COMPARATIVE ASSESSMENT OF HEAVY METALS IN BOREHOLE AND WELL WATER AT OLOUNDE ESTATE, IBADAN, OYO STATE, NIGERIA

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ABSTRACT

Water pollutants spread faster within biological components of the environment. Heavy metal is known to have a longer lifespan in our environment, thereby, posing a severe threat to human and other living organisms in contact with it. The study was conducted to determine the concentration level of following heavy metals: iron, cadmium, manganese, chromium, zinc, lead, copper in borehole and well water. This research was carried out at Olounde estate a residential area in Ibadan. Three borehole water and three well water were sampled. A random sampling technique was used, at about 16 m difference to each other. From point zero to borehole A(16.4 m), from borehole A to borehole B(16.5 m), from borehole B to borehole C (16.3 m), from borehole C to well A (16.8 m), from well A to well B (16.2 m), from well B to well C (15.3 m). The result of this research shows that high heavy metal concentration is present in the borehole water and well water in the study area. Zinc was identified to be the highest heavy metal concentration (0.24 mg/l), followed by iron (0.23 mg/l), while Chromium concentration was the lowest (0.001 mg/l). Cadmium presence was only found in Borehole A (0.005 mg/l).Iron and Chromium were very high above the WHO and USEAP permissible level of heavy metals in water. Borehole had the highest heavy metal concentration (zn^{2+}) at borehole C (0.24 mg/l).

Keywords: Concentration; Heavy metal; Borehole; Well-water; Permissible.

INTRODUCTION

One of the greatest challenges of the 21st century is the availability of portable drinking water, a source basic to our existence, survival and growth (WHO, 2014; Abong'o *et al.*, 2017; Skudi *et al.*, 2011). Globally, over 5 billion inhabitants are dependent on groundwater and surface water system since people use these resources in numerous ways such as potable water, housing, crops production, and manufacturing applications (KEBS, 2007; WHO, 2004; Baum, *et al.*, 2000; ATSDR, 1999). Groundwater serves as a major source of water resources and readily available in many countries (Selvakumar *et al.*, 2017; Amadi *et al.*, 2013; Guney *et al.*, 2010; Prasad and Kumar 2008). Subsurface water is the main supply of drinking water in most third world countries (Lutterodt *et al.*, 2018). According to Kim and Park (2016),

groundwater is used for drinking purpose by more than 20% of the world population. The alternative to groundwater such as surface water, that can supplement insufficient quantity of water from hand-dug well and boreholes, is not voluntarily present everywhere and more importantly is easily contaminated than groundwater sources (Sorenson *et al.*, 2015; Mbaka *et al.* 2017; Mazhar *et al.*, 2019). However, unhygienic practices such as washing of clothes, dumping of animal waste and open defecation around ground water sources poses as threats to groundwater sources and contribute significantly to the decline in potable water (Farkas *et al.*, 2001). Contaminants in various form can come in contact with the water body through natural and various anthropogenic sources, reduce the amount of potable water to

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the populace, and likely rise in health risks linked with the use of polluted water (Gautam *et al.,* 2014; Momodu *et al.*, 2010; TWAS, 2002; Hanaa *et al*., 2000).

Metals are inextricable part of the earth crust, but their levels in water and porous media such as soil and sediments are a major source of worry for conservationist due to their dangerous, non-biodegradable and long lasting properties (Kumar *et al*., 2020a,b; Giri and Singh 2019; Chen *et al*., 2017;). Heavy metals (HMs) are group of metals and metalloids characterized by specific gravities greater than 5 and atomic densities larger than 4g/cm3 (Barzegar *et al*., 2015; Ganiyu *et al*., 2017; Enuneku *et al*., 2018; Kumar *et al*., 2020c). HMs can be found in water from geological or manmade activities (Nawab *et al*. 2017; Paul *et al*., 2019).

Toxicity of heavy metals can be introduced into the body through inhalation, dermal contact and ingestion (Olujimi *et al*., 2014; Ayedun *et al*., 2015; Ogundele *et al*., 2019; Kumar *et al*., 2020b). It should be noted that only few numbers of heavy metals are considered important for different biochemical reactions in the body (Singh *et al*., 2011; Selvan *et al*., 2017: Shankar, 2019; kumar *et al*., 2020a,b,c). because of their long biological halflives, the majority of heavy metals such as Cd, As, Pb, Mn, Fe, Cr, and Hg pose a significant threat to the normal performance of human body tissue, resulting in various diseases (Suvarapu and Back, 2017; Barzegar *et al*., 2019). For instance, lead (Pb) is reported to be the second most toxic metal after arsenic (As) and comprises 0.002% of the earth crust (Arias *et al*., 2010; kumzr *et al*., 2020a). Large number of people residing in different countries is reported to be exposed to increased intake of arsenic- rich groundwater (Ravindra and Mor, 2019; Gilman *et al*., 2001; EPA, 2008).

The degradation of water resources is a much-studied phenomenon and can be caused by natural processes (climate change and water rock interactions, and geological factors) and human activities as well as presence of considerable chemical compounds since the industrial revolution (Calkins, 2009; Linnik, 2000). Despite this, the management of surface and groundwater as a resource remains complicated in many circumstances and relevant information remain unknown. Apart from anthropogenic activities, natural heterogeneities of rock/soil interaction with water, influencing natural water cycles and affecting water quality across all domains. Such modifications can have severe repercussions for the functioning of human health and the living organism. In addition, the physicochemical and biological characteristics, as well as quality and availability of water resources, fluctuate based on the impact of

natural and human activities. Groundwater pollution, also referred to as groundwater contamination may also happen in nature, according to Momodu and Anyakora (2010) and when the pollutant is small, undesirable element, or impurity in the groundwater, is alluded to as a contamination rather than pollution (Momodu *et al*., 2010; Stern, 2010; Jeffrey *et al*., 1992) happens when impurities are emitted on to the ground and percolate to the groundwater. Several trace metals are constituents of certain rock formations and make their way into the environment through weathering of rocks. Industrial activities like mining, metallurgy, disposal of solid waste, paint and enamel works contributed to increased levels of poisonous metals like lead, cadmium, and chromium (Neal and Guilarte, 2012; Edvardo *et al*., 2005). These impurities possess the ability to reach groundwater (Iqbal and Gupta, 2009; Pain, 2008; John, 2002). The movement of metals and their metalloids into groundwater is dependent on several factors, for instance, chemical reactions that determine the separation of impurities into various phases and species (UNEP, 2009; Hong and Barlett, 2008). Therefore, the movement of these metals is dependent on the pH and redox state of groundwater (Omwoma, 2011; Kallis, 2006).

The objective of this study was to investigate the comparative levels of heavy metals in borehole and well water available to the inhabitants in Olounde Estate.

Materials and Methods
Study area
This study was carried out at Olounde Estate in Ido local government, Oyo State. Ido local government is geographically bounded within latitude 7º 30'27.74'N and Longitude 3º 43'9.82" E and covers an area of about 986 Km².

Water Sample Collection
Random sampling technique was employed to collect three borehole and well water, in three replicate samples at Olounde Estate in Ido Local Government area.

Experimental Design
The experiments were arranged in a Randomized Design (RD). There were six different points, with about 16 m distance, as treatments, 3 water samples taken at each point, as replicates. In this, water samples were collected at different distance from one another. From point zero (0) to borehole A (16.4 m) borehole A to B (16.5 m), B to C (16.3 m), from C to well A (16.8 m), well A to well B(16.2 m), well B to well C (15.3 m). Total 18 water samples were collected in all.

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Sampled water analysis Water samples of 20ml each were transferred into beakers and 1 mL of concentrated HNO_3 were added. The beaker with the content was placed on a hot plate. The samples were boiled slowly and then evaporated on the hot plate to the lowest volume of 5 mL. The beakers were allowed to cool and another 1mL of concentrated HNO_3 was added. The beakers were covered with watch glass and returned to the hot plate. Heating was continued and HNO3 was added as necessary until the solution appeared light colored and cleared (i.e. digestion was complete).The watch glass and beaker walls were washed with distilled water and filtered to remove insoluble materials that could clog the atomizer. The filtrates were transferred to 50 mL volumetric flasks and diluted to the mark with distilled water. These solutions were then used for the analysis (i.e. obtaining the concentration of each metal).The   digested water solution samples were analyze with Bulk Scientific 122A Atomic Absorption spectrophotometer using the flames and wavelength specified for the metals wished to be determined and used background correction. A calibration graph of absorbance was constructed against metals concentration.

Calculation of the concentration of the water samples:

Concentration in water (mg/L) = (C x V)/M

C = concentration of metal in the water (ug/mL)

V = volume of final water (mL)

M = volume of the initial water (mL).

Results and Discussions
Results

Table 1: Presence of heavy metals in borehole and well water.

Treatment	Fe^{2+}	Zn^{2+}	Mn^{2+}	Pb^{2+}	Cd^{2+}	Cr^{3+}	Cu^{2+}
Bh A	0.23a	0.11c	0.04b	0.01a	0.05a	0.12d	0.003c
Bh B	0.08d	0.02d	0.004b	0.00b	0.00b	0.01e	0.00d
Bh C	0.08d	0.24a	0.08ab	0.11ab	0.00b	0.00e	0.01cd
Wl A	0.12c	0.19b	0.13a	0.01a	0.00b	0.52b	0.09b
Wl B	0.17b	0.23ab	0.13a	0.01a	0.00b	0.70a	0.13a
Wl C	0.03e	0.08c	0.06ab	0.00b	0.00b	0.19c	0.02c
LSD	0.04	0.05	0.08	0.009	0.02	0.03	0.02

Means with the same letters are not significantly different.

Bh A= borehole from the first compound, Bh B= borehole from the second compound, Bh C= borehole from the third compound, Wl A= well from the first compound with a well, Wl B= well from the second compound with a well, Wl C = well from the third compound with a well .

Table 2: WHO and USEPA level for permissible heavy metals in water

Heavy metals	WHO[18]	USEPA[19]
As(iii) As(v)	0.05	0.01
Pb	0.05	0.015
Cd	0.005	0.005
Cr	0.05	0.05
Hg	0.001	0.002
Zn	5.0	5.0
Cu	1.5	1.3
Co	0.01	–
Fe	0.03	0.3
Mn	0.3	0.05

Source:em.m.wikipedia.org/w/index.php?title =Drinking_water_quality_standaedrs&action =e dit&selection=1

Discussions

The water sample taken from borehole A produced the highest significant iron (fe^{2+}) concentration (0.23 mg/l), followed by well B (0.17 mg/l), while well C produced the least significant Fe^{2+} concentration (0.03 mg/l). However, borehole B produced 0.08 mg/l Fe concentration which was not significantly different from borehole C.

The water sample taken from borehole C had highest significant zinc (zn^{2+}) concentration (0.24 mg/l), followed by well B (0.23 mg/l) while borehole B produced the least significant zn^{2+} concentration (0.02 mg/l). However, borehole A produced (0.11 mg/l) zn^{2+} concentration which was not significantly different from well C.

The water sample taken from well A and B produced the highest significant manganese (mn^{2+}) concentration (0.13 mg/l) followed by borehole C (0.08 mg/l).While borehole B has the lowest significant in mn^{2+} concentration (0.004 mg/l). However borehole A and B produced (0.04 mg/l, 0.00 4mg/l) which was not significantly different. Also borehole C and well C produced (0.08 mg/l and 0.06 mg/l) mn^{2+} concentration respectively which has no significant difference and well A and B produced (0.13 mg/l) of mn^{2+} concentration which is not significantly different. Borehole A, C and well B had the highest significant concentration of lead (0.01mg/l) and (0.11 mg/l). Borehole B, well A and C has no traces of lead. However concentration of lead in borehole A, C and well B is not significantly different from one another.

Borehole a produced or had the highest significant in concentration of cadmium (Cd^{2+}) (0.05mg/l). While the presence of cadmium in borehole B and C, well A, B and C was not detected.

Well B has the highest concentration of chromium Cr^{3+} (0.70 mg/l) followed by well a which has a concentration (0.52 mg/l). Borehole has the least chromium concentration (0.01 mg/l) while chromium was not detected in borehole C.

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However borehole B and C produced (0.01mg/l) and (0.00mg/l) respectively, which has no significant difference.

Well B showed highest significant concentration of copper Cu^{2+} (0.13 mg/l) followed by well A which has a concentration of (0.09 mg/l). Borehole C has the lowest significant concentration of copper Cu (0.01 mg/l), while borehole B has no traces of copper. However concentrations of copper in boreholes A, B,C and well A,B,C are all significantly different from one another.

From table 2, it is evident that iron (fe^{2+}) in borehole A, B,C and well A and B were high above permissible level of heavy metals in water set by WHO and USEPA(1996). It was only well C that is below permissible level. The relative density of iron compound to water is in moderation and so therefore iron in well C is not toxic or harmful. Zn^{2+} in the study area is very low according to WHO and USEPA standard and therefore, it does not pose any danger to human health, especially to the occupants of Olounde Estate. Manganese (mn^{2+}) in the study area is high above permissible level and is therefore toxic to the occupants in the study area. Lead (pb^{2+}) in the study area has no toxic effect since it is low compared to the standard limit set by WHO and USEPA (1996). However, the water is lead friendly. Cadmium (cd^{2+}) in borehole A is moderate while borehole B, C and well A, B, C had no traces of cadmium. Chromium in borehole B was low, borehole C had no traces of chromium while borehole A, well A, B, C has high amount of chromium (cr^{3+}) beyond the limit. Concentration of copper(cu^{2+}) in the study area were all below the acceptable limit set by WHO and USEPA standard (1996).

Conclusion

In conclusion, the water available to the residents contains high level of fe^{2+}, zn^{2+}, cr^{3+} and mg^{2+} according to WHO and USEPA beyond permissible level of heavy metals in drinkable water.

Recommendation

Based on the findings from this research work, it is recommended that:

Residents of the area should be enlightened by appropriate arm of government and commensurate non-governmental organizations to sensitize the people on the impending danger inherent in discharge of toxic waste into the area. Government should assist in screening available water for drinking so as to know the metals present in drinkable water and how to treat this water so as to make it healthier for drinking.

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