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Arsenic level determination in selected well water from Sokoto state, Nigeria

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ABSTRACT

Twenty samples of domestic water sourced from different underground wells in Gidan Dare and Gidan Igwai areas of Sokoto were collected and analyzed in the laboratory. The pH and the electrical conductivities (EC) of the water samples were also determined. The mean results obtained from the analyses were pH (7.68, 6.72) and electrical conductivities (1061µs/cm, 1057µs/cm) for Gidan Dare and Gidan Igwai, respectively. The results also showed mean arsenic concentrations of 0.110mg/L and 0.217mg/L for Gidan Dare and Gidan Igwai water samples respectively, which are above the World Health Organization (WHO) drinking water guideline. Wells in Gidan Dare and Gidan Igwai were found to be contaminated with abnormal concentration of arsenic, high enough to cause serious adverse health effects to its consumers. The high arsenic concentrations could be attributed to both natural and anthropogenic activities such as erosion, underground weathering, toxic chemicals, improper waste and sewage disposal waste from industries, agricultural activities and vehicular emissions.

Introduction

The importance of water to human being and other living organisms cannot be over emphasized, as many experimental evidences had proved that it shortage could lead to sudden death of any living organism (Irogolic, 1982; Garba *et al*., 2008). More so, neither any domestic nor industrial activities could be carried to a satisfactory level without sufficiency of pure water (Garba *et al*., 2010). Studies by the Food and Agricultural Organization (FAO, 2007) of United States shows that in developing countries such as Nigeria, water-related problems are critically affecting human development, particularly the women and girls. .

The two major sources of water that are available to man are surface water, that includes: lakes, streams, drainage areas which funnels water towards the holding reservoirs and the method of catching and holding the rain water and secondly, ground water which includes: well, springs and horizontal galleries. Hence, the sources of impurities, since water is a universal solvent, it will dissolve a large number of substances than any other solvent due to it high solvation and auto protonation abilities (Musa, 2008; Garba *et al.,* 2010). The water resources were stressed by a number of factors which includes cattle grazing, environmental pollution and rapidly growing urban areas. FAO (2007) reported that more than 1 billion people lack access to daily safe fresh water globally.

Arsenic has been identified as a key contaminant (Eugene, 1979; Garba *et al*., 2010) for many decades and that it occurs naturally in variety of minerals which includes 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 (Bello, 1996; Garba *et al*., 2008). Chemically, Arsenic is similar to its predecessor Phosphorus, so much that it can partly substitute for it in biochemical reactions and is therefore poisonous. When heated it rapidly oxides to arsenous oxides, which has a garlic odour. Arsenic and some of it compounds can also sublime when heated changing directly to a gaseous form. Elemental arsenic occurred in two solid forms; yellow and grey limetallic, with specific gravities of 1.97 and 5.73 respectively (Garba *et al*., 2010). Environmental arsenic and it 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 it compound as group 1carcinogens, and the EU list arsenic trioxide, arsenic pentoxide and arsenate salts as category 1 carcinogens (Garba *et al*., 2010). Chronic over exposure to arsenic may cause decrease motor coordination , nervous disorders, respiratory diseases and kidney damage as well as increased risk of skin, liver, bladder and lung cancer. Elemental arsenic in particular, is not harmful. The commonly used poison is arsenic (III) oxide (As_2O_3). It’s a white compound and it dissolves in water and if administered over a period of time is hard to detect (Chang, 1996; Garba *et al*., 2010). Large number of organic and inorganic compound of arsenic are toxic and are mostly used as pesticides and insecticides, hence it is largely used for agricultural activities examples are sodium arsenate ($NaAsO_2$) is effective against locusts, arsenic (III) oxide (As_2O_3) is a powerful rodent poison while calcium arsenate ($CaAsO_4$) is used as a pesticides against the cotton ball weevil and the potato beetle (Garba *et al*., 2010).

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 arsenates (AsO_2^-) followed by the pentavalent arsenate (AsO_3^-) (Giannini, 1978; Garba *et al*., 2010).

Therefore, it is a necessary concern to seek a complete sustainable balance between the purity of our present available fresh water and proper management. Thus, speciation of water contaminants, in particular the heavy metals like mercury (Hg), Arsenic (As), Cadmium (Cd) etc. is essential due to their associated health hazards.

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This paper present a study on the arsenic concentration in drinking water collected from wells in Gidan Dare and Gidan Igwai areas in Sokoto North Local Government, Sokoto State, Nigeria, with the primary aim of determining whether the concentration of arsenic contaminant in the drinking water is potentially high enough to cause adverse health effect to its consumers.

Experimental

Sample Collection

Twenty water samples were randomly collected from different underground wells, 10 each from Gidan Dare and Gidan Igwai areas in pre-cleaned plastic sample bottles and analyzed shortly after collection in the laboratory.

Materials

In the preparation of reagents, BHD chemicals of analytical grade purity and distilled water were used. All weighing were carried out using analytical weighing balance (Electronic balanced type DT1000). The standard solution of iodine (0.1M to 0.01M) and starch were prepared according to 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 samples was pipetted into a 250cm^3 conical flask and a spatula full of sodium bicarbonate was added followed by the addition of 3 drops of starch indicator. The resulting solution was titrated against 0.01M Iodine solution to the first appearance of deep blue colour which marked the end point. The experiment was repeated 3 times for each sample.

Equation of reaction:

$$As_2O_3 + 2H_2O + 2I_2 \rightarrow AsO_5 + 4H^+ + 4I^-$$

Determination of pH

The pH of the well water samples were determined using digital pH meter (Model PV/meter, 8519N). The meter was calibrated for 15 minutes and further standardized with reference buffer solution of pH 7.00. The electrode of the meter was thoroughly rinsed with distilled water and was immersed into the sample solution. The pH values of the samples were digitally recorded accordingly.

Determination of Electrical Conductivity (EC)

The electrical conductivity (EC), of the well water samples were determined using a digital conductivity meter (Model Labortechnik, 9008). The meter was calibrated and accordingly rinsed with distilled water and then immersed directly into the samples solution. The electrical conductivity values of the samples were accordingly recorded.

Results and Discussion

As earlier mentioned, twenty different samples of well water, 10 each from the study areas were analyzed. The underground wells were to the depth of about 4-8m below the surface. Tables 1 and 2 report the results for all the water samples analyzed, showing mean arsenic concentration (mg/L) for each sampling unit and the pH and mean electrical conductivity (µs/cm), respectively.

The pH values obtained from the analyses as shown in Table -2 were found to be within the range of 4.27 to 8.08 for all the samples analyzed. It is obvious that eighteen of the water samples had pH within the WHO, acceptable limits (6.5 to 9.5), while two of the water samples (all from Gidan Igwai) were found to fall below the permissible limits, this means that the two water samples are not safe for drinking.

The conductivity values as also presented in Table-2 were also found to be between 157 to 1698µs/cm for all the samples analyzed. The results showed that fourteen samples had conductivity values that are in good agreement with the maximum acceptable limits of 1000µs/cm set by the Standard Organization of Nigeria (SON) and the World Health Organization (WHO), while six of the water samples were found to fall below the maximum permissible limits. This also implies that the six water samples are not fit for human consumptions.

Table 1: Arsenic concentrations, mean pH and the electrical conductivities values of the well water from Gidan Dare and Gidan Igwai, areas. Standard deviation generally ranges between 0.001 to 0.001 mg/L

S/NO.	Location	Mean As conc. (mg/L)
1	Gidan Dare	0.090
2	Gidan Dare	0.096
3	Gidan Dare	0.096
4	Gidan Dare	0.110
5	Gidan Dare	0.126
6	Gidan Dare	0.110
7	Gidan Dare	0.146
8	Gidan Dare	0.146
9	Gidan Dare	0.120
10	Gidan Dare	0.116
11	Gidan Igwai	0.246
12	Gidan Igwai	0.186
13	Gidan Igwai	0.174
14	Gidan Igwai	0.250
15	Gidan Igwai	0.220
16	Gidan Igwai	0.210
17	Gidan Igwai	0.250
18	Gidan Igwai	0.266
19	Gidan Igwai	0.156
20	Gidan Igwai	0.150

Mean pH	Mean conductivity (µs/cm)
7.60	1450
7.40	1277
7.59	293
7.81	1083
7.00	157
7.77	1333
7.87	1397
8.08	1102
7.76	1698
7.90	816
7.60	1583
7.46	1272
4.27	1391
6.87	1229
7.36	1069
7.44	1018
7.76	1208
4.55	672
7.21	494
7.52	636

Table-2: Mean pH and the electrical conductivity values of the well water from Gidan Dare and Gidan Igwai, areas. Standard deviation generally ranges between 0.005 to 0.01 mg/L. Note: Sample number and sampling locations are exactly the same as in Table-1 above

The results (Table-1) obtained from the analyses, also showed very high concentration of arsenic in all the samples when compared with the WHO maximum permissible limits of 0.01mg/L for drinking water. This showed that there is high arsenic contamination in well water from Gidan Dare and

Gidan Igwai areas, which might be as a result of the deepness of the wells (usually more than 25m but less than 100m deep), natural processes, industrial 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 well water. Musa *et al*., (2008) reported a mean arsenic concentration 0.02 to 0.51mg/L in Zaria City. Also, Garba *et al*., (2008) from their research findings, reported high level of arsenic concentration of 0.809mg/L in Kutama and 0.765mg/L in Gesto in Gwarzo Local Government Area, Kano State. They have fundamentally attributed the contamination of the various water sources with arsenic to these key factors. Natural processes are generally difficult to be mitigated, however, the anthropogenic factors can be limited or fully avoided if appropriate measures are put in place.

Conclusion

Assessment of well water from Gidan Dare and Gidan Igwai Areas, Sokoto State shows a mean arsenic concentration higher than the maximum permissible limits set by the World Health Organization (0.01mg/L) and therefore the water samples are not fit for human consumptions. The major consumers of water from these areas may likely suffer from arsenic related diseases such as; cancer, birth defects, cardiovascular problems, convulsions, organ damage, disorder of the nervous system and damage to the immune system. In view of these risks, we recommend the Sokoto State Government to provide adequately treated water to the inhabitants of the two areas and also ensure that all sources of drinking water are fit for human consumption. In local communities where the major sources of fresh water is well, improved water system should be provided and the well should be adequately protected from all surface and underground sources of contaminants.

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