Trace Metals Concentration Determination In Domestic Water From Keana Mine Area Of Nasarawa State, Nigeria

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Abstract

Water samples from Keana mine area of Nasarawa State were analysed for some trace metals concentration, using the Inductively Coupled Plasma Optical Emission Spectrometry technique (ICP OES). The results of the analysis were compared with the standards of the World Health Organisation (WHO) and the European (EU) for domestic water.A total of 12 water samples were drawn from sources across the study area, comprising of 4 well samples, 4 stream samples, and 4 borehole samples. Analyses were carried out for a total of seven (7) elements which included; As, Cd, Cr, Sr, Pb, Th and Zn. Arsenic (As) was detected in all the samples at a mean concentration of $(0.164 \pm 0.052 \, mg/L)$ which is very high when compared with the recommended maximum permissible value of 0.010 mg/L by the environmental Protection Agency. The mean concentration of strontium (Sr) in the sample was $(0.798 \pm 0.307 \, mg/L)$. The maximum permissible concentration for this element varie from 0.8 – 5.0 mg/L, therefore the concentration detected may just be acceptable. These observations suggest that water from the study area should be closely monitored to reduce its harmful effects on the environment and health of the inhabitants.

Keywords: water, contaminants, trace metals, concentration levels, analytical techniques, plasma, emission, spectrometer

1. Introduction

Water is essential to all living organisms and its quality from different sources varies widely. An adequate supply of safe drinking water is one of the major pre-requisites for a healthy life but man in his effort to get rid of his wastes has introduced into natural water bodies, toxic substances (contaminants) that promote the growth of pathogenic bacteria, fungal, viral and protozoan microbes (Adams and Kolo, 2006). Exposures come from lead (Pb) in paint and tap water, chemical residues in processed foods, and in personal care products such as cosmetics, shampoo, mouth wash, tooth paste and soap. In today's industrial society there is no escaping exposure to these contaminants. Most of these contaminants directly or indirectly find their ways into our ponds, rivers, streams, and seas. That is why the World Health Organization (WHO) and the European Union (EU) have set a maximum permissible or recommended limit for drinking water and other water sources. The WHO estimated that about 80% of ill health especially in developing countries are water related (Cheesbrough, 2000).

The access of faecal matter to water through direct contamination of surface run-off or sewage may add a variety of contaminants. Atiribom et al (2007) reported that high concentration of contaminants discharged into surface water can occur from animal husbandry operations like grazing and that this can result in health hazards to man due to the presence of enriched contaminant levels. Other problems that could arise include degradation of host environment, disruption of host community and introduction of diseases and parasites and socio-economic consequences (Welcomme, 1988).

It is generally accepted that underground water is purer than surface water because of the straining action of rock as water percolates through it (Ademoriti, 1996). Studies have shown that underground water contamination occurs by seepage of contaminants through the soil and by contaminants migration from surface waters. In many developing countries, the use of dirty bucket and rope to fetch water from deep wells also lead to the incidence of diseases (Ademoriti, 1996). The use of soakaways for the disposal of domestic and industrial effluents and even citing of refuse dumps for both domestic and industrial solid waste may impair ground water quality unless there is an impermeable stratum between the disposal area and the ground water table.

The presence of these contaminants (trace metals) in domestic waste water is of serious concern because of the toxic properties of some trace metals. Some trace metals are considered to be essential for plant and animal nutrition and they serve some useful biological functions. Thus, copper (Cu), Cobalt (Co), Manganese (Mn), Molybdenum (Mo), selenium (Se) and Zinc (Zn) are essential to both plants and animals. Minute traces of Arsenic (As), Chromium (Cr), Nickel (Ni) and Tin (Sn) have been found to be essential for animals but not plants. One of the serious threats of their persistence is biological amplification in food chains. These metals can be toxic and also have adverse health effects following long term exposure (Lopex et al, 2002).

The aim of this study is to build upon the information in the data base of trace elements concentration

in water using the ICP OES technique and to assess the extent of environmental hazard or otherwise. Also to relate the metal concentration to recommended permissible limit established by the world health organization (WHO) and the European Union (EU).

2. Theoretical Background

A plan of action to ameliorate some of these effects can only be effective if there is information on the elemental composition of drinking water in the area. Such information can be generated by highly analytical procedures. Amodu (2010) has listed some of these analytical techniques to include the Atomic Absorption Spectrometer (AAS), X-Ray Fluorescence (XRF), Particle Induced Gamma Ray Emission (PIGE), Instrumental Neutron Activation Analysis (INAA), Particle Induced X-ray Emission (PIXE) and the Inductively Coupled Plasma Optical Emission Spectrometry Technique (ICP OES).

In atomic absorption spectrometry (AAS), light of a wavelength characteristic of the element of interest is shone through this atomic vapor. Some of this light is then absorbed by the atoms of that element. The amount of light that is absorbed by these atoms is then measured and used to determine the concentration of that element in the sample. (Boss & Fredeen,1997)

In optical emission spectrometry (OES), the sample is subjected to temperatures high enough to cause not only dissociation into atoms but to cause significant amounts of collisional excitation (and ionization) of the sample atoms to take place. Once the atoms or ions are in their excited states, they can decay to lower states through thermal or radiative (emission) energy transitions. In OES, the intensity of the light emitted at specific wavelengths is measured and used to determine the concentrations of the elements of interest.

One of the most important advantages of OES results from the excitation properties of the high temperature sources used in OES. These thermal excitation sources can populate a large number of different energy levels for several different elements at the same time. All of the excited atoms and ions can then emit their characteristic radiation at nearly the same time. This results in the flexibility to choose from several different emission wavelengths for an element and in the ability to measure emission from several different elements concurrently. (Boss & Fredeen, 1997)

3. Materials And Method

Keana mine is located in Keana local government area of Nasarawa state (Figure 1). Agricultural activities and human activities/settlements exist within and around the mine. The samples were collected at Keana mine of Nasarawa state, both within and around the immediate physical environment of the mine. The details of its location, climate, relief, as well as geology of the area had previously been discussed (Obaje et al, 2007).

A total of Twelve (12) sampling locations comprising of 4 well samples, 4 borehole samples and 4 stream samples were selected based on population distribution and degree of usage. Water from these streams are constantly being used to wash cars, bathing, laundry and washing of household utensils. Infact, it is also a source of drinking water to people living around these areas. Also some of the wells were sited close to latrines and septic tanks. The sample collection sites and specific locations are shown in Figure 1. The samples were collected during the dry season and are shown in table 1. Generally the samples were collected in such a way that there is adequate representation of the whole study area. Each sample was collected in a 250ml container which had been thoroughly washed with dilute H_2SO_4, rinsed with dilute water and dried. Each container was firmly sealed to prevent cross contamination. Samples from the wells were obtained by employing the usual manual procedure for collection by the local users. Before collection of water from the borehole, the faucet was first turned on at full speed for several minutes to purge the plumbing system of any water which have been there for some time. The faucet was thereafter turned down to a low flow rate to reduce turbulence.

Prior to measurement, the collected samples were acidified at the point of collection. That was to stabilize the metals so as not to lose some of the elements (metals). The samples were then taken to the laboratory of the department of geology and mining for analysis. The samples were first filtered and the machine calibrated with the metals of interest which were As, Cd, Cr, Sr, Pb, Zn and Th. The sample was then introduced via the peristaltic pump to the nebulizer of the ICP – OES machine for analysis. In the system, an aqueous sample was introduced into the ICP by a peristaltic pump (Perkin-Elmer) at a constant rate of 1.0 ml per minute. The solution stream was nebulized into a Scott type spray chamber by a cross-flow nebulizer and then introduced into the plasma. Argon was used as the nebulizing gas. The computer system was used for data acquisition and data reprocessing. The software used to control the Optima 3000 XL is Perkin-Elmer Winlab (version 1.06). The data analysis was done using commercially available software (Microsoft Excel 2007) for results.

Table 1: Sample Description

SAMPLES	DESCRIPTION OF SAMPLES
A	Well 1 (W1)
B	Well 2 (W2)
C	Well 3 (W3)
D	Well 4 (W4)
E	Borehole 1 (Bh1)
F	Borehole 2 (Bh2)
G	Borehole 3 (Bh3)
H	Borehole 5 (Bh5)
I	Stream 1 (St 1)
J	Stream 2 (St 2)
K	Stream 3 (St 3)
L	Stream 4 (St 4)
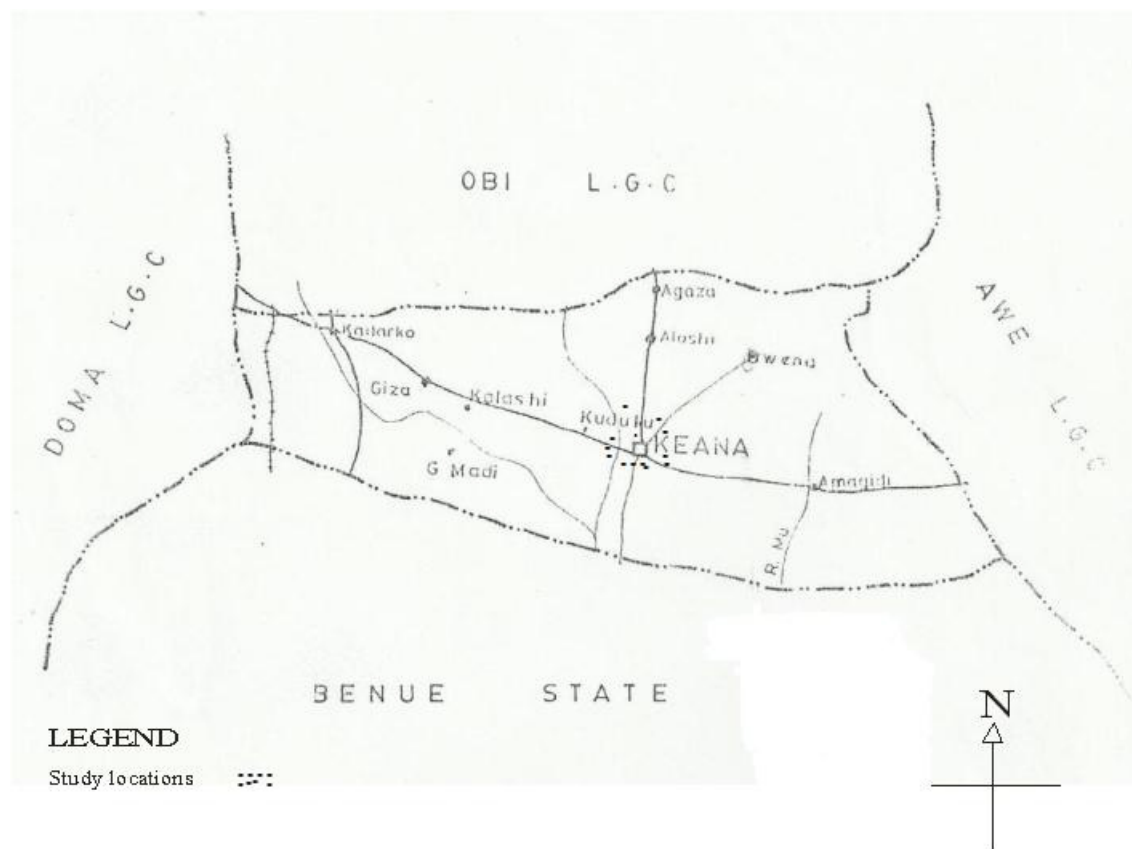
4. Results

The results from the analysis of all samples across the study area are shown in table 2.

TABLE 2: Result Of Trace Metal Concentration (mg/L) In Water Samples From Keana Mine Area

SAMPLE	As	Cd	Cr	Pb	Sr	Th	Zn
A	0.068	0.001	0.000	0.010	1.119	0.000	0.000
B	0.118	0.000	0.000	0.000	0.902	0.000	0.038
C	0.116	0.000	0.000	0.000	0.675	0.000	0.000
D	0.092	0.000	0.000	0.004	0.753	0.000	0.003
E	0.201	0.000	0.000	0.003	0.523	0.000	0.543
F	0.214	0.000	0.000	0.004	0.585	0.000	0.018
G	0.202	0.000	0.000	0.000	1.260	0.000	0.007
H	0.192	0.000	0.000	0.006	1.299	0.000	0.000
I	0.162	0.000	0.000	0.003	0.630	0.000	0.003
J	0.204	0.000	0.000	0.003	0.258	0.000	0.001
K	0.186	0.000	0.000	0.002	0.787	0.000	0.019
L	0.212	0.000	0.000	0.003	0.790	0.000	0.007
MEAN	0.164	8.33E-05	0.000	0.003	0.798	0.000	0.053
S.D	0.052	0.000	0.000	0.003	0.307	0.000	0.155

Table 3: International Standard for Drinking Water (mg/L)

ELEMENT	WHO	EU
As	0.010	0.010
Cd	0.003	0.005
Cr	0.10	0.05
Sr	3	5
Pb	0.01	0.01
Zn	3.00	NA

Source: World Health Organization (2011) and European Union (1998) in Lenntech (1998 - 2009)

5. Discussion And Conclusion

The elemental concentrations in well, borehole and stream samples as shown in table 2 show that;

- The concentration of Arsenic (As) ranged from 0.068 mg/L – 0.214 mg/L
- The concentration of Lead (Pb) ranged from 0.000 mg/L – 0.010 mg/L
- The concentration of Strontium (Sr) ranged from 0.258 mg/L – 1.299 mg/L
- The concentration of Zinc (Zn) ranged from 0.000 mg/L – 0.543 mg/L

The concentration of Cadmium (Cd) was detected in one sample and undetected in other samples. The concentration of Chromium and Thorium (Th) were undetected in all the samples.

It is clear from the above values that:

1. Arsenic (As) had high mean concentration of $(0.164 \pm 0.052)\, mg/L$ as against the recommended value of 0.010 mg/L of 01-03-2006 by the EPA. The high concentration of **As** poses a serious threat or danger (skin damage, problems with circulatory systems, and increased risk of getting cancer) to the inhabitants and therefore people should be advised to sink wells 500 feet or deeper to reach purer water (Radloff et al, 2011). Also phosphorous fertilizers should be greatly prohibited as this could also aggravate the concentration of As, Cd in the water samples. (Morrow, 2010).

2. Lead (Pb) had low mean concentration of $(0.003 \pm 0.003)\, mg/L$ even though the recommended safety value of concentration is 0.015 mg/L. WHO (2011). This could be attributed to the spread of lead from vehicle exhaust (Anzene, 2005) and the washing of lubricating oils and grease from vehicle parts which could have dispersed into the sources of water.

3. Strontium (Sr) had slightly low mean concentration of $(0.798 \pm 0.307)\, mg/L$ since the recommended safety value of concentration is 0.8 – 5.0mg/L.WHO (2011). It is interesting to note that Strontium exhibits biochemical behaviour similar to Calcium and tends to enter the organism most often by ingestion with contaminated food or water. Its presence in bones might possibly cause cancer of nearby tissues and leukaemia and hence should be closely monitored.

4. Zinc (Zn) had low mean concentration of $(0.053 \pm 0.155)\, mg/L$ since the recommended safety value of concentration is 3 mg/L by the WHO (2011). However it is interesting to note that despite widespread use of zinc for paints, electroplating, in dyes and tires, the values obtained for zinc are not up to the recommended WHO threshold limit value of 3 mg/L. It could be possible to deduce that the

obtained values for zinc during the study are not harmful, so those using this water from these area for drinking and other domestic purposes are not at the risk of zinc deficiency because of its low concentration, since zinc deficiency in humans is reported to cause dwarfism, reduced rates of blood clothing, wound healing and skin abnormalities (Aliyu and Bello, 2003).

The values obtained for Pb, Sr, and Zn are below the recommended safety value by the WHO and the EU while the value for As are above the recommended safety value by the WHO/EU. The accumulations of these trace elements could have negative consequences even though essential for good health and development are also dangerous to health and the environment if their concentration exceeds some limit. (Hambidge et al., 1985; Wang et al., 1996; Adejumo et al., 1994). This study shows that there is the need therefore to protect the environment for adequate health and well being of the people as well as to conserve and use sustainable environment and natural resources for the benefit of the present and future generations.

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