INDUSTRIAL ESTATE, SOUTHWEST NIGERIAASSESSMENT OF SOME SELECTED HEAVY METALS POLLUTION IN DRINKING WATER SOURCES OF AGBARA

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ABSTRACT
The impact of heavy metal in drinking water sources of Agbara Industrial Estate, Southwest, Nigeria, was examined to evaluate the level of heavy metal (Arsenic, Cadmium, Chromium, Copper and Lead) pollution. Water samples were collected from borehole, river, tap-water and well-water within and outside Agbara industrial estate. The concentration of the selected heavy metals in the water was analyzed. The concentration of Arsenic in water samples within the study area ranges from 0.014 to 0.040 MgL^{-1}. The highest mean Arsenic concentration (0.035MgL^{-1}) within the study area was observed from water samples collected from river, Cadmium concentration within the study area ranged from 0.018 to 0.035 MgL^{-1}, Chromium concentration ranged from 0.11 to 0.28 MgL^{-1}, Copper concentration ranges from 2.20 to 2.69 MgL^{-1}, while the concentration of Lead ranges from 0.19 to 0.34 MgL^{-1}. The concentration of all the metals investigated is higher than their maximum permissible limit for consumption. The results of this research proved that drinking water sources are significantly affected by the presence and activities of industries within the study area. This water when consumed over time poses serious health related hazards, therefore in other to reduce contamination of drinking water by heavy metals, Companies should treat their wastes by precipitating metals thus reducing their mobility through seepage, companies should also construct ponds with adequate retention times that can enhance the removal and retention of metals.

Keywords: Heavy metals, Drinking water sources, Agbara Industrial Estate, Southwest, Nigeria.

INTRODUCTION

Environmental pollution by heavy and toxic metals because of mining, metallurgic processes and other chemical industries is a worldwide problem affecting both human health and the environment (Chang-ho *et al.*, 2016). Environmental pollution specifically water pollution is alarming both in the developed and developing countries (Shahabaldin*et al.*, 2016). Water pollution is a global problem threatening the entire biosphere and affecting the life of many millions of people around the world. Not only is water pollution one of the foremost global risk factors for illness, diseases and death, but it also contributes to the continuous reduction of the available drinkable water worldwide (Sreenath*et al.*, 2019). Heavy metal contamination in water resources is a critical issue which adversely affects humans, plants and animals (Shahabaldin*et al.*, 2016).

Populations are exposed to heavy metals primarily through water consumption, but few heavy metals can accumulate in the human body (e.g., in lipids and the gastrointestinal system) and may induce cancer and other risks (Shakhawat*et al.,* 2016). The industrial growth is the major source of heavy metals introducing such pollutants into different segments of the environment including air, water, soil, and biosphere (Arezoo*et al.,* 2017). The concentration of heavy metals present in drinking water is still not within the recommended limits as set by the regulatory authorities in different countries of the world (Kanwal*et al.*, 2018). Both natural and anthropogenic activities are responsible for water, air and land pollution, i.e. wastewater released from the industries (effluents), toxic chemicals and heavy metals that pollute the environment and contaminate the soil (Tahira*et al.*, 2019).

The term "heavy metals" refers to any metallic elements that has a relatively high density and is toxic or poisonous even at low concentration (Lenntech, 2004). Although there is no specific definition of a heavy metal, literature has defined it as a naturally occurring element having a high atomic weight and high density which is five times greater than that of water (Vhahangwele and Khathutshelo, 2018). Unlike organic pollutants, heavy metals are not created nor are biodegradable materials. They naturally occur in earth crust and many of them reach the environment via anthropogenic activities, which belonged to mining, smelting, production of fertilizers, pesticide applications and others (Ahmed and Mosaad, 2018).

Heavy metals like arsenic, copper, cadmium, chromium, nickel, zinc, lead, and mercury are major pollutants of fresh water reservoirs because of their toxic, non-biodegradable, and persistent nature. Heavy metals are easily absorbed by fishes and vegetables due to their high solubility in the aquatic environments. Hence, they may accumulate in the human body by means of the food chain (Arezoo*et al.*, 2017). Occupational exposure to heavy metals is known to occur by the utilization of these metals in various industrial processes and/or contents including color pigments and alloys. However, the predominant source resulting in measurable human exposure to heavy metals is the consumption of contaminated drinking water and the resulting health issues may include cardiovascular disorders, neuronal damage, renal injuries, and risk of cancer and diabetes. Thus utilization of heavy metals in contaminated water is resulting in high morbidity and mortality rates all over the world (Kanwal*et al.*, 2018).

JUSTIFICATION

Like most industrial estate of the world, Agbara industrial estate has a very high demand for water. The estate host many industries such as plastic, glass, pharmaceutical, food processing and manufacturing as well as hotels. The estate derives its water mainly through hand dug well, surface water and bore hole for its daily water need. Effluents from these industries flows into the drainage system and is therefore deposited into the river, some of the effluent leaches through the highly porous soil there by contaminating the shallow water table. As a result of these anthropogenic influences on the various sources of drinking water, the water becomes polluted with toxic heavy metals. It becomes imperative therefore that investigation on heavy metal pollution in drinking water be carried out in the study area.

AIMS AND OBJECTIVES

The broad objective of this study was to assess some selected heavy metals pollution in drinking water sources of Agbara industrial estate, Southwest Nigeria.

The specific objectives were to;

I. Assess the level of pollution of the selected heavy metals in the sources of drinking water (borehole, river, tap, and well) in the study locations.

ii. Compare the concentration of the selected heavy metals in the sources of drinking water (borehole, river, tap, and well) in the study locations.

MATERIALS AND METHODS

Description of the Study Area

The study was conducted at Agbara industrial estate, southwest Nigeria. Agbara is a border town between Lagos state and Ogun state, Nigeria and located between latitude 6°27' and 6°45' North and longitude 3°23' and 3°49' East (Agbara Estate Limited AEL, 2008).Agbara industrial estate is a model integrated town development on 451.1 hectares of land. It is situated approximately 31km west of Lagos on the Lagos-badagry express way on high ground above the OwoRiver and derived its name from the neighboring Agbara village (AEL, 2008). Agbara Estate consists of industrial, commercial, residential and recreational areas. The industrial areas constitute 41.55% (188.289 hectares) of the whole estate. The industrial area provide sites for a number of industrial concerns, many of which are members of multinational conglomerates, operating some of their most modern purpose built factories in the country (AEL, 2008). The study area is also an excellent mix of various types of manufacturing industries which fall into different sectoral groups according to the Manufacturers Association of Nigeria (MAN) industrial classification (Mohammed, 2017). These motives essentially informed why thestudy area was preferred for the study.

Climate of the area

The study area is characterized by wet and dry season. The onset of rainy season is usually February to November while the dry season takes the remaining part of the year. The study area falls within the tropical rainforest climate while the annual temperature is moderate with a value of about 28°C. Humidity is high (89%) in the rainy season and drops to its lowest (32%) level during December due to harmattan (Amadi*et al.*, 2013)

Collection and preparation of samples

Water sample was collected from tap water (TW), borehole water (BW), well water (WW), and river water (RW). Four samples from each water source, from Agbara industrial estate and outside Agbara industrial estate were taken randomly, labeled in plastic containers (Total of 32 samples). The water samples were collected in a clean polyethelene bottles to ensure accuracy in analysis because glass bottle absorb metals. The water samples were filtered through a 0.45 micrometre membrane filter as soon as possible after collection.

For the digestion, each sample was measured into a clean digestion flask. 9ml of concentrated HNO_3 and 3ml of concentrated HCl was added into the samples in the digestion flask (USEPA, 1986; Bader, 2011).

The whole sample was heated in a hot plate until all the brownish fumes is expelled out (Nitrogenous compound) which confirm that the sample is digested, and the sample will be allowed to cool at room temperature. A few millimeters (2mm) of distilled water was added and the mixture was filtered into a 25ml standard flask and was transferred into plastic reagent bottle for Atomic Absorption Spectrometry (AAS).

The Atomic Absorption Spectrometry is a spectro-analytical procedure for the quantitative determination of chemical element using the absorption of optical radiation (light) by free atoms in the gaseous state. The technique measures the concentration of elements in digested samples down to parts per million (ppm) in a sample (Orosun, *et al*., 2016).

RESULTS AND DISCUSSION

RESULTS

The results of analysis of water on the assessment of heavy metals pollution (ppm or MgL^{-1}) within the study area is presented in table 1.

The results of analysis of water on the assessment of heavy metals pollution (ppm or MgL^{-1}) outside the study area is presented in table 2.

The current drinking water quality guidelines (ppm or MgL^{-1}) for the selected heavy metals by WHO, USEPA and ADWA is presented in table 3.

Comparisons of mean concentrations (ppm or MgL^{-1}) of water samples with current drinking water guidelines is presented in table 4.

DISCUSSION

Arsenic

The mean concentrations of arsenic (As) in water samples within the study area are 0.017, 0.035, 0.028, and 0.022 MgL^{-1} from borehole, river, tap water, and well water respectively, while the mean concentrations of arsenic (As) in water samples outside the study area are 0.022, 0.045, 0.024, and 0.025 MgL^{-1} from borehole, river, tap water, and well water respectively. The highest mean arsenic (As) concentration within the study area was observed from water samples collected from river. The mean concentrations of arsenic (As) are well above the standard guideline of 0.01MgL^{-1} set by WHO and USEPA. This could lead to arsenic poisoning if consumed over a long period of time. Symptoms of arsenic poisoning begin with headaches, confusion, severe diarrhea and drowsiness. As the poison develops, convulsions and changes in fingernail pigmentation called leukonychiastriata may occur (Tseng *et al*., 2003).

Cadmium

For cadmium (Cd) within the study area, the mean concentrations are 0.026, 0.034, 0.023, 0.021 MgL^{-1} for borehole, river, tap and well water respectively, while the mean concentrations of Cadmium (Cd) outside the study area are 0.13, 0.32, 0.18, 0.23 MgL^{-1} for borehole, river, tap and well water respectively. The values for the mean concentrations are well above the standard guideline of 0.003 and 0.005 MgL^{-1} set by WHO and USEPA respectively. The highest mean concentration of cadmium (Cd) within the study area (0.034 MgL^{-1}) was observed in river water sample. This could be as a result of runoff or surface flow of water containing effluents from industries within the study area. Cadmium (Cd) exposure produces kidney damage and hypertension

Table1 Heavy Metal Concentrations (ppm or MgL^{-1}) in Water Samples Collected from Study Area.

Source	Cu	Pb	As	Cd	Cr
Borehole					
	2.61	0.21	0.014	0.025	0.13
	2.69	0.25	0.020	0.028	0.18
Mean	2.65	0.23	0.017	0.026	0.15
River					
	3.40	0.30	0.027	0.032	0.25
	3.48	0.34	0.040	0.035	0.28
Mean	3.44	0.32	0.035	0.034	0.27
Tap					
	2.28	0.19	0.026	0.022	0.12
	2.33	0.22	0.029	0.024	0.16
Mean	2.31	0.21	0.028	0.023	0.14
Well					
	2.20	0.19	0.020	0.018	0.11
	2.24	0.19	0.024	0.023	0.14
Mean	2.22	0.21	0.022	0.021	0.13

Table 3 Current Drinking Water Quality Guidelines (ppm Or MgL^{-1}) for the Selected Heavy Metals.

Parameter	WHOa	USEPAb	ADWGc
Arsenic	0.010	0.010	0.010
Cadmium	0.003	0.005	0.002
Chromium	0.050	0.100	0.050
Copper	2.000	1.300	2.000
Lead	0.010	0.015	0.010

SOURCE:

a. World Health Organization (WHO, 2011); b United Stated Environmental Protection Agency (USEPA, 2011); c Australian Drinking Water Guidelines (ADWG, 2011).

Table 4 Comparisons of Mean Concentrations (ppm or MgL^{-1}) of Water Samples with Current Drinking Water Guidelines.

Heavy Metals	Source	Mean Concentrations Within Stdy Ar. Conc.	Outside Stdy Ar. Conc.	WHO	USEPA
As	Borehole	0.017	0.022	0.01	0.01
	River	0.035	0.045		
	Tap	0.028	0.024		
	Well	0.022	0.025		
Cd	Borehole	0.026	0.025	0.003	0.005
	River	0.034	0.040		
	Tap	0.023	0.027		
	Well	0.021	0.027		
Cr	Borehole	0.15	0.13	0.05	0.10
	River	0.27	0.32		
	Tap	0.14	0.18		
	Well	0.13	0.23		
Cu	Borehole	2.64	2.62	2.00	1.30
	River	3.44	3.61		
	Tap	2.31	2.33		
	Well	2.22	2.24		
Pb	Borehole	0.23	0.22	0.010	0.015
	River	0.32	0.36		
	Tap	0.21	0.24		
	Well	0.21	0.29		

Chromium

The mean concentrations of chromium (Cr) within the study area are 0.015, 0.027, 0.014 and 0.013 MgL^{-1} for borehole, river, tap-water and well-water respectively, while the mean concentrations outside the study area are 0.025, 0.040, 0.027 and 0.027 MgL^{-1} for borehole, river, tap-water and well-water respectively. It was observed that water samples collected from river contains the highest mean concentration of chromium. The lowest mean concentration of chromium was observed in well water samples. The mean concentration of chromium in water samples within and outside the study area are well above the recommended limit of 0.05 and 0.10 MgL^{-1} set by WHO and USEPA respectively. It has been reported that long term exposure to chromium (Cr) can cause damage to liver, kidney circulatory and nerve tissues, as well as skin irritation (Tseng *et al*., 2003). Cromium is carcinogenic to humans. Long-term exposure has been associated with lung cancer in workers exposed to levels in air that is in the order of 100 to 1000 times higher than usually found in the environment (Finkelman, 2005).

Copper

The mean concentration of copper (Cu) within the study area are 2.65, 3.44, 2.31, and 2.22 MgL^{-1} for borehole, river, tap-water and well water respectively, while the mean concentration of copper (Cu) outside the study area is 2.62, 3.61, 2.33 and 2.29 MgL^{-1} for borehole, river, tap-water and well water respectively. The permissible limit for copper (Cu) in drinking water according to WHO and USEPA standard is 2.00 and 1.30 MgL^{-1} respectively. Copper can become toxic when there is an excess of the metal in the body. Copper can occur from eating acidic foods cooked in uncoated copper cookware or from exposure to excess copper in drinking water and other environmental sources. Acute symptoms of copper poisoning by ingestion include vomiting, hematemesis (vomiting of blood), hypotension/low blood pressure, Melema (black tarry faeces), coma, jaundice (yellowish pigmentation of the skin), and gastrointestinal distress (Casarret and Doulls, 2013).

Lead

The mean concentration of lead within the study area is 0.23, 0.32, 0.21 and 0.21 MgL^{-1} for borehole, river, tap-water and well water respectively, while the mean concentration outside the study area is 0.22, 0.36, 0.24, and 0.29 MgL^{-1} for borehole, river, tap-water and well-water respectively. These values exceed the permissible limit of 0.010 and 0.015MgL^{-1} set by WHO and USEPA respectively. The highest mean concentration for lead was observed in the water samples collected from river within and outside the study area. Lead is a commutative poison and a possible human carcinogen. The concentration of Pb is above the permissible limit in drinking water, so people consuming the water should be worried of its bioaccumulation over time as higher concentrations of Pb can even cause irreversible brain damage (Bakare-Odunola, 2005, WHO, 2008). Studies report that chronic exposure to lead can cause anemia and high blood pressure, especially in the elderly and middle-aged groups. However, water with less than 0.05 mg/L concentration of Pb may have a slight risk of behavioral changes and the possibility of neurological impairment in young children with developing brain tissues (Jaidhankar*et al*., 2014). Expectedly, the concentration of the metals investigated is higher than their maximum permissible limit for consumption (see Table 4). Study by the United States Food and Drug Administration (2003) reveals similar observations.

CONCLUSION

Drinking water sources within the study area are significantly affected by the presence and activities of industries. The mean concentrations of selected heavy metals are well above the recommended drinking water limit set by World Health Organization (WHO) and United State Environmental Protection Agency (USEPA).Water samples from river have the highest concentration of selected heavy metals. This is likely as a result of the presence of heavy metals in high concentrations in effluents and waste-water from the industries which flow into the river.

RECOMMENDATIONS

On the basis of this research, the following recommendations were made:

* Studies should be carried out on other heavy metals that could be found in the study area.
* Companies should treat their wastes by precipitating metals thus reducing their mobility through seepage.
* Companies should construct ponds with adequate retention times that can enhance the removal and retention of metals.

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