Atomic Absorption Spectroscopy Analysis of Heavy metals in water at Daura Gypsum Mining Site, Yobe State, Nigeria

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Abstract

This study was designed to detect heavy metals level in water collected from Daura gypsum mining site, Yobe State, Nigeria. Samples were collected and analyzed using Atomic Absorption Spectroscopy. The level of Pb, Ni, Cd, As, Cu and Zn, were assessed. Also the conductivity of the water samples detected using Conductivity meter. The result shows significant level of As at 0.0382 mg/l, Cd at 0.06-0.18 mg/l and 0.9852 mg/l for Ni which exceeded the WHO limit (0.01 mg/l). Cu, Zn, and Pb were detected at 0.95mg/l, 1.77 mg/l and 0.244 mg/l respectively. Cu, Pb, and Zn were found below the WHO, USEPA limits. This may bring kidney related risk to the people over a long period of time, Therefore, incorporation of ion exchange, reverse osmosis or adsorption in water sources will help reduce the heavy metals burden of the public in the area.

Introduction

Water is an indispensable component in our lives, an essential substance to man, animal and all that surrounds them. It has been in existence right from the origin of the universe itself. Water forms greater percentage of human and animal's blood and tissue. The use of water cuts across industrial agricultural and domestic uses (Abba, 2013). The two main sources of water are rain and ground water sources. The ground water can be deep ground water like wells and boreholes, or surface ground water, like rivers, seas, oceans, lakes and streams. This surface water can also be collected, passed through purification processes and channeled through pipes as tap water. This is the most portable source of drinking water in Nigeria. However, water sources are constantly polluted by some human activities and natural phenomena; thus adversely affecting the quality of water. Water pollution arises from

wastes and sewage disposals into rivers and streams from industries, hospitals and rain wash out from fertilizers used for farming (Tasiu, et al., 2019). Atomic Absorption Spectrometry (AAS) is a technique for measuring chemical quantities of elements present in environmental samples by measuring the absorbed radiation by the chemical element of interest. This is done by reading the spectra produced when the sample is excited by radiation. The atoms absorb ultraviolet or visible light and make transitions to higher energy levels. Atomic absorption methods measure the amount of energy in the form of photons of light that are absorbed by the sample. A detector measures the wavelengths of light transmitted by the sample, and compares them to the wavelengths which originally passed through the sample. A signal processor then integrates the changes in wavelength absorbed, which appear in the readout as peaks of energy absorption at discrete wavelengths. The energy required for an electron to leave an atom is known as ionization energy and is specific to each chemical element. When an electron moves from one energy level to another within the atom, a photon is emitted with energy E. Atoms of an element emit a characteristic spectral line (García & Báez, 2013).

Atomic absorption was originally the study of the interaction between radiation and matter as a function of wavelength, λ. Spectroscopic techniques form the largest and most important single group of techniques used in physical sciences. Atomic spectroscopy is the determination of elemental composition by its electromagnetic or mass spectrum. Moreover, spectroscopy is the used of absorption, emission, or scattering of electromagnetic radiation by atoms or molecules (or atomic or molecular ions) to qualitatively or quantitatively study the atoms or molecules, or to study physical properties (Kislaya, 2013). Atomic absorption is so sensitive that it can measure down to parts per billion of a gram in a sample. The technique makes use of the wavelengths of light specifically absorbed by an element. They correspond to the energies needed to promote electrons from one energy level to another, higher energy level (Chasten, 2000). Alternate sample introduction systems such as graphite furnaces are also available but will not be discussed here.

Heavy metals were literally heaven's sent by originating from asteroid impacts. Typically, heavy metals occur in the earth's crust in rather low concentrations between the low ppb ranges (noble metals) and up to 5% (iron); here, heavy metals are mainly found chemically bound in carbonate, sulfate, oxide, or silicate rocks or also occur in their metallic, elemental form. Weathering and erosion resulted in their leaching and mitigation into soil, rivers, and groundwater. About 4–5 billions of years ago, when Earth's mantle was still liquid, heavy metals sank to Earth's center and formed Earth's core, which today predominately consists of the heavy metals iron and nickel (Duffus, 2002).

Heavy metals are usually present in traced amounts in natural water sources such as ponds, lakes along with underground water sources. Some of the heavy metal ions are very toxic even at low concentration for human beings. Heavy metals are widespread pollutants of water. They originate primarily from industrialized regions where streams and rivers flow. Micro-concentrations of heavy

metals in water influence harmfully on the environment gradually by the time they accumulate in certain parts of the animal and plant organism, causing the change in their biochemical balances. Therefore, accurate information about the presence of heavy metals in seawater is of great biological and environmental significance (Filov, 1988). Metals which are reported to be having an adverse effect on human beings are arsenic, lead, cadmium, nickel, mercury, chromium, copper, zinc, and selenium. These metal ions are increasing day by day in the natural resources as currently numbers of industrial complexes are increasing near human population in cities with a goal of improving the quality of human life. These contaminants are increasing in water bodies which are a natural source of drinking waters. The increase in concentrations of contaminants in water bodies is due to their discharge through industrial wastewater, without any proper pre-treatments.

Site Description

The Study locality is at Daura gypsum mining village (Alangafe) Fune L.G.A. of Yobe State and fall into the Southwestern Chad Basin. Fune is located between latitudes 11° 29' N and 11° 41' N and longitudes 11° 25' E and 11° 30' E. Fune Local Government was created in 1976 in Borno State and is one of the oldest LGA in the State. The Local Government headquarter is Damagum which is situated west of the State capital. The LGA share border with Jakusko, Nangere (North west), Potiskum and Fika (West), Tarmuwa, Damaturu and Gujba LGA (South west). Fune has a total population of 355, 240 based on 2006 census. The occurrence of gypsum in Nigeria is generally confined to result from sequence of Cretaceous to Tertiary age and they occur as lenses, seams and vein lets within these argillaceous Formation.

Sample Collection and Preparation

A total of five (5) water samples were collected; three (3) samples from surface and two (2) from wells for the analysis. Since these sources of water are the major water supplies in the study area.

The container (0.75-liter polyethylene (bottle)) used for the collection of water sample was first cleaned by washing with detergent solution and then thoroughly rinsed with distilled water, then finally rinsed with the Acetone. The container was labeled according to the areas where sample water was collected.

Sample preparation is often simple, and the chemical form of the element is usually unimportant. This is because atomization converts the sample into free atoms irrespective of its initial state. The sample is weighed and made into a solution by suitable dilution. Elements in biological fluids such as urine and blood are often measured simply after a dilution of the original sample. The water samples were collected in a clean polyethylene bottles, because glass bottles absorb metals and therefore will cause inaccuracy in analysis. For the digestion, 0.75L of each sample was measured into a clean

digestion flask. 9ml of concentrated HNO3 and 3ml of concentrated Hcl was added into the sample in the digestion flask. The whole sample was heated in a hot plate until all the brownish fumes was expelled out (Nitrogenous Compound) which confirm that the sample is digested and the samples was allowed to cool at room temperature. A few milliliters of distilled water were added and the mixture was filtered into 25ml standard flask and it was transferred into plastic reagent bottle for Atomic Absorption Spectrometry (AAS).

Calibration of Atomic Absorption Spectrometry

A calibration curve is used to determine the unknown concentration of an element – eg lead – in a solution. The instrument is calibrated using several solutions of known concentrations. A calibration curve is produced which is continually rescaled as more concentrated solutions are used; the more concentrated solutions absorb more radiation up to a certain absorbance. The calibration curve shows the concentration against the amount of radiation absorbed.

Sample Characterization

The water sample collected from the study area was characterized using Atomic Absorption Spectroscopy and the conductivity of each water sample was measured using Conductivity Meter. The trace amount of heavy metals was obtained using Atomic Absorption Spectrometer (AAS).

Results and discussion

The results for heavy metal levels in ground water for both the boreholes and hand-dug wells are presented graphically. The figure below shows the measured concentration of As (mg/l) in water sample from the study area.

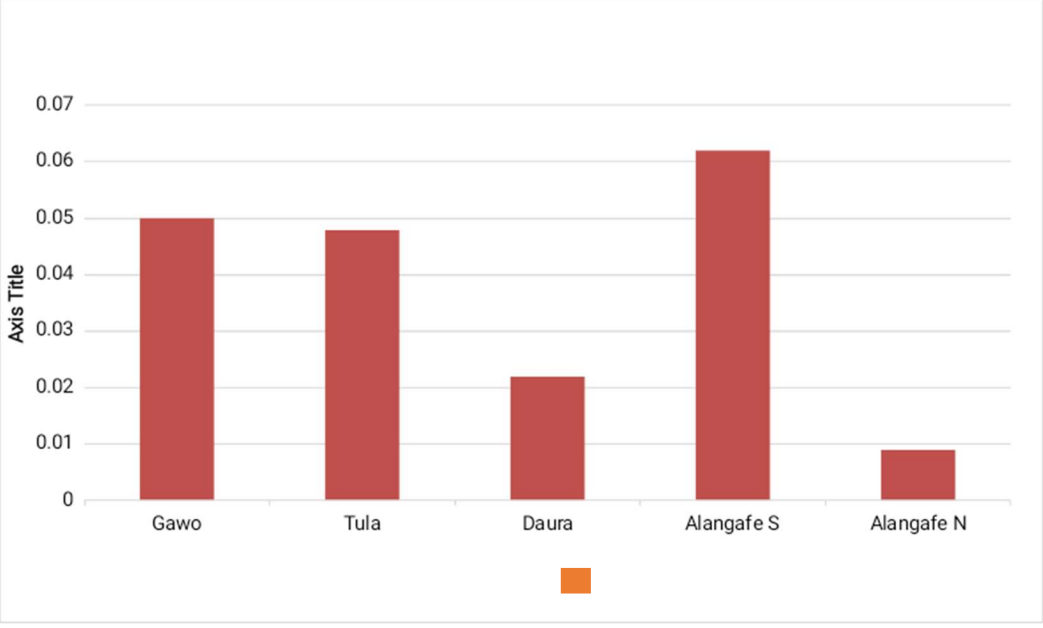

Fig.4.1: Arsenic, As conc. (mg/l)

The figure below shows the measured concentration of Pb (mg/l) in water sample from the study area.

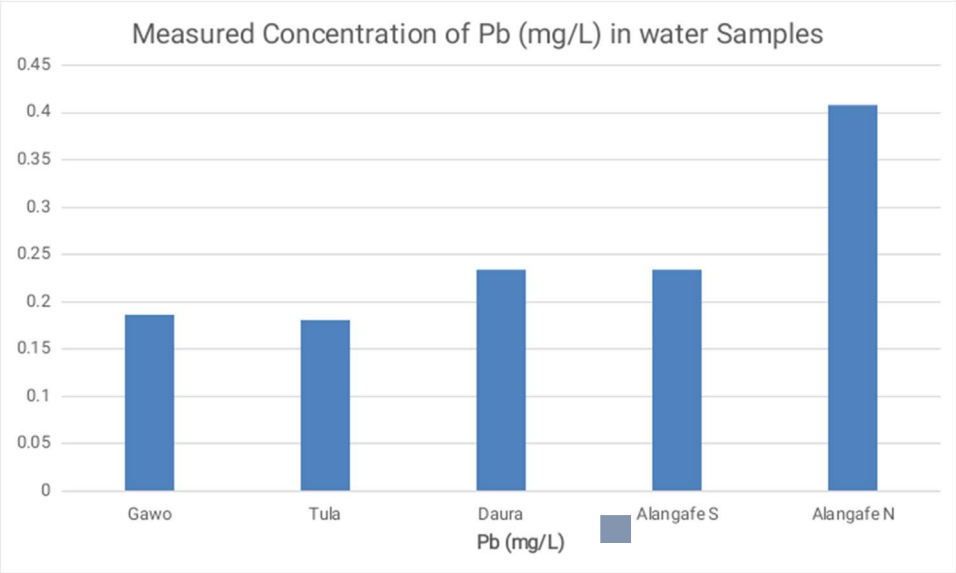

Fig.4.2: Lead, Pb conc. (mg/l)

The figure below shows the measured concentration of Cd (mg/l) in water sample from the study area.

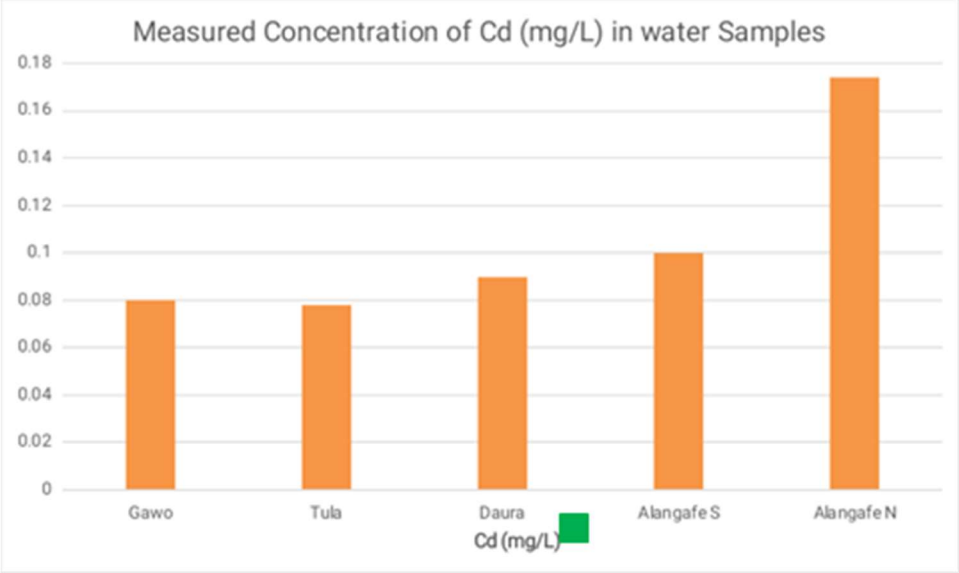

Fig.4.3: Cadmium, Cd conc. (mg/l)

The figure below shows the measured concentration of Zn (mg/l) in water sample from the study area.

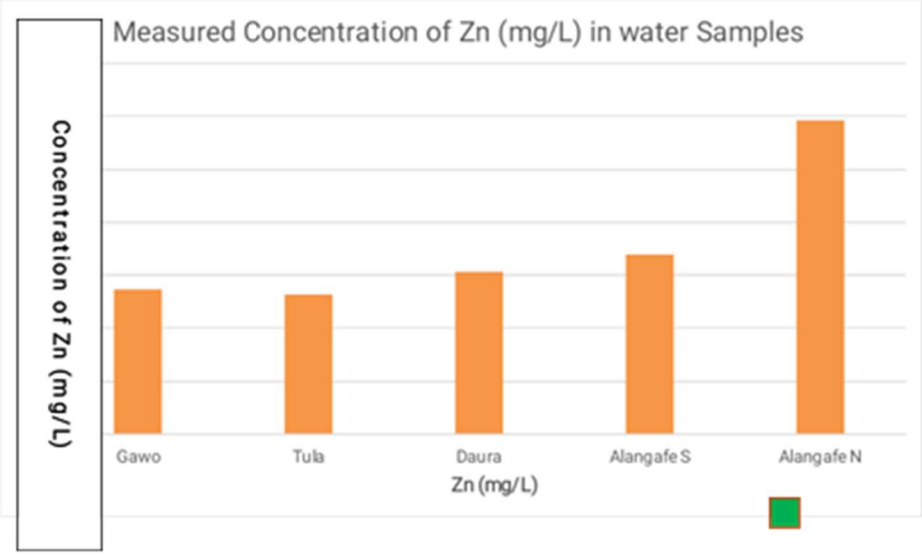

Fig.4.4: Zinc, Zn conc. (mg/l)

The figure below shows the measured concentration of Cu (mg/l) in water sample from the study area.

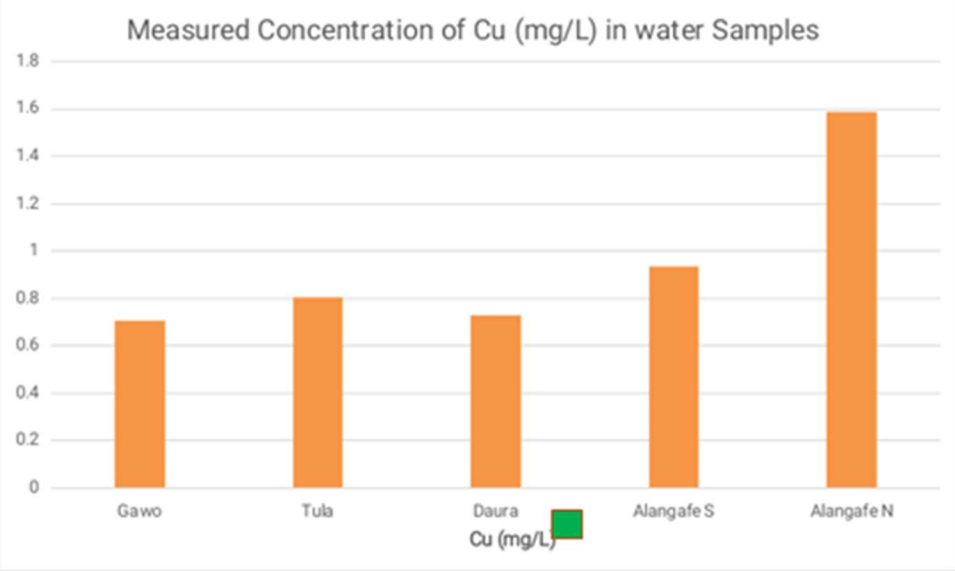

Fig.4.5: Copper, Cu conc. (mg/l).

The figure below shows the measured concentration of Ni (mg/l) in water sample from the study area.

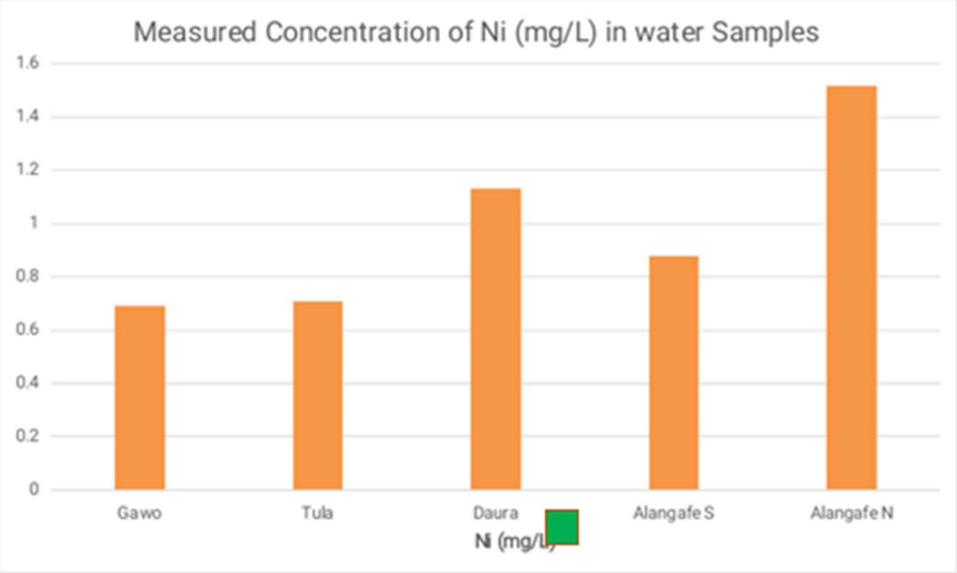

Fig.4.6: Nickel, Ni conc. (mg/l)

The results of the analysis are presented in Figure 1-6 and comparisons with other studies are presented in Tables above. Current drinking water quality guidelines (in mg/L) for the selected heavy metals published by several organizations, committees or agencies throughout the world are given in Table 4.1 and Table 4.2 gives a comparative chart for the results obtained with other analysis.

For Zinc, Zn within the study area, the mean concentrations for Alangafe and neighboring areas water is recorded below the maximum permissible limit set by both national and international bodies. The permissible limit of zinc in water according to WHO standards is 5 mg/l. In all the collected water samples concentration of zinc was recorded below the permissible limit.

Lead, Pb within the study area, the mean concentrations is 0.244 mg/l for the water samples. 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; Lawrence, 2014). In addition, Lead may cause the development of autoimmunity in which a person's immune system attacks its own cells. This can lead to joint diseases and ailment of the kidneys, circulatory system and neurons (Bakare- Odunola, 2005). Cd in the study area was measured and recorded above the maximum permissible limit although exposure to cadmium leads to kidney damage and hypertension.

It was observed that the Lead, Pb measured in Alangafe was less than that of Pakistan and Maiganga coal mining village but greater than that of Abakaliki. The measured copper was greater than those of Manganga, Abakaliki and Dutse. The result of the study shows that the concentration of the metals determined decreases in the order Cd>As>Ni > Cu >Pd> Zn. The concentrations within the study area are much higher than the concentrations compared with other studies of different study areas. This implies that the concentration of these selected heavy metals is enhanced by the mining activities.

CONCLUSION

The study showed that drinking water from these sources is heavily contaminated with Cd, As and Ni which exceeded the WHO recommended maximum limits specifications for drinking water. The analyzed heavy metals include Cd, Cu, Ni, As, Zn and Pb. The concentrations range from 0.06-0.18 mg/l for Cadmium. The mean concentrations for Cu, Ni, As, Zn, are: 0.95mg/l, 0.9852mg/l, 0.0382mg/l, 1.777mg/l, respectively and, 0.244mg/l for Pb. The most contaminated water was found in the surface water of Alangafe South and Alangafe North (Wells).

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