infrastructure provision in slums with a view of proposing a sustainable framework for infrastructural provision in slums.

### Water safety plans

A Water Safety Plan (WSP) is a preventive management approach used to assess and manage threats to a drinking water system from catchment to consumer. It helps in the

- Management of activities in the watershed to control contamination of source water.
- Removal or inactivation of contaminants during treatment.
- Prevention of recontamination during distribution, storage, and handling.

**Water safety plan conceptual framework:** Implementing WSPs can lead to many positive changes, from intermediate outcomes such as improved operational procedures to ultimate impacts like water supply and health improvements. Therefore, evaluating the impacts of a WSP requires a much broader analysis than simply looking at water supply and health improvements. The diagram below outlines a conceptual framework for that type of analysis. Various intermediate outcomes (i.e., institutional, operational, financial, and policy changes) resulting from the WSP process subsequently affect water supply and health. It is important to acknowledge all of these changes, and also to recognize

that they will not all occur immediately or simultaneously. Simply focusing on water quality and health improvements in the context of a WSP will overlook these important intermediate outcomes (discussed

on reverse) that can provide a better picture of the significance and success of the WSP (Figure 2).

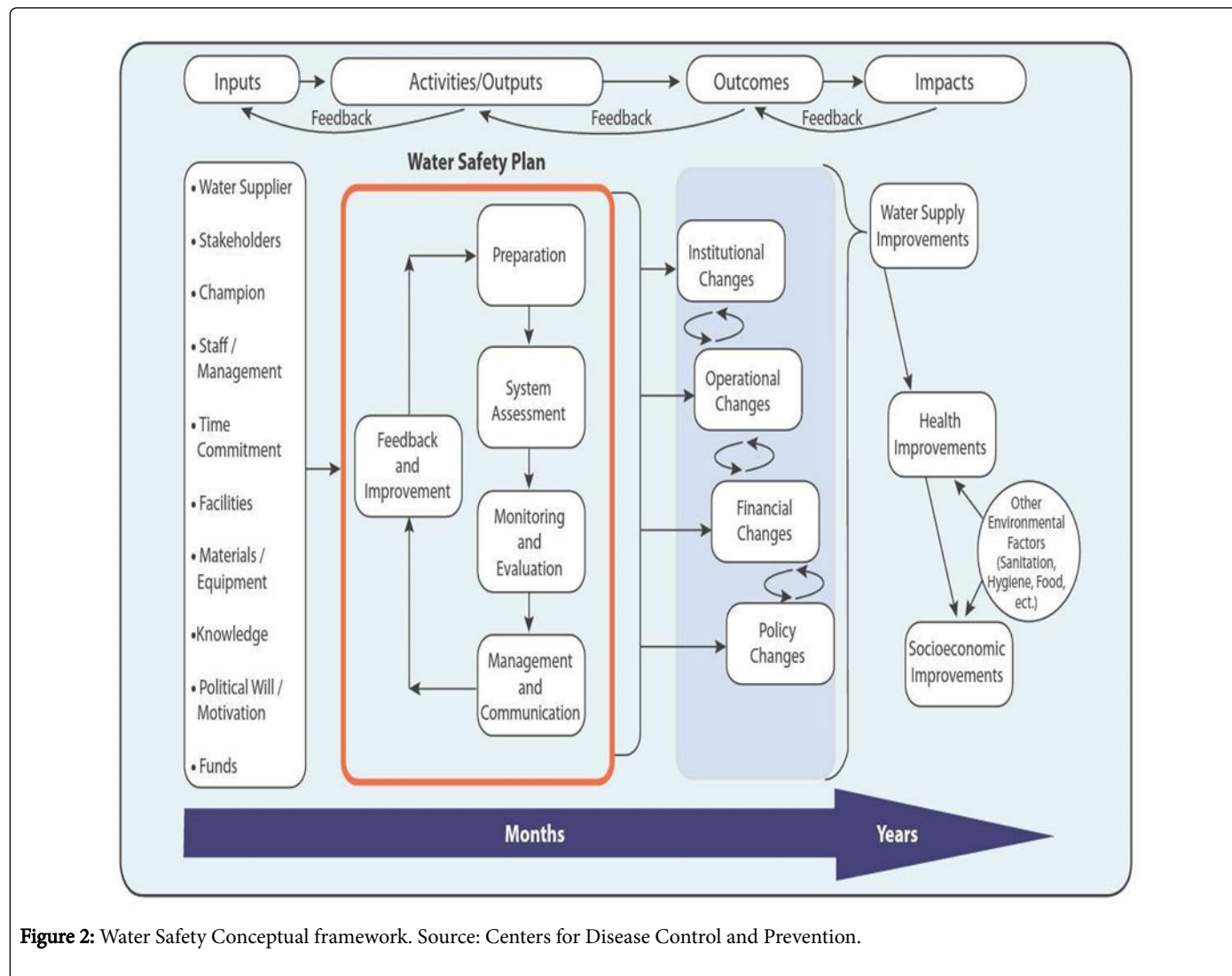


Figure 2: Water Safety Conceptual framework. Source: Centers for Disease Control and Prevention.

## Literature Review

**Explanations of slums:** Slum is a British slang word from the East End of London meaning “room”, which evolved to “back slum” around 1,845 meaning ‘back alley, ghetto, street of poor people’ [16]. Slums were common in the United States and Europe before the early 20th century. London’s East End is generally considered the locale where the term originated in the 19th century, where massive and rapid urbanisation of the dockside and industrial areas of led to intensive overcrowding in a warren of post-medieval streets cape. By the 1920s it had become a common slang expression in England, meaning either various taverns and eating houses, “loose talk” or gypsy language, or a room with “low going-ons”. Slum began to be used to describe bad housing soon after and was used as alternative expression for rookeries [17].

A slum is a squalid and overcrowded urban street or district inhabited by very poor people. They are home to the poorest of urban populations in Africa. The houses inhabited by slum dwellers are mostly decrepit, overcrowded, in neighbourhoods that are prone to

flooding and beset with poor sanitation and shortage of potable water [18]. It can also be defined as a contiguous settlement where the inhabitants are characterized as having inadequate housing and basic services; and is often not recognized and addressed by the public authorities as an integral or equal part of the city” [19].

### Major characteristics of slum are:

- Informal settlement;
- Location and growth;
- Substandard housing, overcrowding (high density) and squalor;
- Inadequate or no infrastructure; and
- Predominant in heavily populated urban areas [20].

**Slum types in Nigeria:** According to Agbola, two types of slum exist in Nigerian cities [21]: they are

1. Traditional slums; which arises in towns from the decay of existing structures and

2. Spontaneous slums; which are created by squatters on illegally acquired lands [21].

If this pattern represents the majority of the slums in Ibadan, it is necessary to reconsider the use of such terms as “traditional” and “spontaneous”, and to show that some slums can appear outside the inner city on legal land. In a study on urban decay in forty (40) Nigerian cities, Abumere [2] concluded in his study that the cities closely identified the phenomenon of overcrowding are large cities (Lagos, Kano, Ibadan, Benin, Onitsha), and they are generally ancient (all except Onitsha).

Moreover, most of these cities are closely associated with overcrowded and dirty/degraded environments (Lagos, Ibadan, and Onitsha). So, urban decay connected with overcrowding is almost entirely a big town problem in Nigeria and concerns, first of all, cities like Lagos, Kano, Ibadan and Onitsha. In 1985, about 68.2 per cent of the slums in Nigerian cities were found within a radius of 1 km from the city center [2]. If there are no resources for urban renewal, the city center, which is the oldest by definition, turns into a slum in time.

However, slums on the city outskirts can also be found, normally in the largest Nigerian cities [2]. In the large and fairly large cities, such as Enugu, Kano, Ibadan, Lagos, a considerable proportion of slums occur at the city outskirts, more than five (5) km from the center. The main reason is that accommodation in many of the cities has been priced, beyond what most citizens can afford. Many low-income workers, therefore, live in low-cost shanties or slums at the city outskirts. 15 years later, the situation has not improved in Ibadan. General poverty has spread out in all Nigerian cities and the Ibadan governments have not really addressed the issue of slums in their city.

**Categories of slum in Ibadan:** There are two categories of slum in Ibadan according to their age and size.

And can be classified into three according to age;

1. The oldest and largest slum is the core area of the city, which covers the entire precolonial town. A large part of the ancient walled city can be seen as a slum, even if the inhabitants do not agree that they live in a slum for historical reasons.
2. Another category is a few small-scale slums on land occupied illegally by squatters and can be found at the margins of the planned city.
3. The third one is the numerous slums which is generally occupied by tenants on legal lands and are found at the outskirts of the city along major roads or close to local labour markets.

The size, history, socio-economic and cultural features of slums in Ibadan differ from one to another, and can be further explained:

The inner-city area is the oldest, has the lowest quality residence and the highest population density in the city. In the 19th century, large compounds for extended families and warrior lineages constituted this part of the city. With the development of the town, the core area “growth by fission”, compounds were broken up into a number of separate housing units [22].

Mabogunje further stated that in the 1960s, one of the major problems of Ibadan was the pre-European foundation “because of its almost unbelievable density of buildings, their spectacular deterioration, and virtual absence of adequate sanitation [22]. The differences in their wealth, education, acquired skills, social customs, and attitudes emphasize the social distance between the two sections of the city” i.e., the core area and the new colonial town [22].

According to the same author, half of the city constituted by this core area was occupied by “slum dwellings characterized by no identifiable sanitation facilities, housing in mud, physical deterioration and the highest population density area of the town” [22]. This statement is still valid today. In 1985, 70 per cent of the derelict houses were found in the inner city, i.e., at less than two km from the centre [2]. Since then no renewal scheme has been implemented in the core area except in one specific ward.

Yemetu in 1995 stated that inner city today has the following characteristics: it is the highest density area of the city because it has a high percentage of the population by household. It has a very high percentage of land devoted to residential land use, as high as 90 percent in a ward called Elekuro.

The second category of slums is the squatter settlements found at the margins of the planned town. The planned city has witnessed the decay of some parts of its area in the past twenty years and the development of a few slums at its margins. Apart from the European reservations, the colonial town was built for the accommodation of immigrants. Layouts were designed, and roads were constructed [4].

The newer eastern and western suburbs represent the low and medium quality residential districts set up in the first half of the 20th century. Some of the wards which had been established at the beginning of the 20th century have now declined. Mokola, for instance, was renewed in 1995 (World Bank Project). This is also the case of Sabo, the first Hausa ward created in 1911 by the Colonial Authority to settle the Hausa trader community at the margins of the inner city [23].

The development of makeshift structures in Sabo since the 1980s corresponds to the general increase of poverty in the country and the willingness of the Sabo Sarkin Hausa (head of the Hausa community in Sabo) to welcome poor Hausa people to the area in an interview with El Hadj Bature, Representative of Sarkin Hausawa, Sabo [5]. However, despite this decay, the ward cannot be considered today to be a slum because it hosts rich Hausa traders who are integrated within the city. Moreover, because most of these traders in Sabo are the owners of their houses they have interest in maintaining them. This is in contrast to the Hausa residents at the outskirts of the city who have difficult access to land ownership (ibid).

The development of unplanned urbanization along the major roads of the city from the 1970s to the 1990s has finally given birth to notable slums in the north, the east and the south of the city. Thirty (30) percent of the derelict houses in Ibadan are found in the outskirts of the city at more than five km from the centre [2].

Most of them have been developed because a new labour market gave opportunities for employment which is particular to the case of Agbowo that is close to the University and inhabited by students and junior staff of the university. It is also the case of Ojoo, which is a mixed Hausa-Yoruba settlement founded in the mid-1970s around the main transit market on the Lagos-Kano Road. And it is the case of Sasa that is very close to the International Institute of Tropical Agriculture (IITA); another Hausa-Yoruba settlement [4].

This list of peripheral slums cannot be considered as exhaustive and some slums probably exist in other parts of the city. The peripheral slums can be described as follows:

Population densities in the outskirts tend to be lower than in the inner city, but there is unfortunately no data available.

Densities in peripheral slums depend on their capacity to attract residents.

Agbowo, for instance, became extremely populous because of the development of a rental housing market for thousands of students and junior staff who cannot find accommodation on campus. There is an average of 3.16 students per room in Agbowo, and around 40 percent of students occupy rooms which house between four and eight students [24].

### Water quality

Water quality refers to the chemical, physical, biological, and radiological characteristics of water [25]. It is a measure of the condition of water relative to the requirements of one or more biotic species and or to any human need or purpose [26]. It is most frequently used by reference to a set of standards against which compliance can be assessed. It is at the national level that critical issues and needs must be analyzed and addressed from policy and legislation downwards [27].

A major problem in the core area is not just availability but the quality of available ground water. Even houses which have the facilities (pipes and taps) cannot get water more than once in month. The Oyo State Water Corporation (OSWC) is still the only public agency responsible for the supply and distribution of piped water in Ibadan. This agency has been criticized several times for its technical and managerial deficiencies. In, 1999, only 28 percent of Ibadan inhabitants used the water facilities provided by the OSWC in an interview with Tunde Agbola, Director of Centre for Urban and Regional Planning, Ibadan [4].

This situation seems to be worse in slum areas than in other areas. For instance, in three other wards of Ibadan, "only" 50 percent of the get water supplies from alternative sources of water [28]. These alternative sources apart from rainfall are contaminated due to lack of sanitary facilities. Water is the strategic resource of the 21st century (Ibid). The management of water resources and supply is essential to the development and growth of cities.

Water related diseases continue to be one of the major health problems globally due to consumption of contaminated water. The high prevalence of diarrhoea among children and infants can be traced to the consumption of unsafe water. The most dangerous form of water pollution occurs when faecal contaminant like *Escherichia coli* enters the water supply. Also, the sanitation which include faecal-oral routes of transmission, in which pathogens are shed in human or animal faces. Contaminants put into water supply which may perpetuate many diseases examples of such pathogen are *Salmonella* spp, *Shigella* spp, *Vibrio cholerae*, *Escherichia coli* according to United States Environmental Protection Agency [29].

Sustainable resource use and the provision of quality services to a growing urban population underpins the success of future cities, enables them to act as poles of economic growth, and is at the core of social and economic development in an urbanizing world (Ibid). Over the last decade, privatization to a greater degree has been seen as one of the primary ways to infuse capital in to the urban water sector and to overcome some of the inefficiencies of municipal management. It has been urged upon developing countries by international lending agencies as an essential component of water sector reform [30].

The parameters for water quality are determined by the intended use. Work in the area of water quality tends to be focused on water that is treated for human consumption, industrial use, or in the environment. As observed by Faniran [31], large quantities of pollutants have continuously been introduced into ecosystems as a consequence of urbanization and industrial processes. Heavy Metals are persistent pollutants that can be biomagnified in the food chains, becoming increasingly dangerous to human beings and wildlife. Therefore, assessing the concentrations of pollutants in different components of the ecosystem has become an important task in preventing risk to natural life and public health. Heavy metals enter into the environment mainly via three routes namely: (i) deposition of atmospheric particulate, (ii) disposal of metal enriched sewage sludges and sewage effluents and (iii) by-products from metal mining process. Water is one of the repositories for anthropogenic wastes [9] Sewage sludge (the product of sedimentation at a sewage treatment works) is frequently heavy metal-rich, derived from industry discharging waste into the sewerage system. When untreated sewage is discharged into groundwater heavy metals can be found in the sediments. Where there is a combined sewage and storm-water drainage system for an urban area, untreated sewage can be discharged during a storm event when the sewage treatment works cannot cope with the extra storm water [32].

The environmental impact of metals and the pollution level in the sediments can be determined with the help of two parameters; the enrichment ratio (ER) and geoaccumulation index (Igeo). The enrichment factor (EF), due to its universal formula, is a relatively simple and easy tool for assessing the enrichment degree and comparing the contamination of different environmental media [33]. The ER is a normalisation method proposed by Simex and Helz to assess the concentration of the metals. It normalises metal concentration as a ratio to another constituent of the sediments. Rubio et al. stated that there is no consensus about the most appropriate sediment constituent to be used for normalisation. Among those used have been Al, Fe, total organic carbon, and grain size. The constituent chosen for this purpose should also be associated with finer particles (related to grain size) and its concentration should not be anthropogenically altered (ibid).

Geoaccumulation index (Igeo) was originally stated by Muller in order to determine and define metal contamination in sediments by comparing current concentrations with preindustrial levels, Igeo is calculated as follows:

$$I_{geo} = \log_2 [C_n / 1.5B_n]$$

Where  $C_n$  is the measured concentration in the sediment for the metal  $n$ ,  $B_n$  is the background value for the metal  $n$ , and the factor 1.5 is used because of possible variations of the background data due to lithological variations and natural fluctuation. The quantity Igeo is calculated using the global average shale data from Turekian et al. [34].

Geo-accumulation index is used in assessing the rate of contamination. The index has six classes (Table 1).

Class	Value	Classification
0	<0	Uncontaminated
1	0-1	Uncontaminated to moderately contaminated
2	1-2	Moderately contaminated
3	2-3	Moderately to strongly contaminated
4	3-4	Strongly contaminated
5	4-5	Strongly to extremely strongly contaminated
6	>5	Extremely strongly contaminated

**Table 1:** Geoaccumulation Index [34].

**Water quality standards:** The incidents of water borne disease and epidemics nationwide arising from drinking water of doubtful quality have become of great concern. The primary purpose of the guideline for drinking water quality is the protection of public health. As described by Horsefall and Spiff, water quality standard is a measure, principle or rule established by authority set to protect the water resource for uses such as drinking water supply, recreational uses and aesthetics, agriculture (irrigation and livestock watering), protection of aquatic life and industrial water supplies. In order to maintain water quality, guidelines for drinking water was set up by the World Health Organization. A guideline value represents the level (a concentration or number) of a constituent that ensures aesthetically pleasing water and does not result in any significant risk to the health of the consumer (Table 2).

The World Health Organization, Guideline for Drinking-water Quality (GDWQ) include the following recommended limits on naturally occurring constituents that may have direct adverse health impact [35].

Metals	Highest Desirable	Maximum Permissible
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S/N	Parameters	Standards	Unit Weight (Wn)
1	PH	6.5-8.5	0.1951
2	Dissolved oxygen	5	0.3317
3	Total dissolved solids	500	0.0033
4	Total suspended solids	500	0.0033
5	Electrical conductivity	300	0.0055

**Table 3:** WHO standards for Physicochemical parameter in a potable water [35].

**Human consumption:** Contaminants that may be in untreated water include microorganisms such as viruses, protozoa and bacteria; inorganic contaminants such as salts and metals; organic chemical contaminants from industrial processes and petroleum use; pesticides and herbicides; and radioactive contaminants. Water quality depends on the local geology and ecosystem, as well as human uses such as sewage dispersion, industrial pollution, and use of water bodies as a heat sink, and overuse (which may lower the level of the water) [7].

Arsenic mg/l	0.01	0.01
Chromium mg/l	0.05	0.05
Iron mg/l	0.3	3
Lead mg/l	0.03	1.5
Manganese mg/l	0.4	0.4
Mercury mg/l	0.001	0.001
Nickel mg/l	0.01	0.03
Zinc mg/l	1	3

**Table 2:** WHO standards for Heavy metals in a potable water [35].

WHO recommends standards for Nigeria potable drink water (All values except PH and electrical conductivity are in mg/l). While water taste, colour and odour are unobjectable [35] (Table 3).

The United States Environmental Protection Agency (EPA) limits the amounts of certain contaminants in tap water provided by US public water systems. The Safe Drinking Water Act authorizes EPA to issue two types of standards:

- Primary standards regulate substances that potentially affect human health;
- Secondary standards prescribe aesthetic qualities, those that affect taste, odour, or appearance (ibid).

**Domestic use:** Dissolved minerals may affect suitability of water for a range of domestic purposes. The most familiar of these is probably the presence of ions of calcium ( $\text{Ca}^{2+}$ ) and magnesium ( $\text{Mg}^{2+}$ ) which interfere with the cleaning action of soap and can form hard sulfate and soft carbonate deposit in water heaters or boilers. Hard water may be softened to remove these ions. The softening process often substitutes sodium cautions.

Hard water may be preferable to soft water for human consumption, since health problems have been associated with excess sodium and with calcium and magnesium deficiencies. Softening decreases nutrition and may increase cleaning effectiveness [36]. Various industries' wastes and effluents can also pollute the water quality in receiving bodies of water [37].

**Environmental water quality:** Environmental water quality or ambient water quality, it relates to water bodies such as lakes, rivers, and oceans. Water quality standards for surface waters vary significantly due to different environmental conditions, ecosystems, and intended human uses. This also relate to the sanitation of the environment. Sanitation which is the means of promoting hygiene through the prevention of human contact with hazards of wastes especially faeces, by proper treatment and disposal of the waste, often mixed into waste-water [38].

These hazards may be physical, microbiological, biological or chemical agents of disease. Wastes that can cause health problems include human and animal excreta, solid wastes, domestic waste-water (sewage or grey water) [38] which is common in Slum areas. While Water Supply and Sanitation Collaborative Council defines sanitation as the collection, transport, treatment and disposal or reuse of human excreta, domestic waste water and solid waste, and associated hygiene promotion [39]. Large input of organic load and nutrients from raw material sewage to a weak hydrodynamic environment poses serious environmental and health and problem from deterioration of water quality [40].

Toxic substances and high populations of certain microorganisms can present a health hazard on drinking purposes and other uses such as irrigation, swimming, fishing, rafting, boating, and industrial uses. These conditions may also affect wild life, which use the water for drinking or as habitat. Modern water quality laws generally specify protection of fisheries and recreational use and require, as a minimum retention of current quality standards.

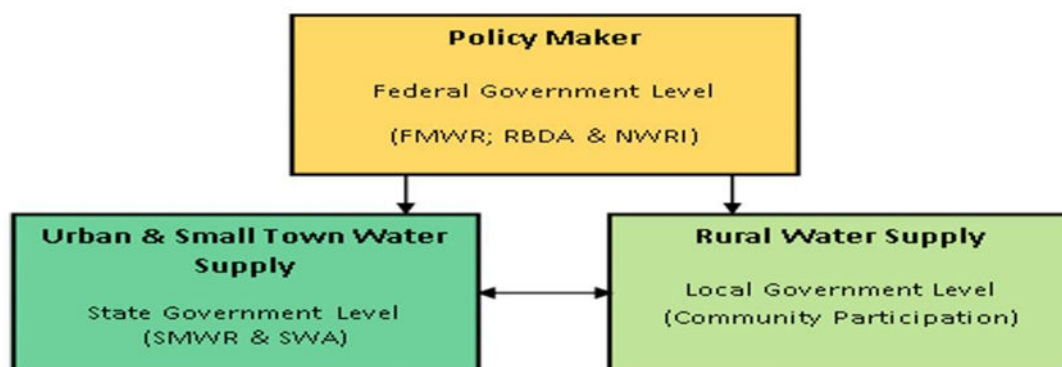
The challenge related to the management of water supply, distribution and quality exists partly due to extensive industrialization, increased population density and a high rate of urbanization [41]. It is estimated that 88 per cent of diarrhea disease is caused by unsafe water supply, and inadequate sanitation and hygiene. Trachoma, one of the world's leading cause of preventable blindness, results from poor hygiene and sanitation. Other preventable diseases like typhoid, dysentery, hepatitis, polio and cholera have proliferated in Africa because of a lack of access to clean water as well as a poor understanding of proper hygiene [39]. Critical to life in all its diversity, water is the life blood of society and a foundation of civilization [12].

**Legal and institutional framework:** Nigeria being a Federal republic is made up of thirty-six states, have Water Boards or Corporations i.e., public utilities managing their public water supply schemes; with their efforts being supplemented in many cases Local Governments supplying water to small villages in their areas of jurisdiction.

They are saddled with the responsibility of providing water supply to their various state citizens by the 1999 constitution. Even at the states level, water laws exhibit similar characteristics as those at the Federal level. The State Water Agencies (SWAs) have unclear and conflicting roles i.e., they are both suppliers and regulators (they combine policy making, service delivery and regulatory functions). As presently enacted, state water laws fail to recognize the need for stakeholder participation in policy, planning and management decision.

Following the enactment of the Water Act 101 of 1993, and the preparation of the National Water Resources Master Plan (NWRMP) of 1995, the Water Resources Management Reform Programme (WRMRP) commenced in 1997. This programme carried out a water sector review with respect to the legal and regulatory framework; institutional framework and participatory approach; information and water resources database; water resources economics and sustainability; water resources infrastructure; assets management and international waters. The three levels of institutional arrangement that exist in Nigeria are; the Federal, and Local, share responsibility for water resources management. This has led to fragmentation, duplication and lack of inter-sectoral coordination with each segment pursuing its independent water agenda. The institutional arrangements in Nigeria's water resources are as follows (Figure 3).





**Figure 3:** Existing three levels of Water Sector Institutional Arrangement in Nigeria [40].

Federal Government Level-(Federal Ministry of Water Resources (FMWR) including River Basin Development Authorities (RBDA's) and National Water Resources Institute (NWRI). The Federal Ministry of Water Resources is responsible for formulating and coordinating national water policies, development and management of large water resources infrastructure, dam reservoirs, irrigation and water supply schemes.

State Government Level-(State Ministry of Water Resources (SMWR) and State Water Agencies (SWA's). The State Ministry of Water Resources is responsible for potable water supply, through the State Water Agencies.

Local Government Level-Department of Rural Water Supply (DRWSS). The local Government is responsible for provision of rural water supplies and sanitation facilities through the Department of Rural Water supply and Sanitation. Community level participation in rural water supplies and sanitation. financing; environment and resource.

**The Federal Ministry of Water Resources (FMWR):** The FMWR is the parent Ministry responsible for resources mobilization and initiation of preparatory activities programme. This includes adoption of policies and guidelines with the director of special duties, representing the Minister, who is head and chief operating officer of the Ministry. FMWR plays only an advisory role and cannot enforce any regulatory powers on the States and Local Government. The salient features of water resources management in Nigeria include: weak data base, fragmented responsibility and weak institutional framework among others. Because of the fragmented and uncoordinated approach to water management issues, the regulatory and monitoring machinery within the water sector in Nigeria is diverse, diffused and weak.

**National Water Resources Institute (NWRI):** The NWRI enabling law is the NWRI Act, Cap 284 LFN 1990. Section 2, thereof, spells out the functions of the institute in both general and specific terms. It is empowered to perform engineering research function related to such major water resources projects as may be required for flood control, river regulation, reclamation, drainage, irrigation, domestic and industrial water supply, sewage and sewage treatment. The institute is further charged with the performance of other functions related to planning of water resources management and river basin development. Quite significantly, the institute has a specific legal mandate to

promote the establishment of a uniform national data collection system relating to surface and subsurface water resources. It is yet to fulfil this mandate owing to a variety of factors including paucity of funds, shortage of skilled manpower, and inadequate equipment among others. The next section defines infrastructure services from various perspectives with its role and importance in the development of the economy of a country and the nature of infrastructure as a monopoly, which is characterized with inefficiency.

## Methodology

### Source of data

The research was designed to assess the quality of water in slum areas of Ibadan. The areas where sampling were carried out from are within Ibadan metropolis slums includes the following LGA and immediate communities (Figure 4);

- Ibadan North,
- LGA Agbowo,
- Akingbola,
- Yemetu Inalende,
- Akinyele,
- LGA Moniya,
- Sasa,
- Ido LGA,
- Awotan,
- Apete.

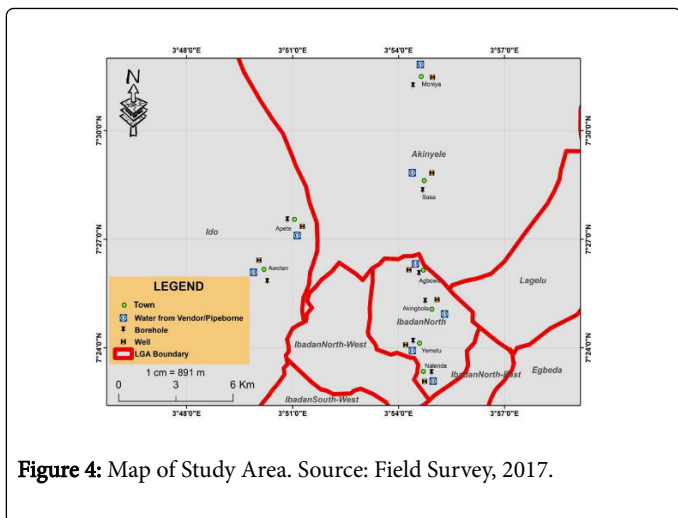


Figure 4: Map of Study Area. Source: Field Survey, 2017.

### Sample collection

Primary data was used for the research and 24 water samples was obtained by a plastic bottle of 75 cl from well, borehole and pipe borne or water from vendor. The sample location was also taken by the aid of GPS. the following physicochemical analysis was tested includes;

Physical indicators: Water temperature, Total suspended solids (TSS) and Total dissolved solids (TDS).

Chemical indicators like Water pH, Dissolved oxygen (DO) and Heavy metals which consists of Iron(Fe), Zinc(Zn), and Lead(Pb).

### Method of data analyses

**Laboratory techniques:** To analyses the water quality of a ground water, consideration has to be given to what type of test may be carried out and the sampling pattern to be used. There are numerous parameters that can be measured, and each is important for the part they play in an overall water-quality story. It is not necessary to measure them all for a single water quality analysis study; instead the relevant parameters for a particular study should be identified.

Laboratory analysis to obtain is the physicochemical properties of the water sample using environmental indicators which include physical indicators, chemicals indicator (physicochemical). Standard laboratory methods were employed for the analysis of the information on state of well.

Parameter	Minimum	Maximum	Mean	WHO	Std Deviation	skewness
Water Temperature	24	26	25.208333	27	0.83297094	-0.42601

Table 4: Summary Statistics for Temperature.

For physicochemical using standard analytical techniques and instruments such as thermometer to measure temperature, electricity pH meter to measure pH, an atomic absorption spectrometer to measure the concentration of trace metals and dissolved oxygen meter to measure the dissolved oxygen, was employed.

**Statistical techniques:** Data collected were analyze using SPSS 23 for analysis of variance (ANOVA) and Paired Samples “T” Test. ANOVA was used to measure the variance between quality of water from the boreholes, while Paired Samples “T” Test was used to test the Significance differences between WHO and quality of water in these slum areas.

### Problem faced during laboratory work

The cost and availability of the laboratory to carry out the required and necessary analysis on the water sample is scares and experience due to the inability to use the departmental laboratory which could have make the work easier.

Lack of equipment that can give precise and minute change, the instrument and equipment used to carry out the measurement of some of the parameters use to test for the quality of water in this slum area are not very accurate and precise to give there results in decimal places with could have ease the interpretation of the results.

### Results and Discussion

In this project, water quality from different sources in slum areas within Ibadan was studied with the aid of different parameters. These parameters are physical and chemical parameters. While chemical parameters include the concentration of a particular chemical substance that is being assessed, physical parameters included the physical measurements of the sampled water.

#### Physcio-chemical parameters

**Temperature:** Temperature is a physical parameter which effect the amount of oxygen the water can dissolve. Warm water holds less dissolved oxygen than colder water. Water temperature is also a controlling factor in the rate of chemical reactions occurring within a river. Warm water will increase the rate of many chemical reactions occurring in a river, which affect the quality of water. This is due to a weakening of the hydrogen bonds and a greater ability of the bipolar molecules to surround anions and cations (Table 4 and Figure 5).

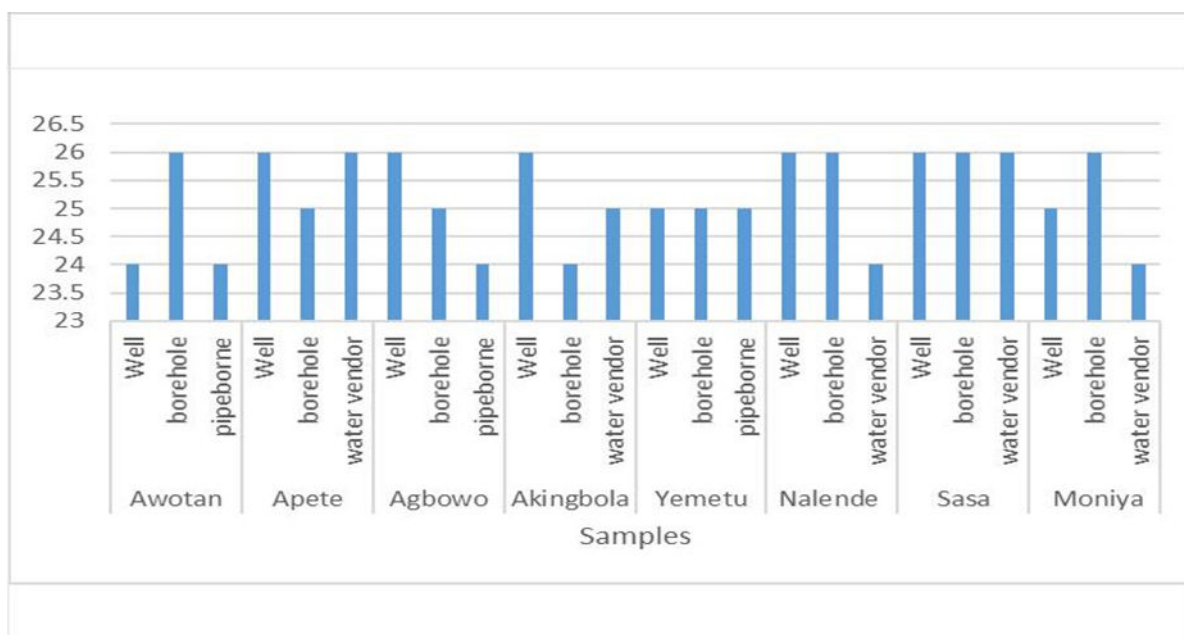


Figure 5: A column chart showing changes in temperature from different sampled source. Source: Field Survey, 2017.

**Dissolved oxygen:** Dissolved oxygen is a chemical parameter; its content is also an important factor in the way we taste water. It determines the potability of water in these slums areas. Since water to be potable it must be tasteless, and water saturated in oxygen tastes fresh to human palates; hence drinking water is almost always oxygenated before being sent to be consumed (Table 5 and Figure 6).

Parameter	Minimum	Maximum	Mean	WHO	Std Deviation	Skewness
Dissolved Oxygen	1.3	7.7	5.1916667	5	1.86382418	-0.890304

Table 5: Summary Statistics for Dissolved Oxygen.

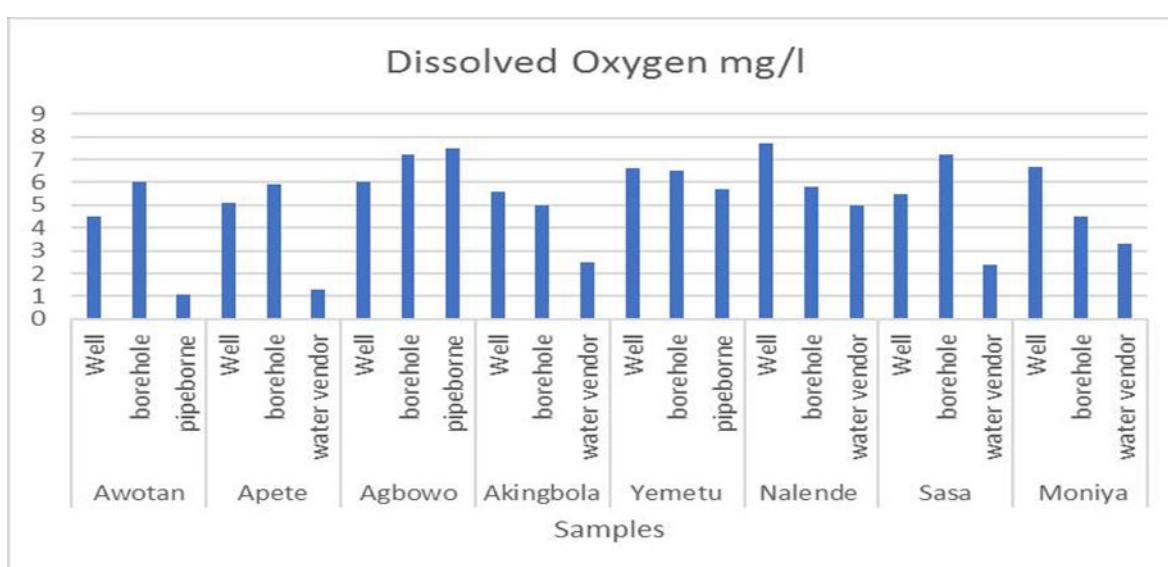


Figure 6: A column chart showing the Dissolved Oxygen in different sample source. Source: Field Survey, 2017.

**Relationship between dissolved oxygen and water temperature:** The most important feature of temperature is the interdependence it has with dissolved oxygen content. There are two methods by which dissolved oxygen content is considered percentage saturation and

concentration (mg/l). These two measures are interrelated through temperature, as the dissolved oxygen content of water is highly temperature dependent (Figure 7).

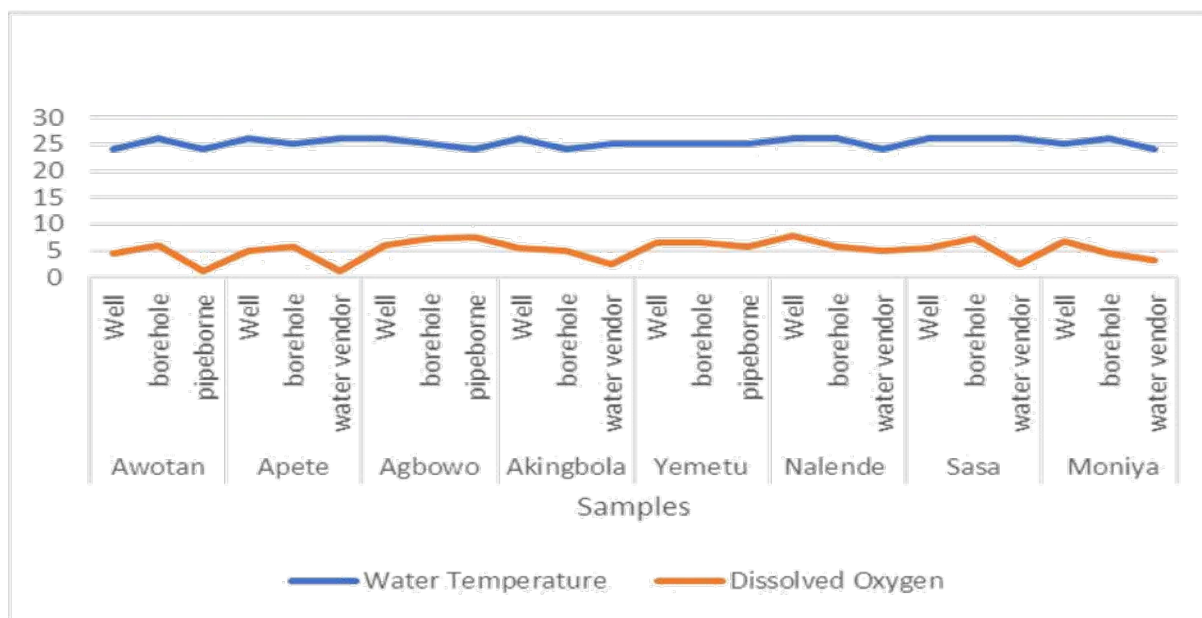


Figure 7: Relationship between maximum dissolved oxygen content (i.e. saturation) and temperature. Source: Field Survey, 2017.

**Water pH:** Chemists think of water as naturally disassociating into two separate ions: the hydroxide (OH<sup>-</sup>) and hydrogen (H<sup>+</sup>) ions.



The acidity of water is given by the hydrogen ion, and hence pH (the measure of acidity) is a measure of the concentration of hydrogen ions present. Infact it is the log of the inverse concentration of hydrogen ions.

$$pH = \log 1/[H^+]$$

This works out on a scale between 1 and 14, with 7 being neutral. A pH value less than 7 indicates an acid solution; greater than 7 a basic solution (also called alkaline). It is important to bear in mind that

because the pH scale is logarithmic (base 10) a solution with pH value 5 is ten times as acidic as one with pH value 6. In natural waters the pH level may vary considerably. The acidity of a river is an important control for the amount of dissolved ions present, particularly metal species. The more acidic a river is the more metallic ions will be held in solution.

In Ibadan the below sampled analysis shows a minimum pH of 5.75 and a maximum of 7.1 that Awotan well (Sample 1) is the most acidic which is therefore not safe to consume and not potable. And that the water from vendor at Apete (Sample 6) is neutral and the most potable. Since the WHO standard is 6.5-8.5, therefore only Sample 3 and 6 meets with the provided standards (Table 6 and Figure 8).

Parameter	Minimum	Maximum	Mean	WHO	Std Deviation	Skewness
Water pH	5.75	7.1	6.2479167	7.5	0.2643282	0.979846

Table 6: Summary Statistics for Water pH.

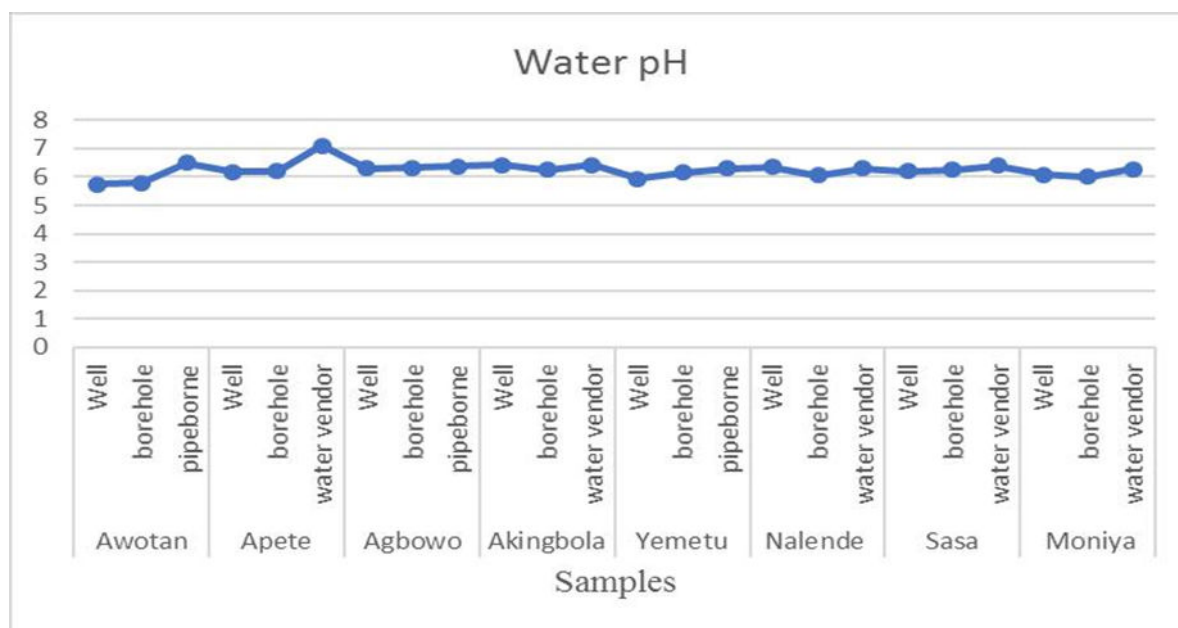


Figure 8: Line graph showing the water pH of various sources sample. Source: Field Survey, 2017.

**Total dissolved solids:** Water remarkably act as solvent, as water passes through a soil column or over a soil surface it will dissolve many substances attached to the soil particles. Equally water will dissolve particles from the air as it passes through the atmosphere as rain.

The amount of dissolved substances in a water sample is referred to as the total dissolved solids (TDS). The higher the level of TDS the more contaminated a water body may be, whether that be from natural

or anthropogenic sources. It is estimated by WHO that the average total dissolved solid (TDS) load in potable water is around 500 mg/l.

It is less than that in Ibadan because of the underlying rock and how close to the water table is to the surface. Awotan and Apete that is sample 1 and 2 respectively have the highest total dissolved solid that is it is more contaminated (Table 7 and Figure 9).

Parameter	Minimum	Maximum	Mean	WHO	Std Deviation	Skewness
Total Solids Dissolved	29.6	40.2	32.75416	500	2.27309006	1.8155163

Table 7: Summary Statistics for Total Dissolved Solids.

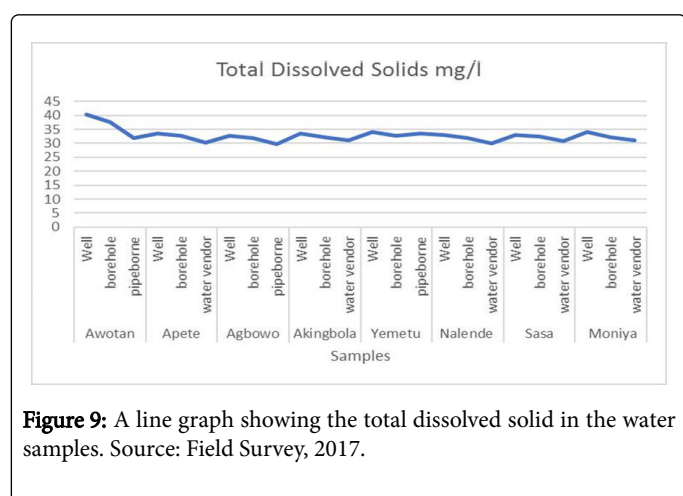


Figure 9: A line graph showing the total dissolved solid in the water samples. Source: Field Survey, 2017.

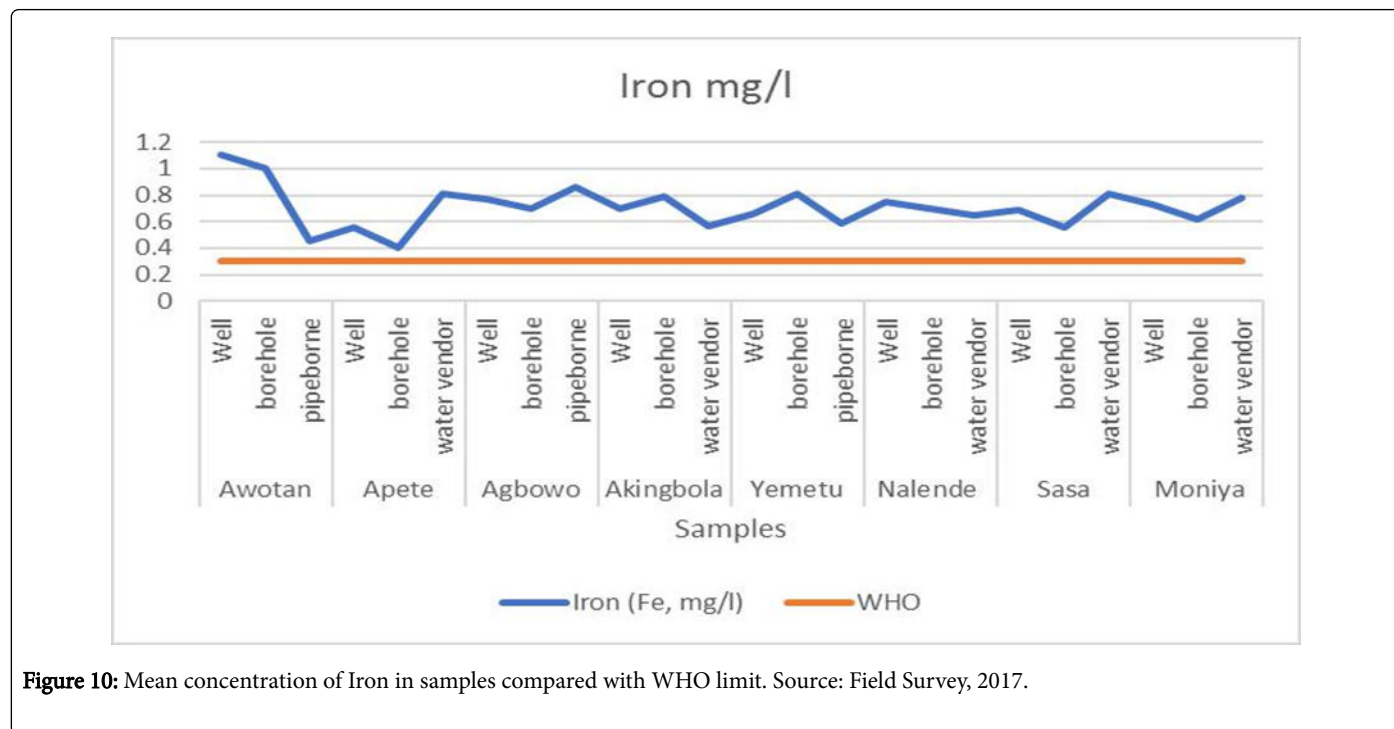
### Concentration of heavy metal

Heavy metals' is the term applied to metals with an atomic weight greater than 6. They are generally only found in very low levels dissolved in fresh water but may be found in bed load sediments. In acidic waters metals can be dissolved (i.e. found in ionic form). They are often toxic in concentrations above trace levels. The toxicity, in decreasing order, is mercury, cadmium, copper, zinc, nickel, lead, chromium, aluminium and cobalt. For this research Iron, Zinc and Lead are tested for.

**Iron (Fe):** The result for Iron shows the the minimum concentration of Iron(Fe) in the study area is 0.455 mg/l and the maximum concentrated water is 1.102 mg/l, a standard deviation of 0.1571 and a mean 0.710 mg/l while WHO standard is 0.3 mg/l. The valve obtained from Awotan contain the highest contamination of Iron with sample 1 (Awotan well) as high from the WHO standard with the value of 1.1 mg/l with none of the water sampled at the same level with the WHO standard (Table 8 and Figure 10).

Parameter	Minimum	Maximum	Mean	WHO	Std Deviation	Skewness
Iron (Fe, mg/l)	0.455	1.102	0.71025	0.3	0.15709793	0.4039169

**Table 8:** Summary Statistics for Concentration of Iron.



**Figure 10:** Mean concentration of Iron in samples compared with WHO limit. Source: Field Survey, 2017.

Zinc (Zn): The concentration of Zinc(Zn) has its minimum concentration as 0.059 mg/l and the maximum concentrated water is 0.1 mg/l, a standard deviation of 0.0112 and a mean 0.0778 mg/l while WHO standard is 3 mg/l. The water of these slum areas all fall below the WHO acceptable standards (Table 9 and Figure 11).

Parameter	Minimum	Maximum	Mean	WHO	Std Deviation	Skewness
Zinc (Zn, mg/l)	0.059	0.1	0.0777917	3	0.01124811	0.1018515

**Table 9:** Summary Statistics for Concentration of Zinc.

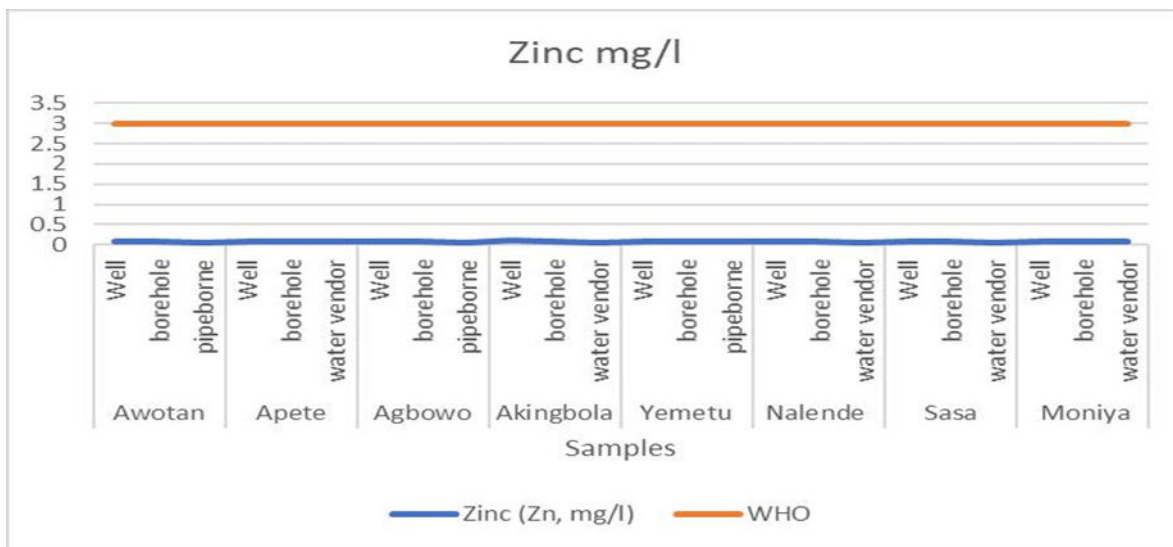


Figure 11: Mean concentration of Zinc in samples compared with WHO standard. Source: Field Survey, 2017.

**Lead (Pb):** The concentration of lead(Pb) in water in the study area has its minimum concentration as 0.079 mg/l and the maximum concentrated water is 0.259 mg/l, a standard deviation of 0.0408 and a 0.111 mg/l while WHO standard is 0.01 mg/l.

moderately low compared with well and borehole. The well and borehole of Awotan and Apete of Ido LGA are higher (Table 10 and Figure 12).

The value of Lead is above the required WHO standards. The graph has a sinusoidally pattern which represents the water from vendor are

Parameter	Minimum	Maximum	Mean	WHO	Std Deviation	Skewness
Lead (Pb, mg/l)	0.079	0.259	0.111	0.01	0.04080494	2.9233437

Table 10: Summary Statistics for Concentration of Lead.

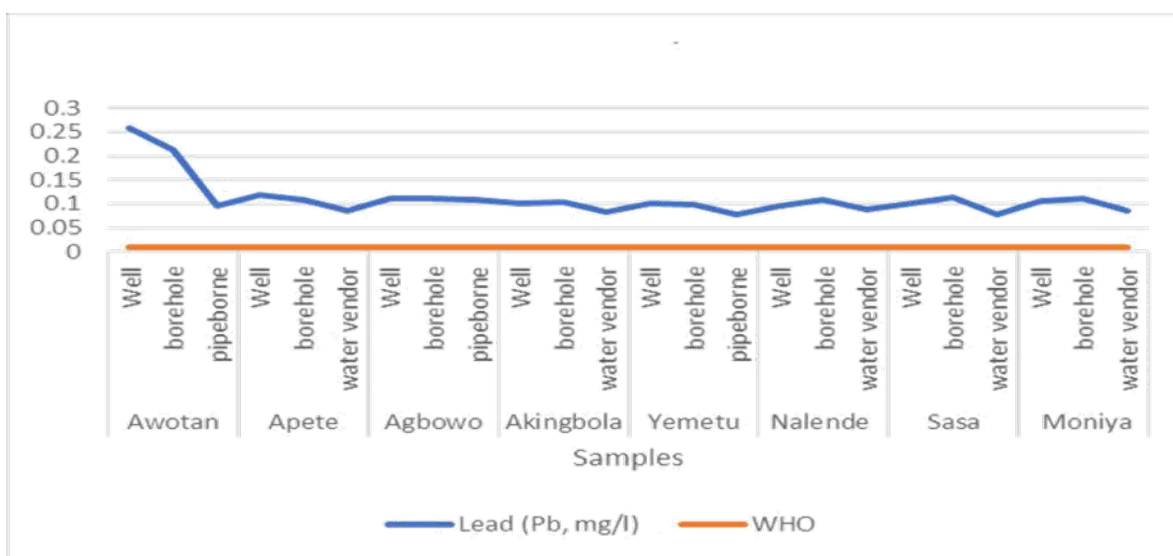


Figure 12: Mean concentration of Lead in samples compared with WHO standard. Source: Field Survey, 2017.

### Comparison of water quality over space

Figure 13 shows a comparison of water quality over space in the slums areas of Ibadan. Awotan and Apete have the lowest quality of

water, with total dissolved solid, and water pH highest among sampled areas, which is a rural landuse. This showed a difference in water quality across different landuse compared to within the landuse.

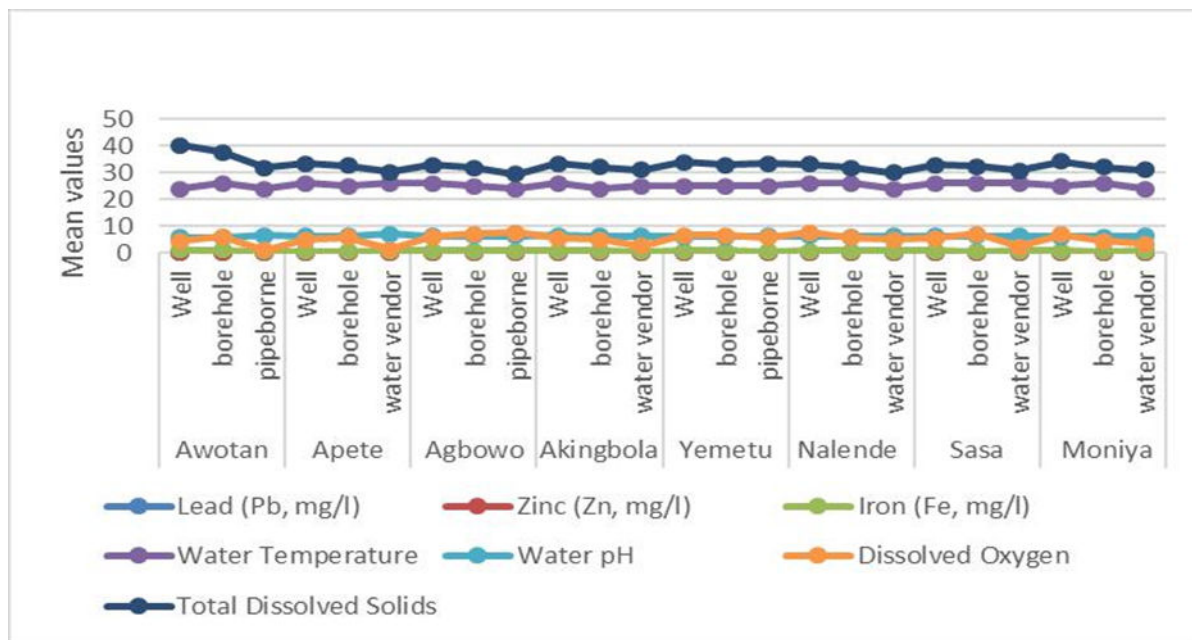


Figure 13: A line graph showing the spatial variation of water quality. Source: Field Survey, 2017.

### Comparison of water quality from different sources

Figure 14 belows shows a comparison of water quality from different sources in the slums areas of Ibadan. Well water source has the lowest quality of water, followed by Borehole. While Water from vendor or pipeborne has the highest quality (water from vendor contain high portion of this category as many slum areas does not have pipeborne).

Result below shows that water pH, total dissolved solid and dissolved oxygen has a significant value of 0.028, 0.031, and 0.000 and F value of 3.723, 3.608, and 14.232 respectively using significant level of 0.05 and a confidence level of 95%. Therefore, the null hypothesis is rejected, and the alternative hypothesis (H1) is accepted.

There is significant variation in different water source of water pH, total dissolved solid and dissolved oxygen. While water temperature, Concentration of Iron, Concentration of Zinc, Concentration of Lead have no significant variation, and their null hypothesis (H0) accepted.

The result shows an inference that significant variation in different water source of water pH, total dissolved solid and dissolved oxygen. This could have been induced by the physical environment (atmosphere, rock etc.) of the different water source because all the parameter significant are physical (Table 11).

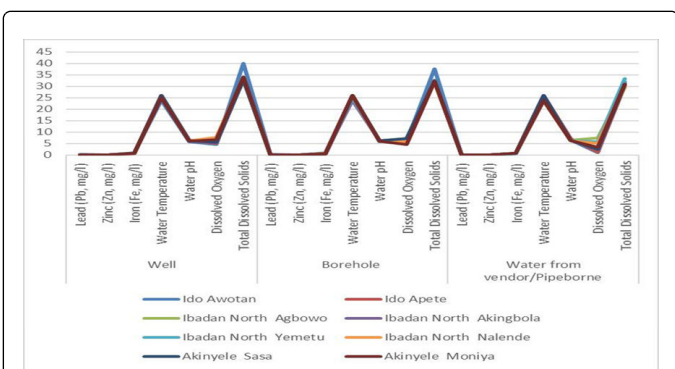


Figure 14: A line graph showing the quality of water in different water source. Source: Field Survey, 2017.

### Hypothesis testing

**Variation in the quality of water in different source:** Variation of water quality in different water source in the slum areas of Ibadan.



Parameters		Sum of Squares	df	Mean Square	F	Sig
Water Temperature	Between Groups	33.417	3	11.139	0.409	0.748
	Within Groups	545.083	20	27.254		
	Total	578.500	23			
Water pH	Between Groups	0.576	3	0.192	3.723	0.028
	Within Groups	1.031	20	0.052		
	Total	1.607	23			
Water Total Dissolve Solid	Between Groups	41.735	3	13.912	3.608	0.031
	Within Groups	77.105	20	3.855		
	Total	118.840	23			
Dissolved Oxygen	Between Groups	54.411	3	18.137	14.232	0.000
	Within Groups	25.488	20	1.274		
	Total	79.898	23			
Concentration of Lead	Between Groups	0.006	3	0.002	1.340	0.290
	Within Groups	0.032	20	0.002		
	Total	0.038	23			
Concentration of Zinc	Between Groups	0.001	3	0.000	2.524	0.087
	Within Groups	0.002	20	0.000		
	Total	0.003	23			
Concentration of Iron	Between Groups	0.017	3	0.006	0.211	0.887
	Within Groups	0.550	20	0.028		
	Total	0.568	23			

Table 11: A Table showing the Anova of water quality in different sources. Source: Field Survey, 2017.

**Spatial variation of water quality in slum areas of ibadan:** Spatial variation of water quality in the slum areas of Ibadan. Table 12 below show that concentration of lead, has a significant value 0.033 and F value of 2.983, using significant level of 0.05 and a confidence level of 95%. Therefore, the null hypothesis is rejected, and the alternative hypothesis (H1) is accepted.

There is significant spatial variation of the level of lead concentration in the slums areas of Ibadan. While water pH, has a significant value 0.432 and a F value of 1.058, water temperature, has 0.432 sig value and F value of 1.059, total dissolved solids, have a

significant value of 0.101 and F=2.121, concentration of zinc, have a significant value of 0.682 and F value of 0.686 and concentration of iron, with a significant value of 0.722 and F value of 0.633 all have no significance variation, and their null hypothesis (H0) accepted.

This inference where carefully draw that the water in this area are contaminated with Lead which is a toxic heavy metal element and could lead to water borne disease like abdominal pain increase in blood pressure, anaemia when taken in the water. This could have been induced because of the nature of the underlain rock material in the study area (Table 12).

Parameters		df	Mean Square	F	Sig.
Water pH	Between Groups	7	0.073	1.058	0.432
	Within Groups	16	0.069		
	Total	23			
Water Temperature	Between Groups	7	26.167	1.059	0.432

	Within Groups	16	24.708		
	Total	23			
Water Total Dissolve Solid	Between Groups	7	8.170	2.121	0.101
	Within Groups	16	3.853		
	Total	23			
Dissolved Oxygen	Between Groups	7	3.774	1.129	0.393
	Within Groups	16	3.343		
	Total	23			
Concentration of Lead	Between Groups	7	0.003	2.983	0.033
	Within Groups	16	0.001		
	Total	23			
Concentration of Zinc	Between Groups	7	0.000	0.686	0.682
	Within Groups	16	0.000		
	Total	23			
Concentration of Iron	Between Groups	7	0.018	0.633	0.722
	Within Groups	16	0.028		
	Total	23			

Table 12: A Table showing the Anova the spatial variation of water quality. Source: Field Survey, 2017.

**Difference between the water quality in the study area and who standards:** Significant difference between the water quality in this region and WHO standards. The student one sample T test of two sample equal variable is =0.1750456, using the significant level of 0.05

and confidence interval of the difference of 95%. Since 0.350 is > than 0.05. Therefore, the null hypothesis is accepted or retain. There is no significance difference between water quality and WHO standards (Table 13).

	Paired Differences	95% Confidence Interval of the Difference		t	DF	Sig. (2tailed)			
		Mean	Std. Deviation				Std. Error Mean	Lower	Upper
Pair 1	Mean Values WHO Standard	-67.5	176.275	66.626	-230.528	95.526	1.01	6	0.35

Table 13: A Table showing the mean of parameters and WHO standards. Source: Field Survey, 2017.

### Conclusion

The quantity of water is as important as the quality, since these affect the quantity and the quality of available water, water quality is used to express the suitability of water and sustainable to various uses or processes. It is affected by a wide range of natural and human influences, the most important of the natural influences is hydrological influence.

The water qualities study was carried out in Ibadan using three landuse (urban, peri urban and rural) in slum areas of Ibadan were evaluated for these physicochemical parameters: temperature, total dissolved solid (TDS), pH, and dissolved oxygen (DO), from well, borehole, water from vendor or pipeborne, from 8 localities and 3 LGA

in Ibadan. The results showed variations in the water quality parameters the slum areas.

The evaluation carried out therefore implies a significant spatial variation of water quality of Lead concentration and a significant variation in different water source of water pH, total dissolved solid and dissolved oxygen respectively. The quality of water depreciates with landuse type from rural to urban and that, Rural slums area in Ido local government in Awotan and Apete have less potable water, the water quality in this area are acidic this can be because of anthropogenic activities like agriculture and refuse dump with have affected the groundwater.

Also, on the aspect of the depth of borehole, it is generally presumed that the deeper the borehole, the higher the volume of water produced. This has been proven to be a wrong presumption as the amount of water quantity and quality is not a function of the depth of borehole but largely a function of the underlying lithology.

## Summary

This research is based on the assessment of water quality in the slum in Ibadan. This chapter gives summary of all the various analysis carried out in the course of the study. The result gotten are used to draw out conclusion and make recommendations. It is clear from the above research on assessment of water quality in the slum areas of Ibadan.

That the water from difference source used for domestic uses in the slum areas of Ibadan comprises of well, borehole and water from vendor/pipeborne. The safest and best quality of water from this source is the water from vendor which are not free but to be purchase by residents which will make it not adequately readily available for all financial class of people and cannot be afford by majority for their domestic use.

Water pH is lowest in Awotan and Apete of Ido LGA water source which makeup rural slums landuse. with water pH of 5.7 well and 5.8 borehole which is acidic, there is highest value of conc of Lead (Pb) in these areas of (0.259 mg/l) compared to other landuse and locality, water is of best quality among water from vendors. Using the sig value of 0.05, that is no sig difference between the water quality in slum areas and WHO standards.

ANOVA was used to define if there is statistically significant correlation between dependent variables of physico-chemical parameters of water temperature, pH, Dissolved Oxygen, Total Dissolved Solids, conc of zinc (Zn), and iron (Fe) also having no significant. But a significant spatial variation of water quality of Lead (Pb) concentration with the sig value of 0.033 and F value of 2.983. There is significant variation in different water source of water pH, Total Dissolved Solid and Dissolved Oxygen. a sig value of 0.028, 0.031, and 0.000 respectively.

## Recommendations

The possible recommendations aimed at slums areas the well and Borehole which is the major source of water need improvement especially the water of the rural slum areas in Ibadan.

Diseases related to consuming contaminated water is a major burden on human health. And slums areas have been a major home for this, according to WHO, a holistic approach to water quality assessment and drinking-water supply risk assessment and risk management increases confidence in the safety of drinking-water. This approach entails systematic assessment of risks throughout a drinking-water supply from the catchment and its source water through to the consumer. There is the need therefore to intensify effort to minimize or completely eliminate post treatment contamination of public tap water by effective monitoring of the distribution system

Monitoring: As far as possible, well and boreholes should be used for establishing monitoring stations and not just water from vendors. Monitoring procedures for groundwater must be coordinated to evaluate the relationship between infiltration and recharge. This can be achieved by establishing with piezometers that are equipped with data

loggers to frequently record groundwater level changes. This will allow for an evaluation of consequently any recharge generated.

Judging from the paper there is increasing pollution with concentration of heavy metals in rural landuse, this may be as a result of the construction of Wells which most in this rural slum area are unprotected wells design has been proven to be the poor for proper hygiene and protection of wells. However, the combined effects of installing wells close to sanitary facilities, waste dumps, industrial effluent discharge area and burial ground, resulting in the deterioration of the quality and its potential public health risk. This is also collaborated by Oyeleke et al. in the literature above [40,41].

Hence, the recommendations for planning of potable pipeborne water and a periodic water quality monitoring and incorporation of household water treatment practices especially for water use for domestic uses. Upgrade of semi-protected and unprotected wells is recommended, and public enlightenment on water quality is necessary to forestall potential public health treats from such sources. I recommend a periodic research like this by government agencies like WHO, SON, NHS and should be used for taking decisions.

Finally, I recommend urban planning and development in his areas and the updating knowledge of Geology and underlying rock materials in these areas. By personnel with adequate know how this is called lithology. If these recommendations are considered, they will help in addressing the problems manifested in increasing waterborne disease, adequate and better water supply, cost of living, inadequate performance, shortened work life and a good and better environment as well as problem related to water quality, quantity, demand, and leakage.

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