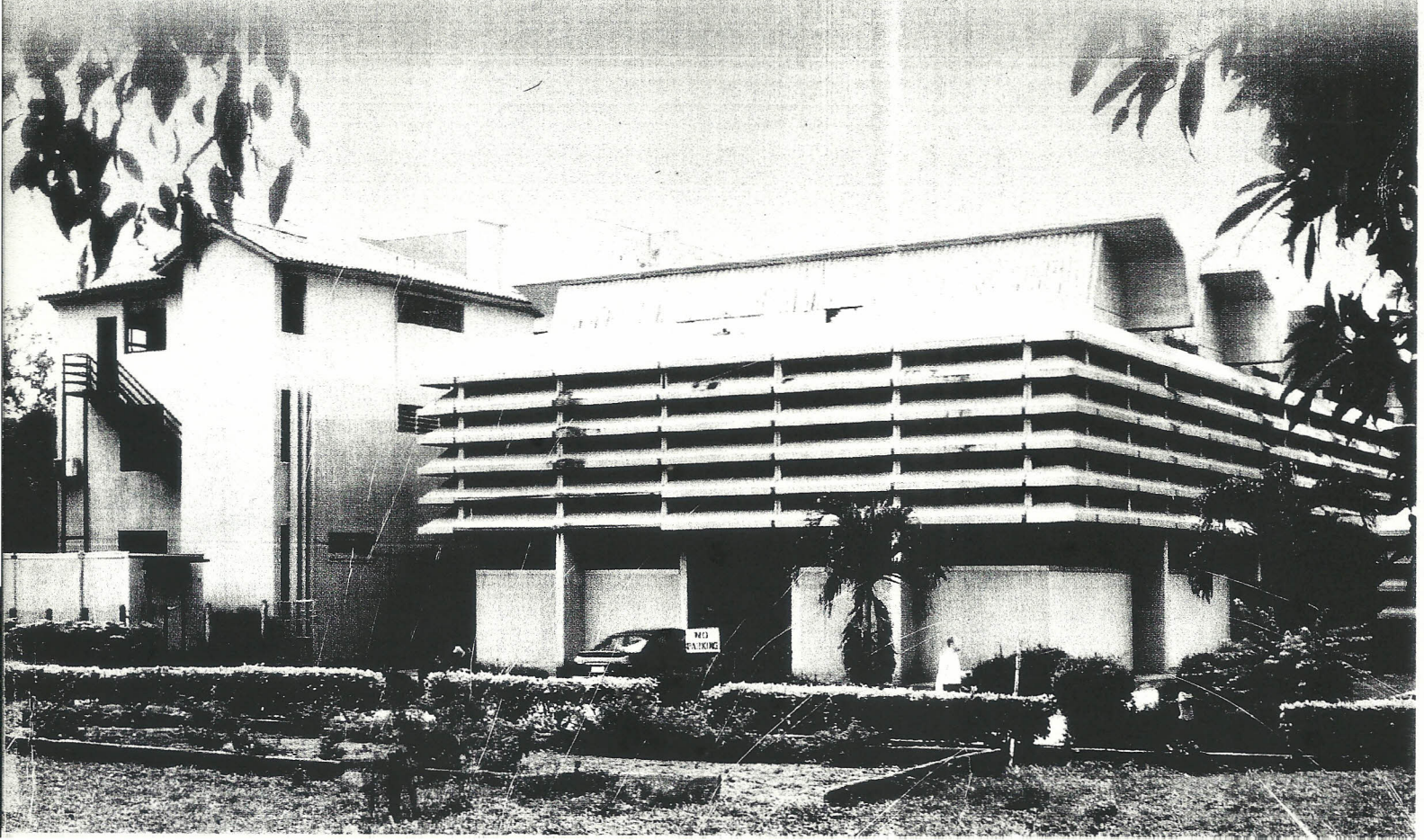
JOURNAL OF ENGINEERING RESEARCH

ISSN: 0795 - 2333

MARCH, 2012 JER-17, No. 1



JOURNAL OF ENGINEERING RESEARCH

ISSN: 0795 – 2333

March, 2012 JER-17, No. 1

CONTENTS

ASSESSING THE SAFETY OF DRINKING WATER SOURCES IN ADO-ODO/OTA LOCAL GOVERNMENT AREA, OGUN STATE, NIGERIA

E.O. LONGE, D.O. OMOLE** and C.S. MGBACHI***

**Department of Civil and Environmental Engineering, University of Lagos, Akoka, Yaba, Lagos State, Nigeria.*

***Department of Civil Engineering, College of Science and Technology, Covenant University Canaanland, Ota, Ogun State, Nigeria.*

ABSTRACT

This study investigated the sources and quality of domestic water supply to 124 households in 16 communities of Ado-Odo/Ota Local Government Area of Ogun State, Nigeria. In order to achieve the set objective, field surveys as well as administration of questionnaires were carried out while ten water samples from three different water supply sources were collected and analyzed for various water quality variables of interest. The field survey was carried out between April and May 2009. From survey results, surface and groundwater are the two major water supply sources in the investigated area. On coverage level, only 1.6% of the sampled population is serviced by pipe borne water from the state water works while 79.1% and 17.7% obtain their domestic water supply from groundwater and surface water sources respectively. The remaining 1.6% of the sampled population is serviced by private water vendors. Laboratory results show that water from all the sources investigated is generally slightly acidic, while levels of cadmium were higher than the Nigerian Standard for Drinking Water quality limit of 0.003mg/l specified for potable water supply. The results of chemical and microbiological analyses also reveal impairments in quality of River Atuwara, a major source of domestic water supply and intake for the state public water work with high levels of Pb, Ni and Total Coliform. The water quality status of the various sources of domestic and public water supply in the surveyed area is unsafe and thus poses health concerns to users if not adequately treated.

Keywords: *Water Sources, safety, effluents, health hazards*

1.0 INTRODUCTION

Water is one of the most vital natural resources required for the sustainability of all forms of life on earth. There is an ever increasing demand for water in-spite of its widespread availability. This demand is occasioned by the fact that terrestrial life is sustained only by fresh water which represents only 2.5% of the total world water and this percentage is not readily available for direct human use. Over 70% of the available fresh water is frozen up in polar ice caps while an estimated 30% of the remaining fresh water is trapped in aquifers, hence, only about 0.007% of all freshwater in the form of rivers, streams, brooks and lakes is directly available for man's use (Krantz and Kifferstein, 2003; UNESCO, 2006; Omole and Longe, 2008). Salt water accounts for more than 97.5%. Water availability and water quality are two different issues. Availability of

water should match safety of drinking water. In most developing nations of the world, water is not only scarce but also unsafe. The state of human health has inextricably been linked to a range of water-related conditions: safe drinking water, adequate sanitation, minimized burden of water-related disease and healthy freshwater ecosystems. In Nigeria, different sources of water supply have been under threat of pollution from anthropological activities. In its report, World Bank (1995), decried high level of contamination of most surface water bodies by discharges of industrial effluents, sewage and agricultural wastes. Ota town hosts more than 84 registered manufacturing industries prominent among them are food and beverages, agricultural products processing, pharmaceuticals, paints, chemicals and metallurgical. The food, beverages and raw agricultural companies produce wastes that are high in Biochemical Oxygen Demand (BOD). The metallurgical, pharmaceuticals, paints and chemical manufacturing outfits produce varying degrees of acidic and hazardous wastes with high concentrations of metals. Uncontrolled disposal of industrial effluents into rivers is a serious environmental and health problem for users. The current study was aimed at assessing the safety of different water supply sources in Ota town and environs and the impacts of industrial effluents on the existing water supply sources.

2.0 MATERIALS AND METHOD

2.1 Study Area

Ado-Odo/Ota Local Government Area (LGA) is located between the boundaries of Lagos and Ogun States; it is also a border town between Nigeria and Benin Republic. Ado-Odo/Ota LGA is the most populous among the 20 Local Government Areas in Ogun State with a population of 526, 000 people (NBS, 2006). It has an average elevation of 53 m above sea level, with high run-off even with minimum precipitation (Omole, 2010). Rivers Atuwara and Illo are the major rivers in the LGA and both are located within the River Owo catchment. The two river bodies are sources of a number of economic activities to the people in Ado-Odo/Ota LGA. Such economic activities include sand mining, fishing, transportation and lumbering. Generally, both rivers also serve as sinks for domestic, commercial and industrial wastes (Omole and Longe, 2008; Omole, 2011).

2.2 Field Survey, Sampling and Laboratory Analysis

Data on domestic water supply sources to 124 households in the following 16 randomly selected communities within Ado-Odo/Ota LGA (Figure 1) was collected, while direct questionnaire administration to each family head of the 124 selected households was followed by personal interviews. A sub-sample of the respondents to the questionnaire had a detailed analysis of the sources, quantity and quality of sources of domestic water supply. The surveyed communities are detailed in Figure 1.

Field survey, sampling of effluent and water samples from River Atuwara, public tap, groundwater and water vendors were carried out in April and May 2009. In an effort to investigate the extent of contamination of water sources, ten samples from groundwater and public tap sources were collected. The sampling points were designated as B1, B2, B6, B9 and B10 (borehole source), D3, D4, D7 and D8 (dug well source), and T5, the only public tap source (Figure1). In order to assess the water quality level of River Atuwara, two water samples were collected at two different points, upstream and downstream of the raw water intake point (w) for domestic water supply by Ogun State Water Corporation (Figure 1).

Water samples were collected in 2-litre plastic bottles. Prior to collection as part of the quality

control measures; all the bottles were washed with non-ionic detergent and rinsed with de-ionized water prior to usage. Before the final water sampling was taken, each bottle was rinsed three times with sampled water at the point of collection. Each bottle was labeled according to sampling location while all the samples were preserved at 4^0C and transported to the laboratory.

2.3 Analytical methods

All the samples were analyzed for the following specific physico-chemical parameters and heavy metals of interest depending on water supply source; pH, total dissolved solids (TDS), total suspended solids (TSS), dissolved oxygen (DO), chloride (Cl^-), biochemical oxygen demand (BOD), chemical oxygen demand (COD), nitrite (NO_2^-), nitrate (NO_3^-), sulphate (SO_4^{-2}), calcium (Ca^{2+}), lead (Pb^{2+}), cadmium (Cd^{2+}), iron (Fe^{2+}), magnesium (Mg^{2+}). The physico-chemical analyses of water and wastewater samples were carried out in accordance to standard analytical methods (APHA, 1995). Data were evaluated using standard statistical methods (Kottegoda and Rosso, 1997; Gupta, 2009).

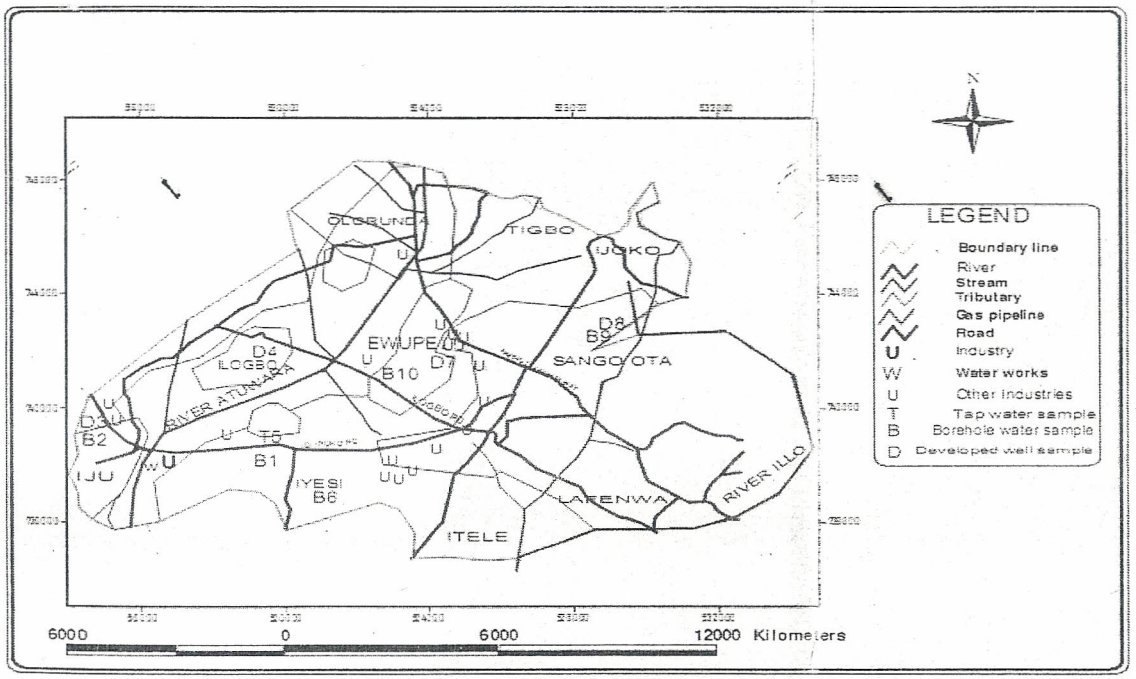


Figure 1: Map of Ado/Odo Ota showing locations of interest

3.0 RESULTS AND DISCUSSION

3.1 Sources of Water

From survey results, 79.1% of the households interviewed have their domestic water supply as groundwater, 17.7% as surface water, 1.6% as public pipe borne water while the remaining 1.6% of the population is served by water vendors (Table 1). By inference more than 64% of the 124 households surveyed have their domestic water supply from unreliable and unsafe sources (dug wells, rivers and vendors). Public water supply coverage to the residents of Ado-Odo/Ota LGA is very low and it is not on track with the Millenium Development Goals target on access to safe drinking water. A great

application of lime, this deficiency can be easily corrected. The obtained levels of total dissolved solids (TDS), total hardness and chloride varied from 13 to 105 mg/l, 3.10 to 6.70 mg/l and 17.91 to 31.20 mg/l respectively. The mean concentrations, TDS (46.10 mg/l), total hardness (23.59 mg/l) and chloride (4.62 mg/l) are far below the stipulated NSDWQ tolerance concentrations of 500mg/l, 150 mg/l and 250 mg/l for TDS, total hardness and chloride respectively. Aside from the deficiency caused by the acidic nature of the groundwater and tap water, the potability of both sources becomes suspect by the noted generally high levels of cadmium in all water samples. Lowest level of of cadmium (0.02mg/l) was obtained in B2 while the highest, 0.07mg/l in B6. Obtained mean value for all sources is 0.04mg/l. From field observation, B6 was located about 100m downstream of a battery manufacturing plant which discharges its wastewater into the natural drain channels and hence could be the possible source of the high level of cadmium in the borehole water.

Table 2: Physico-chemical characteristics of Groundwater and tap water sources

PARAMETERS (mg/l)	SAMPLES B1	B2	D3	D4	T5	B6	D7	D8	B9	B10	NSDWQ
pH	5.79	5.92	5.96	5.76	6.37	5.98	6.19	6.71	6.56	5.96	**6.5 – 8.5**
Conductivity (μS/cm)	25.00	56.00	202.0	38.00	180.0	63.00	57.00	57.00	147.0	64.00	**1000**
DO	11.60	8.60	8.40	9.60	9.60	9.00	8.80	9.40	9.20	9.80	**None**
TDS	13.00	29.00	105.0	20.00	93.00	34.00	30.00	29.00	75.00	33.00	**500**
TSS	5.00	4.00	7.00	3.00	3.00	ND	8.00	4.00	5.00	6.00	**15**
Total Hardness	18.61	20.66	19.87	17.91	30.68	18.01	29.11	31.20	28.19	21.61	**150**
Chloride	3.10	5.90	3.60	5.10	3.30	5.00	5.30	4.40	3.80	6.70	**250**
Cadmium	0.042	0.020	0.038	0.039	0.040	0.073	0.051	0.021	0.037	0.041	**0.003**
Lead	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	**0.01**
Iron	0.338	ND	ND	ND	ND	ND	ND	ND	ND	ND	**0.3**
Total Coliform (MPN/100ml)	0.00	NI	0.00	0.00	4.00	NI	NI	NI	NI	NI	**10**

NOTES: B: Borehole; **D:** Developed well; **T:** Tap water; NSDWQ-National Standard for Drinking Water Quality (FMEnv, 2007): **ND:** Not Detected

The magnitude of cadmium levels in water samples are 7 to 24 times higher than the tolerance level of 0.003mg/l specified by the national requirements for drinking water quality (NSDWQ, 2007). For instance, obtained level of cadmium in the public tap water of 0.04mg/l is 13.3 times higher than the national acceptable level. The observed high levels of cadmium in the water samples render all the water supply sources unsafe for human consumption and therefore pose great risk to human health. Cadmium is known to cause kidney failure due to bio-accumulation in the human body. Known sources of cadmium pollution in the environment include corrosion of galvanized pipes, batteries, television phosphors and metallurgical activities (WHO, 2004a).

effort and improvement will therefore be needed on the part of the state government to significantly lower the proportion of people without sustainable access to safe drinking water in the LGA.

Table 1: Distribution of domestic water sources by household

Source Type	No. of Household	Percentage
Private borehole	8	6.5
Public borehole	50	40.3
Tap water	2	1.6
Hand dug well	40	32.3
River/Stream/Pond	22	17.7
Vendor	2	1.6
Total	124	100.0

Figure 2: Fetching of water from River Atuwara by Iju town residents

3.2 Groundwater and Tap water Quality

Analytical results of physico-chemical characteristics of groundwater and tap water samples are presented in Tables 2 and 3. The groundwater and the tap water are generally acidic with pH values ranging from 5.76 and 6.71. The mean pH value of 6.12 obtained for both sources is below the pH tolerance range of 6.5 to 8.5 recommended by the National Standard for Drinking Water Quality (NSDWQ) for potable water. However, water samples from D8 and B9, a developed well and a borehole respectively conforms in quality with NSDWQ stipulated pH standard (NSDWQ, 2007). It is of importance also to note that the pH value of 6.37 recorded for the tap water supplied by the State Water Corporation equally falls short of the NSDWQ pH value requirements. With appropriate

Table 4: Physico-Chemical Characteristics of River Atuwara

Parameters (mg/l)	Upstream	Downstream	NSDWQ
pH	6.8	6.8	6.8-8.5
Conductivity (µS/cm)	85	76	1000
TSS	0.118	0.030	15
TDS	0.060	0.170	500
Ca	8.82	9.6	NS
Mg	13.18	3.5	NS
BOD	15	18.0	NS
COD	67.5	88.02	NS
DO	3.4	2.4	NS
Cl	56.72	49.63	250
NO_3	3.4	22.5	50
SO_4	30.0	32.0	100
Cu	0.18	0.30	1
Mn	0.024	ND	0.2
Iron	0.014	0.008	0.3
Zinc	1.396	1.462	3
Lead	0.090	0.101	0.01
Cd	ND	ND	0.003
Ni	1.382	1.181	0.07
Cr	0.014	ND	0.05
Total Coliform (cfu/100ml)	160	1000	10

Notes: ND - Not detected, NS- Not Specified

Dissolved oxygen (DO) values obtained for at upstream and downstream of the state water works were 3.4 and 2.4 mg/l as shown in Table 4. Even though there is no limit specified for the DO by NSDWQ for water potability, DO is however a measure of the degree of pollution by organic matter, the destruction of organic substances as well as the degree of self-purification capacity of the water body. From literature, the standard for sustaining aquatic life is stipulated at 5mg/l of DO, a concentration below this value could adversely affect aquatic biological life, while concentrations below 2mg/l may lead to death of most fishes (Chapman, 1992). Mean DO level for Atuwara River stands at 2.9mg/l. The BOD concentrations ranged between 15.0 and 18 mg/l with a mean concentration of 16.5 mg/l, those of COD ranged between 67.5 and 88.02mg/l with a mean concentration of 77.76mg/l. Both the BOD and COD indicate the potential dissolved oxygen needed to breakdown organic matter in water. There are also no specific guidelines proposed for BOD and COD in the national standard for drinking water quality for the DO. The mean values of 16.5 mg/l and 77.76mg/l for BOD and COD respectively are well below the stipulated WHO maximum allowable limits of 30 mg/l and 100mg/l for human consumption (WHO, 2004b).

The concentrations of all other water quality parameters such as total suspended solids, total dissolved solids, total hardness, sulphate, nitrate and chloride found in River Atuwara conform to the national drinking water quality standard (Table 4). Results of analysis of water samples from Atuwara River show no impairments in the quality of the river body from pollution by heavy metals when compared with the national drinking water quality standards (NSDWQ, 2007).

Table 3: Descriptive Statistics for Physico-Chemical Characteristics of Groundwater and Tap Water Sources

Parameter (mg/l)	Min	Max	Mean	Variance	Range	Std. Error	Std. Dev
pH	5.76	6.71	6.12	0.11	0.95	0.10	0.33
Conductivity	25.00	202.00	88.90	3949.88	177.00	19.87	62.85
TDS	13.00	105.00	46.10	1049.21	92.00	10.24	32.40
TSS	3.00	8.00	5.00	3.00	5.00	0.58	1.73
Hardness	17.91	31.20	23.59	30.48	13.29	1.75	5.52
Chloride	3.10	6.70	4.62	1.40	3.60	0.37	1.18
Cadmium	0.02	0.07	0.04	0.00	0.05	0.005	0.01

Aside from the above two water quality parameters, pH and cadmium, all other analyzed parameters used to assess the potability of the water sources conform with the national drinking water quality standards.

3.3 Surface Water Quality

The Atuwara River is weakly acidic, pH values ranged between 6.79 and 6.82, a result that is consistent with the general quality of surface water quality of rivers in the south-west and in Nigeria in particular (World Bank, 1995, Omole and Longe, 2008). Hydrogen ion concentration defines the acidic and alkaline conditions of water status; from literature, the normal pH range in natural fresh waters is between 4 and 9 units and it is controlled by the bicarbonate-carbonate system (McNeely et al., 1979, Chapman, 1992). The mean pH value of 6.81 obtained for the river body is within the NSDWQ and WHO pH tolerance level of drinking water quality standards (WHO, 2004b, NSDWQ, 2007).

Based on above tested parameters only, water from Atuwara River appears fit for human consumption, but this is not normally the case in water quality issue as a combination of parameters determine the potability of a source. For instance, environmental range of nitrate in surface water varies from few hundreds mg/l but they rarely contains as much as 5mg/l, but mostly often less than 1mg/l. Levels greater than 0.1mg/l indicates anthropogenic inputs (McNeely *et al.*, 1979).

The concentrations of Pb in the river body which stands at 0.09 and 0.101mg/l with a mean value of 0.096 mg/l is above stipulated national drinking water quality standard of 0.01mg/l of Pb in water. The direct effect of Pb in drinking water is delayed physical or mental development in infants and children; Pb is carcinogenic while it can also be toxic to the central and peripheral nervous system. The microbiological results, presented in table 4 equally indicate gross pollution of the water body by human activities. A mean Total Coliform count of 5.8 x 10^2 cfu/100ml was obtained for the river body. Even though total coliform is not a health threat it's an indicator of faecal pollution, and an indication of bacteriological pollution by pathogens. Based on this premise detailed bacteriological assay of water from River Atuwara would be necessary in order to ascertain the presence of pathogens like *Escherichia coli* and *Faecal streptococcus* before use. The national standard for drinking water quality stipulates 10cfu/ml of total coliform for water potability in Nigeria.

4.0 CONCLUSION

It is established that groundwater is a major source of water supply to the majority of the sampled population (79.1%) in Ado-Odo/Ota LGA, while 17.7% obtains their water requirements from surface water sources. The target for the MDGs for safe drinking water to reduce by half the number of people in the world with no access to safe water by 2015 is far from being achieved in the communities investigated.

The current water quality status of River Atuwara appears to be minimally impaired. However, observed high levels of nickel and lead in river body as well as the levels of total coliform make it unsafe for use as drinking water without adequate treatment among the communities investigated. The quality of water from groundwater and public tap sources has 100% compliance with the NSDWQ with exception of cadmium. The observed high levels of cadmium in groundwater and public tap sources poses drinking water quality problem and health challenges to consumers in the study area. The exact source(s) of cadmium could not be ascertained without a further investigation for adequate water quality protection measures. The water quality status of the identified water supply sources in Ado-Odo/Ota LGA is low and thus requires adequate treatment before usage.

ACKNOWLEDGEMENT

This research was partly supported by the International Foundation for Science, (IFS), Stockholm, Sweden. The IFS is gratefully acknowledged. The authors are also grateful to the Management of Covenant University and the University of Lagos for providing the platform to conduct this research.

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