WORLD JOURNAL OF ADVANCE HEALTHCARE RESEARCH

SJIF Impact Factor: 3.458

ISSN: 2457-0400
Volume: 3.
Issue: 1.
Page N. 06-10
Year: 2019

Original Article www.wjahr.com

# EVALUATION OF CONCENTRATION OF HEAVY METALS IN SURFACE AND GROUND WATER IN AKPABUYO, SOUTH-EASTERN NIGERIA, WA

**Jeremiah Anwakang***

Department of Environmental Health, College of Health Technology Calabar, Cross River State, Nigeria.

**Received date:** 24 October 2018 **Revised date:** 14 November 2018 **Accepted date:** 05 December 2018

***Corresponding author: Jeremiah Anwakang**

Department of Environmental Health, College of Health Technology Calabar, Cross River State, Nigeria.

**ABSTRACT**

Heavy metal analyses were carried out on twenty (20) surface water and twenty (20) groundwater samples obtained from a rapidly changing area and system in part of Eastern Niger Delta. Heavy metal levels: barium, cadmium, copper, iron, manganese, lead and zinc were analyzed using Atomic Absorption Spectrophotometer. Most of the heavy metal concentrations in both surface and groundwater are within the WHO (2011) permissible limits for drinking and industrial usage of water. However,the concentration of these heavy metals are more pronounced in surface water than in groundwater with anomalous concentrations of Cd and Pb. The high concentrations of most heavy metals in surface water could be due to the fact that heavy metals are found naturally in the earth, and become concentrated as a result of human caused activities.

**KEYWORDS:** Heavy metals, surface water, Ground water.

## INTRODUCTION

The term heavy metal was originally used for metals that have harmful effects on human such as cadmium, mercury and lead, all of which are denser than iron. It has since been applied to any other similarly toxic metal, or metalloid such as arsenic, regardless of density. Commonly encountered heavy metals are chromium, cobalt, nickel, copper, zinc, arsenic, selenium, silver, cadmium, antimony, mercury, thallium, lead, iron and manganese.

Other criteria used to define heavy metals include density, atomic weight, atomic number, or periodic table position. In terms of density criteria, heavy metals are those metals from $3.5g/cm^3$ to $7g/cm^3$. Atomic numbers of heavy metals are generally greater than 20 and sometimes capped at 92 (Uranium). Hawkes (1997) suggested referring to heavy metals as ‘all the metals in groups 3 to 16 that are in periods 4 and greater”.

All heavy metals exist in surface waters in colloidal, particulate, and dissolved phases, although dissolved concentrations are generally low (Kennish, 1992). The colloidal and particulate metal may be found in 1) hydroxides, oxides, silicates, or sulfides; or 2) adsorbed to clay, silica, or organic matter. The soluble forms are generally ions or unionized organometallic chelates or complexes. The solubility of trace metals in surface waters is predominately controlled by the water pH, the type and concentration of ligands on which the metal could adsorb, and the oxidation state of the mineral components and the redox environment of the system (Connell et al., 1984).

Excess metal levels in surface and groundwater can be detrimental to aquatic organisms and may pose a health risk to humans. Living organisms require trace amounts of some metals, including cobalt, copper, iron, manganese, molybdenum, vanadium, strontium, and zinc. Metals that are non-essential to living organisms such as lead, cadmium, mercury, arsenic, barium, and chromium, may pose great health risks. Cadmium (Cd) is a toxic metal and can induce and/or promote diseases in humans (cancer, aging diseases, kidney and bone diseases, etc.) (Nzengue, 2011).

Irrigation water may transport dissolved heavy metals to agricultural fields. Although most heavy metal do not pose a threat to humans through crop consumption, cadmium may be incorporated into plant tissue. Accumulation usually occurs in plant roots, but may also occur throughout the plant (De Voogt et al., 1980).

## MATERIAL AND METHODS

### Study area

The study area, Akpabuyo Local Government Area, is located approximately between Latitude $4^{0}$ 45' and $5^{0}$05' North and Longitudes $8^{0}$20' and $8^{0}$40´ East (FIG.1). It covers an area of 1241 $km^2$. The climate of the area is typical of tropical humid region with a mean annual rainfall of 3500-4000 mm, a mean annual temperature of 26-27$^{0}$C and a mean relative humidity of 80-90%.

### Geology and hydrogeology

Geologically, the area is underlain mostly by Tertiary to Recent (Alluvium) sediments known as the Benin Formation (Coastal Plain Sands). The Formation consists of alternating sequences of gravel and sand of various grain sizes, silt, clay and alluvium.These alternating sequences built up a multi – aquifer system in the area. The aquifers have been generally delineated into the upper unconfined gravelly sandy aquifer and lower fine sandy aquifer. Groundwater recharge is through precipitation and the surrounding Great Kwa and Akpa-Ife Rivers. High concentration of ferromagnesium minerals in the soils also affects hydraulic conductivity with the consequence on surface crusting and compaction. The landscape has a gentle slope within undulating topography.

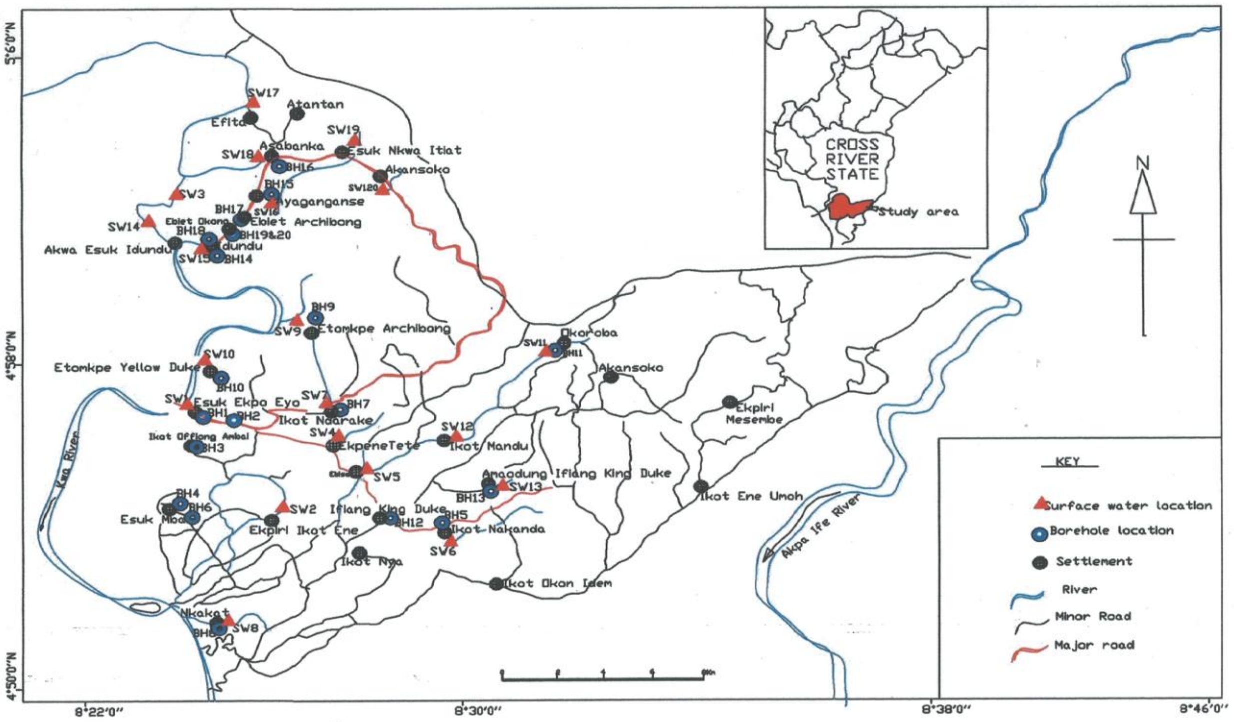


**Fig. 1: Map of the study area showing surface water and ground water sample locations. Source: Adapted from Cross River State Surveyor General Map (2008).**

## METHODOLOGY

Heavy metal levels (Ba, Cd, Cu, Fe, Mn, Pb, Zn) were analyzed using a Perkin-Elmer Atomic Absorption Spectrophotometer (AAS). This technique was used, which is relatively simple, versatile, accurate and free from interference.

In Atomic absorption spectrometry, a sample of water was aspirated into a flame and atomized. A light beam was directed through the flame, which was focused through the sample cell into a monochromator, and onto a detector that measured the amount of light absorbed by the atomized element in the flame. For some metals, atomic absorption exhibits superior sensitivity over flame emission. Because each metal has its own characteristic absorption wavelength, a source lamp (hollow cathode lamp) composed of that element was used; this made the method relatively free from spectral or radiation interferences. The amount of energy at the characteristic wavelength absorbed in the flame was proportional to the concentration of the element in the sample over a limited concentration range. By measuring the amount of light absorbed, a quantitative determination of the amount of analyte was made. The used of special light sources and careful selection of wavelengths allowed the specific determination of individual elements.

## DISCUSSION

Heavy metals that are considered in this research work include: Barium (Ba), Cadmium (Cd), Copper (Cu), Iron (Fe), Manganese (Mn), Lead (Pb) and Zinc (Zn) (Tables 1, 2 and Fig. 2).

**Barium**

The concentrations of barium (Ba) in surface water range from 0 to 0.02 mg/l with mean value of 0.01 mg/l, while that of groundwater ranges from 0 to 0.02 mg/l with a mean value of 0.01 mg/l. The measured values fall below maximum acceptable concentration of 0.7mg/l for barium by WHO (2011).

**Cadmium**

The average concentration of cadmium in surface and groundwater in the study area is 0.02mg/1 and 0.01mg/1 respectively. It ranges from 0 to 0.04mg/l in surface water and 0 to 0.01mg/1 in groundwater. However, most of the concentrations of cadmium in water samples are higher in surface than in groundwater as well as above the WHO (2011) standard of 0.003mg/l for drinking water. These high concentrations of cadmium in surface water could be as a result of anthropogenic activities in the study area.

Cadmium may interfere with the metallothionein's ability to regulate zinc and copper concentrations in the body. Metallothionein is a protein that binds to excess essential metals to render them unavailable. When cadmium induces metallothionein activity, it binds to copper and zinc, disrupting the homeostasis levels (Kennish, 1992). Cadmium is used in industrial manufacturer and is a byproduct of the metallurgy of zinc.

**Copper**

The concentration of copper in surface and ground waters varied from 0.01 to 0.03mg/l and 0.01 to 0.02 mg/l respectively. These values are below the maximum acceptable concentration for copper by WHO (2011) standard of 2.0 mg/l. Copper, according to UNESCO and WHO (1978) is rarely found in natural waters. Their presence usually enhance the concentration of trace elements such as Cu, Mn, Zn, Pb, Ni and Cr (ASTM, 1969; Azmatullah and Ekwere, 1984).The undesirable effects due to high concentrations of copper in water include astringent tastes, staining of utensils and corrosion of pipes.

**Table 1: Concentration of heavy metals in surface water.**

| Code | Ba mg/l | Cd mg/l | Cu mg/l | Fe mg/l | Mn mg/l | Pb mg/l | Zn mg/l |
|---|---|---|---|---|---|---|---|
| SW1 | 0.01 | 0.02 | 0.01 | 0.02 | 0.02 | 0.02 | 0.25 |
| SW2 | 0.01 | 0.01 | 0.01 | 0.03 | 0.03 | 0.01 | 0.18 |
| SW3 | 0.01 | 0.01 | 0.01 | 0.03 | 0.02 | 0.02 | 0.22 |
| SW4 | 0.01 | 0.02 | 0.03 | 0.02 | 0.01 | 0.02 | 0.25 |
| SW5 | 0 | 0.0 | 0.02 | 0.02 | 0.02 | 0 | 0.23 |
| SW6 | 0.01 | 0.02 | 0.02 | 0.01 | 0.01 | 0.03 | 0.22 |
| SW7 | 0.01 | 0.02 | 0.02 | 0.01 | 0.01 | 0.02 | 0.24 |
| SW8 | 0.02 | 0.01 | 0.01 | 0.03 | 0.02 | 0.01 | 0.27 |
| SW9 | 0.01 | 0.02 | 0.02 | 0.02 | 0.01 | 0.03 | 0.25 |
| SW10 | 0.02 | 0.01 | 0.01 | 0.02 | 0.02 | 0.02 | 0.24 |
| SW11 | 0.02 | 0.02 | 0.02 | 0.03 | 0.02 | 0.02 | 0.25 |
| SW12 | 0.01 | 0.03 | 0.01 | 0.04 | 0.01 | 0.03 | 0.25 |
| SW13 | 0.01 | 0.03 | 0.01 | 0.02 | 0.02 | 0.03 | 0.27 |
| SW14 | 0.02 | 0.04 | 0.02 | 0.04 | 0.01 | 0.02 | 0.24 |
| SW15 | 0.02 | 0.02 | 0.01 | 0.03 | 0.01 | 0.04 | 0.22 |
| SW16 | 0.01 | 0.02 | 0.01 | 0.02 | 0.01 | 0.05 | 0.25 |
| SW17 | 0.01 | 0.02 | 0.01 | 0.03 | 0.03 | 0.03 | 0.18 |
| SW18 | 0.01 | 0.02 | 0.01 | 0.03 | 0.02 | 0.02 | 0.22 |
| SW19 | 0.02 | 0.01 | 0.03 | 0.02 | 0.01 | 0.01 | 0.25 |
| SW20 | 0.01 | 0.02 | 0.02 | 0.02 | 0.02 | 0.03 | 0.23 |
| Min | 0 | 0 | 0.01 | 0.01 | 0.01 | 0 | 0.18 |
| Max | 0.02 | 0.04 | 0.03 | 0.04 | 0.03 | 0.05 | 0.27 |
| Mean | 0.01 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.22 |
| WHO: 2011 | 0.7 | 0.003 | 2.0 | 0.3 | 0.4 | 0.01 | 3 |
| NIS | 0.05 | 0.05 | 1.00 | 0.30 | 0.05 | 0.05 | 5.0 |

**Table 2: Concentration of heavy metals in groundwater.**

| Code | Ba mg/l | Cd mg/l | Cu mg/l | Fe mg/l | Mn mg/l | Pb mg/l | Zn mg/l |
|---|---|---|---|---|---|---|---|
| BH1 | 0.01 | 0 | 0.02 | 0.01 | 0.0 | 0 | 0.1 |
| BH2 | 0.01 | 0.01 | 0.01 | 0.02 | 0.01 | 0.01 | 0.11 |
| BH3 | 0.01 | 0.01 | 0.02 | 0.03 | 0.01 | 0.O1 | 0.12 |
| BH4 | 0.01 | 0 | 0.02 | 0.02 | 0.02 | 0.01 | 0.05 |
| BH5 | 0 | 0 | 0.02 | 0.02 | 0.02 | 0 | 0.06 |
| BH6 | 0.01 | 0 | 0.02 | 0.0 | 0.01 | 0.01 | 0.03 |
| BH7 | 0.01 | 0 | 0.04 | 0.0 | 0.0 | 0.01 | 0.07 |
| BH8 | 0.02 | 0.01 | 0.01 | 0.02 | 0.0 | 0.01 | 0.02 |
| BH9 | 0.01 | 0.01 | 0.02 | 0.02 | 0.01 | 0.01 | 0.03 |
| BH10 | 0.02 | 0.01 | 0.02 | 0.01 | 0.02 | 0.01 | 0.04 |
| BH11 | 0.02 | 0.01 | 0.02 | 0.01 | 0.01 | 0.002 | 0.05 |
| BH12 | 0.01 | 0 | 0.04 | 0.01 | 0.01 | 0.002 | 0.05 |
| BH13 | 0.01 | 0 | 0.03 | 0.02 | 0.02 | 0.002 | 0.04 |
| BH14 | 0.02 | 0 | 0.01 | 0.01 | 0.01 | 0.001 | 0.06 |
| BH15 | 0.02 | 0 | 0.02 | 0.01 | 0.02 | 0.001 | 0.06 |
| BH16 | 0.01 | 0 | 0.03 | 0.02 | 0.01 | 0.001 | 0.05 |
| BH17 | 0.01 | 0.01 | 0.04 | 0.01 | 0.0 | 0.02 | 0.15 |
| BH18 | 0.01 | 0.01 | 0.03 | 0.03 | 0.01 | 0.01 | 0.11 |
| BH19 | 0.01 | 0.01 | 0.02 | 0.03 | 0.01 | 0.02 | 0.12 |
| BH20 | 0.01 | 0.01 | 0.02 | 0.02 | 0.02 | 0.01 | 0.09 |
| Min | 0 | 0 | 0.01 | 0 | 0 | 0 | 0.02 |
| Max | 0.02 | 0.01 | 0.04 | 0.03 | 0.02 | 0.02 | 0.15 |
| Mean | 0.01 | 0.01 | 0.02 | 0.02 | 0.01 | 0.01 | 0.07 |
| WHO 2011 | 0.7 | 0.003 | 2.0 | 0.3 | 0.4 | 0.01 | 3 |
| NIS | 0.05 | 0.05 | 1.00 | 0.30 | 0.05 | 0.01 | 5.00 |

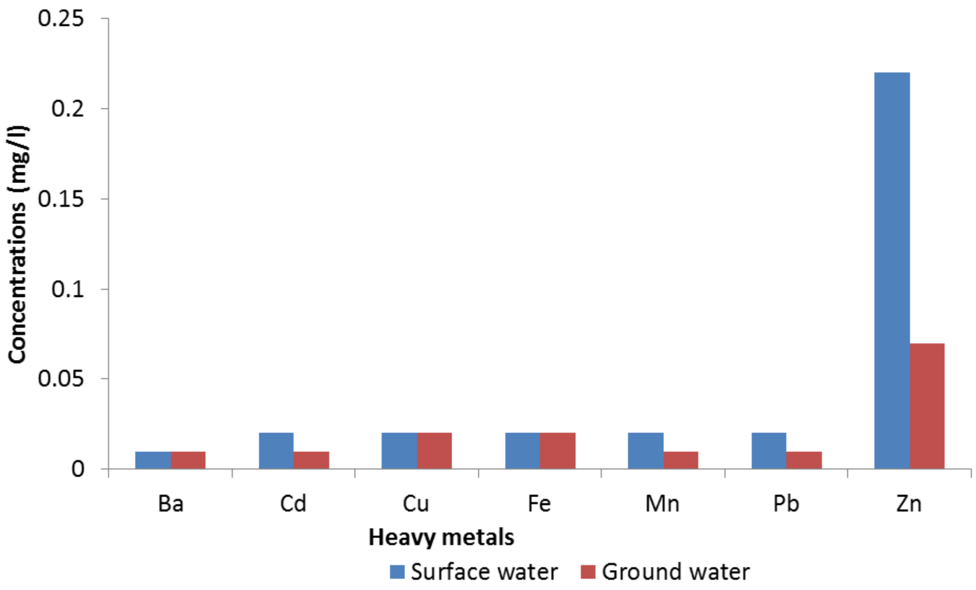


**Fig. 2: Comparison of heavy metal mean concentrations in surface and groundwater.**

**Iron and manganese**

Iron (Fe) and manganese (Mn) occur in relatively low concentration in the water of the area. However, Fe and Mn indicate higher concentration in the surface water than in the groundwater. The level of concentrations of Fe in surface water varies from 0.01 to 0.04mg/1 with an average of 0.02mg/1. In groundwater, Fe has range of concentration (0-0.03mg/1) with a mean of 0.02mg/1.

Manganese on the other hand ranges from 0.01 to 0.03mg/1 with a mean of 0.02 mg/1 for surface water and 0 to 0.02mg/1 with a mean of 0.01mg/1 for groundwater. The Mn content of the water is within the WHO (2011) recommended standard of 0.4mg/1.

### Lead

Lead in surface water has a range of 0-0.05mg/l while in groundwater it has a range of 0-0.02mg/l. The maximum permissible level for lead (Pb) in domestic water supply according to WHO (2011) is 0.01mg/l. The concentrations of lead in surface water are found to be higher than those in groundwater. Furthermore, the concentration of Pb in most surface and few groundwater are above WHO (2011) permissible standard of 0.01mg/1.

Ingestion of metals such as lead (Pb) may pose great risks to human health. Trace metals such as lead will interfere with essential nutrients of similar appearance, such as calcium ($Ca^{2+}$) and zinc ($Zn^{2+}$).

Because of size and charge similarities, lead can substitute for calcium and included in bone. Children are especially susceptible to lead because developing skeletal systems require high calcium levels. Lead that is stored in bone is not harmful, but if high levels of calcium are ingested later, the lead in the bone may be replaced by calcium and mobilized. Once free in the system, lead may cause nephrotoxicity, neurotoxicity, and hypertension.

In 2013, the World Health Organization estimated that lead poisoning resulted in 143,000 deaths, and “contributed to 600,000 new cases of children with intellectual disabilities”, each year.

### Zinc

The average concentration of zinc (Zn) in surface and groundwater is 0.22mg/l and 0.07 mg/l respectively. It ranges from 0.18 to 0.27 mg/l in surface and 0.02 to 0.15mg/l for groundwater.

## CONCLUSION

Generally, the heavy metal concentrations in both surface and groundwater are within the WHO (2011) permissible limits for drinking and industrial usage of waters (Tables 1 and 2). However,the concentration of these heavy metals are more pronounced in surface water than in groundwater (Fig.2) with anomalous concentrations of Cd and Pb. The high concentrations of most heavy metals in surface water could be due to the fact that heavy metals are found naturally in the earth, and become concentrated as a result of human caused activities.

Common sources of heavy metals are from mining and industrial wastes; vehicle emissions; lead-acid batteries; fertilizers, paints and treated woods. Groundwater, streams and rivers can be polluted by heavy metals leaching from industrial and consumer waste; acid rain can accelerate this process by releasing heavy metals trapped in soils in the study area.

## REFERENCES

1. American Society for Testing and Materials (ASTM). *Manual on water* (4th ed.). Philadephia: Saunders, 1969; 472.
2. Azmatullah, M. & Ekwere, S. J. Heavy metal distribution in sediments from Cross River Estuary. *Journal of Mineral Geology*, 1984; *2*(1-2): 129.
3. Hawkes, S. J. What is a ‘heavy metal’? *Journal of Chemical Education,* 1997; *74*(11): 1374.
4. Nzengue Y[1], Candéias SM, Sauvaigo S, Douki T, Favier A, Rachidi W, Guiraud P., The toxicity redox mechanisms of cadmium alone or together with copper and zinc homeostasis alteration: its redox biomarkers. National Center for Biotechnology Information, U.S. National Library of Medicine 8600 Rockville Pike, Bethesda MD, 20894 USA. (internet), 2011.