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Arsenic in drinking water from Kaduna state, Nigeria

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ABSTRACT

One hundred and twenty samples of drinking water sourced from wells and boreholes from eight local governments that constituted Kaduna south senatorial district of Kaduna state, Nigeria were randomly collected and subjected to Arsenic elucidation using standard laboratory methods. The wells have the following mean results 0.33, 0.35, 0.36, 0.37, 0.28, 0.33, 0.34 and 0.35 mg/L while the result obtained from the boreholes were as follows 0.11, 0.11, 0.17, 0.13, 0.13, 0.16, 0.12 and 0.20 mg/L both from Jeba, Jemaa, Kachia, Kagarko, Kauru, Kaura, Sanga and Zangon Kataf local governments respectively. Both results were found to be above the Maximum Contamination Level of 0.01 mg/L set by World Health Organization (WHO) and agreed by Standard Organization of Nigeria (SON) therefore, the two sources were found to be contaminated with abnormal concentration of arsenic and consumers are vulnerable to severe health hazards. The high arsenic concentrations was attributed to both natural and anthropogenic processes such, as erosion, present of rocks in the area, undersurface weathering, toxic chemicals, improper waste and sewage disposal, wastes from industries, agricultural activities and vehicular emissions.

Introduction

Arsenic is an identified key contaminant (Eugene, 1979) for many decades that occurs in a variety of minerals including Arseno pyrite (FeAsS), Realgar (As_2S_2), Orpiment (As_2S_3), Arsenolite (As_4O_6), native Arsenic in ores of Copper, Lead, Cobalt, Nickel, Zinc, Silver, Tin and also as nickel glance (NiAsS) or mispickel (Bell, 1996; Garba et al. 2008). Arsenic is chemically very similar to its predecessor phosphorus, so much that it will partly substitute for it in biochemical reactions and is thus poisonous. When heated it rapidly oxides to arsenous oxide, which has a garlic odour. Arsenic and some arsenic compounds can also be sublime upon heating, converting directly to a gaseous form. Elemental arsenic is found in two solid forms; yellow and grey limetallic, with specific gravities of 1.97 and 5.73 respectively (Antman, 2001).

Elemental arsenic and arsenic compounds are classified as "toxic" and "dangerous for the environment" in the European Union (EU) under directive 67/548/EEC. The International Agency for Research on Cancer (IARC) recognizes arsenic and arsenic compounds as group 1 carcinogens, and the EU lists arsenic trioxide, arsenic pent oxide and arsenate salts as category 1 carcinogens (Klassen and Watkins 2003). Below are some pictures (figures 1a and b) showing the victims of arsenic poisoning from some parts of Asia (Grund *et al*, 2008).

Figures 1 a and b: Illustrative example of Arsenic poisoning.

Chronic over exposure to arsenic may cause decrease motor co-ordination, nervous disorders, respiratory diseases and kidney damage as well as increased risk of skin, liver, bladder and lung cancer. Elemental arsenic is not particularly harmful. The commonly used poison is arsenic (III) oxide (As_2O_3). This compound is white and dissolves in water and if administered over a period of time is hard to detect (Chang, 1996).

Many inorganic and organic compounds of arsenic are toxic and are frequently used as pesticides and insecticides, thus the major usage is agricultural example sodium arsenite ($NaAsO_2$) is effective against locusts, arsenic (III) oxide (As_2O_3) is a powerful rodent poison while calcium arsenate [$Ca(AsO_4)$] is used as pesticide against the cotton boll weevil and the potato beetle. In one notorious application, the organo arsenic compounds known as adamsite and lewisite were used as poison gases during the First World War. The most toxic form of arsenic is the trivalent arsenite (AsO_2^-) followed by pentavalent arsenate (AsO_4^-) (Giannini, 1978).

Drinking water comes from ground sources such as ground water and aquifers. It can also be obtained from surface water body such as rivers, streams and glacier other sources including rain, hail and snow, biological sources such as plants and sea through desalination surface water picks up deferent minerals resulting from the presence of animal or human activities. While for the ground water, the contaminants come from leachate, landfills and septic systems.

Haphazard disposal from agricultural chemicals and household cleaning products cannot be ruled out. The contaminants in ground water take more time to be cleaned because it moves slowly and isn't exposed to the natural cleansing benefits of air, sunlight and micro-organism (Uduma, 2008).

Generally, the quality of drinking water is determined based on the appearance taste, colour and odour of the water. These are not enough to tell if the water should be free from hazardous compounds.

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There are two main sources of water supply that are available to man, surface water, that includes: lakes, stream, drainage areas which funnels water toward the holding reservoirs and the method of catching and holding rain water and secondary, ground water which includes well, springs and horizontal galleries. Hence the source of impurities, since water is a good solvent, it will dissolve a greater variety of substance than any other liquid due to it high solvation and auto-protonation properties (Musa, 2008). The water resources were stressed by a number of factors, including cattle grazing, pollution and rapidly-growing urban areas. More than 1 billion people don't have access to recommended daily safe freshwater globally

(FAO, 2007). A necessary concern therefore seeks a complete sustainable balance between the purity of our currently available fresh water and proper usage. Thus, speciation of water contaminants, especially heavy metals like Mercury (Hg), Arsenic (As) etc is vital due to their associated health hazards.

This paper reports a study on the arsenic concentrations in drinking water sourced from wells and boreholes from eight Local Governments that comprised Kaduna South Senatorial district of Kaduna State, Nigeria, with the aim to ascertain whether the level of arsenic contaminant in the drinking water is sufficient to cause health hazards to the inhabitants.

Experimental

Sample collection

One hundred and twenty water samples were collected from two different types of water sources namely; Hand Dug Wells and Hand Pump Operated Boreholes randomly from Jeba, Jemaa, Kachia, Kagarko, Kauru, Kaura, Sanga and Zangon Kataf and were evenly spread. Boreholes were operated for at least five minutes before sample collection. The samples were collected in pre-cleaned plastic sample bottles and analyzed within one hour after collection.

Figure 2: Map of Kaduna state Nigeria, showing the various sampling sites.

Materials

In preparation of reagents, BDH chemicals of analytical grade purity and distilled water were used. All weighings were carried out on analytical weighing balance (Gallenkamp Metler Model H3O). Standard solutions of iodine (0.1M to 0.0001M) and starch were prepared according approved chemical procedures (Garba et al., 2008).

Arsenic Concentration Determination

The determination procedure, previously validated by Garba et al. (2008), considers both organic and inorganic Arsenic to exist as initial As_2O_3 species that are equally available to the iodine molecules (Garba et al., 2008). 25cm^3 of each water sample was pipetted into a 250 cm^3 conical flask and a spatula full of sodium bicarbonate was added followed by the addition of a 3 to 4 drops of starch indicator. The resulting solution was titrated against 0.0001M iodine solution to the first appearance of deep blue colour which marked the end point. The experiment was repeated 3 times within each sample.

$$As_2O_3 + 2H_2O + 2\,I_2 \longrightarrow As_2O_5 + 4H^+ + 4I^-$$

To ensure the accuracy of the titrimetric procedure, some of the experiments were repeated using Atomic Absorption Spectroscopy (AAS) as reported by Behari and Prakash (2006).

Presentation of Results

As earlier indicated, two categories of water samples, underground wells and boreholes water samples were analyzed. The underground wells were to the depth of about 3-8m while the boreholes were from 100-700m below the surface. A total of one hundred and twenty (120) samples comprising both the underground wells and boreholes were analyzed by titrimetric method of analysis. Figure 3 reports the results for all the water samples analyzed showing the mean arsenic concentration (mg/L) for both the wells and boreholes from all the local governments while figures 4-11 showed the results as obtained for Jeba, Jemaa, Kachia, Kagarko, Kauru, Kaura, Sanga and Zangon Kataf local governments respectively. The summary of the mean arsenic concentration for all the local governments is presented in table 1. It could be seen that, Kachia and Zangon Kataf have the highest arsenic concentrations for wells and boreholes respectively. Whereas Kauru and Sanga have the lowest respective concentrations. However, all the sources are contaminated with arsenic, due to concentrations exceeding 0.01 mg/L recommended internationally for drinking water (WHO, 199a-c; 2007).

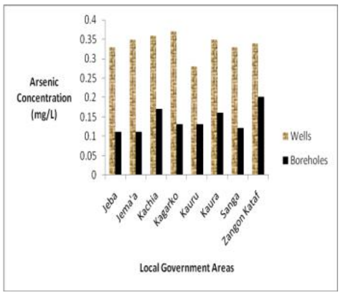

Figure 3. Mean arsenic concentration of both wells and boreholes water from eight Local Government Areas of Kaduna State constituting the Northern Senatorial District of the State.

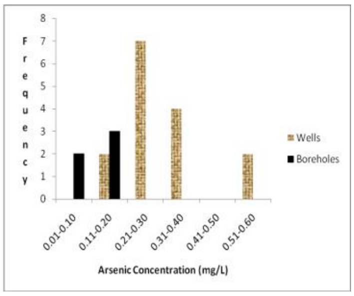

Figure 4. Mean arsenic concentration of both wells and boreholes from Jeba Local Government of Kaduna State.

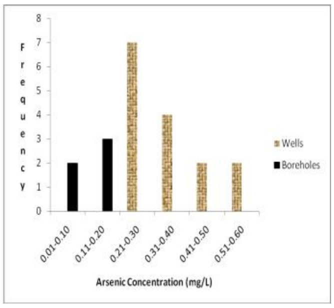

Figure 5. Mean arsenic concentration of both wells and boreholes from Jemaa Local Government of Kaduna State.

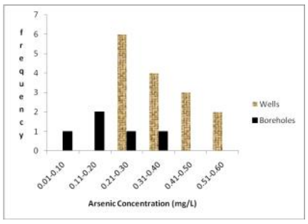

Figure 6. Mean arsenic concentration of both wells and boreholes from Kachia Local Government of Kaduna State.

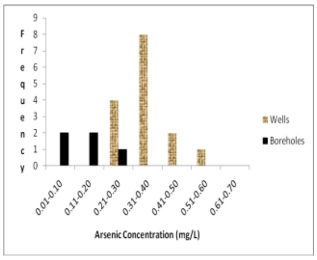

Figure 7. Mean arsenic concentration of both wells and boreholes from Kagarko Local Government of Kaduna State.

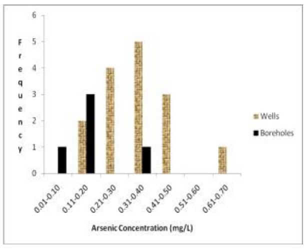

Figure 8. Mean arsenic concentration of both wells and boreholes from Kaura Local Government of Kaduna State.

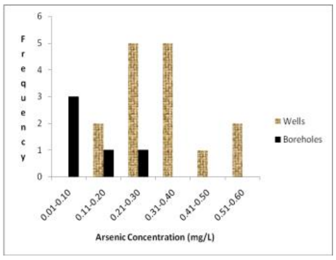

Figure 9. Mean arsenic concentration of both wells and boreholes from Sanga Local Government of Kaduna State.

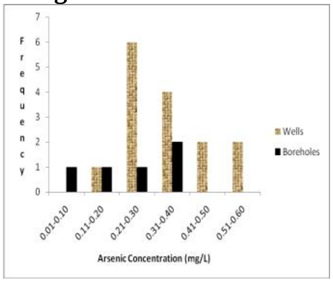

Figure 10. Mean arsenic concentration of both wells and boreholes from Zangon Kataf Local Government of Kaduna State.

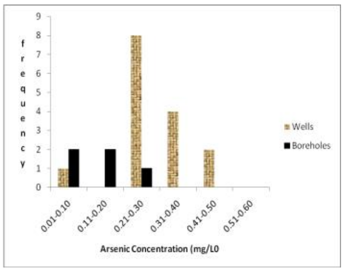

Figure 11. Mean arsenic concentration of both wells and boreholes from Kauru Local Government of Kaduna State.

Discussion

The frequency distribution pattern for arsenic from the samples in the eight Local Governments that comprise Kaduna South Senatorial Zone has a mean of 0.34mg/L from the wells and 14mg/L from the boreholes (figure 3). Kaduna South Senatorial Zone has very high concentration of arsenic for both wells and the boreholes (figure 3). This is because the area is rockier than the other two senatorial districts i.e. Kaduna North and Kaduna Central Senatorial Zones, so wells and boreholes sunk in these areas tend to show high content of pyrites, to which arsenic may be associated (Dipankar *et al.*, 1995). As a result of over extraction, the ground water table may drop significantly, thus making the arsenic bearing rocks to dry out and for the pyrite minerals to be oxidized thus mobilizing the arsenic and enabling it wash into these water sources (Dipankar et al., 1995).

The mean arsenic concentration in both the wells and the boreholes were higher than the maximum allowed in drinking water by both Standard Organization of Nigeria (SON, 2003). and World Health Organization (WHO, 199a-c; 2007). This may be due to the wide distribution of its compound in the environment, soils and the natural water (Chowdhurry *et al.*, 2000).

Arsenic is widely distributed in the environment and many of its compounds e.g. arsenic oxide (As_2O_3), arsenous acid [$As(OH)_3$] are soluble in water and are usually low, except in some geothermal waters (Seth e*t al.*, 2002).

Arsenic concentrations in water depends much on source of arsenic contamination which may be as a result of natural processes, industrial or agricultural activities and increase in human activities in the area where the wells are located. Different works have been reported by many researchers on arsenic concentrations in wells and boreholes water. Musa *et al*., (2008) reported a mean arsenic concentration of 0.02 to 0.51mg/L in Zaria city. Garba *et al*., (2008) from their research findings, reported high level of arsenic concentration of 0.81mg/L in Kutama and 0.77mg/L in Getso, Gwarzo Local Government area, Kano State, both of which are above the Maximum Concentration Limit (MCL) of 0.01mg/L. They attributed these high concentrations to likely be due to disposal of arsenic containing materials, burning of solid wastes, natural processes and human activities (Garba *et al*., 2008 and Musa *et al*., 2008). High concentration of arsenic was recorded in wells from the sampled areas because most of them are open and the areas where they are located have high human, agricultural activities and natural processes.

Drinking arsenic-rich water over a long period can lead to arsenicosis, resulting in various health conditions, including skin problems (such as changes in skin color and hard patches on the palms and soles of the feet), skin cancer, cancers of the bladder, kidney and lung and diseases of the blood vessels in the legs and feet (Hossain, 2006).

Symptoms of chronic arsenic poisoning can take 5-15 years to reveal themselves depending upon the amount of arsenic ingested. According to a recent field study conducted jointly by the Bangladesh Rural Advancement Committee (BRAC), and the International Centre for Diarrhoeal Diseases and Research, Bangladesh, 25-77 million people in Bangladesh are today ingesting dangerously high levels of arsenic in their drinking water (Hossain, 2006), and have already started showing numerous of these symptoms.

As the study area is heavily contaminated with arsenic, an appropriate action is necessary. Current options for providing safe drinking-water include; obtaining low-arsenic groundwater by accessing safe shallow groundwater or deeper aquifers (deeper than 200 metres), rain water harvesting, pond-sand-filtration, household chemical treatment, and piped water from safe or treated sources.

Conclusion

The arsenic concentration in wells and boreholes water samples from Southern part of Kaduna State has been determined. Data obtained from the study shows that the mean arsenic concentration from the well water samples (0.34mg/L) was higher than that from the borehole water samples (0.14mg/L), and both exceeded the Maximum Concentration Limit (MCL) of 0.01mg/L set by World Health Organization (W.H.O.), and adopted by the Standard Organization of Nigeria (S.O.N.). It is expected that the people of Kaduna South Senatorial District of Kaduna State, Nigeria may likely suffer because the arsenic concentrations in both the wells and the borehole waters are high enough to cause the above mentioned diseases as they are taking the water directly without proper treatment.

References

Behari J.R, Prakash R (2006) Determination of total arsenic content in water by atomic absorption spectroscopy (AAS) using vapour generation assembly (VGA). Chemosphere. 2006 Mar;63(1):17-21.

Chang, R. (1996). General Chemistry the Essential concept. McGraw-Hill, London pp 90.

Chang, R. (2005). General Chemistry the Essential concept. McGraw-Hill, London pp 160.

Chowdhury, U.K., Biswass, B.K, and Chowdhury, T.R. (2000). Grounwater
Arsenic contamination in Bangladesh and West Bengal India, Environmental Health Perspectives, 108(4): 393-397.

Croal, L.R., Jeffrey, A.G., Davin, M. and Dianne K.N. (2006). " The Genetics of
Geochemistry." Annual Review of Genetics: 175–206.

Dipankar, D., Amit, C., Badal, K.M., Gautam, S., Chakraborti, D. and
Bhabatosh, C. (1995). Arsenic in groundwater in six districts of West Bengal, India: the biggest arsenic calamity in the world. Part I. Arsenic concentration in drinking water and urine of the affected people. Analyst 120: 643-651.

Durrant, J.P and Durrant B. (1962). Introduction to Advance Inorganic Chemistry, ELBS, London pp 754.

Eugene, M. (1979): Introduction to Modern Chemistry, ELBS. London, Pp 132.

Food and Agricultural Organisation(FAO, 2007): Coping with water scarcity, 2007 World Water day, 22nd March, 2007. Available on 127 017 2010 from: http://www.fao.org/nr/water7docs/wwd07brochure.pdf

Garba, Z.N., Gimba, C.E., Hamza, S.A and Galadima, A. (2008): Tetrimetric determination of arsenic in well water from Getso and Kutama, Gwarzo Local Government Area, Kano state, Nigeria Chem class journal, vol. 5, pp78-80-

Garba, Z.N., Gimba, C.E., Hamza, S.A and Galadima, A. (2008) .Titrimetric Determination of Arsenic in well water from Getso and Kutama, Gwarzo Local Government Area, Kano state, Nigeria. Chemclass Journal, (5): 78-80.

Giannini, A.J. (1978). The Psychiatric Psychogenic Somatopsychic Disorder Handbook New Hyde Park, New York. Medical Examination Publishing Company, Newyork pp. 81–82.

Grund, S.C., Hanusch, K., and Wolf, H.U. (2008). “Arsenic and Arsenic Compounds” in Ullmann’s encyclopaedia of industrial chemistry,VCH-Wiley, 2008 Weinhein [Retrieved July 16, 2009], from: Wikipedia, the free encyclopedia.

Hicks J. (1963). Comprehensive Chemistry, Macmillan press, New York pp 477- 481.

Hossain M.F (2006). “Arsenic contamination in Bangladesh, an overview”. Agriculture Ecosystem & Environment, 113(1-4): 1-16.

Irogolic, K.J. (1982). Speciation of Arsenic compounds in water supplies. Research Triangle Park, NUGS Environmental Protection Agency EPA-600/5 1-32-010.

Leoschubert, L. A. and Veguilla B. (1973). Chemistry and Society, Allyn and Bacon Inc. Boston pp 253-255.

Musa, H., Yakasai, I.A., Musa, K.Y., Isah, A.B. and Mshelbwala, K. (2008). Determination of Arsenic concentration in well and borehole waters in Zaria, Nigeria. Journal of applied sciences, 8(11): 2183 - 2186.

Uduma, U.A. (2008). Quality of Sachet Water in Kano Metropolis. A M.Sc. Thesis, Chemistry Department, Bayero University, Kano. Pp 62

Welch, A.H, Lico, M.S and Hughes, J.L (1988). Arsenic in ground water of the western United States. Ground water, 26:333-347.

Williams, P.N. (2006). Increase in Rice Grain Arsenic for Regions of Bangladesh Irrigating
Paddies with Elevated Arsenic in Groundwaters. Environmental Science and Technology, 40 (16): 4903- 4908.

World Health Organization (WHO) (1999a). Guidelines for Drinking Water Quality Recommendations. (2nd edition) volume1. Delhi: AITBS Publishers.

World Health Organization (WHO) (1999b). Guidelines for Drinking Water Quality. Health criteria and other supporting information. (2nd ed.) Volume 2 Delhi: AITBS Publishers.

World Health Organization (WHO) (1999c). Guidelines for Drinking Water Quality Surveillance and control of community supplies. (2nd edition) Volume 3 Delhi: AITBS Publishers.

Table 1: Summary of Mean Arsenic Concentrations in the Sampling Sites

Name of Sampling site/Local Government	Mean Arsenic (ppm) WELLS	Mean Arsenic (ppm) BOREHOLES
Jeba	0.33	0.11
Jemaa	0.35	0.11
Kachia	0.36	0.17
Kagarko	0.37	0.13
Kauru	0.28	0.13
Kaura	0.33	0.16
Sanga	0.34	0.12
Zangon Kataf	0.35	0.20