Assessment of Heavy Metals in Groundwater of Ado-Ekiti Area, Southwestern Nigeria

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Abstract. This study evaluated the concentrations of some heavy metals in groundwater at Ado-Ekiti Area, southwestern Nigeria, to determine their potability and establish their health implications. A total of twenty two groundwater samples were collected and analyzed at the Central Research Laboratory of Federal University of Technology, Akure, Nigeria using Atomic Absorption Spectrophotometer. Results of the analysis revealed that only Cd with concentrations that ranged from 0.15 – 0.58mg/L occurred in concentrations (>3µg/L) above approved standard for drinking water. The remaining heavy metals concentrations (mg/L) ((Fe (0.02 – 2.08), Mn (0.01 – 0.25), Cu (0.02 – 0.16), Zn (0.02 – 0.82), Pb (0.02), Co (0.01 – 0.09) and Cr 0.03 – 0.21)) seem to not cause any serious threat to humans' health. The extensive open waste dump at Ilokun village has impacted the concentrations of metals in groundwater of the study area as indicated in Fe, Cu and Cd concentrations. Literature search revealed very scanty researches on heavy metals of the study area. Excess Cd in water can result into kidneys, liver and lungs damage. This present study calls for further detail hydrochemical evaluation of heavy metals in water of the area at a closer sampling space and extensive coverage. Additionally, research towards any relationship between cadmium concentrations in water of the area and cadmium related diseases should be investigated.

Key words: Groundwater samples, analysis, humans' health, waste dump, kidneys, sampling space

Introduction

Water plays a tremendous role in humans' personal hygiene, agricultural activities, industrial and other sundry activities. Demand for fresh water has been on the increase and will continue to increase in view of rapid growth in population and accelerated pace of industrialization.

No water can be declared suitable for drinking and other domestic purposes until it has been tested. Non suitability of water for domestic, industrial and agricultural activities can be as a result of some dissolved constituents in the water exceeding their threshold level. Major ions contributing about 98% of dissolved solutes in water include $Ca^{2+,}$ Mg^{2+}, Na^{+}, K^{+}, HCO_3^{-}, SO_4^{2-}, Cl^{-}, and NO_3^{-}. In most instances, these ions may not pose threats to Humans' health as they rarely exceed their approved standard values. However, the minor heavy metal constituents (Fe, Mn, Zn, Cu, Co, Cr and Ni) needed in trace amounts for biological metabolism may constitute threat to humans' health if they occur in higher concentrations above approved National and International standards. Other heavy metals such as Pb, Hg, Cd and As, that are not suitable for biological functions are often toxic and can be deleterious to humans' health (Gautam et al., 2014; USEPA, 2015).

The occurrence of contaminants or pollutants in water constitutes a major environmental and social problem. The major sources of fresh water on earth are the surface water and groundwater. Sources of heavy metals in water could be through anthropogenic sources as well as from natural geochemical weathering of soil and rocks (Gautam et al., 2014). The main sources of contamination include mining wastes, landfill leachates, municipal wastewater, urban runoff and industrial wastewaters.

Heavy metals can cause severe health *effects*. Report after (ATSDR, 2015) indicated that significant fraction of Pb in drinking water can affect the central nervous, renal, hematopoietic, cardiovascular, gastrointestinal, musculoskeletal, endocrinological, reproductive, neurological, developmental and immunological systems of humans. Though, there could be other prevalent sources such from Pb paint, dust and gas. Additionally, among the most commonly reported heavy metal in drinking water, Cd ranked third and it has been recognized as a public health concern (USEPA, 2015; ATSDR, 2015; World Bank, 2016; Fernández-Luqueño, 2013). Cd contaminated drinking water is also considered to be the cause of chronic renal failure (ATSDR, 2015; Bawaskar et al., 2010). Chronic exposure to Cd could lead to anemia, anosmia (loss of sense of smell), cardiovascular diseases, renal problems, osteoporosis and hypertension (ATSDR, 2015; Burke et al., 2016). Cd is highly toxic to the kidney. When kidney is exposed to Cd in drinking water at low concentration for long, kidney disease, fragile bones and lung damage could crop up (Bernard, 2008). Henson and Chedrese (2004), reported that exposure to drinking Cd infected water during pregnancy could lead to premature birth and reduced birth weights.

Research by Orjiakor et al. (2017) on quality assessment of surface waters within Ekiti State, Nigeria, revealed that the concentrations of Cr, Pb, Fe and Ni exceeded WHO (2011) approved standard for drinking water. Research work of Oguntuase et al. (2019), though on localized quarry site at Afao-Ekiti, indicated that all analyzed heavy metals (Fe, Mn, Cu, Pb, Zn, Ni, Cd and Cr) had concentrations within WHO (2006) approved standard for drinking water. Researches on heavy metals concentrations in water in Ado-Ekiti Area are at low level. Considering the dynamic nature of water and the health effects of occurrence of Cd concentrations in water, this work focused on excess Cd in water of the study area with a view to elaborate on the health implications and suggests solutions to the problem.

Location and Geology of the Study Area

Ado-Ekiti Area is found within Latitudes 7˚32.44′N and 7˚43.26′N, Longitudes 5˚8.35′E and5˚18.05′E (Figure 1). The terrain is fairly rugged with elevation that ranged from 373 – 570m. The area has two distinct seasons; the rainy and dry seasons. The rainy season covers a period of April to October while the dry season is from November to April. The harmattan (dusty and dry wind from the Sahara) season is an integral part of the dry season that spans from December to January. The study area, with an average monthly temperature of 27°C is hottest in February and March each year (Adebayo & Arohunsoro, 2014). Minor variations may occur within the stated periods in sight of global climatic change ravaging the planet. Geologically, the study area may be a prototype of the basement complex of southwestern Nigeria. The principal rocks are the migmatites as dominant rock, migmatite gneiss, quartzites, charnockites and granite. The Pre-cambrian rocks (migmatites, migmatite gneiss and quartzite) undergone different deformational episodes during progressive regional metamorphism. During the deformational periods, historic events were produced as diagnostic marks on the basement rocks. The younger rocks (granites and charnockites) intruded into the older rocks during the Pan-African orogeny. The Pan-African event was so overwlming that it utterly wiped out most of the structures of the earlier events, leaving only their traces (Grant, 1978; Ekwueme, 1987, 1994; Akinola et al., 2017).

Research Methods

A total of twenty two groundwater samples were collected within the study area for physic-chemical analysis. More samples (8 samples) were collected at Ilokun village where there's an open refuse dump (Figure 1). The groundwater samples were collected, filtered through 0.45 m membrane and placed in pre-sterilized polyethylene bottles (1.5liter size) that were rinsed for a minimum of twice with sampling water before collection. The sampling

bottles were utterly crammed and sealed to prevent reaction. All samples were stored in an exceedingly freezer at approximately 04°C. Subsequently, collected samples were stored in ice containers and transported to the Central Laboratory Federal University of Technology, Akure Nigeria for analysis. Analysis for Fe, Mn, Cu, Zn, Pb, Co, Cr and Cd were executed using Atomic Absorption Spectrophotometer (AAS) following APHA (2012) normal methodology. Results of analysis were subjected to statistical evaluation and compared with WHO (2011) approved standard for drinking water.

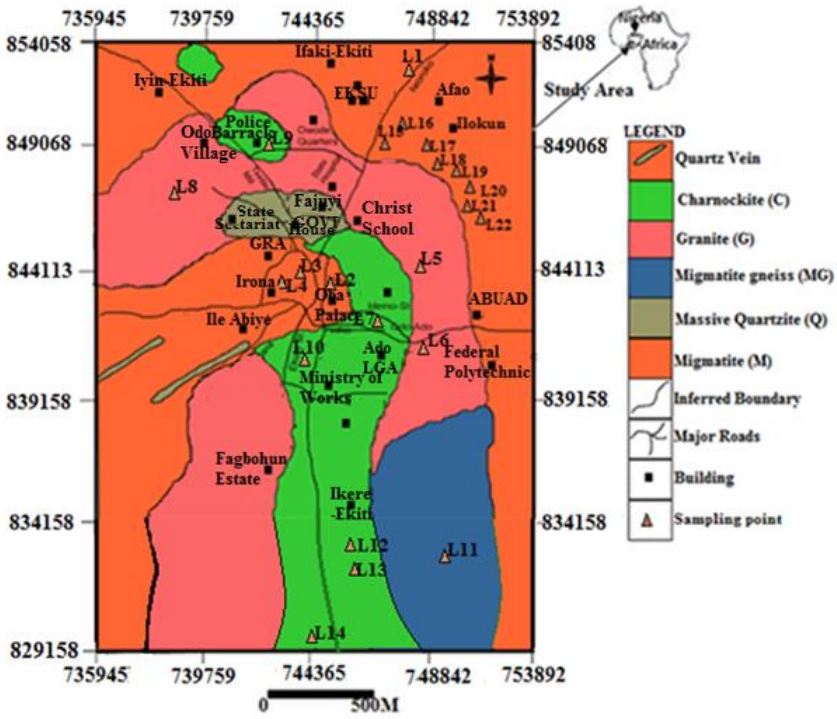

Figure 1. Geology Map of Ado-Ekiti Study Area showing the rock types and the street roads (Modified after Talabi *et al.*, 2014)

Results and Discussion

The result of the heavy metal analysis in groundwater of the study area is conferred in Table 1. Generally, all the heavy metals seem to not cause any serious threat to humans' health except cadmium with all concentrations above approved WHO (2011) and NSDWQ (2007) standards (3.0 µg/L) for drinking water. There are many elements present in water within the required ranges which are recommended by the WHO (2011) that play important functions within the frame. Manganese, copper and zinc had all their concentrations within approved standard for drinking water. Lead was not detected in all locations except in L9 and L10 (Table 1 and Figure 2). Both locations had concentrations of 0.02 mg/L > 0.01mg/L approved standard for drink, signifying local anthropogenic contamination. Exposure to lead, cadmium, and arsenic constitute the main trouble to human health from heavy metals (Buragohain et al., 2010; Burke et al., 2016). Guideline values for As, Cd, and Pb which are of health significance in drinking water is 10, 3.0, and 10 µg/L, respectively (WHO 2004). Consumption of excess cadmium in water is significantly dangerous to human as it's capable of damaging the kidneys, liver and lungs (Rezende et al., 2011). It is known that cadmium accumulates in both liver and kidneys and has a half-life of between one and four decades in human body (Mendez et al., 2011).

Table 1. Result showing heavy metal concentrations from the study Area

Sample location	Locality	Northing	Easting	Fe (mg/L)	Mn (mg/L)	Cu (mg/L)	Zn (mg/L)	Pb (mg/L)	Co (mg/L)	Cr (mg/L)	Cd (mg/L)
L1	EKSU	853098	748317	ND	0.05	0.03	ND	ND	ND	0.11	0.15
L2	Ogbon Aro	843356	745090	ND	0.02	0.07	0.02	ND	0.05	ND	0.18
L3	EKSU Guest H.	843862	743935	0.19	0.02	0.07	ND	ND	ND	0.15	0.26
L4	Kayode avenue	843637	742608	ND	0.01	0.04	ND	ND	0.04	0.21	0.38
L5	Irona	842514	744750	ND	ND	0.07	ND	ND	0.01	0.1	0.4
L6	Erifun	841385	752300	0.02	0.02	0.02	0.03	ND	0.03	0.06	0.51
L7	Odo-Ado	842533	746380	0.11	ND	0.02	0.82	ND	0.02	ND	0.35
L8	Egiri-Oke, Iyin	847323	738774	2.08	0.25	0.03	0.15	ND	0.01	0.05	0.49
L9	Odo -Iro, Iyin	848954	742046	ND	0.01	0.04	0.09	0.02	0.03	0.03	0.49
L10	Ekute, Ado	840996	744158	ND	0.04	0.03	0.09	0.02	0.06	ND	0.45
L11	Ado-Ikere road	832688	745156	ND	0.01	0.04	0.16	ND	0.09	ND	0.49
L12	Sunbare-Ikere	832150	745785	ND	ND	0.08	0.14	ND	ND	ND	0.46
L13	Moutain of Fire	832212	745862	ND	0.02	0.07	0.13	ND	ND	0.08	0.58
L14	Ilawe-road	829687	744421	0.09	ND	0.09	0.06	ND	ND	ND	0.52
L15	Ilokun	850454	749143	ND	ND	0.08	ND	ND	ND	ND	0.27
L16	Ilokun	850528	749178	0.72	ND	0.16	ND	ND	0.02	ND	0.5
L17	Ilokun	850504	749115	ND	ND	0.1	ND	ND	0.08	ND	0.31
L18	Ilokun	850461	749099	0.31	ND	0.11	ND	ND	0.01	ND	0.34
L19	Ilokun	850579	749604	0.78	0.04	0.1	ND	ND	0.03	ND	0.41
L20	Ilokun	850578	749608	0.82	0.03	0.13	ND	ND	0.05	ND	0.46
L21	Ilokun	850583	749613	0.8	0.04	0.14	ND	ND	ND	ND	0.56
L22	Ilokun	850588	749618	0.87	0.03	0.14	ND	ND	0.03	ND	0.43
			Min	0.02	0.01	0.02	0.02	0.02	0.01	0.03	0.15
			Max	2.08	0.25	0.16	0.82	0.02	0.09	0.21	0.58
			Mean	0.62	0.04	0.08	0.17	0.02	0.04	0.10	0.41
			Stdev	0.59	0.06	0.04	0.23	0.00	0.02	0.06	0.12
	NSDWQ (2007)			0.30	0.01	1.00	3.00	0.01	-	0.05	0.003
	WHO (2011)			0.20	0.05	2.00	3.00	0.01	-	0.05	0.003

Note. ND (Not detected)

Cadmium in water samples during this study exceeded approved WHO (2011) standard of 3.0 µg/L and necessitate concern in view of the health implications arising from excess Cd in water. Research of Edward (2013) on "Determination of Heavy Metal Concentration in Fish Samples, Sediment and Water from Odo-Ayo River in Ado-Ekiti, Ekiti-State, Nigeria", revealed metals concentrations (mg/L) of Zn (4.65), Mn (0.79), Cu (0.84), Fe (5.87), Pb (0.16) and Cd (0.13). The concentration of Cd in the surface water exceeded approved international standard. The work of Asaolu et al. (2009) on concentration of heavy metals in water and sediment samples from ERO River in Southwestern, Nigeria only detected Cd concentration of 0.6mg/L in one location while other locations were undetected. Additionally, the research of Adebayo (2017) revealed Cd concentration of 0.03 ± 0.01mg/L in one location while the remaining one location was undetected. Researches on heavy metals in water of the study area are scanty and additional extensive work may become imperative to verify this preliminary revelation of excess Cd in water of Ado-Ekiti Area. Cadmium in water samples in this study exceeded approved WHO (2011) standard of

3.0 µg/L and calls for concern in view of the health implications arising from excess Cd in water. Comparing water samples from Ilokun with the remaining samples from other parts of Ado-Ekiti Area revealed that the waste dump has impacted the concentrations of the metals especially Fe, Cu and Cd. (Figure 3). Iron is fairly abundant within the earth crust with 5% representation. it's often formed by the dissolution from soil and the underlying geologic formation by the infiltrating rainfall. Subsequently, it seeps into the aquifers that function as sources of groundwater to wells. Iron isn't hazardous to health but inflicts reddish coloration on water when it exceeds concentration >0.3mg/L (WHO 2011).

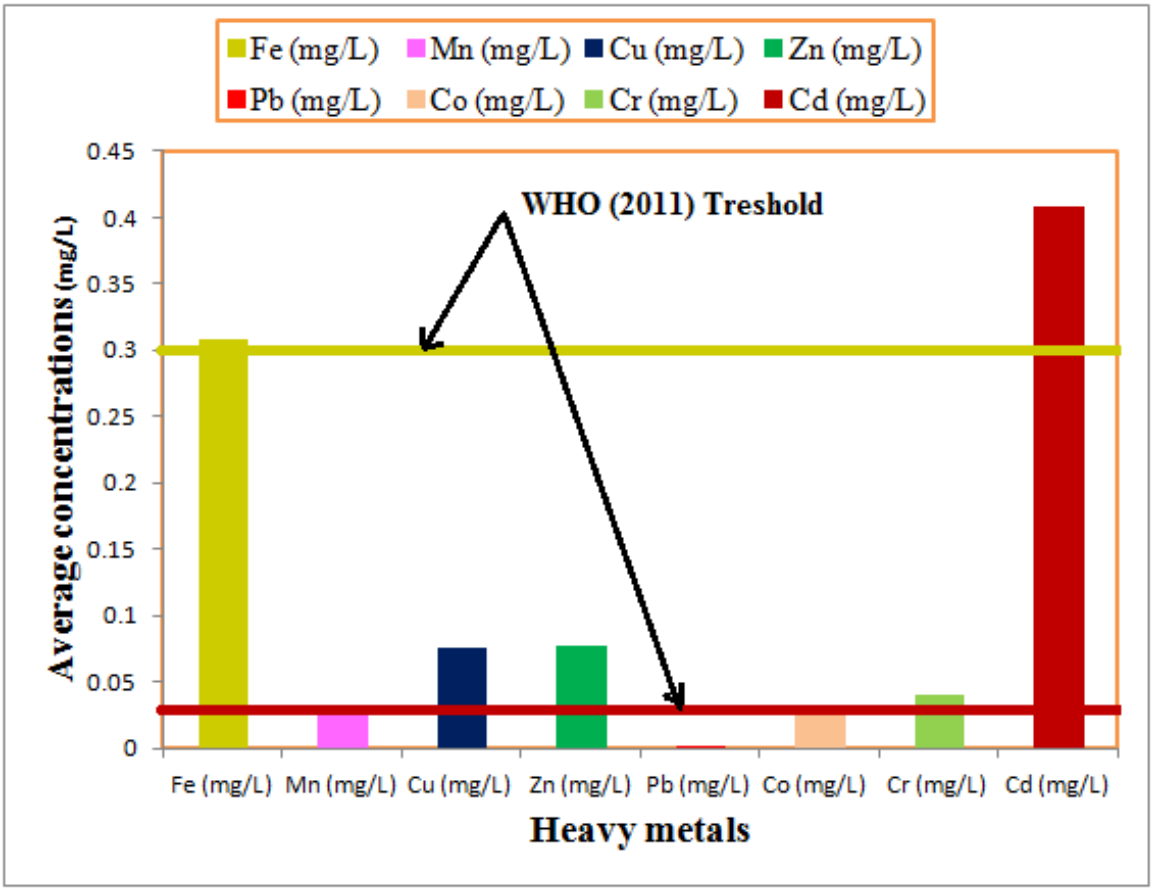

Figure 2. Bar chart showing average concentrations of heavy metals in the study Area

Thus it's an aesthetic contaminant because it can give water disagreeable metallic taste. Iron is important for heath because it transport oxygen within the blood of humans. Iron exists in two forms; ferrous and ferric forms. it's completely dissolved in water when in ferrous state and therefore the water in this state is clear. However, if such water is exposed to air, oxidation to ferric state may occur and therefore the water turns cloudy and a reddish-brownish substance may develop constituting undissolved sediment within the water. Copper is one of the heavy metals occurring in rocks and soils of the environment. it's a necessary element required to take care of physiological state in humans but existing often in low concentrations in natural water (Government of Western Australia, 2016). Drinking of water with high concentration of copper may result into nausea, vomiting, diarrhoea, gastro-intestinal disease and headaches. A high level of copper in drinking water with concentration >2.0mg/L will impose a bitter taste on the water and such water isn't potable (WHO 2011). Additionally, copper even at low concentration level in water, generally leaves a green/blue stain on taps, hand basins showers etc. This water remains safe to drink and running the

faucet for about 30seconds each morning can substantially reduce the extent of copper in water apart from the employment of water filters. In this study, Cu doesn't pose any significant health issue as all concentrations of water samples were within approved WHO (2011) standard for drinking water. Zinc occurs principally as sulphide ores and to a lesser degree as carbonates naturally at low concentrations in many rocks and soils.

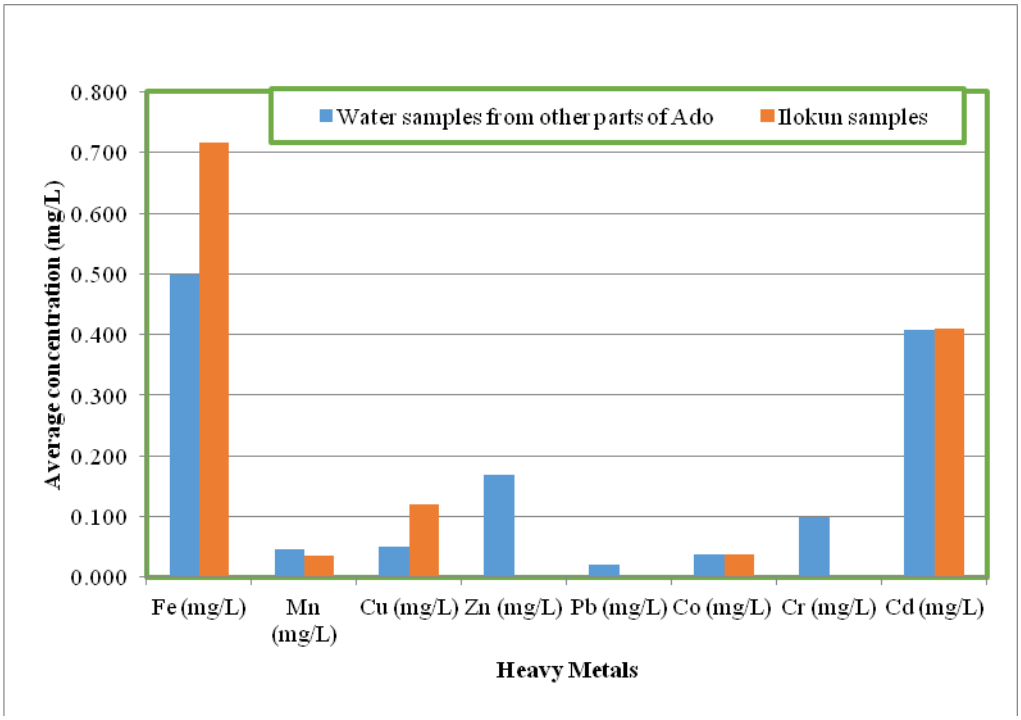

Figure 3. Bar chart of average concentrations of Metals of water samples from other parts of Ado-Ekiti compare to Ilokun water samples

Zinc could be a basic nutrient required for body growth and development; however drinking water with high concentrations of zinc may cause stomach cramps, nausea and vomiting. Growth retardation, delayed sexual maturation, infection susceptibility, and diarrhea are the results of consumption of water with deficiency of Zinc. The most efficient methods to remove zinc from water are distillation and reverse osmosis (RO) (Prasad, 2003; Hambidge & Krebs, 2007). Concentrations of Zn in the water of Ado-Ekiti Area are within approved standard for drinking water.

Conclusion

This study revealed that all the heavy metals analyzed in water of the area seem to not cause any serious threat to humans' health except for Cd that occurred in concentrations (>3µg/L) above approved standard for drinking water. The extensive open waste dump at Ilokun village has impacted the concentrations of metals in water of the study area as indicated in Fe, Cu and Cd concentrations. Literature search revealed very scanty research on heavy metals of the study area. Excess Cd in water can result into kidneys, liver and lungs damage warranting further work as a follow up to this present investigation.

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Conflict of Interest
There is no conflict of interest with regards to this manuscript.

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