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Identification of Heavy Metals and their Concentrations in Ushata and Rafin Tsamiya Water Sources of Nasararawa Local Government Area in Nasarawa State, Nigeria

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Abstract: Water is an essential component of life, fresh water constitutes about 3% of the total water on the earth, only 0.01% of this fresh water is available, with two thirds of the earth covered by water and the human body consisting of 75% of it, it is obvious that, water is one of the prime elements responsible for life. Present study aimed at assessing the heavy metals concentration in water sources across Ushata and Rafin Tsamiya using Micro Plasma Atomic Emission Spectroscopy (MP-AES). The result revealed that, heavy metals for Ushata and Rafin Tsamiya in mg/L (Zn (0.2 and 0.09), Cd (0.00 and 0.00), Fe (0.06 and 0.05), Cu (0.01 and 0.02), Pd (0.02 and 0.08), Ni (0.001 and 0.004) and Mn (0.038 and 0.058)) respectively were present in the water. It can be concluded that the mean concentration is insignificant and the water in those areas is considered a good water, though, on accumulation, heavy metals may have much impact radiation burden of the populace, hence, gross alpha and beta in the area is recommended.

Keywords: Heavy metals, Bioaccumulation, Toxicity, Bio-indicators, Gastropods, Micro Plasma Atomic Emission Spectroscopy (MP-AES).

1 Introduction

Water is an essential component of life, fresh water constitutes about 3% of the total water on the earth surface, only 0.01% of this fresh water is available [1], with two thirds of the earth's surface covered by water and the human body consisting of 75% of it, it is evidently clear that water is one of the prime elements responsible for life on earth. Regrettably, even this small portion of fresh water is under pressure due to anthropogenic sources that results from rapid growth in population and industrial activities [2]. Heavy metals are the main pollutants and elements of risk in drinking water [3]. Investigation on water contamination by heavy metals has become the prime focus of environmental scientists in recent years [4]. More attention should be given to toxic heavy elements because of bio accumulation and bio magnification potential, and their persistence in the environment. Some metals like copper (Cu), and zinc (Zn) are essential for normal body growth and functions of living organisms and are referred to as essential elements. Other elements are referred to as non-essential, high concentrations of these metals like cadmium (Cd), iron (Fe), chromium (Cr), manganese (Mn), nickel (Ni) and lead (Pb) are considered highly toxic to human and aquatic life [5]. A certain amount of Cr for instance is needed for normal body functions; but at the same time high concentrations may cause toxic effect such as liver, kidney problems and genotoxic carcinogen [6]. Like Cr, Co is also one of the required metals needed for normal body functions as a metal component of vitamin B12 [7]. However, high intake of Co via consumption of contaminated food and water can cause abnormal thyroid artery, polycythemia, over-production of red blood cells (RBCs) and right coronary artery problems [8]. Generally, high concentrations of Mn and Cu in drinking water can cause mental diseases such as Alzheimer's and Manganism [9]. High Mn contamination in drinking water also affects the intellectual functions of 10-year-old children. Similarly, the Ni-sulfate and Ni-chloride ingestion can cause severe health problems, including fatal cardiac arrest [6,10]. Pb is also a highly toxic and carcinogenic metal and may cause chronic health risks, including headache, irritability,

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abdominal pain, nerve damages, kidney damage, blood pressure, lung cancer, stomach cancer and gliomas. As the children are most susceptible to Pb toxicity, their exposure to high levels of Pb cause severe health complexities such as behavioral disturbances, memory deterioration and reduced ability to understand, while long-term Pb exposure may lead to anemia [11]. Like other heavy metals, sufficient amount of Zn is also very significant for normal body functions. Its deficiency can lead to poor wound healing, reduced work capacity of respiratory muscles, immune dysfunction, anorexia, diarrhea, hair loss [7,11]. Cd exposure can cause both chronic and acute health effects in living organisms [12]. The chronic effects include kidney damage, skeletal damage and itai-itai (ouch-ouch) diseases [7,11,12]. Experimental data in humans and animals showed that Cd may cause cancer in humans, diarrhea, hair loss, dermatitis (Acrodermatitis enteropathica) and depression. Cd exposure can cause both chronic and acute health effects in living organisms [13]. The aim of this study is to disclose the heavy metals concentration in water sources across Ushata and Rafin Tsamiya in Nasarawa Local Government Area, Nasarawa State, Nigeria using Micro Plasma Atomic Emission Spectrometer (MP-AES).

2 Materials and Method

2.1 Materials

The instruments/materials that were used for the assessment of heavy metals concentration in portable drinking water across Ushata and Rafin Tsamiya are shown in Table 1.

Table 1: Materials, Specifications and Uses

Materials	Uses
500ml bottles	Used for collection of water samples.
Funnel	Used for easy passage of water samples into the sample bottles.
Cup	Used for easy transfer of water sample through the funnel to bottles.
Hand Glove	Used to protect the hand from direct contact to the chemicals.
pH Metre	Used for measuring the acidity and basicity of the water samples.
Concentrated Nitric Acid	Used for rinsing the sample bottles before (HNO_3) sample collection.
Drawer	Used for drawing water from the well.
Masking Adhesive Tapes	Used for labeling the water samples as well as sealing the mouth of the bottles.
Global Positioning System	Used for taking the coordinates of each sample points.
Sack	Used for packaging of collected water samples for easy transportation.
Macro Plasma Atomic Emission Spectrometer .	Used for analyzing the water samples in the laboratory.

2.2 Method

On the basis of geologic and tectonic setting, two towns having 3 sites each were selected for water sampling. The representative water samples (1 L each) were therefore, collected from Borehole (1 sample), well (1 sample) and stream (1 sample). The pH was measured on the spot, using a pH meter (Hanna instrument). From each sampling point, the water samples were collected in cleaned plastic bottles pre-washed with 20% dilute nitric acid (HNO_3) and double distilled water. The water samples were filtered and a few drops of $HNO_3$was then added before transporting the sample to the laboratory for analysis.

2.2.1 Study Area

This research work centered on Ushata and Rafin Tsamiya of Nasarawa Local Government, in Nasarawa State. The sample points are abbreviated as U1, U2 and U3, for Ushata Borehole, Ushata Well and Ushata Stream respectively, while, R1, R2 and R3 for Rafin Tsamiya Borehole, Rafin Tsamiya Well and Rafin Tsamiya Stream respectively. These points are located at various coordinates as shown in Table 2.

Table 2: Sample Points and their Respective Coordinates.

S/No.	Sample Point	Coordinate	
		North	East
1.	U1	$8^{0}33'08.23''$	$7^{0}42'05.61''$
2.	U2	$8^{0}32'40.46''$	$7^{0}42'25.64''$
3.	U3	$8^{0}05'16.97''$	$7^{0}49'55.28''$
4.	R1	$8^{0}08'07.99''$	$7^{0}50'53.24''$
5.	R2	$8^{0}08'07.89''$	$7^{0}50'54.99''$
6.	R3	$8^{0}08'14.43''$	$7^{0}49'47.11''$

2.2.2 Sample Collection

Six (6) water samples were randomly collected from different points in different district across Ushata and Rafin Tsamiya. The sampling was carried out in a season. Two (2) drops of nitric acid ($HNO_{3)}$ was added to each water sample before analyzed to maintain the constant pH and minimize loss of sample because of variation in pH, evaporation, precipitation and other relevant physical and chemical properties. Samples were collected from different water sources such as streams, wells and boreholes located in Ushata and Rafin Tsamiya. The samples were collected randomly using acidified plastic bottles and mixed. The bottles were filled and then sealed tightly to avoid head space that might cause loss of samples because of oxidation.

2.2.3 Sample Preparation

The samples for analysis were digested by measuring 250ml of the water sample in a conical flask and 5ml of concentrated nitric acid was added to the measured sample and then heated on microwave machine until the total volume was reduced to about one third of the initial volume to break the complex bond and release the sample into solution. The solution was then filtered using a filter paper into another beaker, made up of 50ml with distilled water and mixed thoroughly. The sample was packaged into samples bottles before taking to MP-AES machine for analysis.

2.2.4 Sample Analysis

All filtered and acidified water samples were analyzed for all the heavy metals by using Micro Plasma Atomic Emission Spectrometer under standard operating conditions. In view of data quality assurance, each sample is analyzed in triplicate and after every 10 samples two standards (one blank and another of 2.5 mg/L) of respective metal was analyzed on atomic emission. The reproducibility was found to be at 95%confidence level. Therefore, the average value of each water sample was used for further interpretation. Standard solutions of all elements was prepared by dilution of 1000 mg/L certified standard solutions of corresponding metal ions with double distilled water. All the acids and reagents used were of analytical grade. All these analyses were performed in the Micro Plasma Atomic Emission Spectrometer (MP-AES), at Bayaro University Kano, Kano State, Nigeria.

3 Results and Discussion

3.1 Results

Table 3: Heavy Metals Concentration (mg/L).

S/P	Zn	Cd	Fe	Cu	Pb	Ni	Mn
U1	0.29	0.00	0.07	0.02	0.02	0.003	0.045
U2	0.15	0.00	0.03	0.01	0.03	0.000	0.067
U3	0.16	0.00	0.07	0.01	0.02	0.000	0.001
Mean	**0.20**	**0.00**	**0.06**	**0.01**	**0.02**	**0.001**	**0.038**
R1	0.07	0.00	0.06	0.03	0.14	0.004	0.011
R2	0.19	0.00	0.05	0.01	0.01	0.000	0.051
R3	0.08	0.00	0.05	0.02	0.09	0.009	0.111
Mean	**0.09**	**0.00**	**0.05**	**0.02**	**0.08**	**0.004**	**0.058**
WHO	**3.00**	**0.03**	**0.30**	**2.00**	**0.01**	**0.100**	**0.500**
U&R	**0.15**	**0.00**	**0.06**	**0.02**	**0.05**	**0.003**	**0.048**

1= Borehole; 2 = Well; 3 = Stream; U = Ushata; R = Rafin Tsamiya and S/P = Sample Point

3.1.1 Result Analysis

In this study, the results presented in Table 3 were used to plot chart presented in Fig. 1 in order to compare the results with the World Health Organization guide line.

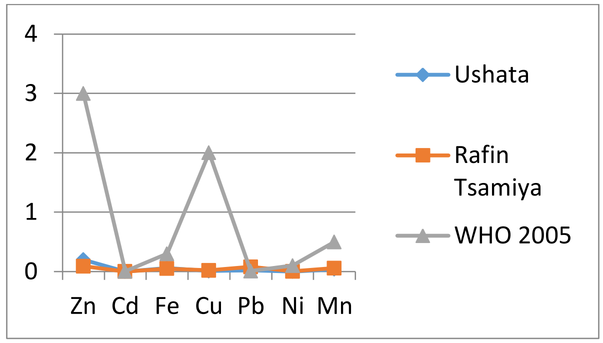

Fig. 1: Comparison of Mean Concentration with World Health Organization guideline.

3.2 Discussion

The results of the Identification of Heavy Metals and their Concentrations in Ushata and Rafin Tsamiya Water Sources of Nasararawa Local Government Area in Nasarawa State, Nigeria using Micro Plasma Atomic Emission Spectrometer have been presented. The mean concentration of various heavy metals found in the water samples are presented in Table 3. Seven heavy metals along with their respective concentrations for Ushata and Rafin Tsamiya in mg/L (Zn (0.2 and 0.09), Cd (0.00 and 0.00), Fe (0.06 and 0.05), Cu (0.01 and 0.02), Pd (0.02 and 0.08), Ni (0.001 and 0.004) and Mn (0.038 and 0.058)) respectively were found in the water samples.

Finding of this study have revealed that the mean Concentration of the analyzed heavy metals in the all water samples for all villages arranged in decreasing order is Zn > Fe > Mn > Pb > Cu > Ni > Cd for Ushata, while Zn > Pb > Mn > Fe > Cu > Ni > Cd for Rafin Tsamiya.

On Zinc mean concentration level, finding of this study has revealed that the zinc mean concentration level for water samples is 0.145 mg/L. This implies that the mean concentration level of zinc in those areas is not significant compared to [13] who's mean concentration level for zinc was 3.00 mg/L, and may not cause radiological hazard to the populace unless when accumulated over a long period of time.

On Cadmium mean concentration level, finding of this study has revealed that the cadmium mean concentration level for water samples is 0.00 mg/L. This implies that the mean concentration level of cadmium in those areas is not significant compared to [13] who's mean concentration level for cadmium was 0.03 mg/L, and may not cause radiological hazard to the populace unless when accumulated over a long period of time.

On Iron mean concentration level, finding of this study has revealed that the iron mean concentration level for water samples is 0.055 mg/L. This implies that the mean concentration level of iron in those areas is not significant compared to [13] who's mean concentration level for iron was 0.3 mg/L, and may not cause radiological hazard to the populace unless when accumulated over a long period of time.

On Copper mean concentration level, finding of this study has revealed that the copper mean concentration level for water samples is 0.015 mg/L. This implies that the mean concentration level of copper in those areas is not significant compared to [13] who's mean concentration level for copper was 2.0 mg/L, and may not cause radiological hazard to the populace unless when accumulated over a long period of time.

On Lead mean concentration level, finding of this study has revealed that the lead mean concentration level for water samples is 0.05 mg/L. This implies that the mean concentration level of lead in those areas is significantly high compared to [13] whose mean concentration level for lead was 0.01 mg/L, and may cause radiological hazard to the populace of the study area.

On Nickel mean concentration level, finding of this study has revealed that the nickel mean concentration level for water samples is 0.0025 mg/L. This implies that the mean concentration level of nickel in those areas is not significant compared to [13] who's mean concentration level for nickel was 0.1 mg/L, and may not cause radiological hazard to the populace unless when accumulated over a long period of time.

On Manganese mean concentration level, finding of this study has revealed that the manganese mean concentration level for water samples is 0.048 mg/L. This implies that the mean concentration level of manganese in those areas is not significant compared to [13] who's mean concentration level for manganese was 0.5 mg/L, and may not cause radiological hazard to the populace unless when accumulated over a long period of time.

4 Conclusions

To quantify and evaluate the damages done by the intake of untreated water is not a simple problem. This work shows the preliminary net that is chosen to analyze Ushata and Rafin Tsamiya, and it is possible to verify that seven heavy metals along with their respective concentrations for both Ushata and Rafin Tsamiya in mg/L (Zn (0.2 and 0.09), Cd (0.00 and 0.00), Fe (0.06 and 0.05), Cu (0.01 and 0.02), Pd (0.02 and 0.08), Ni (0.001 and 0.004) and Mn (0.038 and 0.058)) respectively were present in the water samples. From the findings presented, it can be concluded that the mean concentration level of heavy metals in those areas with the exception of Lead (Pb) in all locations is not significant and may not cause radiological hazard to the populace unless when accumulated over a long period of time. Since concentration levels found shows that the study site can be considered as a free area. It is therefore an indication that the water in the area may be considered as a good water, even though, on accumulation, it may appear to have much impact on the radiation burden of the populace, hence, gross alpha and beta as well as carcinogenic and non-carcinogenic risk assessment of water in the area will compliment this work. It is therefore recommended that proper monitoring exercise should be conducted on the water in the study area from time to time in order to safeguard the population from high concentration of these heavy metals as they elevate with time and cause various forms of cancer to the populace of the study areas.

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