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Determination of some metals contained in well drinking water obtained from some secondary schools in Sokoto East District, Nigeria

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ABSTRACT

This study determined the levels of metals (calcium, magnesium, potassium, cadmium, chromium, lead, copper, zinc, and iron) in well water obtained from three secondary schools in Sokoto East district, Nigeria. Standard methods, procedures, and analytical grade reagents were used to determine the metals in atomic absorption spectroscopy. The results were expressed using calculated mean and standard deviation and tested using one-way analysis of variance (ANOVA) and found to be significant ($P < 0.05$). The ranges of determined potassium, calcium, and magnesium are $2.01 \pm 0.001 - 4.01 \pm 0.001$ ppm, $2.10 \pm 0.001 - 3.10 \pm 0.003$ ppm, and $1.00 \pm 0.002 - 5.00 \pm 0.001$ ppm respectively; the ranges of zinc, copper, and iron are: $1.21 \pm 0.001 - 4.01 \pm 0.002$ ppm, $0.61 \pm 0.001 - 2.31 \pm 0.001$ ppm, and $0.40 \pm 0.005 - 0.70 \pm 0.001$ ppm respectively; and the ranges of determined cadmium, chromium, and lead are: $0.05 \pm 0.002 - 0.12 \pm 0.001$ ppm, $1.12 \pm 0.001 - 2.31 \pm 0.003$ ppm, and $0.01 \pm 0.001 - 0.06 \pm 0.001$ ppm respectively. Thus, the water contains heavy metals that can elicit adverse effects on school-aged children, especially chronic exposure; therefore, treated drinking water should be provided to safeguard the health and academic capacity of students and other school actors.

ABSTRAK

Penelitian ini bertujuan untuk menentukan kadar logam (kalsium, magnesium, kalium, kadmium, kromium, timbal, tembaga, seng, dan besi) dalam air sumur yang diperoleh dari tiga sekolah menengah di distrik Sokoto East, Nigeria. Metode standar, prosedur, dan reagen kelas analitik digunakan untuk menentukan logam dalam spektroskopi serapan atom. Hasilnya dinyatakan dengan menggunakan rata-rata yang dihitung dan standar deviasi dan diuji menggunakan analisis varians satu arah (ANOVA) dan ditemukan signifikan ($P < 0,05$). Kandungan kalium, kalsium, dan magnesium yang ditentukan masing-masing adalah $2,01 \pm 0,001 - 4,01 \pm 0,001$ ppm, $2,10 \pm 0,001 - 3,10 \pm 0,003$ ppm, dan $1,00 \pm 0,002 - 5,00 \pm 0,001$ ppm; kisaran seng, tembaga, dan besi masing-masing adalah: $1,21 \pm 0,001 - 4,01 \pm 0,002$ ppm, $0,61 \pm 0,001 - 2,31 \pm 0,001$ ppm, dan $0,40 \pm 0,005 - 0,70 \pm 0,001$ ppm; dan rentang kadmium, kromium, dan timbal yang ditentukan adalah: $0,05 \pm 0,002 - 0,12 \pm 0,001$ ppm, $1,12 \pm 0,001 - 2,31 \pm 0,003$ ppm, dan $0,01 \pm 0,001 - 0,06 \pm 0,001$ ppm. Dengan demikian, air tersebut mengandung logam berat yang dapat menimbulkan efek buruk pada anak usia sekolah, terutama paparan kronis; oleh karena itu, air minum olahan harus disediakan untuk menjaga kesehatan dan kapasitas akademik siswa dan pelaku sekolah lainnya.

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1. Introduction

Water is an essential component of the environment needed for human existence [1]. An unavoidable resource that supports the existence of all life forms on Earth. For humans, fresh, enough, and qualitative water should be provided as a basic need [2]. Therefore, a school has to be friendly by providing all children's rights [3], especially clean and healthy water. Safe water is among the significant mandated rights of school children and the attainment of sustainable development [4]. Groundwater is a better source of fresh, qualitative, and balanced water in contrast to most of the surface waters that are exposed to contamination [1].

However, due to pollution from various anthropogenic processes, water quality is threatened, especially in developing countries [5]. Unequivocally, the water quality in arid and semiarid regions like Sokoto East is often in a state of concern because of poor policies, the nature of the environment, climate, and other avoidable factors [6-8]. Intentional and unintentional disposal of chemicals in soil and water bodies is becoming a scourge that spurs the incorporation of harmful chemicals such as heavy metals into the food chain/ web [1, 9-11].

Albeit metals are generally part of the ecosystem, the disruption due to anthropogenic activities has incorporated them into the food chain and food web, subsequently leading to effects [12]. Metals such as potassium, magnesium, and calcium are essential to the human body's functioning and building; therefore, their low or high levels are expected to cause noxious problems to the body's health and functioning. Zinc, copper, and iron, albeit regarded as heavy metals due to their physical properties; on the other hand, they play essential roles in the body when an optimum concentration is maintained [13]. Excess levels of zinc, copper, and iron can adversely affect the human body because they have high densities, bioaccumulate, and are potentially toxic in excess amounts [13-14].

Invariably, other metals such as lead, chromium, and cadmium are regarded as heavy metals due to their high densities, persistence, and toxicity, even in small amounts. They cause effects in the body such as oxidative stress (that destroys proteins, DNA, lipids, and RNA), cancer, effects on vital organs (such as the kidney, liver, ad brain), inhibition of enzymes, and other related adverse effects [13]. Humans exposed to cadmium long-term are expected to suffer renal failure, lung disease, osteomalacia, osteoporosis, and fractures [7, 15-16]. Lead exposure is significant and spurs effects such as teratogenic, inhibition of hemoglobin formation, kidney dysfunction, reproductive effects, and damage to nervous system apparatuses [7, 15, 17-18]. Therefore, it is essential to monitor the levels of metals (especially the heavy ones) in healthy water expectedly utilized by school-aged children at school to safeguard their health and give out data to respective authorities for taking appropriate measures. It is worth reiterating that school-aged children are more affected because their body is developing, they have longer life expectancy, curiosity, and a low tendency to take guard their health [19].

School-children should be given a healthy environment to learn properly and effectively. Students feeding on water polluted with heavy metals become unhealthy more often and must be taken to hospitals or abandoned classes or schools, leading to poor academic performance [20]. Moreover, some heavy metals are associated with poor academic performances in the affected consumers of their ability to traverse the blood-brain bilayer or hinder the absorption of valuable elements, leading to malnutrition. Malnourished students learn poorly. Therefore, metals at excess water levels affect consumers' education [19, 21-22, 29]. This work aimed to determine the levels of metals (calcium, magnesium, potassium, cadmium, chromium, lead, copper, zinc, and iron) in well water obtained from three secondary schools in Sokoto East district, Nigeria.

2. Method

The study was carried out in Sokoto State, Nigeria. Sokoto State is located in the North West Zone of Nigeria between longitude 11^o 30'–13^o 50' and latitude 4^o–6^o. It borders Niger Republic to the north, Benin Republic to the northwest, Kebbi State to the south, and Zamfara State to the east. It has a land mass area of about 32,000 sq km and 23 local government areas, and 244 political wards. The population is predominantly rural, Muslim and consists almost entirely of Hausa/Fulani ethnic groups.

The water for analysis was collected from well drinking water of three secondary schools in Sokoto East district, Nigeria using convenience sampling techniques. Thus, metal elements were determined according to standard methods described by [2]. Moreover, data analysis was done using analysis of variance (ANOVA) at a 5% significance level.

3. Results and Discussion

The levels of potassium, calcium, and magnesium contained in well drinking water of some secondary schools of Sokoto East are shown in Table 1. The ranges of determined potassium, calcium, and magnesium are 2.01± 0.001-4.01± 0.001 ppm, 2.10± 0.001-3.10± 0.003ppm, and 1.00± 0.002-5.00± 0.001ppm respectively. Therefore, the maximum value was shown by the level of magnesium (5.00± 0.001ppm), then potassium (4.01± 0.001 ppm), and lastly, calcium (0.003ppm). The results indicating the essential macro metals (potassium, calcium, and magnesium) are similar to the finding of a study in well water in Sokoto City [23]. However, elevated levels of calcium and magnesium act to impede thyroid gland activities and lead to problems in growth and learning; therefore, they must be regulated in water [23].

Table 1. Macro metals in well water among secondary schools in Sokoto.

	Potassium (ppm)	Calcium (ppm)	Magnesium (ppm)
School A	2.01± 0.001	3.00± 0.002	5.00± 0.001
School B	4.01± 0.001	3.10± 0.003	4.1± 0.01
School C	3.02± 0.005	2.10± 0.001	1.00± 0.002

The levels of zinc, copper, and iron contained in well-drinking water obtained from some secondary schools of Sokoto East are shown in Table 2. The ranges determined for zinc, copper, and iron are 1.21± 0.001-4.01± 0.002 ppm, 0.61± 0.001-2.31± 0.001 ppm, and 0.40±0.005-0.70± 0.001 ppm, respectively. From Table 2, it was revealed that the highest level of elements was recorded by zinc, then copper, and iron in all the water samples examined from drinking wells of the sampled secondary schools in Sokoto East, Nigeria. However, all the ranges of zinc, copper, and iron indicated (in Table 2) are more elevated than the levels found in well water in the Sokoto metropolis, as [23] recorded.

This study's maximum copper levels are slightly higher than the 2.00ppm WHO acceptable limit [23]. In this vein, the iron element determined in this water could be helpful at a certain level when it is bioavailable in the consumers' biological system because the optimum iron level is beneficial in many respects, such as the formation of hemoglobin, an essential actor in life. However, high levels of iron in the human body, especially in school-aged children, could lead to vomiting, cyanosis, dizziness, diabetes, shock, pallor, abdominal pain, hematoma, and others [24]. Copper determined in well water (as shown by Table 2) is an essential trace nutrient, at least acting in many catalytic reactions and maintenance of body pigment. However, when its level is elevated, effects resurface.

For instance, it can instigate iron toxicity, membrane destruction, and peroxidation of lipids [24]. Therefore, its level in water or any food taken by humans must be monitored, especially in children that have to face elevated effects due to toxicity. Moreover, too much zinc instigates anemia, reduced immunity, the transmogrification of iron functions, and neurological defects [12, 21]. Likewise, in Table 2, only one result in school B is among the recommended dietary intake (RDI), and iron levels are above the dietary intake reported elsewhere [1].

Table 2. Useful heavy metals determined in well water obtained from secondary schools in Sokoto.

	Zinc (ppm)	Copper (ppm)	Iron (ppm)
School A	3.21± 0.001	2.31± 0.001	0.40± 0.005
School B	4.01± 0.002	1.31± 0.001	0.50± 0.002
School C	1.21± 0.001	0.61± 0.001	0.70± 0.001

The levels of cadmium, chromium, and lead contained in well-drinking water obtained from some secondary schools of Sokoto East are shown in Table 3. The ranges determined for cadmium, chromium, and lead are 0.05± 0.002-0.12± 0.001 ppm, 1.12± 0.001-2.31± 0.003 ppm, and 0.01± 0.001-0.06± 0.001 ppm respectively. Therefore, it was shown that chromium (12± 0.001-2.31± 0.003 ppm) was most elevated, followed by cadmium (0.05± 0.002-0.12± 0.001 ppm), and lastly, lead (0.01± 0.001-0.06± 0.001 ppm). However, the values (as in Table 3) are more elevated than those reported from soils of dumpsites in Makurdi, Nigeria [25], albeit there is a similarity between the findings in Table 3. The one reported in well water in Sokoto Capital, Nigeria [23]. The cadmium observed was mostly higher than the recommended dietary intake. All chromium is higher than the RDI, as [1] reported.

Table 3. Non-useful heavy metals determined in well water obtained from secondary schools in Sokoto.

	Cadmium (ppm)	Chromium (ppm)	Lead (ppm)
School A	0.12± 0.001	2.31± 0.003	0.01± 0.001
School B	0.05± 0.002	2.21± 0.001	0.05± 0.002
School C	0.07± 0.001	1.12± 0.001	0.06± 0.001

The presence of these heavy metals with a no-known biological role in the body is of great concern, especially to the health of school-aged children who are bound to drink this water and use it for other purposes. Parable, the presence of lead in the water could expose vulnerable school children to effects on the kidney, liver, and other vital organs [26]. Cadmium is another toxic element that could trigger effects such as kidney and liver problems [26]. Chromium exposure manifests effects such as dermatitis and cancer [12].

Generally, calcium and magnesium are essential; their presence in the observed water could be helpful, as surplus levels of macroelements are harmful [27]. Parable, calcium, and magnesium inhibit the thyroid gland's activity, thereby affecting children's growth and development [19]. Indeed, the pollution of water experienced by this study is an aberration on the rights of school-aged children that can cause ill health and lead to school absenteeism; likewise, the effects of elements (lead, cadmium, and chromium) affect learning capacity as well. An effect on growth and development can occur due to the excess goitrogenic effect of calcium and magnesium and, in turn, reduce/ slow learning abilities in children [19, 22].

The information revealed by this study (in Tables 1-3) has indicated that the well water in the study schools contains heavy metals. This situation is supposed to be the after-effects of polluted soils, air, and possibly water pollution (of water bodies that might seep into the wells); all of which are primarily human-made actions [2]. However, the presence of heavy metals in water could expose school children to chronic levels of elements over their stay at schools and, in turn, instigate possible effects that sometimes vary depending on the specific metal in question [2, 28]. More concern is that the non-essential heavy metals such as cadmium, chromium, and lead revealed in the water indicated in Table 3 are toxic at very little concentration [2]. Therefore, government and stakeholders should provide quality water for school consumption to save the children from waterborne consequences.

4. Conclusion

The well water observed in the affected secondary schools contains metals in disparity. Much concern is about heavy metals, especially the non-essentially heavy ones that can elicit toxicity at small concentrations. Toxicity due to metals causes ill health and hospitalization that, in turn, causes students to be absent from classes/schools and affects their academics. Likewise, metals can affect the brain and stir up low academic performance in students. Therefore, students and school actors should be fed enough pure water to protect their health and achieve educational goals.

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