IJST EXPLORE International Journal of Science and Technology
CENTRE OF PROFESSIONAL RESEARCH PUBLICATIONS
ISSN 2049-7318

International Journal of Science and Technology Volume 3 No. 4, April, 2014

Assessment of Heavy Metals of Boreholes and Hand Dug Wells in Ife North Local Government Area of Osun State, Nigeria

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Short Communication

ABSTRACT

Though some heavy metals are necessary in little quantities for the normal development of the genetic cycles, most of them become toxic at high concentrations. The major sources of heavy metal pollution in urban areas of Nigeria are anthropogenic while contamination from natural sources predominates in the rural areas. The study examined the status of heavy metals in wells and boreholes in Ife North Local Government Area of Osun State, Nigeria. Forty-one functional hands dug wells and nine boreholes in the area were sampled. Results showed that the concentrations ofzinc (Zn), lead (Pb), and manganese (Mn) were within WHO maximum permissible limits with mean values of 0.02 mg/l, 0.14 mg/l and 0.03 mg/l respectively. The proportion of cadmium (Cd) in the sampled wells and boreholes was zero, indicating the absence of these metals while the value of chromium was found significantly high (6.5 mg/l). The low levels of heavy metal contents in the sampled wells and boreholes showed they were not polluted and as such suitable for human consumption. In order to sustain quality status of wells and boreholes in the area, their routine monitoring and assessment by sanitary inspection officers was recommended.

Keywords: *Heavy metal, sanitation, water facilities, functional wells and boreholes and genetic cycle*

1. INTRODUCTION

Heavy metal is a general term that depicts the cluster of metals and metalloids with atomic density greater than 4 g/cm^3 or 5 times or more, greater than water. Heavy metal has little to do with density but concerns the chemical properties of the element (Duruibe *et al*. 2007) . Among the heavy metals, lead, cadmium, mercury and arsenic constitute threats to human health when exposed to them. Mildvan (1970) noted that heavy metals such as Cd, Ni, As, Pb cause a number of hazards to humans; and are indeed cofactors as activator biochemical reactions. Heavy metals are natural components of the earth's crust, as can neither be degraded nor destroyed. Environmental pollution by heavy metals is common in mining and old mine sites and pollution reduces with increasing distance away from mining sites (Mildvan, 1970).

Through rivers and streams, the metals are transported as either dissolved species in water or as an integral part of suspended substances causing the most detrimental effects on aquatic life (Duruibe *et al*., 2007). Also, to a small extent, the metals enter the human bodies via food, drinking water and air. Though, some heavy metals (e.g. copper, selenium, zinc) are essential to maintain the metabolism of the human body, but their concentration above the desirable levels can be poisonous (Lenntech, 2011). Heavy metal poisoning could be, from drinking-water contamination (e.g. lead pipes), high ambient air concentrations near emission sources, or intake via the food chain.

Heavy metals are dangerous because they tend to bioaccumulate. Bioaccumulation results when there is an increase in the concentration of a chemical in a biological organism over time, compared to the natural concentration of chemicals in the environment. Heavy metals may enter a water supply from industrial and household wastes, or acidic rain resulting in the breakdown of soils and releasing heavy metals into streams, lakes, rivers, and groundwater (Lenntech, 2011).

Many trace elements are necessary in small amounts for the normal development of the biological cycles, but most of them become toxic at high concentrations. The major sources of heavy metal pollution in urban areas of Africa are anthropogenic, while contamination from natural sources predominates in the rural areas (Lenntech, 2011).

Anthropogenic sources of pollution include those associated with fossil fuel and coal combustion, industrial effluents, solid waste disposal, and mining and metal processing. In animal bodies, metals enter through feeds, green fodder, drinking water and pharmaceuticals, consumption of mineral supplements with high content of trace metals and leaking of painted surfaces containing metallic pigments (Raikwar *et al.*, 2008).

However, among these pathways, the atmosphere tends to be of great threat to human health, as a result of the quantities of contaminants involved and the pervasive dispersion and exposure (Raikwar *et al.*, 2008).

According to Olade (1987), the impact of these pollutants is confined mostly to the urban centres with large populations, high traffic density and consumer-oriented industries. Natural sources of pollution include weathering of mineral deposits, bush burning and windblown dusts. Among the heavy metals, the most serious effect of pollution is presently associated with lead (Pb) emission (Olade, 1987). Heavy metals like Fe, Cu, Zn, Ni and other trace elements are important for proper performance of biological systems and their deficiency or when in excess could lead to a number of disorders. Food chain contamination by heavy metals has become a serious issue in recent years because of their potential accumulation in biosystems through contaminated water, soil and air. Therefore, a better understanding of heavy metal sources, their accumulation in the soil and the effect of their presence in water, soil and on plant systems seem to be particularly important issues of present day research on risk assessment (Sharma *et al*., 2004). Ife North Local government Area of Osun State, is a semi- urban centre with rapid development, commercial activities and service industries. The absence of potable water to every household has led to the proliferation of boreholes and shallow wells as a result of its high demand and important nature. As such, in some areas, boreholes or wells are located too near and downstream of soak away pits or waste dump sites.

The concentration of heavy metal in water sources (river, stream, well and boreholes) has attracted concerns by researchers as a result of its health implications on biotic organisms especially man. The literature is rich on the subject, and many studies examined the levels of these metals in water sources in their respective ecosystems (Olade, 1987; Duruibe *et al*., 2007; Prabu, 2009; Momodu and Anyakora, 2010; Nwankwoala *et al*., 2011). However, despite the abundance of literature on heavy metals, there is a dearth of information on heavy metal status of wells and boreholes in Ife North local government Area. This study therefore assess the heavy metal status ofwells and boreholes in the area as well as discusses the health implications of drinking water with high concentration of heavy metals.

2. MATERIAL AND METHODS

Study Area

The study was conducted in Ife North Local Government Area of Osun State, Nigeria between December, 2012 and January, 2013. Ife **North Local Government** is one of the present 30 Local Governments in Osun-State (Figure 1). It is therefore, one of the Seven hundred and seventy-four (774) Local Government Councils so recognized by the constitution. The Local Government is made up of the historical seven (7) sister towns (*known as Origbo meje*) comprising **Ipetumodu**, the head quarter, Edun abon, Moro, Yakooyo, Asipa, Akinlalu and Isope, which had however, fused with Ipetumodu.

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The vegetation of Ife North Local Government Area is characterized by rainforest ecosystems which form part of the rich fauna and flora of the state. The major economic activities in the area are farming and the public sector which are basically government owned schools. The major sources of water for drinking in the area are water from borehole, and river (Sustainable Urban Development and Good Governance in Nigeria, 2001).

Sample Collection and Analysis

The procedure for data collection started with a reconnaissance survey to the area. The study identified functional wells and boreholes as one that are frequently in use with level of patronage (use) greater than 50 persons per day. Through this approach, 51 functional wells and boreholes were randomly selected, with their coordinates recorded. Water samples were collected in 1 litre plastic bottles. Before the collection of water samples, the boreholes were allowed to pump for 15 minutes so that water with a constant temperature and pH. Water samples were collected at the borehole heads. Prior to sample collection, all plastic bottles were rinsed thrice with the sample water. After sampling, the containers were tightly covered. The samples were appropriately labeled and put in an ice-packed cooler, and immediately taken to the laboratory for analysis for heavy metals using Flame atomic absorption spectrophotometer, AAS (model AAanalyst 400 Perkin); 220GF. Preparation of samples was carried out using acid digestion before 2ml of sample was injected into the machine by flow method. Detection limit set for each element varied from 0.02 -0.1µg/ml. Cadmium and lead used 0.04 – 0.1 µg/ml while the remaining three elements used 0.02 – 0.1µg/ml. In addition, physical properties such as pH, TSS, turbidity, chloride and total hardness were determined using standard methods (APHA, 1998). Results were subjected to analysis of variance (ANOVA) using SPSS 17.0 for Windows. The trace elements analysed were Mn, Cr, Zn, Pb and Cd.

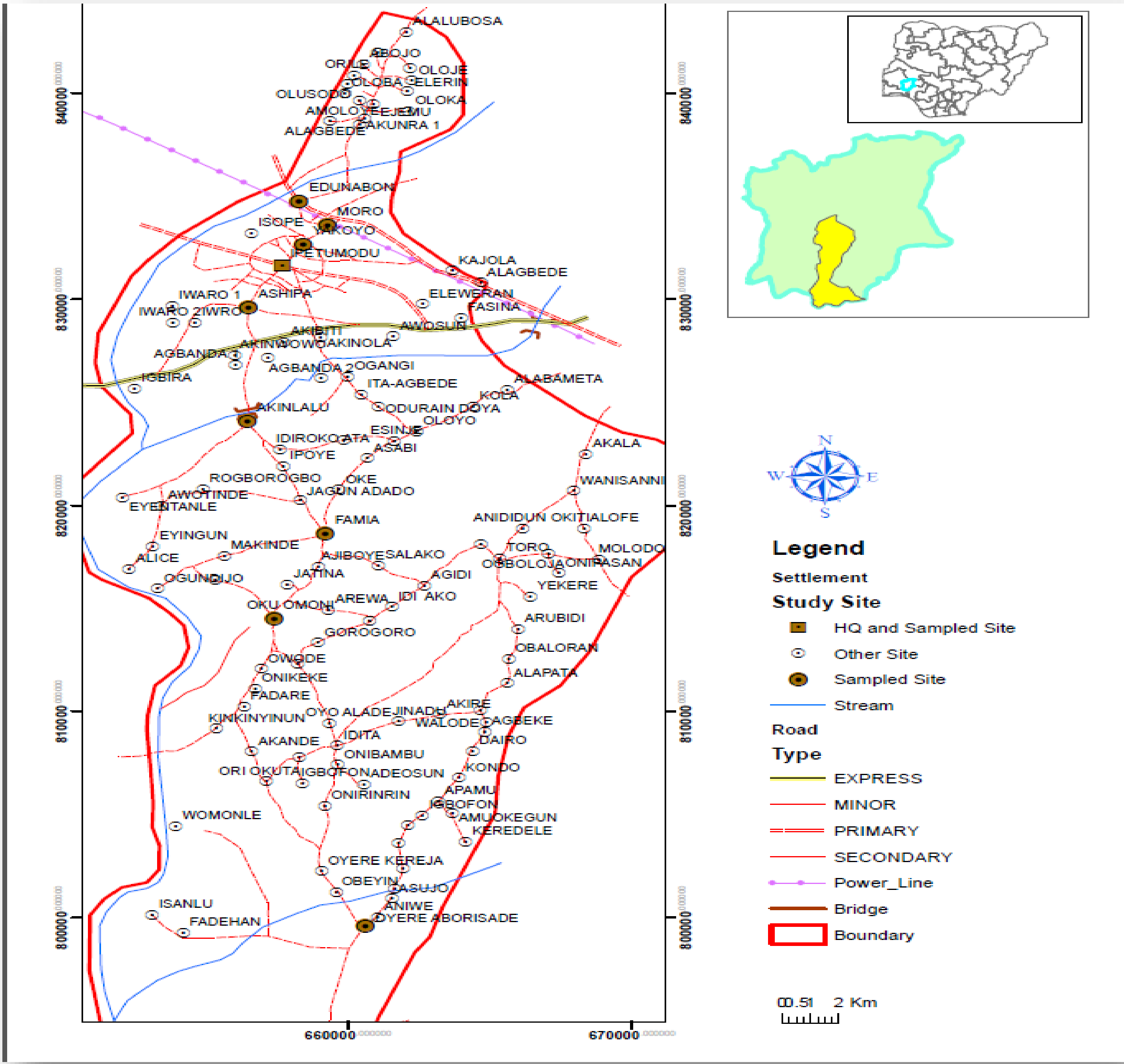

Figure 1: Map of the Study Area

3. RESULTS AND DISCUSSION

Data on the physico-chemical parameters of water samples from the fifty- one water facilities (forty-two wells and nine boreholes) shows that pH of the water samples ranged between slightly acidic to slightly alkaline (near neutral) with a mean pH range between 7.4±0.5 in Ipetumodu wells, to 10.1±0.2 in Famia water sample as presented in Table 1. The acidic nature of the water samples has been attributed to the presence of tiny shale intercalations in the aquiferous coastal plain sand (Afangideh, *et al.*, 2011).

The pH values are slightly above the maximum desirable limits of 8.5 set by WHO (WHO, 2006). The average values of total suspended solids (TSS) and total solids (TS) are 0.3 and 0.7mgl^{-1} respectively. Of all the physical parameters, only the turbidity (109.8NTU) exceeded the WHO limit; meaning that if minimum treatment is given to the water to reduce the turbidity to make it totally harmless and ideal for human consumption. (Afangideh, *et al.*, 2011). The chloride content of the borehole samples had a mean value of 86.4mgl^{-1}. This value is less than WHO desirable limit of 500mgl^{-1} for drinking water. However, total hardness of the water samples ranged from 36 to 247.72mgl^{-1} with a mean value of 107.2mgl^{-1}, and is below the WHO 500mgl^{-1} acceptable limit, implying the water is soft and foamy. This indicates that the wells and boreholes in the area are suitable for domestic consumption.

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Table 1: Physico-Chemical Parameters of the Sampled Facilities

Measured parameters	Range		Concentration	WHO
Zn (mgl^{-1})	0.01	0.07	0.02	5.0
Pb (mgl^{-1})	0.11	0.19	0.14	0.05
Mn (mgl^{-1})	0.02	0.06	0.03	0.1
Cd (mgl^{-1})	0	0	0	5.0
Cr (mgl^{-1})	6.1	7.7	6.5	0.05

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Mn (mgl^{-1})	0.02	0.06	0.03	0.1
Cd (mgl^{-1})	0	0	0	5.0
Cr (mgl^{-1})	6.1	7.7	6.5	0.05

Heavy metal analysis of the groundwater samples

Table 2 provides information on the contents of heavy metals in the sampled wells and boreholes. The value of manganese (Mn) ranged from 0.02 to 0.06mgl^{-1} with a mean value of 0.03mgl-1. The mean value of Mn (0.03mgl^{-1}) falls within the maximum desirable limit of 0.5mgl- 1 set by WHO. The low concentration of Mn implies that water from the sampled wells and boreholes has good taste and would not promote the growth of algae in reservoirs or collection tanks (Nwankwoala *et al.*, 2011). Zinc is considered non-toxic, but in excess amount can cause system dysfunctions that result in impairment of growth and reproduction of the contaminants. The clinical signs of zinc have been reported to include vomiting, diarrhea, bloody urine, liver failure, kidney failure and anemia (Fosmire, 1990; Duruibe *et al*., 2007). Zinc (Zn) content in the borehole water samples ranged from 0.01 to 0.07 mgl^{-1} with a mean value of 0.02mgl^{-1} which is less than WHO maximum allowable of 3.0mgl^{-1} for drinking water (Table 2). This indicates that water from the sampled water contain the right proportion of Zn which is an essential plant and human nutrient element. The low concentration further implies that the water do not have caustic taste, hence good for consumption and other domestic uses. Lead is the most toxic of the heavy metals. Its inorganic forms are absorbed through ingestion by food, water and inhalation (Ferner, 2001). In humans exposure to lead can result in a wide range of biological effects depending on the level and duration of exposure. High levels of exposure may result in toxic biochemical effects in humans which in turn cause problems in the synthesis of haemoglobin, effects on the kidneys, gastrointestinal tract, joints and reproductive system, and acute or chronic damage to the nervous system (Lenntech, 2011; Duruibe *et al*., 2007). The proportion of lead (Pb) in the water sampled water facilities was 0.14mgl-1, indicating the safe contamination of lead. Cd was absent in the water sampled from boreholes and wells . Chromium is used in metal alloys and pigments for paints, cement, paper, rubber, and other materials. Low-level exposure can irritate the skin and cause ulceration. Long-term exposure can cause kidney and liver damage, and damage to circulatory and nerve tissue. Chromium often accumulates in aquatic life, adding to the danger of eating fish that may have been exposed to high levels of chromium (Lenntech, 2011). The proportion of chromium (Cr) was significantly high (6.5mgl^{-1}), indicating the presence of this metal in the sampled wells and boreholes while cadmium was absent from all the sampled wells and boreholes, which showed absence of this metals in the area (Table 3).

Measured parameters	Range		Mean concentrations	WHO
	Min	Max		
Ph	6.9	8.9	7.4	6.5 – 8.5
Turbidity	0	791	109.8	5
TSS (mgl^{-1})	0.1	0.9	0.3	20
TS (mgl^{-1})	0.14	1.9	0.7	30
Total Hardness (mgl^{-1})	36	247.72	107.2	500
Chloride (mgl^{-1})	7	155	86.4	250

Table 2: Heavy Metal Concentration of Sampled Wells and Borehole Waters

Location	Mean/std. dev/range	Measured parameters				
		Pb (m/l)	Zn (mg/l)	Mn (mg)	Cd mg/L)	Cr (mg/L)
Ipetumodu (n=24)	mean±sd	0.14±0.02	0.02±0.01	0.03±0.01	-0.01±0.01	6.5±0.4
	range	0.11-0.19	0.01-0.07	0.02-0.06	-0.01-0.00	6.1 – 7.7
Moro (n=5)	mean±sd	0.18±0.01	0.19±0.30	0.03±0.02	-0.02±0.0	6.1±0.04
	range	0.17-0.2	0.01-0.70	0.01-0.07	-0.02-0.01	6.0 -6.2
Edunabon (n=8)	mean±sd	0.16±0.02	0.03±0.02	0.04±0.04	-0.02±0.0	6.1±0.1
	range	0.13-0.18	0.01-0.07	0.01-0.1	-0.02-0.02	6.05 -6.2
Yakoyo (n=3)	mean±sd	0.13±0.00	0.01±0.01	0.01±0.01	-0.02±0.0	6.1±0.02
	range	0.10-0.13	0.00-0.01	0.00-0.01	-0.01-0.02	6.04 – 6.08
Oyere Aborishade (n=3)	mean±sd	0.13±0.02	0.01±0.01	-0.0±0.00	-0.02±0.0	6.3±0.1
	range	0.10-0.15	0.00-0.01	-0.01-0.00	-0.02—.0	6.2 – 6.3
Akinlalu (n=3)	mean±sd	0.14±0.01	0.03±0.03	0.04±0.08	-0.02±0.0	6.1±0.01
	range	0.12-0.15	0.00-0.06	-0.00-0.14	-0.02- -0.0	6.12 -6.15
Famia (n=1)	mean±sd	0.11±0.04	0.01±0.00	0.01±0.00	-0.02±0.0	6.1±0.02
	range	0.09-0.14	0.01-0.01	-0.01-0.01	-0.02-0.02	6.11 – 6.15
Okuuomoni (n=1)	mean±sd	0.14±0.00	0.01±0.00	-0.1±0.00	-0.02±0.0	6.2±0.00
	range	0.14-0.14	0.01-0.01	-0.01-0.01	-0.02-0.02	6.2-6.2
Ashipa (n=2)	mean±sd	0.14±0.01	0.00±0.00	0.02±0.03	-0.02±0.0	6.3±0.2
	Range	0.13-0.14	0.00-0.01	-0.01-0.05	-0.02-0.02	6.2 – 6.6

The ANOVA result shows that the contents of heavy metals do not vary significantly among the forty one wells and nine boreholes ($F_{3, 20} = 242$, $P>0.05$).

Table 3: Heavy metals of water samples in selected Towns/Villages in Ife North local Government Area

n = no of samples sd = standard deviation

4. CONCLUSION/ RECOMMENDATIONS

The significantly low levels of heavy metal content in the water across the sampled wells/ boreholes showed they are not polluted and as such suitable for human consumption. The low content also suggests that boreholes in the area are located far away from dumpsites, automobile shops and other sources forms of heavy metal contamination. The result therefore implies that the quality status of water from facilities (wells and boreholes) in the area is not in any way polluted, as the examined parameters are within WHO maximum permissible limits for drinking water. In order to maintain the present quality status of wells and boreholes in the area, routine monitoring and assessment of boreholes mostly to prevent the indiscriminate sinking of these facilities to meet the ever increasing demands of people in the area by sanitary inspection officers is recommended.

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