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Assessment of Heavy Metal Concentration in Drinking Water Sources from some Selected Districts of Michika, Adamawa State, Nigeria

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Abstract
Safe discharge of untreated wastewater and scarcity of water is still a burning issue facing mankind today. The current study was carried out to analyze the concentration of heavy metals in drinking water sources from some selected districts of Michika, Nigeria. Atomic Absorption Spectrophotometer (AAS) was used in the analysis of the water samples from boreholes and wells. The respective mean concentration of heavy metals for borehole and well water is 0.0286 and 0.0209 for Nickel, 0.2051 and 0.3979 for Manganese, 0.0015 and 0.0021 for Copper, 0.5472 and 0.8314 for Magnesium, 0.1457 and 0.1420 for Chromium, 0.0011 and 0.001 for Cadmium, 0.1056 and 6.9317 for Lead, 0.5552 and 0.2183 for Cobalt and 0.9924 and 0.5747 for Iron. The results reveal that the first four element (Ni, Mn, Cu and Mg) have values below the maximum recommended value by WHO and USEPA. However, the concentrations of the remaining elements (Cr, Cd, Pb, Co and Fe) exceed the accepted value set by USEPA, WHO and NSDWQ. The water is thus not completely safe for drinking and domestic use. It is therefore recommended that the water needs proper treatment.

Keywords: Heavy Metal, Water, Borehole, Well, AAS.

INTRODUCTION
Water is crucial for the survival and existence of all forms of life (Dankawu *et al*., 2021). Therefore, ensuring good quality drinking water is important in improving the quality of human life and prevention of possible water borne diseases (Yahaya *et al*., 2021; Dankawu *et al*., 2021). Water is used in many communities for different purposes such as agriculture, power generation and also for domestic purposes (Garba *et al*., 2013; Chifu *et al*., 2016; Shitu *et al*., 2016). Potable good quality water is not only crucial for health, but is also a basic human need that needs suitable management, treatment techniques, and monitoring/control (Fatemah*et al*., 2020). Water is among the most significant resources and a major constituent

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of all living things. For instance, almost seventy percent (70%) of human body is made up of water (Saana *et al*., 2016; Shawai *et al*., 2018). Water as a universal solvent is important to human beings in various ways and/ or activities like ecosystem services, nutrition supply, food security, industrial development, drinking, health of all species, waste disposal and human recreation (Young *et al*., 2021; Kılıç, 2020; Masood, *et al*., 2015). More so, water is used for human consumption and therefore must be free from microbial, radiological and heavy metal contamination (Garba *et al*., 2008).

Drinking water contamination from heavy metal pollution has become a global issue. This affects different parts of the world. Heavy metals are toxic even at low concentrations (Lace and John, 2021). Heavy metal belongs to a loosely-defined subset of elements that display metallic properties such as transition metals, actinides, lanthanides and some metalloids (Srikanth *et al*., 2013). The main sources of heavy metals are industrial sewage, geology, weathering, atmospheric deposition, or discharge of municipal, agricultural (fertilizers & pesticides), mining (i.e. natural and anthropogenic) etc. All these can lead to serious pollution (Dugasa and Endale 2018) in our environment. Water pollution is increasing due to poor management of industrial and agricultural waste (Hashim *et al*., 2018; Koop and vanLeeuwen 2017). Heavy metals cause malfunction in organs such as liver and kidneys. It also affects the blood and central nervous system (Baroni *et al*. 2007; Tolesa *et al*., 2020). Heavy metals increase the likelihood of radiological risk such as gene mutation, chromosomal aberration and even death at some certain stages (Abdullahi *et al*., 2018).

Heavy metals resulting mostly from industrial discharges and mining wastes were found to be the major contaminant in our natural drinking water (Elmer and Jose, 2007). Arsenic (As) is among the most hazardous trace metals obtained in drinking water. This is because As is carcinogenic and very toxic (Olcay *et al*., 2011).

In the recent past years suspected health effects of radiation from defunct uranium mining in Michika LGA became a serious issue of concern. Reports from an unnamed hospital by Daily Trust Newspaper (on August, 3rd 2016) confirmed many deformed babies such as smooth featureless face and numerous deaths in the area. This could be due to the defunct uranium mining in 1980-1983 by French and Nigeria Companies (Oak TV 19th October, 2016). Despite all these problems, no research was carried out to asses heavy metals in water from the community. This current study attempts to analyze heavy metals in common water sources used for drinking and other domestic purposes in Michika, North East, Nigeria.

METHODOLOGY

Study Area

Michika Local Government Area, Adamawa State, Nigeria (Fig.1) consists of 8 districts and 16 wards. The districts are Garta, Sina, Futu, Himike, Nbororo, Ghunchi, Nkala, Baza and Michika town. The Local Government has a population of 179,460 (2011 projection) with an area of 967km^2 and a population density of 186/km^2. The area lies within latitudes 10°32'N to 10°41'N and longitudes 13°19'E to 13°25'E. The area is bounded to the West by AskiraUba Local Government Area, Borno State, to the East by Republic of Cameroon, to the North by Madagali Local Government Area and to the South by Mubi Local Government Area. The area is relatively flat in the west and hilly in the eastern part, and despite the hilly nature of some parts of the area, there are good foot-paths, road networks, and tracks (Nur and Ayuni, 2011).

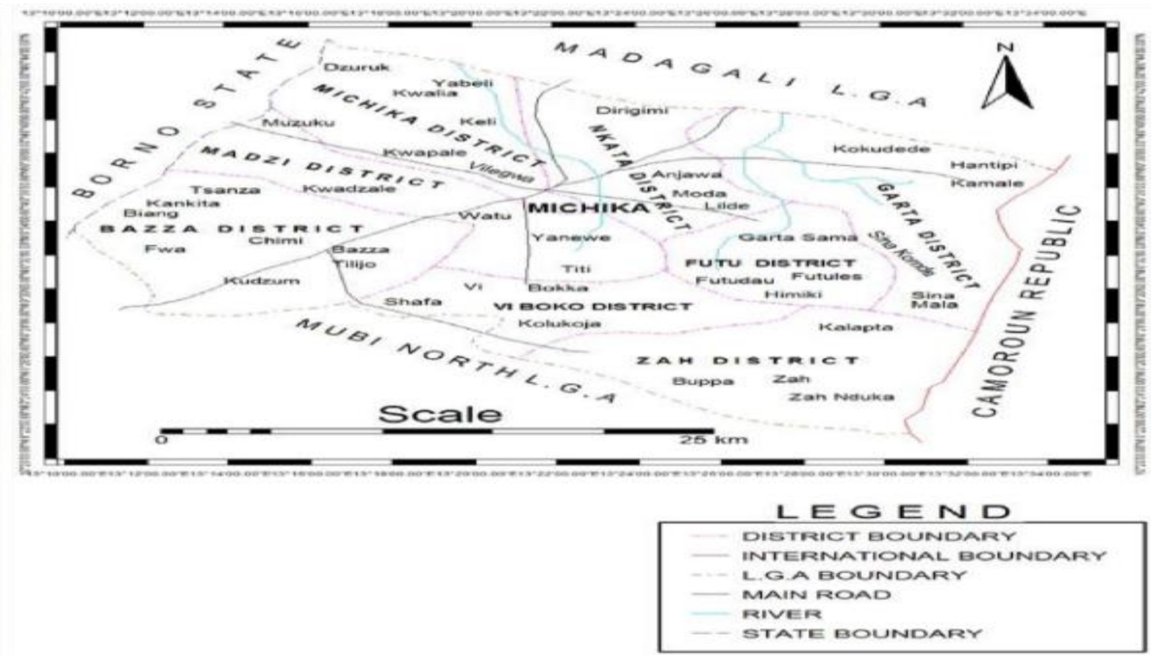

Fig.1: Map of Michika Local Government Area showing all the districts (Williams *et al*., 2015).

The study area is a flat land with patches of granitic outcrops except in the south-eastern part of where the elevations of the mountains attain over 2500 feet (Fig 1.3). There are many rivers that originate from the mountains and generally flow towards west and northwest of the study area. Some of the rivers include River RafinWantse, Yedseram, and Rafin Nanda. The rocks aid in the formation of dendritic pattern of drainage network. The plain soils are alternating bands of light gravel and dark loamy to clay soils (Daral, 1991). The valleys that drain the rivers have alluvial flood plains comprising mainly of coarse quartzitic materials. However, the southern part of the area is predominantly occupied by granites ranging from fine course grained, pegmatites, granodiorites and biotite granite.

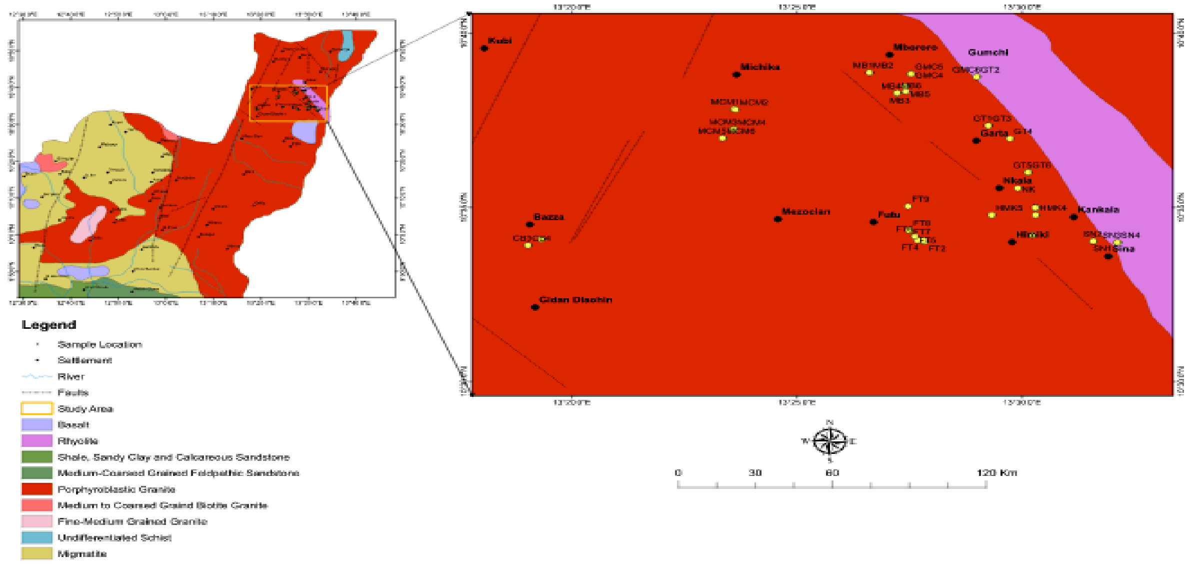

Fig. 2**:** Geological map of the study area (Nur and Ayuni 2011)

Sample Collection

Nineteen (19) water samples were collected randomly across seven (7) different districts under Michika local Government Area. Two sources of water samples were used for this study namely: boreholes and hand-dug wells. The samples were collected during dry season (December, 2019). The samples were collected in clean 2l bottles and analyzed for heavy metals. The 2l bottles were first washed and rinsed with water collected from the source and then with distilled water to avoid any element present in the sample from being contaminated. In order to ensure fresh water samples are obtained, the samples from boreholes were collected after operating for at least three to five minutes. Bailers were used to collect water samples from hand-dug wells, to ensure that fresh samples were obtained. The well water samples were purged almost four times by drawing it out and allowing the wells to refill. About 1% air space of each container was left to ensure room for thermal expansion. 20 ml of diluted nitric acid was added to each sample immediately after collection in order to minimize the pH and to reduce absorption and precipitation on the walls of the container (Chifu *et al*., 2016). All the sample containers were labeled with sample ID, tightly covered, and then transported to National Research Institute Center (NARIC) Zaria for analyses.

Sample Preparation and Analysis

100 ml of the collected water sample was placed in a 125 ml conical flask and digested with 5 ml of concentrated nitric acid, HNO_3 on a hot plate at 95 ^0C until a clear solution was obtained. Deionized water was used to clean the conical flask wall and then filtered.
The filtrate was then transferred into a 100 ml volumetric flask, diluted to mark with deionized water and mixed thoroughly. The total detected metal concentration was determined using Atomic Absorption Spectrometer (AAS) (APHA, 1999).

Table 1: GPS coordinates of all sampling locations

Sample ID	Latitude	Longitude
FB1	13^0 16′ 30″	10^0 31′ 58″
FB2	13^0 19′ 45″	10^0 34 ′30″
GAB1	13^0 19′ 45″	10^0 33′ 50″
GAB2	13^0 19′ 39″	10^0 36′ 55″
GHB1	13^0 19′ 24″	10^0 31′ 52″
GHB2	13^0 17′ 58″	10^0 38′ 54″
MBB1	13^0 22′ 27″	10^0 36′ 31″
MBB2	13^0 24′ 26″	10^0 36′ 36″
SB1	13^0 22′ 44″	10^0 38′ 27″
SB2	13^0 23′ 39″	10^0 37′ 27″
MB1	13^0 23′ 44″	10^0 38′ 42″
FD1	13^0 24′ 49″	10^0 38′ 23″
FD2	13^0 26 ′ 57″	10^0 38′ 18″
ND1	13^0 28′ 57″	10^0 38′ 07″
ND2	13^0 27′ 13″	10^0 36′ 59″
GUW	13^0 27′ 28″	10^0 36′ 57″
HMW	13^0 20′ 24″	10^0 30′ 40″
HMD1	13^0 20′ 23″	10^0 29′ 22″
MBD	13^0 24′ 29″	10^0 29′ 23″

RESULTS AND DISCUSSION

Heavy metal concentration obtained from water samples that were collected from different sampling sites is shown in Tables 2 and 3 for borehole and well water samples respectively.

Table 2: Heavy metal Concentration (mg/l) for borehole water samples

Sample ID	Ni	Mn	Cu	Mg	Cr	Cd	Pb	Co	Fe
FB1	0.0371	0.0377	0.001	0.8821	0.2441	0.0018	0.1729	BDL	3.4999
FB2	0.0235	0.0186	BDL	0.8587	0.054	0.0001	BDL	BDL	1.5068
GAB1	0.0269	BDL	0.0016	0.5591	0.2066	0.0002	0.0052	BDL	0.5238
GAB2	0.0291	BDL	0.0018	0.0748	0.0177	0.0009	BDL	BDL	0.5869
GHB1	0.0294	0.465	0.0014	0.8238	BDL	0.0018	BDL	1.1006	0.5486
GHB2	0.0155	0.3485	0.0008	BDL	BDL	BDL	BDL	1.2061	0.4573
MBB1	0.0267	0.3597	0.0015	0.5238	BDL	0.0018	BDL	0.2616	0.3838
MBB2	0.0322	0.3483	0.0016	0.4280	0.1615	0.0015	BDL	0.2831	0.4005
SB1	0.0355	0.002	0.0005	0.5912	0.1514	0.0009	BDL	0.2247	0.3567
SB2	0.0274	BDL	0.0008	0.0271	0.204	BDL	0.152	0.2426	0.3783
MB1	0.0356	0.0046	0.0032	0.8853	0.1563	BDL	0.1252	0.2469	0.4018
Min.	0.0155	0.002	0.0008	0.0271	0.054	0.0001	0.0052	0.2247	0.3567
Max.	0.0371	0.465	0.0018	0.8821	0.2441	0.0018	0.1729	1.2061	3.4999
Mean	0.0286	0.2051	0.0015	0.5472	0.1457	0.0011	0.1056	0.5552	0.9924

Table 3: Heavy metal Concentration (mg/l) for hand-dug well water samples

Sample ID	Ni	Mn	Cu	Mg	Cr	Cd	Pb	Co	Fe
FD1	0.0328	0.0012	0.0028	0.8231	0.0174	BDL	0.1034	0.2206	0.4286
FD2	0.0232	0.0004	0.0029	0.8895	0.2134	BDL	13.76	0.2138	0.5228
ND1	BDL	0.8025	BDL	0.8689	0.1263	BDL	BDL	0.2047	0.5366
ND2	BDL	0.7913	BDL	0.7323	0.2639	BDL	BDL	0.233	0.3447
GUW	BDL	0.7851	BDL	0.6696	BDL	BDL	BDL	0.2260	0.4461
HMW	BDL	0.7812	0.0006	0.9157	0.1252	BDL	BDL	0.2117	0.4435
HMD1	0.0042	0.0032	0.0021	0.8933	0.2422	BDL	BDL	BDL	0.3684
MBD	0.0235	0.0186	BDL	0.8587	0.0054	0.001	BDL	BDL	1.5068
Min.	0.0042	0.0004	0.0006	0.6696	0.0054	0.001	0.1034	0.2047	0.3447
Max.	0.0328	0.8025	0.0029	0.9157	0.2639	0.001	13.76	0.2260	1.5068
Mean	0.0209	0.3979	0.0021	0.8314	0.1420	0.001	6.9317	0.2183	0.5747

The concentration of nickel was detected in all borehole samples, while for wells only four (4) locations out of eight were detected with nickel. The highest value was obtained from FB1 boreholes sample location while the lowest value was obtained from HMD1 well water sample location. All the values for both boreholes and wells samples location were below the control values of 0.07 and 0.1, set by WHO and USEPA. However only HMD1 sample location amongst the nineteen samples were found to be below the maximum concentration value of 0.02 (Chifu *et al*., 2016). This may be an indication of possible carcinogenic effects if the water is used for domestic purposes as recommended by Nigerian industrial standards for portable water and natural mineral water. The highest value in FB1 borehole may be due to the closeness of borehole with uranium mining defunct.

The concentration of manganese was detected in all water samples except for three from boreholes. The minimum value is 0.002 mg/l found in SB1 borehole samples and maximum value of 0.8025 mg/l from ND1 well water sample location. All the concentrations are below the accepted value of 0.4 and 0.05 set by WHO and USEPA except for ND1, ND2, GUW and HMW with higher concentrations. However, eight samples out of nineteen were found to be below the value of 0.2 as set by NSDWQ. High intake of manganese causes brain damage in invertebrates (Baden and Eriksson, 2006). The values show that the water will not pose any threat to human life

Copper concentration was detected in both borehole and well water samples except for three locations which are below detection level. The minimum and maximum value are 0.0006 and 0.0029, both obtained from well water samples. The concentration for all samples were found to be far lower than the permissible value set by NSDWQ, WHO and USEPA.

For Magnesium, GHB2 borehole sample is the only sample with concentration below detection level amongst all the nineteen samples. 0.9157 is the highest concentration found in well water sample and 0.0271 is the lowest concentration found in borehole water sample.

GHB1, GBH2 and MBB1 are the three water samples from borehole with Chromium concentration below detection limit while GUW is the only sample from well with the concentration below detection limit. The minimum value is 0.0054 obtained from FB2 and MBD sample location while the maximum value 0.2639 obtained from ND2. Almost 90% were higher than the WHO standard value of 0.05 mg/l. These high concentrations may lead to serious neurological disorder to the community people. Also, Chromium as an environmental pollutant may lead to occupational asthma, eye irritation and damage, perforated eardrums, respiratory irritation, kidney damage, liver damage, pulmonary congestion, upper abdominal pain, nose irritation and damage, respiratory cancer. (Gibb *et al*., 2000)

The concentration of cadmium for well water samples were only detected in MBD while for borehole samples, only SB2 and MB1 were found with below detection level. FB2 and MBD are the two-samples from boreholes and wells with lowest concentration and MBB1 sample from borehole has the highest concentration. All the concentration of well samples and four out of eleven boreholes samples were found to be below the permissible limit of 0.003 and 0.005 as set by WHO, USEPA and NSDWQ. The concentration of cadmium in water reduces eggs production resulting to decrease in population. (Cherif *et al*., 2015). Considering these values, it indicates that the water is safe for use.

The concentration of lead was detected in only six samples namely: FB1, FB2, SB1, SB2, FD1 and FD2. The first four were obtained from borehole and the last two from well water samples. 0.0052 and 13.76 are the minimum and maximum concentration obtained from GAB1 and FD2. All the detected concentration was found to be higher than the maximum concentration value of WHO, USEPA and NSDWQ, except for one sample locations GAB1. Lead is very toxic and accumulates in aquatic food chains. Very high lead exposure can cause death. (Afshan *et al*., 2014; Shah, 2017). Exposure to high level of lead may cause anemia, weaknesses, and kidney and brain damage (CDC, 2021; NIOSH, 2021).

Cobalt was detected in all samples, although five samples were found to be below the detection limit, namely MBD from well and FB1, FB2, GAB1 and GAB2 from borehole samples. The minimum value is 0.2047 obtained from ND1 well sample while the maximum value is 1.2061 obtained from GHB2 borehole sample. All the detected values are almost double the maximum control value of 0.1 as recommended by USEPA. The high values may pose threat to the humans and animals in the study area. These high values can harm the eyes, skin, heart and lungs. Also, exposure to Cobalt may cause cancer (NIOSH, 2021).

Iron was detected in all nineteen samples. ND2 well sample had the lowest value of 0.34 and FB1 from borehole is the sample with highest value of 3.50. All the values from the two sources of water (Borehole and Well) were far higher than the maximum accepted values of 0.3 set by WHO; NSDWQ and USEPA. The high value may lead to cancer and it is toxic to the central nervous system as it affects mental development in infants (Thangam *et al*., 2014; Olapade and Omitoyin, 2012).

The finding reveals that quite reasonable number of the water samples from the sampling points contain excess concentration of the heavy metals indicating that the metals have exceeded the recommended values in the guidelines according to United State Environmental Protection Agency (USEPA), World Health Organization (WHO) and Nigerian Standard for Drinking Water Quality (NSDWQ).

CONCLUSION

The result shows that Nickel, Copper, Cadmium and Manganese with mean concentration of 0.0286 and 0.0209, 0.0251 and 0.3979, 0.0015 and 0.0021, 0.5472 and 0.8314 for borehole and well water samples respectively were found to be below the maximum accepted value of United State Environmental Protection Agency (USEPA), World Health Organization (WHO) and Nigerian Standard for Drinking Water Quality (NSDWQ). Chromium, Lead, Cobalt and Iron with mean value of 0.1457 and 0.1420, 0.0011 and 0.001, 0.1056 and 6.9317, 0.5552 and 0.2183, 0.9924 and 0.5747 for borehole and well water samples respectively, exceed the recommended value of USEPA, WHO and NSDWQ. The water needs proper treatment before use. Because high concentration values of heavy metals in water have a serious effect on human beings (He *et al*., 2018). Heavy metals like Copper, Chromium and Manganese are toxic at high level. This make them cause anemia in kidney, fish and destroy liver in human being. However, they are essential for the metabolism of inhabitant (Thangam *et al.*, 2014; Olapade and Omitoyin, 2012).

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