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Determination of some Metals in Drinking Water Samples from Ringim, Jigawa State

Adamu Mohammed Yelwa [1], Aisha Ado Shehu [2]
[1]Department of Chemistry, Federal College of Education (Technical) Potiskum, Yobe State, Nigeria
[2]Department of Science Laboratory Technology, Federal College of Agricultural Produce, Kano, Kano State, Nigeria

ABSTRACT: This study is aimed at assessing the concentrations of some trace elements in tap water, well water, boreholes, and sachet waters consumed in Ringim town, JigawaState. The samples were analyzed for chromium, cobalt, copper, iron, magnesium, manganese, nickel, lead, cadmium, and zinc. These metals were analyzed using Atomic Absorption Spectrophotometer (AAS). The result obtained shows thatcadmium concentrations ranges between (0.996 – 2.85) µg/L, some samples concentrations were not detected while the remaining samples have concentrations within W.H.O. threshold limit of 3.0µg/L. Nickel concentration ranges between (1.5–3.282)µg/L, six samples have concentrations within W.H.O. threshold limit of 20.0µgL-' while the remaining nine samples concentrations were not detected. Iron concentrations also ranges from (3.28-16.45)µg/L, all samples have concentrations within the W.H.O threshold limit of 3000µg/L. Cobalt concentration ranges from (9.228-20.9)µg/L, three samples have concentrations within the W.H.O threshold of 50.0µg/L and the concentrations of the rest samples were not detected. Magnesium concentrations ranges from (70.002-233.776)µg/L, all the samples have concentrations within the W.H.O threshold limit. Manganese concentrations ranges from (2.484-46.296)µg/L, samples have concentrations within the W.H.O threshold while the rest concentrations were not detected. Zinc concentrations ranges from (4.65-10.662) µg/L, seven samples have concentrations within the W.H.O threshold limit, while the rest were not detected. Chromium was not detected in most of the samples while some of the samples have concentration of 36.00µg/L, six samples have concentrations withinW.H.O. threshold limit of 50.0µg/L and nine sample concentrations were not detected. Lead was not detected in most of the samples and has concentration of 10.002µg/L in some samples; twelve samples have concentration within W.H.O. threshold limit of 10.0µg/L while the remaining samples have concentrations above W.H.O. threshold limit. Copper concentrations in all the samples were not detected.

Keys: Metals, Borehole water, Well water, Tap water, Sachet water, Atomic Absorption Spectrophotometer (AAS) etc.

INTRODUCTION

In recent times, there has been an increasing health related concern associated with the quality of drinking water in developing countries. According to a recent report by WHO/UNICEF, about 780 million people in the developing world lack access to potable water due largely to microbiological and chemical contaminations (WHO/UNICEF 2012). Water plays a vital role in the development of communities; hence a reliable source of water is essential for the existence of both human and animals. Water supply is essentially derived from precipitation and is said to be polluted if it is not suitable for the intended purpose (WHO, 2006; Wells, 1977; Waziri*et al.,* 2009; Kolo and Baba, 2004)

There is global concern on water pollution as it affects human health and one of the major causes of groundwater pollution is the disposal of waste materials directly into the land surface. The waste may occur as individual mounds or it may spread out over the land. If the waste material contain soluble materials, they will infiltrate and may lead to ground water pollution (Waziri*et al.,* 2009; Kolo*et al.,*2009).

TRACE ELEMENTS

By definition, trace elements are chemical compounds that naturally occur in water, soil, plants and wildlife in minute concentrations (Karyn, 2010). This may include heavy metals such as lead, cadmium, arsenic and mercury which can be in vitamins as supplements for human consumption. Trace metals also known as trace minerals are necessary for the optimal developments and metabolic functions of all living things. Some of the trace elements are sometimes referred to as

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micronutrients because of their nutritional values (Karyn, 2010).

Trace elements may be essential and non-essential (Dara, 2006). A trace element is said to be essential if it satisfies the following conditions.

(i) If it is present in all healthy tissues in all living things.

(ii) Its concentration is fairly constant among various species.

(iii) Its deficiency from the body could cause structural and physiologicalabnormalities irrespective of the species studies.

(iv) The deficiency symptoms or abnormalities, caused by the deficiency disappear onreplenishment of the elements.

(v) The abnormalities caused by the deficiency of the elements are accompanied by specific biochemical changes.

(vi) The biochemical changes can be prevented or cured if the deficiency is prevented or cured (Dara, 2006).

Examples of the essential trace elements are Mg. Cr, Mn, Fe, Co, Cu, Zn, Sn, K, etc while trace elements such as Pb, Cd, Hg and metalloid like As are considered to be toxic although they seems to play a key role in the development and growth of animals and humans. Also, elements such as Ni, F, B, As, V, Cd, Ba and Sr are considered to be essential on the basis of suggestive but not completely convincing evidence (Dara, 2006).

Non-essential trace elements that do not satisfied the criteria mentioned above include Al, Sb, Hg, Cd, Au, Pb, etc they are said to be environmental contaminants due to contact of the organism with its environment and a long-normal distribution patterns have been reported for the concentrations of these elements in human organs, whereas the essential elements have a normal distribution pattern (Dara, 2006).

SCOPE OF THE RESEARCH

This research involves the determination of heavy metals in drinking water samples, 15 different samples of borehole, well, tap and sachet water were analyzed using AAS and the residue was analyzed using X-ray fluorescence.

SIGNIFICANCE OF THE RESEARCH WORK

This research work may be used to assess the levels of heavy metals which could be toxic in drinking water.

AIM AND OBJECTIVES

The aim of this research is to determine the concentration of some trace elements in drinking water such as Borehole, Well, Tap and Sachet water consumed in Ringim, Jigawa State, using Atomic Absorption Spectrophotometric method, and the Qualitative and Quantitative analysis of the residue obtained from our samples using X-Ray Florescence Method.

The aim is targeted to achieve the following objectives.

(a) To ascertain the suitability of the water for drinking.

(b) To compare the results with the World Health Organization (W.H.O) threshold limits.

(c) To provide a comprehensive data on the level of heavy metals

(d) To identify and outline the threat to water quality from the residue

MATERIALS AND METHODS

SAMPLE COLLECTION AND PREPARATION

Samples were obtained from Ringim Local Government and parts of ZangonSallau and ZangonKanya villages in Ringim Local Government, Jigawa State. Six (6) samples were collected from hand-pump borehole, three (3) samples from well, two (2) samples from tap, and four (4) samples from sachet water.

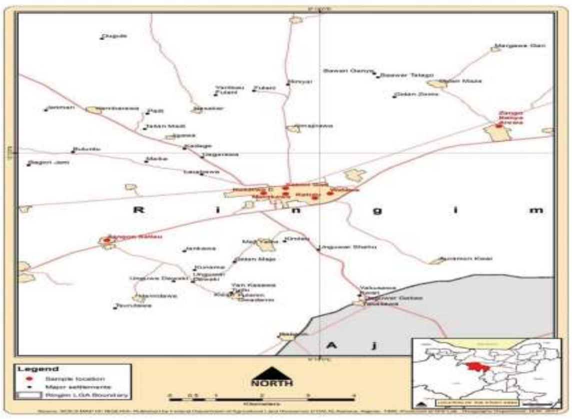

Fig. 3.1: Map showing Sample site Location

SAMPLING METHOD

The sampling was carried out manually throughout this study.

Sampling ofWell and Hand-pump Borehole Water

Samples were collected from wells and boreholes after the well has been sufficiently pumped to ensure that the samples represent the ground water source. Grab samples were collected three times daily at interval of 3 hours and were mixed to obtain composite samples which was then collected in a ten liter polythene plastic container. Water was allowed to run for few minutes from borehole before collection so as to obtain a uniform flow rate (Alpha, 1985).

Sampling of Tap Water

Due to problem of water supply encountered in the state during the period of the sampling, samples were obtained from only a few available sampling sties. Catch samples were collected when the tap was opened to its maximum limit to ensure uniform flow rate and allowed to run for few minutes before collection. Samples were collected thrice daily at interval of an hour and mixed together to obtain composite sample which was collected in a 10litres container.

Sampling of Sachet Water

Sachet water were purchased from different manufacturing companies such as Hilal, Basi, Galadanci and Sa'adatusachet water and filled into a 25L plasticcontainer to obtain composite sample and filled into 10 liters sample container. Samplebottles and caps were rinsed three times with water to be sampled during sampling (Akoto and Adiyiah, 2007).

Identification of Sampling Sites (Ringim Town)

Sampling sites

S/No.	Sampling Sites	Sampling Code
1.	Katutu	B
2.	Nassarawa(SabbinFegi)	B
3.	Marakawa	B
4.	Walawa	B
5.	Marakawa	W
6.	SabonGari (U. M Saidu)	W
7.	ZangonKanya	B
8.	ZangonSallau	B
9.	ZangonKanya	W
10.	Basi	S
11.	Galadanci	S
12.	Saadatu	S
13.	Hilal	S
14.	Walawa	T
15.	Nassarawa (SabbinFegi)	T

Key: B = Borehole water, W = Well water, T = Tap water, S = Sachet water

Elemental Analysis of Water Sample

Each water samples (6.0 litres) was boiled and exactly 5.0 liters was filtered using filter paper and evaporated to dryness using Pyrex beaker on a sand bath. The residue were digested with 30cm^3 of 0.5moldm^{-3} nitric acid and transferred into 60cm^3 Polythene plastic container. Cr, Co, Fe, Ni, Pb, and Cdwere determined using Atomic Absorption Spectrophotometer (AAS). 5cm^3 was taken and further diluted in 30cm^3 of 0.5moldm^{-3} and transferred into 60cm^3 polythene plastic container. Mg, Mn, Zn and Cu were determined using the same method (AAS).

RESULT AND DISCUSSION RESULTS

Sampling code	Cr	Co	Cu	Fe	Mg	Mn	Ni	Pb	Cd	Zn
Katutu(B)	36.0	9.228	ND	16.45	222.066	46.296	1.5	ND	ND	ND
Nassarawa (SabbinFegi)(B)	ND	ND	ND	9.87	185.31	ND	ND	ND	ND	ND
Marakawa(B)	ND	ND	ND	6.58	205.362	2.484	1.5	ND	ND	ND
Walawa(B)	ND	ND	ND	13.16	173.61	20.016	1.5	ND	ND	ND
Marakawa(W)	36.0	20.9	ND	13.16	203.706	ND	3.282	10.002	2.85	4.65
SabonGari (U M Saidu) (W)	ND	ND	ND	6.58	170.262	ND	1.5	ND	ND	ND
Saadatu(S)	ND	ND	ND	3.28	133.506	ND	ND	ND	ND	ND
Hilal(S)	ND	ND	ND	ND	126.81	ND	ND	ND	ND	ND
Basi(S)	36.0	ND	ND	3.28	151.902	ND	ND	ND	ND	4.65
Galadanci(S)	36.0	ND	ND	ND	73.35	ND	ND	ND	0.996	ND
Walawa(T)	36.0	ND	ND	ND	156.906	ND	ND	10.002	0.996	4.65
Nassarawa (SabbinFegi)(T)	ND	ND	ND	3.28	180.36	ND	ND	ND	0.996	4.65
Zangonkanya town(B)	ND	ND	ND	3.28	111.868	ND	ND	ND	0.996	4.65
ZangonSallau(B)	ND	ND	ND	3.28	70.002	ND	ND	ND	0.996	4.65
Zangonkanyatsangaya(W)	36.0	9.228	ND	6.58	233.776	2.484	3.282	10.002	2.85	10.662
WHO Standard	50	50	2000	3000	NG	NG	20	10	3.0	NG

Table showing results obtained from water samples(Concentration, µg/L).
ND: Not detected, **NG**: No Guideline

Element	Percentage
Si	42.51
S	0.215
K	0.473
Ca	1.157
Ti	0.1613
Mn	0.0425
Fe	2.370
Cu	0.0199
Zn	0.0088
Ag	0.804
Ba	0.3134
Ce	0.0325
Nd	0.0042
Eu	0.066
Re	0.076
O	50.583
Cl	1.14

Percentage of the metals analyzed in the residue using x-ray fluorescence

DISCUSSION

Chromium in the samples shows concentration of36.00µgL, all six (6) samples have concentrations within the permissible W.H.O threshold limit 50µg/L, while Cr is not detected in the rest of the samples.Chromium and its salts are used in leather tanning industry, the manufacture of catalysts, pigments and paints, fungicides, the ceramic and glass industry, and in photography. Also, for chrome alloy and chromium metal production, chrome plating, and corrosion control (EPA, 1987).

Cobalt concentrations in the samples analyzed. The concentrations ranges from 9.228-20.9µg/L, three samples have concentrations within the W.H.O threshold 50µg/L and cobalt was not detected in the rest twelve samples.Cobalt is used in production of alloys, in batteries as lithium ion battery cathodes, nickel-cadmium also contain significant amount of cobalt, and the cobalt improves the oxidation capabilities of nickel in the battery. (Armstrong, *et al.* 1988).

The concentration ofcopper was not detected in all the samples (Appendix 3). Copper is found in surface water, ground water, sea water and drinking water, but it is present primarily as complexes or as particulate matter. Copper concentrations in drinking water vary widely as a result of variations in water characteristics such as pH, hardness and copper availability in the distribution system (ATSDR, 2002)

The concentrations of **Iron** ranges from 3.28-16.45µg/L, three samples have concentrations within the W.H.O threshold. The range of Iron concentrations in this study is lowerthan (0.395-22.90mg/l) obtained by Casimir*et al.* (2015)but higher than 0.0200mg/l to 0.3500mg/l obtained by Babagana*et al.*(2014).High concentration ofIron in water samples may be attributed to terrestrial runoff as well as runoff from domestic and urban wastesIndu*et al.* (2010).

The concentrations of **magnesium** in the samples ranges from 70.002-233.776µg/L, all the samples have concentrations within the W.H.O threshold. Magnesium is a dietary mineral that is responsible for membrane function. High doses of magnesium in medicine and food supplement may cause nerve problems and depression. (Grandjean and Campbell, 2004)

The concentrations of **manganese** in the samples ranges from 2.848-46.296µg/L, samples have concentrations within the W.H.O threshold limit, manganese was not detected in the rest of the samples (Appendix 6). The result obtained in this study is lower than (0.046-1.85mg/l) obtained by Casimir*et al.* (2015) and higher than 0.2733mg/l to 0.3670mg/l obtained by Babagana*et al.* (2014). Manganese is an element essential to the proper functioning of both humans and other animals, as it is required for the functioning of many cellular enzymes and can serve to activate many other enzymes (IPCS, 2002).

The concentrations of **nickel** in the sample ranges from 1.5-3.282µg/L, six samples have concentrations above the W.H.O threshold 20µg/L while nickel was not detected in the remaining nine samples (Appendix 7). Nickel is used in its metallic form combined with other metals and non-metals as alloys. Nickel is used in the production of stainless steel, non-ferrous alloys and super alloys because of its hardness, strength and resistance to corrosion and heat. Nickel and its salts are also used in electroplating, as catalysts, in nickel-cadmium batteries, in coins, in welding products and in certain pigments (LARC, 1990).

The **lead** in the samples shows concentration of 10.002g/L, three samples have concentrations above the W.H.O threshold 10µg/L while the rest of the samples have not been detected.Lead was detected in this study and was not detected by Babagana(2014). High lead concentration in all the water samples analyzed may be as a result of terrestrial runoff from sewage effluent and waste sites. Also, excess lead concentrations may be attributed to the agricultural practice in the sampling site.

The concentrations of **cadmium** in the samples ranges from 0.996-2.85µg/L, seven samples have concentrations above the W.H.O threshold 3.0µg/L while the rest have not been detected. The result obtained from this study is lower than (0.009-0.446mg/l) obtained by Casimir, *et al.* (2015). High concentration of cadmium in the samples analyzed may be due to disposal of cadmium bearing products near the water bodies.

The concentrations of **zinc** in the samples ranges from 4.65-10.662µg/L, seven samples have concentrations within the W.H.O threshold 3000µg/L, while the concentrations of the remaining samples were not detected

The result obtained in this study is lower than 0.1133mg/l to 1.2000mg/l obtained by Babagana*et al.* (2014) and (0.073-1.670mg/l) obtained by Casimir, *et al.* (2015).Zinc is used in the production of corrosion- resistant alloys and brass, and for galvanizing steel and iron products. Zinc oxide is widely used in rubber as white pigments. Also, per oral zinc is used to treat zinc deficiency in humans (EIinder, *et al.* 1986).

Isolated elements obtained from XRF analysis

From the result obtained, total number of 17 elements were detected in residues and silicon and oxygen were detected with highest percentage values of 42.51 and 50.583 respectively. Neodymium was detected in trace amount of 0.0042. Within the literature investigated, no formal guideline valued were proposed for these elements in solid residue.

SUMMARY, CONCLUSION AND RECOMMENDATION

CONCLUSION

Summary of Analysis

Elements	Number of Samples with Concentration above WHO limit	Number of Samples with concentration within WHO limit	Number of Samples which were not detected
Cr	6	0	9
Co	3	0	12
Cu	0	0	15
Fe	1	14	0
Mg	0	15	0
Mn	2	2	11
Ni	6	0	9
Pb	3	0	12
Cd	7	0	8
Zn	0	7	8

The results of the analysis of the water samples showed that the level of Cr in six is above the WHO limit which makes them unsafe for consumption; Cr was not detected in the remaining 9 samples which make them safe for consumption. Co in three samples is above the WHO limit which makes them unsafe for drinking while the rest are said to be safe. Cu was not detected in all the samples which make them all safe regarding Cu concentration. Fe is higher than WHO limit in one sample only. Mg concentration in all the samples are within the WHO range, which means all samples are safe for consumption as far as Mg is concerned. Mn have two samples with concentrations above the WHO limit which makes them not safe, two samples have concentration within the limit and eleven samples were not detected of Mn, which makes the thirteen samples portable regarding Mn. Ni have six samples with concentrations above the WHO limits which makes them not safe, while the remaining nine are portable regarding Ni. Pb have three samples with concentrations above the WHO limits which makes them not portable and Pb was not detected in the remaining samples which makes them portable regarding it. Cd have seven samples with concentrations above the WHO limits which makes them not safe and it was not detected in the remaining samples which makes them portable. Zn have seven samples with concentrations within the WHO limits and it was not detected in the remaining samples which makes all the samples safe for consumption regarding it.

It was also observed that apart from the elements analyzed by AAS, some elements were further discovered using X-Ray florescence to qualitatively and quantitatively analyze the residue.

RECOMMENDATION

- It is recommended that further research need to be carried out in Ringim town and nearby villages both in harmattan and raining season so as to ascertain the portability of the water.
- The use of lead pipes in channeling the water from water board to Ringim town should be avoided.
- The pH of water should be monitored because it is an important factor which determines the solubility of metals in water bodies.
- Also, routine chemical analysis of drinking water inRingim town and villages is very important as well as public enlightenment on the sources and effects of drinking water contaminants.
- Further analysis on the residue should be carried out.

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