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Quantitative and Qualitative Assessment of Drinking Water Sources in Ile-Ife and Environs

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ABSTRACT: *Most water supply programmes in Nigeria have focused on providing access to quantitative drinking water to the populace, an approach, which has led to an increasing reliance on ground water supply through sinking of boreholes and wells. However, there has been very few data collected on the quality of the underground source for drinking water purpose in the area. Quality assessment of ground water supply in Ile-Ife and its environs was carried out because much of the population in the area relies on groundwater supplies as a sustainable drinking water source. Laboratory analysis was conducted on water samples collected from 14 public boreholes and wells located at various sections of the study area. Sampling occurred for 12 months from January-December, 2013. The samples were analyzed for bacteriological, physical and chemical qualities. The results show that total coliform and heterotrophic bacteria were present in 50% and 20% of samples analyzed. Heterotrophic bacteria of concern include Trichodema sp, Cladosporium herbarium, microsporium andouini; Rhizopus stolonifer and pulluria pullularis. The physical and chemical properties of the various sources of water compared favourably with the World Health Organisation Standards (WHO). The study showed that there are several parameters of health concern as biological analysis exceeded the minimum standards set by WHO.*

KEY WORDS*: drinking water, assessment, health, water quality, Ile-Ife.*

I. INTRODUCTION

Water is essential to life. The provision of water of adequate quantity for human use and consumption is not only a pre-requisite for development but also a major contribution towards the improvement of health, hygiene and welfare of people [Howard and Bartram, 2003]. They added that access to safe water reduces water-borne and water-washed diseases. More importantly the provision of regulated in-house piped water would lead to massive overall health gains [Hutton and Haller, 2004]. A review of the existing literature revealed that the supply of portable piped-borne water helps to decrease the mortality and morbidity rate particularly among infants and children as well as making life easier for women. Significant health gains accrue by ensuring access to an improved water source within 1 kilometer of the user`s house [Esrey et al., 1985; Howard and Bartram, 2003]. Beyond reducing water-borne and water-related diseases, providing better access to improved water and sanitation confers many other diverse benefits ranging from cost offsets, timed saved to convenience and well-being. Cost offsets are costs avoided due to less illness, costs savings to health sector mainly due to the reduced number of treatments of diarrhea and patients avoided costs incurred in seeking treatment (expenditures on care, drugs and transport as well as the opportunity costs of time spent on seeking care). Another sets of benefits related to less illness are the avoided days lost with respect to formal or informal employment, other productive activities in the household, or school attendance, gained related to lower morbidity and less death. Time savings occur due to the relocation of a well or boreholes to a site closer to use communities and the installation of piped water supply in house. In contrast, poor access to safe and adequate sanitation continues to be a threat to human health. Where the basic access level has not been achieved, hygiene cannot be assured and consumption requirements may be at risk. The adverse impacts on public health from poor water supply take the form of outbreaks and contribution to background rates of disease [Esrey et al., 1991; Ford, 1999; Payment and Hunter, 2001]. Water-borne and water related diseases like cholera, typhoid fever, hepatitis A, schistosomiasis and dysentery can break out in any community that does not have access to safe water supply of adequate quantity.

The most important and immediate risks to human health from using contaminated water drinking water is diarrhea disease especially among children in poor countries [World Health Organisation, 2007]. Data from epidemiological and zero prevalence studies indicate that endemic transmission of disease associated with diarrhea and other gastro intestinal disease estimated at 2.2 million deaths and over 72 millions disability adjusted life years were attributable to unsafe water and sanitation, including lack of hygiene, [Pruss et al., 2002; WHO, 2002; Priss-Uston et al., 2004; Hutton and Haller, 2004; Howard and Bartram, 2005; Bartram, 2007]. The available evidence suggests that, improving access to safe water supply and sanitation services is a preventive intervention and proven contributors to controlling this disease burden, whose main outcome is a reduction in the number of episodes of diarrhea and accordingly a proportionate reduction in the number of death [WHO 2002; Hutton and Haller, 2004; Bartram, 2007]. Given the link between vulnerability to disease and poverty [Payment and Hunter, 2002] the assessment of adequacy and quality of water supplies for human consumption is imperative. For informed rational decision- making it is crucial to carry out a sound quality evaluation of the sources of water supply in different settings. Such information can be acquired through water monitoring and examination, which is the continuous and vigilant public health assessment and oversight of the safety and acceptability of water supplies [WHO, 1976, 1993, 2004]. The regular examination of drinking water samples requires by law in most countries is for the sole purpose of ensuring the supply is safe for consumption. The practice will help to curb the spread of waterborne diseases which can lead to epidemics as well. The examination of water samples will provide information on water quality level. It will also show whether the water is in physically, chemically and bacteriologically accepted conditions, and if it is not, it may indicate why and where the deterioration of quality has occurred and how the quality may be restored.

II. WATER SUPPLY ARRANGEMENT IN NIGERIA

Water supply access in Nigeria is complex. In the pre-colonial Nigeria, the sources of water supply to a community for drinking and households purposes were mainly from rain, dug wells, flowing streams and rivers. Due to urbanization and industrialization, there were organised public water supply systems, where treated and quality water was transmitted from water works, distributed and supplied to households via pipeline networks. Almost all sections of the society especially in urban centres and growing towns have access to safe water piped to their homes. In the last two decades, due to the collapse of public water supply system many of the inhabitants in the study area use unreliable water supplies of poor quality, which are costly and are distant from their home. Poor access to safe water and adequate sanitation continues to be a threat to human health. Factors such as poor reliability (continuity of supply), costs (affordability) and distance between a water source and the home leads the inhabitant to depend on less safe sources, to reduce the volume of water used for hygiene purposes.

The Millennium Declaration Goal (MDG 7) launched in 2000 brought about huge interventions of home governments of most developing countries in the provision of portable water to growing cities rural communities. In Nigeria, the provision of basic amenities to the urban centres and developing cities has been a priority of the Federal, States and Local Governments. Huge sum of money have therefore gone and are still going into mini-water scheme projects such as sinking of boreholes and wells around the vicinity of the neighbourhood as means of sustainable water supply (the study area inclusive). Esrey et al. [1985], Howard and Bartram [2003] and Howard and Bartram [2005] noted that significant health gains accrue by securing access to an improved water source within 1 kilometer of the user`s house. Further significant health gains are accrued once water supply is delivered `on-plot` through at least one tap [Howard and Bartram, 2003]. However, the water needs to be of good quality that represents a tolerable level of risk [Howard and Bartram, 2003]. Information about the quality and health risks faced by the inhabitants in the study area through this intervention remains scarce. The providers hardly performed routine monitoring of water supplies to the growing population. Drinking water from groundwater supply is believed to be sufficiently safe, excellent quality, purer, attractive and palatable to be used without treatment since impurities would not be expected in it because of the filtering action of the aquifer [Throne et al., 2002]. A lot of reasons call for constant examination of quality of drinking water got from groundwater supply. Groundwater sources may be liable to be contaminated by sewage from septic tank and pit latrines if they are not properly constructed, protected and the mandatory minimum distance of 30 m from septic tanks/pit latrines recommended by World Health Organisation is not observed [Ayanlaja et al., 2005; Adejuwon, 2009]. A review of literature also showed that most important source of serious illness and death especially among young children, in both rural and poor urban settlements in developing countries are traceable to the use of untreated water from groundwater sources [Nasinyama et al., 2000; Pokhrel and Viaragham, 2004; World Health Oraganisation, WHO, 2007]. Furthermore, it may almost be impossible to find a source of natural water that will meet basic requirements for public water supply without requiring some forms of treatments. This is because water is a universal solvent; as such most natural as well as man-made substances are soluble in it.

Underground water supply sources may contain much matter dissolved from strata through which it passes. Groundwater absorbs gases of decomposition and degradable oxygen organic matter (such as H_2S, methane) within the pores of soil mantle through which it percolates. In strata which are rich in organic matter, oxygen is removed from percolating water and CO_2 is added. Groundwater has low Ph values. Consequently, water in nature contains dissolved substances and impurities. Therefore, it may be necessary to remove colour, odour and taste imparted to the stored water by the decomposition of organic matter or growth of algae. Infact monitoring of the quality of water got from these interventions become very important because preliminary site investigation showed that septic tank and pit latrines are often dug within few metres from these wells and boreholes. This according to Adejuwon [2009] and Ayanlaja et al. [2005] is dangerous because it may results into massive groundwater contamination. In the past, there have been many cases of recurring epidemic of enteric fevers traceable to drinking water from groundwater supplies. Besides, previous studies [Akinbode, 1986; Ako et al., 1990] in the area showed that a larger percentage of wells in Ile-Ife have high turbidity level and water from them was not fit for human consumption without treatment since the quality was below the appropriate standard recommended by the World Health Organisation. The need was therefore identified for a systematic investigation into the quality of water supplies from this min-water scheme projects as an input to prevent health problems.

The purpose of this study is to critically review the adequacy and quality of water supply through these interventions. The quality of the water supplies was pursued through the analysis of physical, chemical and bacteriological characteristics of water supplies. This information is relevant to public health professionals in helping to set priorities for water supply improvements.

III. METHODOLOGY

Field work: This involved collection of relevant data from local water corporation office, oral interview with residents in various section of the town and collection of water samples from identified sources of water supply.

Zoning of the study area

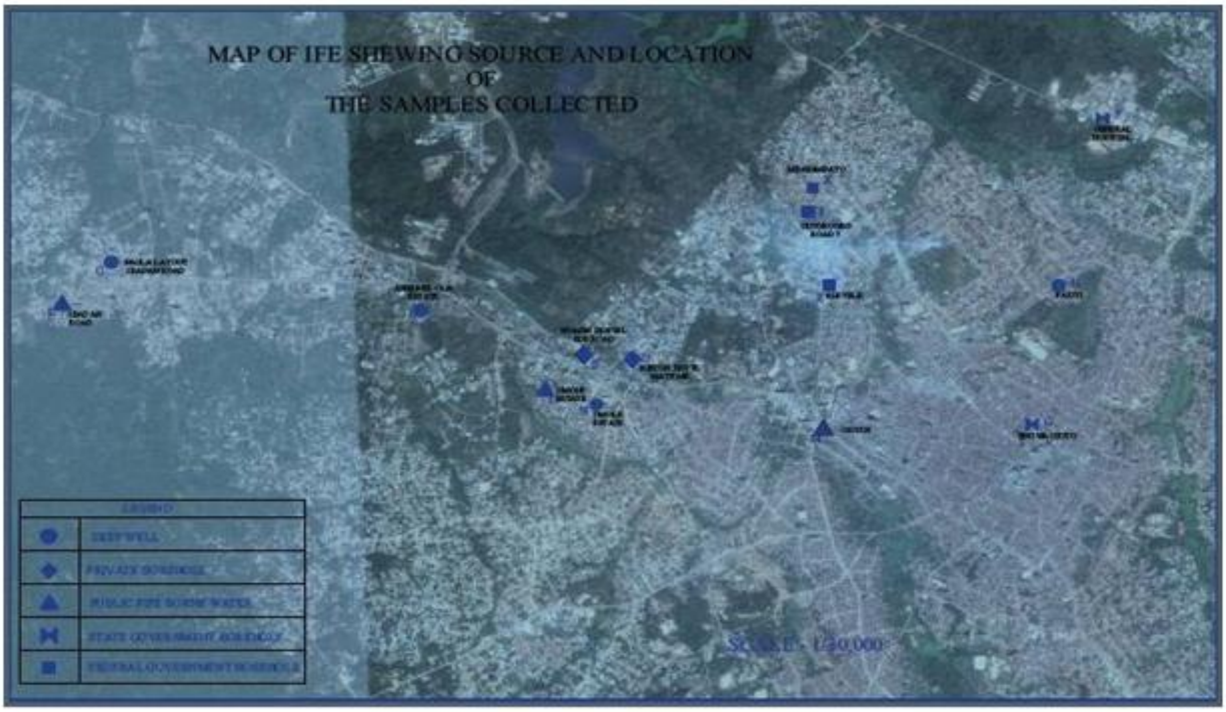

Fig.1: Map of Ile-Ife showing sources and location of sample collected.

Fig.1 is the map of Ile-Ife showing sources and location of sample collected. Ile-Ife and its environs were divided into five zones using the major road network. This was done to enable a representative of the zone to be sampled and analyzed. Zone 1 consisted of Ajebamidele, Ibadan road, Ede road and Faola layout. Zone 2 made up of Fashina, Ife Central Local Government Secretariat area, Asherifa-Ola Estate, Moremi Estate, Omole

Estate and Oba layout. Zone 3 comprises Mayfair and Parakin Scheme. Zone 4 consists of Eleyele, Moore, Ojoyin, Enuwa, Otutu and Oni`s palace while zone 5 comprises Fajuyi, Igboya, Ikoyi quarters, Aladanla and General Hospital area.

Interview and site observation assessment: The five zones into which the study area was divided into was visited for on-spot assessment of water supply technologies and oral interview was conducted with the inhabitants to ascertain the various sources of water supply available to them, frequency of supply, ease and access as well as the quality of water supply. The questions asked during the oral interviews were the same in all the five zones to enable uniformity in data collection.

Sample collection: The water samples analysed for this study were collected from January-December 2013. A structured inspection and sampling programme was created to include a total of 14 samples. The samples were selected purposively based on relative occurrence and importance, ensuring that at least one from each zone was included. This method was employed because it is a difficult task identifying all the households in the study area. A sample was also taken for on-site determination of appearance. All the samples were collected in sterilized containers labeled as indicated in Table 1. The collection of water samples, the sampling equipment, procedures and technique were done according to standards procedures laid down. This was to ensure that changes in the constituents to be analysed did not occur between the time the samples were collected and the time they are analysed. The water samples and were taken to the laboratory for analyses.

Table 1: Sources and location of the samples collected

Source	Sample code	Location	Coordinate	
			Easting (m)	Northing (m)
Deep Well	A	Asherifa-Ola Estate	667824	828358
Private Borehole	B	Women Hostel Ede Road	669058	828202
Deep Well	C	Faola Layout Ibadan Road	665659	828934
Private Borehole	D	Hilton Hotel Mayfair	669149	827886
Timber Market Federal Government Borehole	E	Eleyele	670822	828751
State Government Borehole	F	General Hospital	672789	830075
State Government Borehole	G	Enuwa Otutu	672283	827649
Deep Well	H	Fajuyi	672471	828751
Deep Well	I	Omole Estate	668782	827933
Federal Government Borehole	J	Oluorogbo Road 7	670672	829335
Federal Government Borehole	K	Mbabimbayo	670705	829525
Public Pipe Borne Water	L	Ibadan Road	665306	828615
Public Pipe Borne Water	M	Ojoyin	670781	827625
Public Pipe Borne Water	N	Omole Estate	669149	827806

Laboratory analysis: In the laboratory, the samples were tested for physical characteristics (total solid, total dissolved solids, total suspended solids, apparent colour, turbidity and conductivity), chemical characteristics (pH, alkalinity and acidity) and bacteriological characteristics (total coliform). The following presumptive, confirmatory, completed, isolation and identification, morphological characteristics of the isolates by gram staining technique, triple sugar iron medium, sulphide-iodide-motility, catalase, citrate utilization, methyl red and Vorges-Proskaur, nitrate reduction, oxidation and sugar fermentation tests were also carried out in order to isolate and narrow down E-Coli bacteria. For determination of dissolved gases field analysis was also carried out. All analyses were carried out according to the standard laboratory procedures. Special precaution was also observed during determination of bacteriological characteristics.

IV. RESULTS AND DISCUSSION

Sources and adequacy of water supply : The various sources of drinking supply water in Ile-Ife are presented in Table 2. Table 2 shows that out of five zones only zones 1 and 2 have access to public pipe borne water supply as their primary source of drinking water. The other three zones depend majorly on underground water supply system for their source of drinking water. Even in zone 1 and 2, majority of the people still depend majorly on underground supply system. Further analysis shows that only 10% of the quantity of drinking water required by the inhabitants is met through public pipe borne water supply. Consequent, the inhabitants relies on alternative sources of supply such as individual small point water supplies (dug wells) (Appendix D). This means that the supply of pipe borne water to Ile-Ife and environ is highly inadequate.

Table 2: Sources of Drinking Water

Zone	Location	Primary Source	Secondary Source	Remarks
One	Ajebamidele	Public tap water	Well	Constant public water supply
	Faola Layout	Well	Borehole	Intermittent public water supply
	Ede Road (from Ede)	Public water	Well	Constant public water supply
	Ede Road (to Mayfair)	Well and borehole	Public tap water	Intermittent public water supply
	Ibadan Road	Public tap water	Well	Constant public water supply
	Asherifa-Ola estate	Well	Borehole	Intermittent public water supply
	Oloke	Public tap water	Well	Constant public water supply
	Alawode Estate	Well	Borehole	Intermittent public water supply
Two	Moremi Estate	Public tap water	Well	Constant public water supply
	Omole Estate	Public tap water	Well	Intermittent public water supply
	Mayfair	Well	Borehole	Constant public water supply
	Parakin	Well	Borehole	Intermittent public water supply
	Road 7	Borehole	Well	Constant public water supply
	Sabo	Borehole	Well	Intermittent public water supply
	Eleyele	Borehole	Well	Constant public water supply
	Ilesa road	Well		Intermittent public water supply
	Iremo road	Well		Constant public water supply
	Koyiwo Layout	Well	Public tap water	Intermittent public water supply
	Moore	Well	Borehole	Constant public water supply
Three	Enuwa	Borehole	Well	Intermittent public water supply
	Ojoyin	Well	Public tap water	Constant public water supply
	Fajuyi	Well		Intermittent public water supply
	General	Well	Boreholes	Constant public water supply
	Ikoyi	Well		Intermittent public water supply
	Igboya	Well		Constant public water supply
Four				
Five				
	Aladanla	Well		Intermittent public water supply

Physical Analysis : Table 3 shows the results of total solid, (TS), total dissolved solid (TDS), total suspended solid (TSS), apparent colour, turbidity and conductivity tests carried out on the samples collected, The results indicated that the total solid (TS), total dissolved solid (TDS), total suspended solid (TSS), conductivity and turbidity contents of the water samples collected ranging from 200mg/1-900 mg/1, 120 mg/1-650 mg/1, 20mg/1-380mg/1, 59us l0l0us and *1.53* TNU-*4.56* TNU respectively. Figures 2, 3, *4* and table *4* compared the total solid (TS), total dissolved solid (TDS) turbidity and conductivity results with the World Health Organization approved standards. The results also revealed that sample G (Enuwa Otutu Bore hole drinking water source) had a very high content of total solid. The quantity of total solid in the water supplied on Ibadan road is less than the water supplied in Omole Estate and this in turn is less than water supplied in Ojoyin (samples, L, N and M). This means that as the distance along the pipeline increases so also the total solid increases.

Table 3: Results of Physical Analysis

Sample code	TS (mg/i)	TDS (mg/i)	TSS (mg/i)	Turbidity (TNU)	Conductivity (ii)	Apparent colour
A	400	120	280	1.53	87	Light brown
B	200	180	20	1.53	298	Colourless
C	200	150	50	4.56	59	Colourless
D	200	150	250	4.56	162	Colourless
E	500	260	240	4.56	160	Colourless
F	300	200	100	4.56	281	Colourless
G	900	650	250	4.56	1010	Colourless
H	300	160	140	4.56	312	Colourless
I	500	300	200	4.56	300	Colourless
J	300	130	170	4.56	168	Colourless
K	500	150	350	4.56	165	Colourless
L	200	120	80	1.53	160	Colourless
M	600	220	380	1.53	158	Colourless
N	400	300	100	1.53	155	Colourless

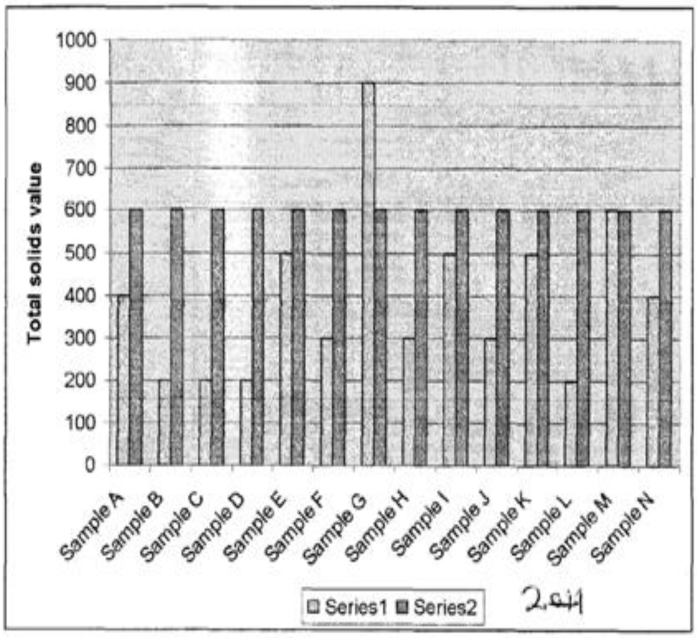

Fig 2: Result of Total Solid (TS) Compared with W.H.O Approved Standards

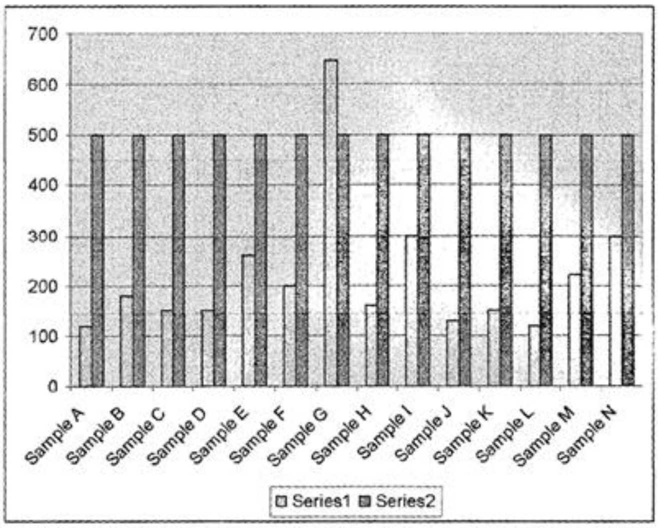

Fig 3: Result Total Dissolved Solid (TDS) Compared with the W.H.O Approved Standards

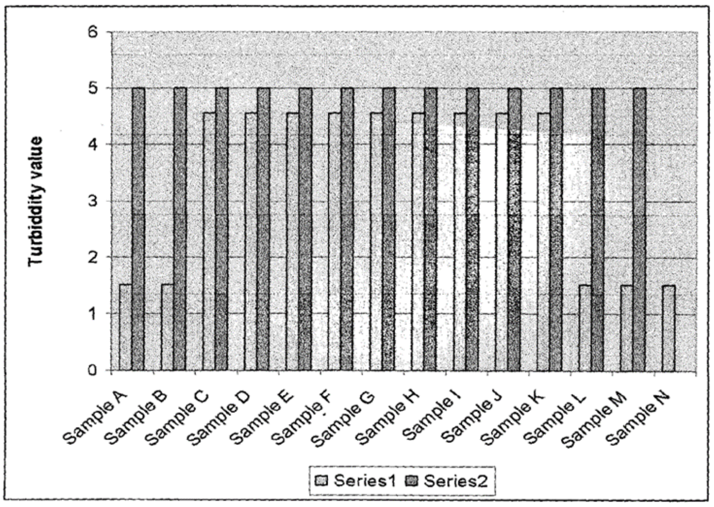

Fig 4: Result of Turbidity (TNU) Compared with the W.H.O. Approved Standards

Table 4: Result of Conductivity analysis compared with the W.H.O Standards

Sample Code	Conductivity	WHO Approved Standards
A	87.0	
B	298.0	
C	*59.0*	
D	162.0	
-E	160.0	
F	281.0	
G	101.0	
H	312.0	
I	300.0	
J	168.0	
K	*165.0*	
L	160.0	
M	158.0	
N	*155.0*	

Chemical Analysis : Table 5 shows the results of PH, Acidity, Alkalinity, hardness and chloride contents of the drinking water sources, while Figures 5, 6, 7 and 8 compared the results of chemical analysis with the World Health Organization approved standards. The comparison demonstrated that the chemical contents of the water samples compared favourably with the World Health Organization approved standards. Furthermore, the alkalinity and acidity values of the water samples were found to be lesser than the hardness values revealing the presence of salts of calcium and magnesium which were more likely to be sulphates instead of carbonates.

Table 5: Results of Chemical Analysis

Sample code	PH	Acidity Mg/1 CaCO3	Alkalinity Mg/I CaCO3	Hardness (mg/L)	Chloride (mg/L)
A	*6.50*	*56*	28	270.2	20.0
B	6.45	58	26	162.0	10.0
C	*6.25*	*54*	24	252.0	10.0
D	6.48	44	84	189.0	20.0
E	6.8	40	110	135.0	10.0
F	7.4	40	166	140.0	20.0
G	7.0	48	188	248.0	10.0
H	6.44	62	24	142.0	10.0
I	6,40	58	24	135.0	20.0
J	6.7	42	112	142.0	10.0
K	6.8	43	110	162.0	10.0
L	7.0	30	26	248.0	20.0
M	7.0	30	26	270.0	10.0
N	7.0	*35*	25	135.0	10.0

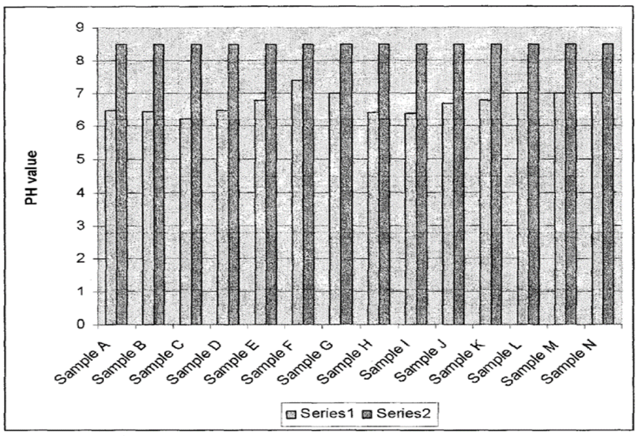

Fig 5: Result of PH Value Compared with the W.H.O Approved Standards

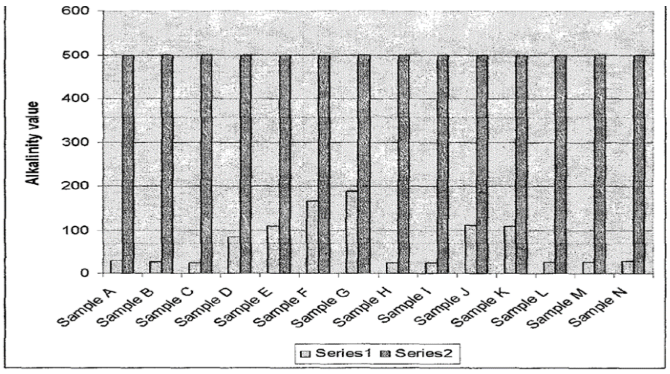

Fig. 6: Result of Alkalinity compared with the W.H.O Approved Stand

Bacteriological Analysis : Table 6 shows the results of the various microbiological tests carried out on the water samples. The results reveal the absence of coli form in the water samples collected from sample D (private borehole), sample E (Timber market Federal Government borehole), sample G (state borehole), sample J (Federal Government borehole), sample L (Public Taps), sample M (Pipe borne water) and sample N (Pipe borne water). The other water samples (A, B, C, F, H, I and K) have coli form, counts ranged between 200 and 1100, the highest value however was recorded in the water samples collected from Deep well at Asherifa Estate, Deep well at Faola layout Ibadan Road and Deep well at Fajuyi. Figure 9 compared the bacteriological analysis results with the World Health Organization approved standards and it revealed that the coli form counts in Samples A, B, C, F, H, I and K were above the recommended standards. Further tests show the presence of Trichodema sp, Cladosporium herbarium, Microsporium audouinii in sample A, Rhizopus stolonifer, Absidia sp ,Cladosporium herbarium in sample C, Mucor mucedo, Rhizopus orzae, pullularis pullularis, Rhizopus Japoricus, Cladosporium herbarium in sample H. However, no form of E. coli was detected in all the samples.

Table 6: Result of Bacteriological Analysis

Sample code	Coliform count/l00m1	E. coli
A	1100	Negative
B	240	Negative

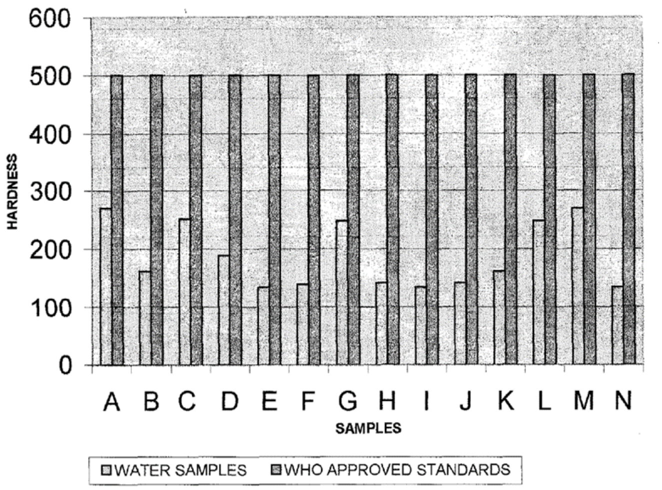

FIG. 7 RESULTS OF HARDNESS COMPARED WITH THE WHO APPROVED STANDARDS

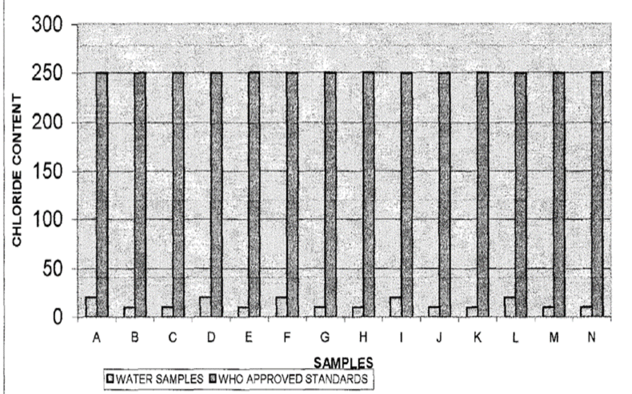

FIG.8: RESULTS OF CHLORIDE CONTENT COMPARED WITH WHO APPROVED STANDARDS

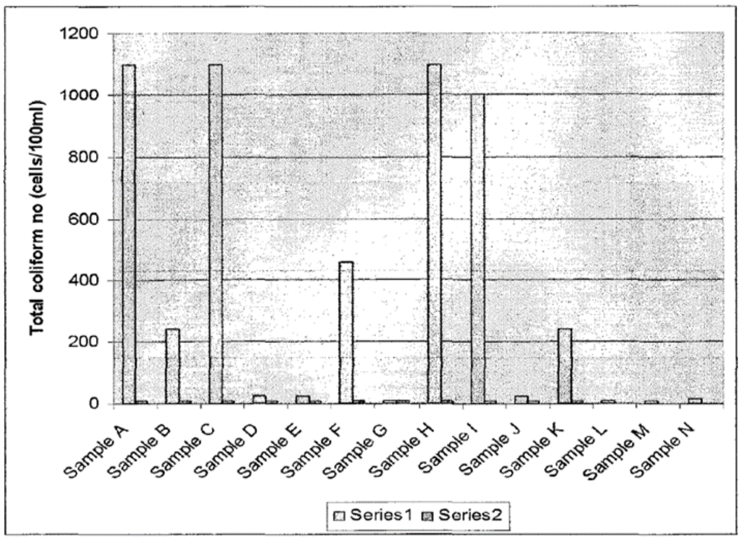

Fig 9: Result of Bacteriological Analysis with the W.H.O Approved Standards.

V. CONCLUSION

This paper probed into the quantitative and qualitative assessment of drinking water supply in Ile-Ile Town. The following conclusions were drawn from the findings. The sources of drinking water supply are public pipe borne water and underground supply system through sinking of boreholes and dug wells. However, underground supply system (boreholes and wells) accounted for the highest source of drinking water supply. Only 10% of the population had access to constant supply of public pipe borne water. The bacteriological tests results of the various sources of drinking water supply exceeded the World Health Organisation approved standards. The total solid content of all the untreated water sources are high. As a temporary solution, the use of alum for coagulation, boiling and filtration of water for drinking purpose should be encouraged. Bacteriological examination and analysis of the various sources of drinking water supply especially the untreated sources should be undertaken at reasonable intervals.

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Appendix A: Determination of adequacy of public pipe-borne water supply

Step 1: calculation of population figure

The population census conducted in 1991 put population of Ile-Ife to be 147, 938 people. Using annual growth rate of 3.2% as given by National Population Commission, the population for the year 2013 was calculated from

$$P = X (1+r)^{n}$$

where, P = Population for 2013
X = Population for 1991
r = growth rate
n = number of year after the last population count

$$P = 147,934 \text{ x } (1 + 0.032)^{22}$$

$$P = 295,815 \text{ people}$$

Step 2: determination of litres of water demanded by the populace

The average daily water consumption per capital as prescribed by W.H.O. is 85 litres per day/person. The quantity of pipe borne water required based on the per capital per person and population figure of 2013 is now expressed mathematically as given below

Total water required, TD = P x per capita

TD =295, 815 x 85 Litres/day

TD = 25, 144, 275 Litres/day

However, the Local Water Corporation pumps 1, 250, 000; 00 litres of water per day.

Step3: Percentage of water requirement met by pipe-borne water supply in the study area

$$= \frac{1,250,000}{25,144,275} x\ 100\%$$

= 5% of total Required.