A Study of the Levels of Nickel, Iron, Cadmium, and Lead in Some Potable Drinking Water from Well Sources in Dutsin-ma, Katsina State, Nigeria

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Original Research Article

ABSTRACT

This study looked into the levels of heavy metal concentrations (Ni, Fe, Cd, and Pb) in a portable well water sample from Dutsin-ma, Katsina State. A water sampler bottle was used to gather ten water samples from various randomly chosen wells. By adding HNO3, and HCl, heating the samples to 90°C and then cooling them, the samples were digested. Heavy elements were measured using a calibrated Atomic Absorption Spectrophotometer. The result indicates that the

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heavy metal concentration levels in a well water sample from Dutsimma, Katsina State for Ni, Fe, Cd, and Pb are in the range (mean) values of $0.005 \pm 0.0008 - 0.055 \pm 0.0024$ mg/kg (0.021 mg/kg), $0.119 \pm 0.0011 - 0.768 \pm 0.0006$ mg/kg (0.3784 mg/kg), $0.035 \pm 1.876 \pm 0.0092$ mg/kg (0.6776 mg/kg), and $0.83 \pm 0.0010 - 1.19 \pm 0.0009$ mg/kg (1.451 mg/kg) respectively. The well water samples are widely used by most of the populace of Dutsin-ma as the main source of drinking water. Very negligible levels of these heavy elements are present and thus pose no harm to the populace. However, constant monitoring of various water sources used for drinking is essential.

1. INTRODUCTION

The necessity of drinking water also carries the risk of spreading diseases, poisoning, and other conditions [1,2]. Drinking water must conform to health standards established by the maximum limit, according to the Ministry of Health. There are various parts to drinking water parameters, including Physical characteristics including taste, temperature, turbidity, amount of dissolved particles, and colour [3-6]. A few of the chemical characteristics are mercury, barium, iron, cadmium, chloride, chromium, and manganese. Coliform bacteria, viruses, and pathogenic bacteria are examples of biological parameters. Alpha- and beta-ray radioactivity characteristics [4,6].

"35 metals are of concern for us because of residential or occupational exposure, out of which 23 are heavy metals: antimony, arsenic, bismuth, cadmium, cerium, chromium, cobalt, copper, gallium, gold, iron, lead, manganese, mercury, nickel, platinum, silver, tellurium, thallium, tin, uranium, vanadium, and zinc" [4,5]. "These heavy metals are commonly found in the environment and diet. In small amounts, they are required for maintaining good health but in larger amounts, they can become toxic or dangerous" [1,6]. "Heavy metal toxicity can lower energy levels and damage the functioning of the brain, lungs, kidney, liver, blood composition and other important organs. Long -term exposure can lead to gradually progressing physical, muscular, and neurological degenerative processes that imitate diseases such as multiple sclerosis, Parkinson's disease, Alzheimer's disease and muscular dystrophy" [7-9]. "Repeated long-term exposure to some metals and their compounds may even cause cancer. The toxicity level of a few heavy metals can be just above the background concentrations that are present naturally in the environment. Hence thorough knowledge of heavy metals is rather important for allowing to provide proper defensive measures against their excessive contact" [5,10].

"To meet the community's need for clean water for drinking, water treatment is carried out from water sources, one of which is well water. The well water can be classified into shallow groundwater (0 - 40 m) and deep groundwater (> 40 m)" [6-8,10]. "Generally, people use well water that comes from shallow groundwater. The decline in groundwater quality is indicated by the detection of several heavy metal pollutants such as chromium (Cr), copper (Cu), mercury (Hg), lead (Pb), and other metals from industrial waste, landfills (TPA), and use of fertilizers. excessive and domestic waste is categorized as a source of direct contaminants, while the source of indirect contaminants is the seepage of surface water that enters groundwater or the atmosphere in the form of rain" [11-13]. Therefore, this research work was aimed at appraising the concentrations of some heavy metals in of Dutsin-ma Drinking water source to ascertain the level of pollution by these metals.

2. MATERIALS AND METHODS

2.1 Study Area

Dutsin-ma is a centrally located town and one of the local government headquarters in Katsina State, Nigeria. It lies within longitude $7°30'$ E and latitude $12° 27'$ N, around the topographical drainage of river Karaduwa flowing east-west. "The vegetation of the area is the savannah type, with more grasses than hardwood trees. The average annual rainfall of the area is 817mm". (Batagarawa *et al.*,2010). The town has witnessed an influx of people from neighbouring villages, as a Local government headquarters. This has increased the concentrations of motor vehicles and some industries over time.

2.2 Collection of Water Sample

The research samples for this study were collected in the Dutsin-ma city in Katsina State, Nigeria, in June 2022. The samples of well water

taken from wells that provide drinking water were chosen at random. With the use of a plastic container fastened to a rope utilised by the villagers, ten water samples total were obtained from the chosen wells. The water samples were obtained using a 1L polyethene water sampler bottle.

All the sampling bottles were cleaned with detergent before use and were rinsed with deionized water. At the point of water sample collection, the bottles were rinsed with the respective well water three times before the water samples were collected. The collected samples were properly sealed and labelled and

were transported to the laboratory for further treatment.

2.3 Digestion of Water Samples

The method developed by the United State Environmental Protection Agency (USEPA) 3005 was adopted for sample digestion. The samples were digested in a beaker covered with a watch glass by adding 1 mL of 70- 80 % concentrated HNO_3 and 2.5 mL of about 40% concentrated HCl and heated at 90 $^{\circ}$C using a hot plate for 30 minutes. The beaker was then removed and cooled. Each of the digested water samples was filtered through Whatman filter paper into a 100

Fig. 1. Map of Study Area

mL volumetric flask and deionized water and 2 mL of nitric acid to get a clear solution.

2.4 Sample Analysis

The stock standard solutions of the element at 1000 ppm in nitric acid were used to create the working standard solutions, which each contained Ni, Fe, Cd, and Pb. Nuclear Absorption Measurements of the heavy elements were made using a calibrated spectrophotometer. The calibration curves were created for each element separately using the least squares method to apply linear correlation. Calibration curves were plotted with different points for each metal standard solution using absorbance against concentrations (mg/L).

Immediately after calibration using the standard solutions, the sample solutions were aspirated into the AAS instrument and direct measurements were made for the heavy metal concentration and were recorded.

3. RESULTS AND DISCUSSION

Table 1 presents the well water samples and the geographical locations of the wells. Heavy metal concentration levels consisting of Nickel (Ni), Iron (Fe), Cadmium (Cd), and Lead (Pb) in portable well drinking water in Dutsimma, Katsina State are shown in Table 2 and Fig. 2. Table 3 and Fig. 3 compared the mean concentration of heavy elements in the well water samples, other countries, and the agency's standard limits.

Table 1. Sample code and location

S/N	Sample	Sample Code		
1	Well water 1	S1	12°27'37.73916"	7°29'45.76092"
2	Well water 2	S2	12°27'47"14884"	7°29'48.84216"
3	Well water 3	S3	12°27'47.32308"	7°29'53.86524"
4	Well water 4	S4	12°26'45.40164"	7°29'27.80412"
5	Well Water 5	S5	12°26'45.40152"	7°29'27.80401"
6	Borehole 1	S6	12°26'40.7832"	7°29'9.53736"
7	Borehole 2	S7	12°26'49.37928"	7°29'22.9326"
8	Borehole 3	S8	12°26'52.3455"	7°29'28.4320"
9	Borehole 4	S9	12°26'51.6564"	7°29'32.4529"
10	Borehole 5	S10	12°45'45.8747"	7°29'34.7054"
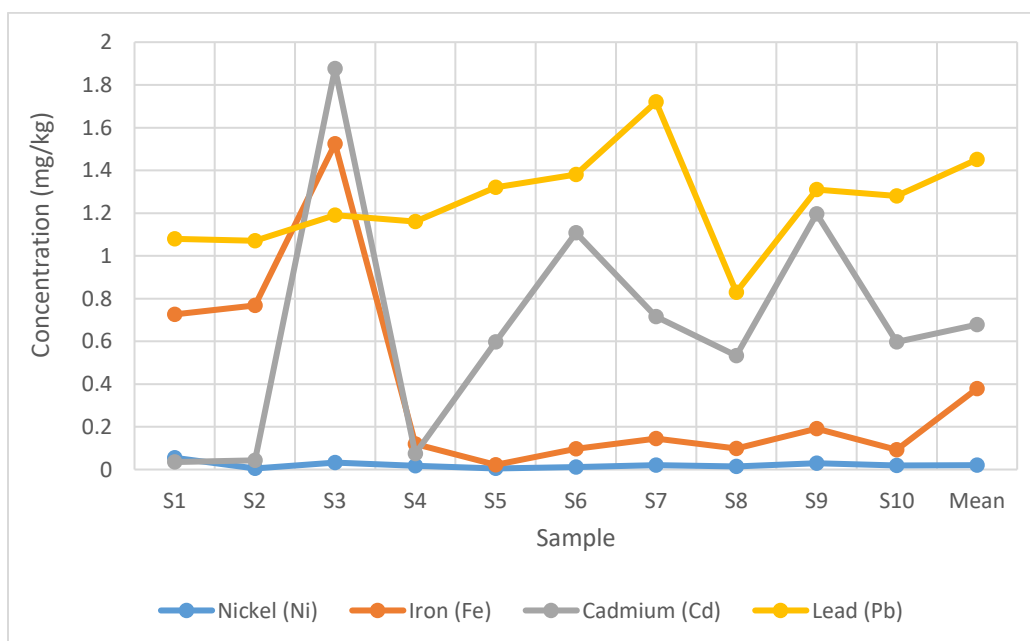
Fig. 2. Comparison of concentration level in well water samples in the study area
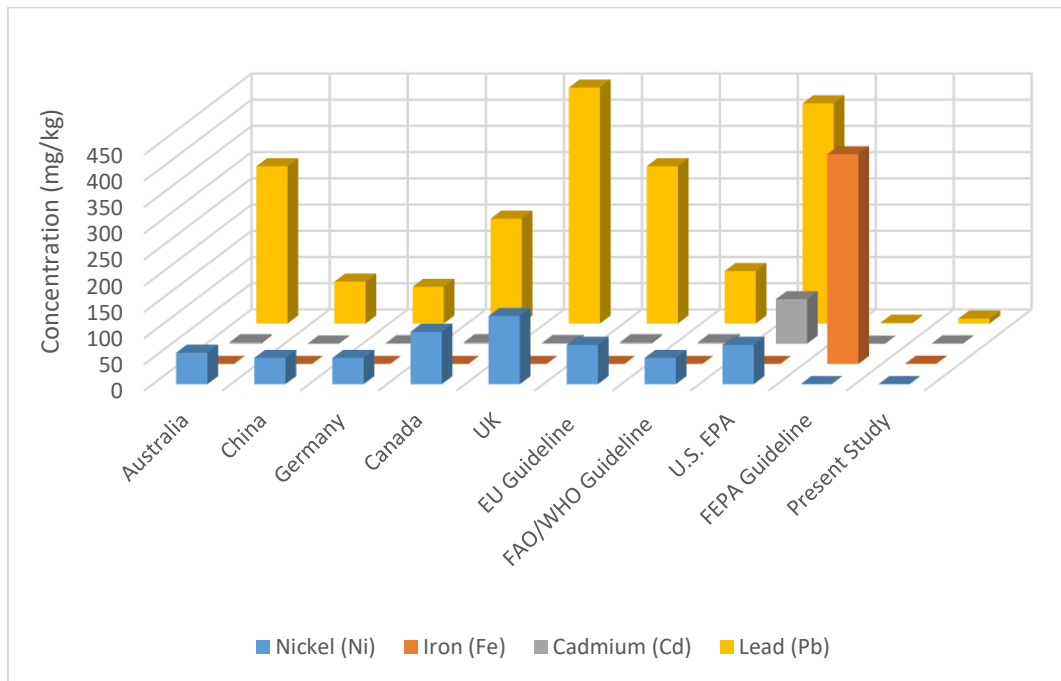
Fig. 3. Comparison of permissible limits of some Countries and agencies

Table 2. Heavy metals concentration level (mg/kg)

S/N	Sample Code	Nickel (Ni)	Iron (Fe)	Cadmium (Cd)	Lead (Pb)
1	S1	0.055 ± 0.0024	0.726 ± 0.0022	0.035 ± 0.0003	1.08 ± 0.0015
2	S2	0.005 ± 0.0010	0.768 ± 0.0006	0.043 ± 0.0001	1.07 ± 0.0008
3	S3	0.032 ± 0.0008	1.524 ± 0.0012	1.876 ± 0.0092	1.19 ± 0.0009
4	S4	0.018 ± 0.0011	0.119 ± 0.0011	0.075 ± 0.0042	1.16 ± 0.0024
5	S5	0.005 ± 0.0008	0.022 ± 0.0004	0.597 ± 0.0007	1.32 ± 0.0007
6	S6	0.011 ± 0.0006	0.097 ± 0.0029	1.108 ± 0.0020	1.38 ± 0.0009
7	S7	0.020 ± 0.0010	0.145 ± 0.0014	0.715 ± 0.0011	1.72 ± 0.0006
8	S8	0.015 ± 0.0013	0.099 ± 0.0028	0.533 ± 0.0054	0.83 ± 0.0010
9	S9	0.030 ± 0.0009	0.191 ± 0.0024	1.197 ± 0.0017	1.31 ± 0.0005
10	S10	0.019 ± 0.0005	0.093 ± 0.0019	0.597 ± 0.0009	1.28 ± 0.0008
	Mean	0.021	0.3784	0.6776	1.451

Table 3. Permissible limit for different countries/agencies

Countries/ Agency	Ni (mg/kg)	Fe (mg/kg)	Cd (mg/kg)	Pb (mg/kg)
Australia	60.0	N.A	3.0	300.0
China	50.0	N.A	0.5	80.0
Germany	50.0	N.A	1.0	70.0
Canada	100.0	N.A	3.0	200.0
UK	130.0	N.A	1.4	450.0
EU Guideline	75.0	N.A	3.0	300.0
FAO/WHO Guideline	50.0	N.A	3.0	100.0
U.S. EPA	75.0	N.A	85.0	420.0
FEPA Guideline	N.A	400.0	N.A	1.6
Present Study	0.021	0.3784	0.6776	9.451

The heavy metal concentration levels in a well water sample from Dutsimma, Katsina State have concentration range (mean) values for Ni, Fe, Cd, and Pb 0.005 $\pm$0.0008 − 0.055$\pm$ 0.0024 mg/kg (0.021 mg/kg), 0.119 $\pm$ 0.0011 − 0.768 $\pm$ 0.0006 mg/kg (0.3784 mg/kg), 0.035$\pm$1.876$\pm$0.0092 mg/kg (0.6776 mg/kg), and 0.83 $\pm$ 0.0010 − 1.19 $\pm$ 0.0009 mg/kg (1.451 mg/kg) respectively.

On account of the research of the authors, the drinking water samples contain metal concentrations below the limit set by most countries and agencies (WHO, EUC, EPA, USEPA). Well, water samples are widely used by most of the populace of Dutsimma as the main source of drinking water. Very negligible levels of these heavy elements are present and thus pose no harm to the populace. However, constant monitoring of various water sources is essential. The water can be used for drinking purposes. The probability that people will suffer disease in drinking water with lower concentrations of heavy metals is very negligible. They may not have physiological effects on the kidneys, digestive system, circulatory system, nervous system, etc.

4. CONCLUSION

We analyzed and identified the amounts of heavy metal pollution in portable well water samples from Dutsimma, Katsina State. The results show that the Ni, Fe, Cd, and Pb levels in the well water samples tested are below the recommended limit established by several nations and agencies. This suggests that the well water used in this research had little heavy element pollution. However, further research needs to be done to look at additional heavy elements like Zn, Mg, Cu, etc.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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