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ANALYTICAL EVALUATION OF TOXIC METALS IN THE PERENNIAL WATER SOURCE AT THE IMT STUDENTS' HOSTEL

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ABSTRACT: *The Perennial Well water sources for the IMT Students' hostellers which has locations at the three different hostels in Campus III of the Institute were analysed for toxic metal's concentrations well as some important parameters such as pH, Turbidity, and Conductivity. The purpose of the research is to ascertain whether the water is safe for domestic use. The research was born out of the complaints by some of the water users who said that the water was causing them some itches. The respective concentration of the toxic metals in the said water sources is determined using the most appropriate analytically method such as Atomic Absorption Spectrophotometer flame (AAS flame) for Lead, Nickel, Cobalt, Molybdenum, Chromium, Iron, Silver, Manganese, Zinc, Copper; Atomic Absorption Spectrophotometer cold vapour (AAS cold vapour) for Mercury; Atomic Absorption Spectrophotometer hydride (AAS hydride) for Arsenic and Selenium; Flame photometer for Magnesium; has been x-rayed. The pH was measured by Electrometric Method. The electrical conductivity was carried out according to APHA 2510B guideline while the Turbidity was done using EPA 180. From the results, one can see the number and names of the Well that is heavily affected by the toxic metals and thereby resort to the suggested means of battling with such water sources as given in this work.*

KEYWORDS: perennial water, toxic metals, IMT students' hostel, concentration

INTRODUCTION

The term toxic metal also taken as heavy metal is referred to any metallic element with relative high density and poisonous to human health, even at low concentration in the body. Generally, there density is about 5kg/dm^3 greater than that of water (Lenntech, 2004). Because of the in-destructive nature of toxic metals, that is, they cannot be decayed easily unlike organic pollutants; they are persistent in all parts of the environment (air, water, and soil) causing environmental pollution. There was need to evaluate the toxic metals in the Perennial water source for IMT Students that live in the Hostels at Campus III of the Institute.

Examples of toxic metals include: cobalt (Co), copper (Cu), chromium (Cr), iron (Fe), magnesium (Mg), manganese (Mn), molybdenum (Mo), nickel (Ni), selenium (Se), zinc (Zn), arsenic (As), mercury (Hg), and lead (Pb). Some metals are essential minerals for healthy biochemical and physiological function. Others, such as lead, chromium, arsenic, and mercury are toxic even when ingested in very small quantities. Arsenic, which is technically categorized as a metalloid, is quite dense and is extremely toxic in very small quantities. Thus, toxicologists typically categorize arsenic as a heavy metal. People can be exposed to toxic metals though ingestion, inhalation, or contact with skin. The severity of health effects of toxic metals is related to the type and chemical form of each particular contaminant, and is also depends on the exposure time and dose.

Acute toxic metal poisoning usually occurs when people are exposed to large amounts of one particular metal at a time. For example, a child swallowing a lead bullet can cause a large amount of lead exposure all at once. Acute exposures can quickly cause serious health effects or death.

Chronic or long-term exposure to lower levels of toxic metals can also cause health problems. The symptoms of chronic toxic metal poisoning can be severe, but are often less obvious and develop much more slowly over time than the symptoms caused by acute exposure. This is a topic of growing scientific evidence that needs to be better researched to clarify all the possible health implications.

Chronic toxic metal poisoning can be challenging for both health care providers and patients because there are often many more questions than answers. Symptoms of chronic metal toxicity can include but is not limited to headaches, fatigue, muscle and joint pain, and weakness.
However, these same symptoms can be caused by many other health problems unrelated to metal toxicity. True chronic toxic metal poisoning is rare but also difficult to diagnose.Lead is regarded as highly hazardous for plants, animals and particularly for microorganisms. If the nervous system is affected, usually due to very high exposure, the resulting effects include severe headache, coma, delirium and death. Continued exposure can lead to decreased fertility and/or increased chance of miscarriage or birth defects (Dobrzanski. *et al.*, 2005).The problems that are associated with chromium exposure are skin rashes, upset stomach, ulcers, respiratory problems, weakened immune systems, kidney and liver damage, alteration of genetic material, lung cancer and ultimately death (McGrath and Smith 1990 and Pendias *et al*., 1984).

MATERIALS AND METHODS

Materials

Materials used in this research work were Well water samples from **Barrack Hostel** (Male hostel), **Diamond Hostel** (Female Hostel), **Indiana Hostel I &II** (Males and Females respectively), Atomic Absorption Spectrophotometer (flame, cold vapour, hydride), flame photometer, white transparent plastic gallons, Reagents, etc.

Methods

Experimental Research Design was adopted. This method was adopted because the results got through it, is always precise unlike the classical method of analysis which normally introduce much error in our results (R, Wehrens 2000).

Water Sample collection

Well water samples were collected in three Hostels, namely: Barrack; Diamond; Indiana; located in the Campus III of IMT, Enugu. Four (4) consecutive water sampling was done in each of the Eight Wells in the respective Hostels in the Morning (at 5:00am), Afternoon (at 1:00pm), Evening (at 4:00pm), and Night (at 7:00pm).

In the sample collection, gallons that were used for the sampling were treated with nitric acid HNO_3 and later rinsed with double distilled water before use. One litre of Well water samples was collected for the toxic metal load determinations. The samples were taken to the laboratory and kept in the fridge prior to analysis. All the samples were analyzed within three weeks after sample collection to eliminate or minimize not only precipitation of analytes but also any possible contaminations.

Accuracy Check

Evaluation of accuracy was performed using Standard Reference Material (Trace Element in Water, 1643e).

Exposure to all these toxic metals is the main trouble to human health. Guideline values for these metals which are of health significance in drinking water are given in the table in mg/l (ppm). For the region interested in this study, there have been no studies in the literature for the analytical evaluation of Toxic metals in Well water samples; however, there are some literatures where toxic metals have been determined in water samples taken from different regions of Enugu metropolis.

In this study, Eight (8) Well water samples from Barracks, Diamond, and Indiana Hostels located in Campus III of IMT, Enugu were analyzed for toxic metal contents under the optimum conditions. Concentrations of analytes (toxic metals) found in the water samples of interest in this study is presented. The water samples were evaluated to ascertain whether they fall under toxic and alert categories.At the end of the experiment, the toxic metals are evaluated and found to be in some of the water sources while some do not have it in large quantity, Ion Exchange method of water treatment can be applied to remove toxic metal ion from water. The compound used in this method is called Permutit. It is a complex compound made up of hydrated sodium aluminium trioxosilicate (IV) commonly called Zeolite. It is represented as Na_2Y (where Y = $Al_2SiO_3.XH_2O$). When water that contains dissolved ion of heavy metals, say mercury, runs over this compound, the sodium ion goes into the water, while the mercury ion (Hg^{2+}) replaces the sodium ion in the zeolite.The concentration in part per million of the tested toxic metals and some important parameters like pH, Turbidity, and Conductivity of the respective Eight (8) Well water samples is given as follows:

Procedure for the determination of Toxic metals in Well water samples

In order to determine toxic metal load in water samples, different high tech analytical instruments such as AAS flame, AAS cold vapour, AAS hydride, Flame photometer were used depending on the nature and size of the analyte (metal of interest) to test for. Deuterium arc lamp background correction was applied for all the analytes.

All of the chemicals that were used throughout the experiments are in the high-purity grade. In all dilutions and standard preparation, double distilled water was used. All of the sampling containers were washed up with hot nitric acid and then rinsed with double distilled water before using in the experiments. All glass beakers and containers were kept and stored in 1.0 mol/L nitric acid (HNO_3) to eliminate any possible contamination. Nitric acid (65%, Merck) was used to eliminate the precipitation of analytes before measurement.

Standard Reference Material (Trace Element in Water, 1643e) brought from NIST was used for evaluating methods used in the determination of toxic metals in the water samples.

Working principle: Atomic absorption spectrophotometer's working principle is based on the sample being aspirated into the flame and atomized when the AAS light beam is directed through the flame into the monochromator, and onto the detector that measures the amount of light absorbed by the atomized element in the flame. Since metals have their own characteristic absorption wavelength, a source lamp composed of that element is used making the method relatively free from spectral or radiation interferences. The amount of energy of the characteristic wavelength absorbed in the flame is proportional to the concentration of the element in the sample.

Preparation of Reference Solution

A series of standard metal solutions in the optimum concentration range was prepared, the reference solutions were prepared daily by diluting the single stock element solutions with double distilled water containing concentrated nitric acid (1.5ml) per litre. A calibration blank was prepared using all the reagents except for the metal stock solutions.

Calibration curve for each metal was prepared by plotting the absorbance of standards versus their concentrations.

Determination of pH

The pH was measured by Electrometric Method using Laboratory pH Meter Hanna model HI991300 (APHA; 1998).

i. The electrodes of the pH were rinsed with distilled water and made dry with a cloth.
ii. The pH electrodes were then rinsed in a small beaker with a portion of the sample.
iii. Sufficient amount of the water sample was poured into a small beaker to allow the tips of the electrodes to be immersed to a depth of about 2cm. The electrode was at least 1cm away from the sides and bottom of the beaker.
iv. The temperature adjustment dial was adjusted accordingly.
v. The pH meter was turned ON and the pH of the water sample recorded.

Determination of Electrical Conductivity

Method: Analysis was carried out according to APHA 2510B guideline Model DDS-307 (APHA; 1998).

Procedure:

i. The conductivity cell was rinsed with at least three portions of the water sample.
ii. The temperature of the water sample was then adjusted to $20 \pm 0.1^{O}C$.
iii. The conductivity cell containing the electrodes was immersed in sufficient volume of the sample.
iv. The conductivity meter was turned ON and the conductivity of the water sample recorded.

Determination of Turbidity

Procedure:

i. 'EPA 180' was selected as the measurement mode.
ii. The sample is placed in a clean, dry turbidity vial and capped securely. Excess liquid or fingerprints was wiped off with a soft cloth.
iii. The MEASURE key is pressed. The result is displayed on the instrument, and can be printed out for future use. If the result is less than 40 NTU, the procedure was repeated for the next sample.

iv. If the result is greater than 40 NTU, the sample is diluted with one or more volumes of turbidity-free water until the turbidity falls below 40 units. The turbidity of the original sample is then computed from the turbidity of the diluted sample and the dilution factor.
v. The water sample is placed into the AQ4500 Nephelometric Turbidity unit (NTU) and the reading, recorded.
The results of the analysis are shown as follows:

WELL WATER I
FEMALE INSIDE INDIANA HOSTEL

Parameter	Conc. of the tested value (ppm)	WHO Value (ppm)	Remark
Chromium	0.606	≤0.1	Toxic
Molybdenum	ND	≤0.01	Accepted
Selenium	ND	≤0.05	Accepted
Mercury	0.009	≤0.001	Toxic
Arsenic	0.013	≤0.01	Toxic
Magnesium	0.128	≤40	Accepted
Cobalt	0.039	≤0.002	Toxic
Iron	ND	≤0.3	Accepted
Nickel	ND	≤0.1	Accepted
Lead	ND	≤0.01	Accepted
Silver	0.124	≤0.1	Toxic
Manganese	0.070	≤0.3	Accepted
Zinc	ND	≤5	Accepted
Copper	0.004	≤2	Accepted
pH	5.66	6-8.5	Acidic
Turbidity (NTU)	1	0.1-4	Accepted
Conductivity (µs/cm)	24.8	≤400	Accepted

Ppm= part per million (mg/litre); ND = Not Detected; WHO = World Health Organization

WELL WATER II
FEMALE OUTSIDE INDIANA HOSTEL

Parameter	Conc. of the tested value (ppm)	WHO Value (ppm)	Remark
Chromium	0.192	≤0.1	Toxic
Molybdenum	ND	≤0.01	Accepted
Selenium	0.100	≤0.05	Toxic
Mercury	0.003	≤0.001	Toxic
Arsenic	ND	≤0.01	Accepted
Magnesium	0.080	≤40	Accepted
Cobalt	ND	≤0.002	Accepted
Iron	ND	≤0.3	Accepted
Nickel	ND	≤0.1	Accepted
Lead	ND	≤0.01	Accepted
Silver	0.022	≤0.1	Toxic
Manganese	0.453	≤0.3	Toxic
Zinc	ND	≤5	Accepted
Copper	ND	≤2	Accepted
pH	5.960	6-8.5	Acidic
Turbidity (NTU)	1	0.1-4	Accepted
Conductivity (µs/cm)	35.6	≤400	Accepted

Ppm= part per million (mg/litre); ND = Not Detected; WHO = World Health Organization

WELL WATER III
DIAMOND HOSTEL I

Parameter	Conc. of the tested value (ppm)	WHO Value (ppm)	Remark
Chromium	0.848	≤0.1	Toxic
Molybdenum	ND	≤0.01	Accepted
Selenium	ND	≤0.05	Accepted
Mercury	0.003	≤0.001	Toxic
Arsenic	ND	≤0.01	Accepted
Magnesium	0.070	≤40	Accepted
Cobalt	0.278	≤0.002	Toxic
Iron	0.422	≤0.3	Toxic
Nickel	0.194	≤0.1	Toxic
Lead	0.285	≤0.01	Toxic
Silver	0.003	≤0.1	Accepted
Manganese	ND	≤0.3	Accepted
Zinc	ND	≤5	Accepted
Copper	ND	≤2	Accepted
pH	5.51	6-8.5	Acidic
Turbidity (NTU)	1	0.1-4	Accepted
Conductivity (µs/cm)	45.8	≤400	Accepted

Ppm= part per million (mg/litre); ND = Not Detected; WHO = World Health Organization

WELL WATER IV
DIAMOND HOSTEL II

Parameter	Conc. of the tested value (ppm)	WHO Value (ppm)	Remark
Chromium	ND	≤0.1	Accepted
Molybdenum	0.050	≤0.01	Toxic
Selenium	ND	≤0.05	Accepted
Mercury	0.166	≤0.001	Toxic
Arsenic	ND	≤0.01	Accepted
Magnesium	0.078	≤40	Accepted
Cobalt	0.316	≤0.002	Toxic
Iron	0.156	≤0.3	Accepted
Nickel	0.508	≤0.1	Toxic
Lead	0.260	≤0.01	Toxic
Silver	0.014	≤0.1	Accepted
Manganese	0.019	≤0.3	Accepted
Zinc	ND	≤5	Accepted
Copper	ND	≤2	Accepted
pH	5.25	6-8.5	Acidic
Turbidity (NTU)	1	0.1-4	Accepted
Conductivity (µs/cm)	48.5	≤400	Accepted

Ppm= part per million (mg/litre); ND = Not Detected; WHO = World Health Organization

WELL WATER V
BARRACK HOSTEL I

Parameter	Conc. of the tested value (ppm)	WHO Value (ppm)	Remark
Chromium	ND	≤0.1	Accepted
Molybdenum	ND	≤0.01	Accepted
Selenium	ND	≤0.05	Accepted
Mercury	0.218	≤0.001	Toxic
Arsenic	ND	≤0.01	Accepted
Magnesium	0.041	≤40	Accepted
Cobalt	0.114	≤0.002	Toxic
Iron	ND	≤0.3	Accepted
Nickel	0.110	≤0.1	Accepted
Lead	ND	≤0.01	Accepted
Silver	ND	≤0.1	Accepted
Manganese	ND	≤0.3	Accepted
Zinc	ND	≤5	Accepted
Copper	ND	≤2	Accepted
pH	4.62	6-8.5	Acidic
Turbidity (NTU)	1	0.1-4	Accepted
Conductivity (µs/cm)	45.1	≤400	Accepted

Ppm= part per million (mg/litre); ND = Not Detected; WHO = World Health Organization

WELL WATER VI
BARRACK HOSTEL II

Parameter	Conc. of the tested value (ppm)	WHO Value (ppm)	Remark
Chromium	ND	≤0.1	Accepted
Molybdenum	ND	≤0.01	Accepted
Selenium	ND	≤0.05	Accepted
Mercury	0.002	≤0.001	Toxic
Arsenic	ND	≤0.01	Accepted
Magnesium	0.024	≤40	Accepted
Cobalt	0.147	≤0.002	Toxic
Iron	0.698	≤0.3	Toxic
Nickel	ND	≤0.1	Accepted
Lead	0.205	≤0.01	Toxic
Silver	ND	≤0.1	Accepted
Manganese	ND	≤0.3	Accepted
Zinc	ND	≤5	Accepted
Copper	ND	≤2	Accepted
pH	5.28	6-8.5	Acidic
Turbidity (NTU)	5	0.1-4	Turbid
Conductivity (µs/cm)	41.6	≤400	Accepted

Ppm= part per million (mg/litre); ND = Not Detected; WHO = World Health Organization

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WELL WATER VII
MALE INDIANA HOSTEL I

Parameter	Conc. of the tested value (ppm)	WHO Value (ppm)	Remark
Chromium	0.145	≤0.1	Toxic
Molybdenum	0.100	≤0.01	Toxic
Selenium	ND	≤0.05	Accepted
Mercury	0.002	≤0.001	Accepted
Arsenic	ND	≤0.01	Accepted
Magnesium	ND	≤40	Accepted
Cobalt	0.095	≤0.002	Toxic
Iron	0.613	≤0.3	Toxic
Nickel	0.313	≤0.1	Toxic
Lead	0.093	≤0.01	Toxic
Silver	ND	≤0.1	Accepted
Manganese	ND	≤0.3	Accepted
Zinc	ND	≤5	Accepted
Copper	ND	≤2	Accepted
pH	4.94	6-8.5	Acidic
Turbidity (NTU)	1	0.1-4	Accepted
Conductivity (µs/cm)	26.0	≤400	Accepted

Ppm= part per million (mg/litre); ND = Not Detected; WHO = World Health Organization

WELL WATER VIII
MALE INDIANA HOSTEL II

Parameter	Conc. of the tested value (ppm)	WHO Value (ppm)	Remark
Chromium	ND	≤0.1	Accepted
Molybdenum	ND	≤0.01	Accepted
Selenium	0.100	≤0.05	Toxic
Mercury	0.002	≤0.001	Toxic
Arsenic	ND	≤0.01	Accepted
Magnesium	0.023	≤40	Accepted
Cobalt	0.055	≤0.002	Toxic
Iron	0.545	≤0.3	Toxic
Nickel	ND	≤0.1	Accepted
Lead	0.257	≤0.01	Toxic
Silver	ND	≤0.1	Accepted
Manganese	0.034	≤0.3	Accepted
Zinc	ND	≤5	Accepted
Copper	ND	≤2	Accepted
pH	4.98	6-8.5	Acidic
Turbidity (NTU)	5	0.1-4	Turbid
Conductivity (µs/cm)	34.6	≤400	Accepted

Ppm= part per million (mg/litre); ND = Not Detected; WHO = World Health Organization

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DISCUSSION

The research was able to reveal that none of the wells is completely free from these toxic metals but some of the wells are the most toxic because of the high concentration of Chromium, Mercury, Arsenic as in the case of Well 1 and Chromium; Mercury and Lead as in the case of Well 3. Out of the most dangerous toxic metals such as Chromium, Mercury, Arsenic and Lead, Well 1,2,3,7 all contain Chromium while Well 3, 4,6,7,8 all contain Lead. In terms of toxicity, it is only Well number 5 with Mercury that is the safest. In terms of pH, Well number 1, 2, 3 are all very close to the acceptable pH of drinking water so there is no much problem with them with respect to acidity. All the Well water is good in terms of Conductivity. The concentration of Magnesium in the whole Wells is ok. Out of the lot, it is only Well 6 and 8 that are turbid. The treatment method(s) that can be applied to the affected Well water is recorded in the Conclusion of the research.

CONCLUSION

Chromium can be removed from drinking water by **Reverse Osmosis**. Reverse osmosis works by forcing the water through a membrane that allows water molecules to pass through but blocks larger ions, such as ones associated with chromium.
Arsenic can be removed from drinking water by reverse osmosis or by adsorption filters designed for arsenic removal. Reverse osmosis works by forcing the water through a membrane that allows water molecules to pass through but blocks larger ions, such as ones associated with arsenic. Arsenic poisoning can cause a number of different ailments, including both acute and chronic (long-term) symptoms. Some of the long-term symptoms include increased risk of cancer (lung, bladder and skin), high blood pressure, heart disease, and discoloration and thickening of the skin, and there is evidence that overexposure to the chemical may lower the Intelligent Quotient (IQ) of children.
Concerned well owners should have their water tested by a certified drinking water laboratory. If unsafe levels are in the well water, then one has a number of possible options:

- Connect to a municipal water supply.
- Modify your well to draw water from an aquifer with lower levels of arsenic.
- Use bottled water for drinking and cooking.
- Treat your drinking water to remove it.

Removal of Copper from Well Water

This can be done by using **Ion exchange filter** which works by removing copper ions by adsorbing them onto mineral particles or resins. This takes place in filter cartridges, which may be part of point-of-use systems. These filters must be replaced periodically to maintain their effectiveness over time.

Removal of Iron and Manganese from Well Water

The treatment of water for iron and manganese depends on the source and type of iron and manganese. If corrosion is the source of iron, raising the pH of the water may be a simple option. Another option that may be used is drilling the Well to a dipper depth. Otherwise, water treatment systems may be used, depending on the type of iron and manganese. Oxidizing filters are made of manganese or zeolite coated with manganese oxide. These filters absorb iron and manganese from the water by converting them to an oxidized form and causing them to precipitate in the filter. These filters must be periodically backwashed to remove the deposited iron and manganese.

Removal of Lead from Well water

Lead can be removed from water by one of several different methods, including **Reverse Osmosis** (RO), distillation, ion exchange filtering, and granulated activated carbon filtering. Reverse osmosis works by forcing the water through a membrane that allows water molecules to pass through but blocks larger ions, such as ones associated with Lead. **Reverse Osmosis Systems** are cost-effective, but they are somewhat slow and can only produce up to 50 to a 100 gallons of treated water each day. The taste of the water will also be affected by the removal of the minerals.
Granulated Activated Carbon (GAC) filters are the least expensive and are simple to use. They can take the form of point-of-use systems or pitchers filled with water manually. However, their effectiveness is sensitive to water pH, and they are most effective at near-neutral pH (pH near 7).

Removal of Mercury from Water

Both inorganic and organic forms of mercury are especially harmful to children, whose bodies more easily absorb mercury. Exposure to high levels of mercury can also damage the brain and developing foetuses. Mercury poisoning is often associated with irritability, tremors, and problems with vision, hearing or memory.
If mercury is present in the well water, one needs to drill a deeper well, tap into a different aquifer, or connect to a municipal water supply. Alternatively, one can treat the water to remove mercury. Mercury can be removed from water by Granulated Activated Carbon (GAC) filters. **Granulated Activated Carbon** (GAC) filters are inexpensive and simple to use. They can take the form of point-of-use systems or pitchers manually filled with water. Their effectiveness is sensitive to water pH, and they are most effective at near-neutral pH (pH near 7). These filters need to be replaced periodically to maintain their effectiveness over time.
Silver, Molybdenum, Selenium, Cobalt, Nickel, Zinc, can be removed from water by the method of World Health Organization of **who.int.**

Recommendation

It is recommended that those wells that have greater number of toxic metals in them should be left completely and another well dug or some of the suggested methods of well water treatment as recorded in this work be applied before the water from the well can be used so that it will not continue to pose life threat to the users especially the hostellers.
More research should be carried out in the determination of Cadmium in the Wells because it was not covered in this research.

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