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A survey of the presence and quantity of heavy metals in water sources at and around the Auto Mechanic village at Lafia Junction, North Bank, Makurdi, Benue State.

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ABSTRACT

This study was carried out with the objectives of accurately determining the effect of the metal activity that goes on in the study area on the water sources in the area. Thus fifteen samples were collected from five different sites such that: three samples each were collected from three shallow strategically situated hand drawn wells in the study area: three samples were systematically drawn from three different locations along the shallow stream that flows east-west in the study area; and three samples were drawn from the only functional bore hole well in the study area. The fifteen samples were systematically homogeneously merged for sample digestion and AAS analysis into three samples: samples $S_{t.}$ (Stream water samples): samples $W_{t,}$ (well water samples), and samples BH, (bole hole water samples). Parameters like conductivity, pH and TDS were tested on the site while TSS and sample preparation and digestion were carried out in the laboratory. The heavy metal presence and quantity was determined after proper samples preparation and digestion via Atomic Absorption Spectrophotometer (ASS) analysis. The results of the study showed that pH values for the surface water samples, (samples $S_{t,}$) were within the limits as recommended by NWQGS and WHO however the values from the well water samples (samples Wt_1) and the bore hole well water samples (samples BH) were slightly below the recommended pH.

Keywords: Quality, standards , survey , village, water.

I INTRODUCTION

Makurdi. is Located in Nigeria. with **Coordinates**: 7°43′50″N 8°32′10″E) Water pollution via heavy metals is fast becoming a menace in our society these days as the means of occurrence of these harmful trace elements in our environment range from industrial waste discharge, use of agrochemicals, corrosion of metals items that are either useful or that have been discarded, and direct dumping of "waste metal" in and around the water source.

Water is very important to all living organisms and their processes on the globe. For this reason it is important to adequately screen water to ascertain its suitability for whatever purpose it is to be used for. Whether for drinking, cooking, bathing, irrigation, leisure, laboratory, industrial etc purposes. This is very important regardless of its source or appearance.

Water quality parameters like Total Dissolved Solids (TDS), Electrical Conductivity, pH, Colour, Biochemical Oxygen Demand (BOD), Total Suspended Solids (TSS), Temperature, Total Dissolved Oxygen (TDO), Total Hardness, Inorganic Phosphorus, Chloride determination, Chemical Oxygen Demand (COD), Turbidity and most importantly, heavy metals present, should be tested and the results obtained compared with the officially accepted standards . This is important in curtailing the risk of environmental and physiological dangers due to contaminated water which has become source of worry to the society, (National Water Quality Guidelines and Standards, 2007).

1.2 Water

Water is a substances which in its chemically pure form, consists of two hydrogen atoms (a hydrogen molecules, H_2), and one oxygen (O).

It does exist in the three states of matter, solid, liquid and gas. Water is usually referred to as the universal solvent due to its ability to dissolve many solutes. The water molecule is polar in nature which makes it an excellent solvent for electrovalent or ionic compounds as well as other covalent compounds that contain the hydroxyl group, and gases (Ababio, 1991). Water is represented with the chemical formula H_2O, its chemical structure is as illustrated in figure below.

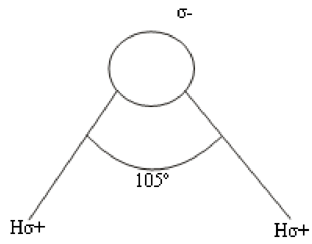

Figure 1. Shows the chemical interaction between the oppositely charged atoms accounts for the polar nature of water, and the hydrogen bond. The existence of hydrogen bonds in water becomes an intrinsic property responsible for the solution of ionic species or electrovalent substances through the principle of like dissolve like (Ababio, 1990)

1.3 Physical Properties of Water

In its pure form water is colorless, odorless and tasteless, freezes at 0^oc and boils at 100^oc , has a density of 1.0gcm-3 at 4.0^oc and dissolves so many substances; mineral salts, mineral acids and bases, organic solids, like sugar, organic liquids like alkanol and propane -1,2,3- trio (glycerol), gases, though some dissolve to a higher extent than others, pure water is neutral to litmus and has a pH of 7 at 25^oc. It is referred to as the universal solvent.

2 Methodology

All apparatus and reagents used in the course of this study were properly handled to minimize error to negligible or manageable levels. Appropriate sampling methods and procedures were employed in order to achieve a high accuracy, and reliable results.

2.1 Research Design

This is a survey research analysis aimed at obtaining data which is relevant to answering the research questions of this survey.

2.2 Population and Sampling

The population of this survey includes; A stream that runs about 2km across the study area (east to west), on the northern end of the study area.

i. One mechanically operated bored-hole which is centrally situated.
ii. Some hand drawn water wells.

five sampling sites were chosen thus;

- Three sampling sites were chosen North-South along the course of the stream with the 3 sites labeled S_{a5}, S_b and S_c being equidistant from each other (i.e. 100m between S_a to S_b and 100m between S_b and S_c)
- Three samples (sample BH) was drawn from the mechanically operated bored hole well and;
- Nine samples were collected from three of the hand drawn water wells (three sample from each well) which were homogenously merged into three samples for digestion and analysis. One of the wells situated on the eastern side of the study area (sample W_a), the 2nd well situated in the central part of the study area (sample W_b), and the 3rd well situated on the Western side of the study area (sample W_c).

2.3 Sample Collection and Preservation

Water samples were collected in clear $75cm^3$ transparent plastic bottles. The bottles were rinsed thoroughly with water from the sampling location before the water samples were collected. The samples were tested for pH, TDS, conductivity and temperature on the site.

The sample bottles were refrigerated and taken to the laboratory cold in an insulated cooler where digestion procedure commenced immediately.

The sampling occurred between 1200 to 1530 hours in the 1st week of October, 2011 and digestion commenced about nineteen hours later.

3 Reagents

The main reagent used for digestion of samples was concentrated $HNO_{3(aq)}$ acid since it is the most suitable reagent for digestion of water samples to be analyzed for heavy metal content (Skoog, West, 2004). The reagents were prepared based on standard methods.

3.1 Instruments

Hanna Instrument H17032 Conductivity/TDS metre.

Parameters like electrical conductivity, and total dissolved solids were taken directly at the sampling spot using Hanna Instrument H17032 Conductivity/TDS metre.

Hanna Instrument (H19024) Microcomputre pH Metre (pocket sized pH metre).

pH was taken on site using the Hanna Instrument mentioned above.

The young Lin 0310 model, South Korea Atomic Absorption Spectrophotometer (AAS) and analytical balance were used to determine the other parameters.

4 **RESULTS, ANALYSIS AND DISCUSSION**

4.1 **Results**

The data obtained from the analysis of those physicochemical properties as well as, heavy metals concentrations, which where the concerns of this study are appropriately represented in Tables 1 and 2 respectively, given below.

Table 1 Physicochemical Properties of the sampled locations.

Parameters	Sample location S_t	Sample Location W_t	Sample Location BH
Inductivity (cm^{-3})	6.50 ± 0.00	5.20 ± 0.54	5.90 ± 0.00
Temperature (ºC)	27.83 ± 0.25	30.00 ± 2.00	27.00 ± 0.01
SS (mgL^{-1})	10.50 ± 0.50	21.67 ± 1.55	30.50 ± 0.71
SS (mgL^{-1})	31.00 ± 0.00	2.67 ± 0.05	0.10 ± 0.00

Table 2: Concentrations of heavy metals analyzed for the various sample locations.

Metal tested	Concentration of metals in sample S_t	Concentration of metals in sample W_t	Concentration of metals in sample BH
As	- 6.286 ± 0.001	-2.857 ± 0.001	-2.571 ± 0.000
Cd	-0.174 ± 0.012	-0.085 ± 0.009	-0.333 ± 0.004
Cr	0.030 ± 0.001	0.030 ± 0.002	-0.006 ± 0.002
Cu	0.947 ± 0.001	0.014 ± 0.001	BDL
Fe	2.347 ± 0.002	0.088 ± 0.003	-0.003 ± 0.002
Hg	-32.00 ± 0.003	-0.500 ± 0.004	-49.500 ± 0.004
Mn	0.044 ± 0.005	0.005 ± 0.001	-3.714 ± 0.005

Ni	0.293 ± 0.005	0.011 ± 0.002	-0.873 ± 0.006
Pb	0.884 ± 0.003	0.651 ± 0.004	-0.047 ± 0.002
Zn	0.383 ± 0.007	0.013 ± 0.005	BDL

4.2 Analysis

Table 3 below compares the values of these parameters and heavy metal concentrations obtained from the field of study of water sources in the study area to the National Water Quality Guidelines and Standards (NWQGS) and WHO acceptable limits.

Table 3

Parameters/heavy metal	NWQGS Recommended values	WHO Recommended values	Sample St	Sample Wt	Sample BH
pH	6.5 – 8.5	7.0 – 8.5	6.50 ± 0.000	5.20 ± 0.043	5.90 ± 0.000
Conductivity (μscm^{-3})	1000	1000			
TDS (mgL^{-1})	500	500	10.50 ± 0.050	21.67 ± 1.555	30.50 ± 0.707
Temperature (ºC)	Ambient	Ambient	27.83 ± 0.031	30.00 ± 0.002	27.00 ± 0.000
TSS (mgL-1)	1000	1000	31.00 ± 0.000	2.67 ± 0.053	0.10 ± 0.000
AS (mgL-1)	0.01	0.01	BDL	BDL	BDL
Cd(mgL-1)	0.003	0.003	BDL	BDL	BDL
Cr(mgL-1)	0.05	0.05	0.03 ± 0.001	0.030 ± 0.002	BDL
Cu(mgL-1)	1.0	1.0	0.917 ± 0.001	0.013 ± 0.001	BDL
Fe(mgL-1)	0.30	0.30	2.347 ± 0.001	0.088 ± 0.003	BDL
Hg(mgL-1)	0.001	0.001	BDL	BDL	BDL
Mn(mgL-1)	0.2	0.2	0.044 ± 0.005	0.005 ± 0.007	BDL
Ni(mgL-1)	0.02	0.02	0.292 ± 0.005	0.011 ± 0.002	BDL
Pb(mgL-1)	0.01	0.01	0.883 ± 0.003	0.651 ± 0.004	BDL
Zn(mgL-1)	3.0	3.0	0.382 ± 0.007	0.012 ± 0.005	BDL

4.3 Discussion

Comparing the results obtained form this study with the recommended values for the tested parameters by WHO and NEQGS as summarized in Table 4.3 showed that the three water sources analyzed had different values for the parameters tested for in the study.

It is also observed that some experimental results for pH and heavy metals from the three samples tested varied significantly with the standard recommended values and concentration.

The average pH for the stream water samples (sample S_t) as given by the experimental results is in line with the recommended standard pH range, but for the well water samples, (sample W_t) and the bored hole water samples (sample BH), their average pH values respectively are below the recommended standard range with sample BH having a pH value closer to the standard range and sample W_t having a more acidic pH value.

Average conductivity values for the three water sources sampled (samples S_t, W_t, and BH) respectively where all individually much less than the standard recommended maximum values. Sample BH shows the highest conductivity value followed by sample W_t, then sample S_t.

Sample BH has the highest average TDS value of the three samples though the value is very much less than the maximum recommended standard values. Sample W_t has the next highest average TDS value, then sample S_t. It is observed form the table that conductivity increases with increasing TDS, and samples BH and W_t which are ground water sources tend to have higher TDS, hence, they have higher conductivity values than sample S_t which is a surface water sources.

The surface water sample, (Sample S_t) has the highest average TSS value of the three samples followed by sample W_t, then sample BH. A progressive increase in average TSS values is observed from sample BH to sample W_t then, sample S_t which has the highest average TSS value. Experimental result show that the average TSS values from the three samples respectively fall below the maximum recommended limit values. This relatively high average TSS value observed in sample S_t could be due to direct run-off of solid matter from the earth's surface which enters the water source as well as human presence and activities.

The average temperatures across the sampling stations as seen in Tables 1 and 3 are ambient with respect to the tropical region where the study are is situated.

Arsenic analysis for the three samples all show negative values (Table 2) implying that the concentrations of this metal in the three samples tested is BDL (below detection limit).

The negative values for Cd obtained from the analysis of the samples implies that the concentrations of Cd in the three samples tested respectively in negligible, of no consequences, and are referred to as being below detection limit (BDL).

The average Cr concentrations in the three samples tested were below the maximum limits set by NWQGS. Even though the average concentration of the metal in sample BH is BDL, the average concentrations of the metal in samples W_t and S_t respectively are not far below the NWQGS and WHO maximum limits (see Table 3).

Sample S_t showed a very high concentration of Cu compared to the NWQGS and WHO maximum limits for good drinking water, (Table 3), while samples Wt and BH showed Cu concentrations less than the NWQGS and WHO acceptable limits. Sample BH even showed Cu concentrations BDL.

The results from analysis show that Cu concentrations in the study area decreases with increase in depth of water source. the extent of contamination of sample S_t makes the water source very unfit for drinking by humans and even livestock like goat and sheep.

The average concentration of Fe in sample S_t as obtained from this study is beyond the maximum values recommended by the statutory bodies referenced in this study and this renders the water source unfit for drinking. This though is not the case with sample W_t which has an average concentration of the metal comfortably below the maximum recommended concentrations and sample BH which showed a BDL concentration for the metal.

As shown in Table 3, the average concentrations of this lethally hazardous metal in the three samples tested are BDL concentrations respectively.

Though with a narrow margin, sample S_t has an average concentration of Mn below the NWQGS and WHO maximum acceptable concentrations respectively (see Table 3). The case is different with sample W_t which has a much lower concentration, and sample BH which shows BDL concentration or the metal.

According to experimental results obtained from this study, sample S_t is not safe for drinking by humans, though it is suitable for other agricultural purposes. Although as noticed in the trend of contamination of water sources in this area, sample W_t shows a much lower concentration of Ni which is very below the maximum recommended concentrations of the metal in suitable drinking water, and sample BH even shows BDL concentration.

Average Pb concentrations in samples S_t and W_t are very high above the maximum acceptable concentrations, with sample S_t showing the highest average concentration. For sample BH, the average Pb concentration shows BDL.

Sample S_t and W_t both showed respective average concentrations that were below the maximum acceptable concentrations recommended by the statutory regulatory bodies referenced in this research project. Sample BH even showed concentration BDL for this metal.

5 Conclusion

Nine water samples were drawn from seven different location in the study area which include three sample from three strategically located hand draw wells respectively, thee sample from thee different spots which were 100s metre apart from each other along the stream, and thee samples which were drawn from one motorized bored hole well these nine samples were given proper pre-analysis sample treatment then homogeneously merged in to thee sampling stations where they were prepared and analyzed for heavy metals.

Each sample was individually tested for physico-chemical properties like conductivity, pH, TDS, temperature and TSS before they were homogeneously merge in to the samples. This account for the mean values of these parameters in table 4.1.

Apart from pH which is too acidic with respect to the acceptable limit for pH for drinking water as given by the statutory regulatory bodies referenced in this study for samples w_t and BH respectively, conductivity, TDS, temperature, and TSS of the water sources in the study area can be approved as being suitable for drinking and other use categories as recommended by National Water Quality Guidelines and Standards, and WHO.

Although the water samples tested for heavy metals form experimental results proved to be suitable for drinking considering the fact that most of the heavy metals tested for had small or negligible concentrated with respect to the maximum values permitted by WHO and NWQGS, Cu, Fe, Ni and Pb showed concentrated in sample S_l which were beyond WHO and NWQGS acceptable limits. Thus streams water sources is not suitable for drinking, watering of animals and irrigation with respect to the concentrations of Cu, Fe, Ni and Pb obtained from the AAS analysis of the samples drawn from this water source.

The high concentration of these metals in the stream water source can be accounted for by the direct run-off of flowing water especially during the rainy season which carries particles which include pieces of these metals (Cu, Fe, Ni and Pb) directly into the stream; and some scrap metal which have been abandoned or dumped along the banks or directly into the stream.

6 Recommendations

Scraps/abandoned metals in the study area should be gathered in a central location which is away from the water sources in the study area especially the stream water source in order to reduce contamination via-off water carrying debris containing such metal contaminants.

People should be discouraged from using stream water sources especially for drinking, watering of animals and irrigation purposes.

Scarps /abandoned metals in the stream, along its banks, and around water sources in the study area should be removed and gathered as recommended in item "I" above.

Such scraps metals are highly useful to the metallurgical industry for the purpose of recycling, thus the gathered metals should be sold to the industry since this will help in reducing the concentration of these non biodegradable matter in the delicate parts of our environment.

The residents and workers in the study area should be given orientation on the dangers of heavy metal pollution and using of polluted water sources, as well as proper ways of safety disposing scraps metals.

A seasonal variation of these parameters should be determined over a sufficient period of time following proper disposing of these metals.

Soil samples in the study area as well as animal samples be tested for concentration of these metals in the soil and bioaccumulation.

Concerned agencies should sink more boreholes in the area since experimental results have proven borehole to be the safest water source in the study.

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