Heavy Metals Assessment (Zn, Cr, N, Cu) Content of Used Borehole Water in General Hospital, Calabar, Cross River State, Nigeria

Otu, Michael Abang
Department of General Studies,
College of Health Technology,
Calabar, Cross River State. Nigeria
Email: Mykab2002@Yahoo.Com

Elijah Eghong Ivi
Department of Environmental Health,
College of Health Technology, Calabar,
Cross River State, Nigeria
elijaheghong@yahoo.com

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Abstract

Heavy metals refer to any metallic chemical element that has relatively high density and toxic at even low concentration values. Examples include Thallium, Lead, Chromium, Aluminium, Mercury, Copper etc. They are usually called trace elements with a worldwide public issue. They are claimed to have caused fatality in about more than 1.8million lives especially in infants. There are evidences that these metals are usually present in most drinking sources of water like boreholes, and food chain contamination. This research work is carried out to investigate the presence and concentration of some of these metals in borehole water used in the General Hospital in Calabar Metropolis of Cross River State. Selected heavy metals for determination were Chromium, Aluminium, Zinc and Copper. The study determined whether the Borehole water of General Hospital, Calabar consist of Chromium (Al), Zinc (Zn) and Copper (Cu) and if their concentrated level exceeds the recommended standard by World Health Organization (WHO). Four hypotheses were stated for the study.The research used an experimental design. Samples were systematically and carefully collected, proper laboratory analysis were done to ascertain the objective of the study. Water samples were collected from 5 overhead tanks through 5 taps and transported to the Laboratory for analysis. The results obtained are as shown below. Minimum range for chromium was 0.01mg/L, maximum range was 0.03 mg/L, variation was 0.01mg/L – 0.03mg/L, Mean was 0.01mg/L and the WHO stipulated standard for Chromium in water is 0.05mg/L. For Aluminium, minimum range is 0.01mg/L and maximum range is 0.13mg/L. The variation was 0.01mg/L – 0.13mg/L. Mean was 0.09mg/L. For Zinc, minimum range was 0.15mg/L, maximum range 0.17mg/L, the Mean was 0.16mg/L and WHO stipulated standard for Zinc in water meant for human consumption is 3.0mg/L. Also for Copper, minimum range was 0.04mg/L and maximum range was 0.010mg/L. The variation is from 0.04 – 0.10mg/L. The Mean was 0.07mg/L and WHO standard is 2.0mg/L. The findings showed that the Borehole water used *in General Hospital, Calabar is not highly dosed with Chromium, Aluminium, Zinc and Copper as compared with WHO recommended standard. It was recommended that adequate and proper measures be adapted to maintain the water standard and to avoid future contamination of the Hospital source of water with heavy metals to avoid deleterious effect on health of users.*

Keywords: *Chromium, Aluminium, Zinc and Copper*

Introduction

Industrial activities over the years have caused severe increase in human exposure to heavy metals. Mercury, Aluminium, Zinc, Chromium, Cadmium and arsenic have been the most common among heavy metals induced poisoning in humans. Acute or chronic poisonings may occur due to exposure through water, air and food. Bioaccumulation of these metals could lead to toxic effects on a variety of body tissues and organs. This is through disruption of cellular activities like growth, body repairing processes and apoptosis (Mahdi, Kobra, Zoya, Mohammed and Mahmood, 2021).

Contamination of water and air by poisonous metals is an environmental concern and hundreds of millions of people are being affected around the world (Luo, Wang, Jian, Huang and Li, 2020). Some heavy metals such as Copper, Selenium, Zinc are essential to maintain the metabolism of the body, but when in a higher concentration can lead to poisonous conditions. Heavy metals can enter a water supply or from acidic rain breaking through soil, and releasing metals into streams, lakes, rivers, ground water and municipal water supply in some cases.

Heavy metals have become of particular interest in recent times within the framework of environmental investigation. Pure water does not exist in nature. Streams and rivers collect impurities from surface run-off and through the discharge of sewage and industrial effluents (AJEST, 2013). It is known that there are millions of people with health related illnesses due toheavy metal poisoning which is now a worldwide public health concern. While about an estimated 1.8million children die globally in a year from diseases attributed to drinking heavy metal contaminated water through food chain contamination (Chen, 2006).

There have been several efforts to offering affordable and healthy drinking water globally through several government interventions, with various laws and regulations to protect and improve the utilization of drinking water resources. Despite all these efforts, there are still challengesbeing experienced in securing safe water supply. This situation can be attributed to several factors of
which the presence of heavy metals and it's contamination is a major factor (Harris, 2000).

Based on these, the study seeks to assess the nature of water quality being used in the Calabar General Hospital community and to suggest ways to bring to the lowest level health risk that may be associated with toxic metal contamination in drinking water, especially borehole water used in the General Hospital, Calabar.

Water is used in every area of life endeavour or institutions. In General Hospital, Calabar, water plays a key role in the activities of life of both staff and patients in the hospital. Although availability of water may not be a serious problem within the said environment, it may be a problem finding good quality fresh water at the required quantity within the Hospital.

Drinking water should be suitable for human consumption. The need for quality water in daily living makes it necessary that water examination should be carried out before usage and periodically analyzed to determine levels of heavy metals before use.

However, the General Hospital Calabar Borehole is not subjected to this periodical test. Based on this, there is possibility of corrosion of the metallic taps. The researcher found out that over the years, water used within the hospital premises has not been analysed to determine it's parameters in line with set standards by World Health Organization. Meanwhile, exceeded levels of heavy metals such as As, Pb, Cu, Al, Hg, Cd and Cr consumed through water has been implicated in healthissues such as brain damage, gastro-intestinal disturbances, inflammation of the brain and spinal cord, fatigue, numbness of the limbs, speech impairment, cancer, coma and death. It is based on the aforementioned health risks that the researcher was motivated to conduct this study to assess the concentration of heavy metals in bore-hole water used in General Hospital so as to proffer necessary recommendations on possible measures of preventingcontamination caused by metals present in borehole water used in the hospital.

Heavy metals enter our bodies through food, drinking water and air as trace elements. Heavy metals are dangerous becausethey tend to bio- accumulate in living organisms (Jones,2004; Sabine, 2004).

Major anthropogenic sources of heavy metals are industrial wastes from mining sites, manufacturing and metal finishing plants, domestic water and run-off from roads. High exposure and intake of these metals poses health risks like kidney and liver damage, acute and chronic poisoning, irregularity in blood composition and damage to the central nervous system (Shuval, 2005).

Chromium is found in natural deposits containing other elements. It is used in metal alloys and pigments of paints, cement, paper, rubber and other materials. Low level exposure can irritate the skin causing ulceration, while long-term exposure can cause damage to the kidney,liver, circulatory and nerve tissues. Chromium often accumulates in aquatic life, adding to the danger of eating fish that may have been exposed to high levels of chromium (Winter, 2003).

Aluminum metal is used as a structure material in the construction of automotive and air-craft industries, production of metal alloys, in electric industries, cooking utensils and in food packaging. Aluminum compounds are used as antacids, antiperspirants, food additives, and widely used in water treatment as a coagulants to reduce organic matter, colour, turbidity and microbial load (Kathrin and Walter, 2018). Aluminum can occur in a number of forms in water. The chemistry of aluminum in water is complex with several parameters including pH, which determine the specie present in aqueous solution (CCME, 1998; ISO, 1994). Aluminum level in drinking water varies according to the levels found in the water source and whether aluminum coagulants are used during water treatment. The average aluminium concentration in treated water facilities range from 0.01-1.3mg/L with an overall average of 0.16mg/L.

It has been hypothesized that aluminum exposure is a risk factor for the development and several health challenges including nausea, vomiting, diarrhea, mouth ulcers, skin ulcers, rashes, Alzheimers disease and arthritic pain (WHO, 2011, Clayton, 1989).

Zinc occurs in small amount in almost all igneous rocks. Water containing zinc at concentration range of 3-5mg/litre tends to appear opalescent and may develop a greasy film when boiled. In naturalsurface water, the concentration of zinc is usually below 10kg/L and in ground water between 10-40mg/Litre. In tap water, zinc concentration would be much higher due to the leaching of zinc from pipings and fittings (Solomons, 2003; Chanda; 2006 and Elinder, 2002).

Samman (2009) opined that the most corrosive waters are those of low pH, high carbondioxide content, and low mineral salt contents. In a finish survey of about 67% of public water supplies, the median zinc content in water samples taken upstream and downstream of the waterworks was below 20mg/litre. Much higher concentration were found in tap water, the highest being 1.1mg/litre (WHO, 2011).

Drinking water usually makes a negligle contribution to zinc intake unless high concentration of zinc occurs as a result of corrosion from pipes and fittings. Under certain circumstances, tap water can provide up to 10% of the daily intake of zinc (Prassad, 2000).

Potter (2006) states that excretion of zinc takes place mainly through urine and sweat. Long-term exposure to zinc causes toxicity in mammals and can also lead to cancer in humans. Acute toxicities arises from the ingestion of excessive amount of zinc. Vomiting usuallyoccurs after the consumption of more than 500mg of zinc. Other symptoms associated with zinc poisoning include fever, nausea, stomach cramps and diarrhea (Chin, 2006).

Copper is a transition metal that isstable in it's metallic state. Dissolved copper can sometimes impart light blue or green collogue and an unpleasant metallic, bitter taste to drinking water (Zacarias, 2001). The fate of elemental copper in water is complex and influenced by pH, dissolved oxygen, presence of oxidizing agents and chelatingcompounds or ions. The most important analytical methods for detection of copper in water is the Atomic Absorption spectrometry (AAS) (Zacarias, 2001). Copper is found in surface water, groundwater, sea and drinking water, but it is primarily present in particulate matter or complexes (ATSDR, 2002).

Copper concentrations in drinking water often varies and increases especially in systems with an acid pH or high carbonate waters with an alkaline pH.Results from a number of studies indicate that copper levels in drinking water can range from <0.05to >30mg/litre with the primary source most often being from corrosion of interior copper plumbings.

Consumption of standing or partially flushed water froma distribution system that includes copper pipes or fittings can considerably increase total daily copper exposure, especiallyfor infants fed formula reconstituted with the water (Linder, 1996). The highest concentrations of under normal conditions are found in the liver, brain, heart and kidneys, with moderate levels found in the intestine, lung and spleen, excluding hair and nails (Harris, 2000).This study thereforeinvestigates heavy metals assessment (Zn, Cr, N, Cu) content of used borehole water in General Hospital, Calabar, Cross River State, Nigeria.

Methodology

An experimental study design was adopted. This was carried out by the careful and systematic collection of samples and their analysis in the laboratory. Laboratory procedures were strictly followed during analysis to arrive at the result.

General hospital Calabar is a healthcare providing institution located in Calabar South Local Government Area of Cross River State. The hospital has the laboratory, mortuary,emergency and accident ward, Intensive care unit, female ward, male ward, children ward, family-planning unit, and post natal care ward. The hospital has 100 (one hundred) staff that helps in the effective running of the hospital.

The hospital has (3) three boreholes that supply water to the 5-over head tanks. The study that constitute the sample sizewas (3) three borehole stands, (5) five over head tanks / stands and (15) fifteen taps for the collection and delivery of the water.

The researcher sampled the whole taps found in the premises of the hospital, since the numbers of taps were not too many to leave any of the tap unturned. However, the taps are strategically located at different parts of the hospital, such as 3 three taps around the theater block (3) three other taps around the female ward, (3) three taps at the male ward, three (3) taps at the children ward and three taps around the food vendor stand making a total number of (15) fifteen taps in the entire compound of the hospital.

During collection of water sample for analysis, the following methods were used:

- The researcher washed his hand thoroughly with soap and water to discourage fresh contamination at the collection point
- Sterilized the mouth of the tap with methylated spirit soaked in cotton wool to ensure sterilization of the tap.
- Turn the tap and allow the water to run for few minutes, to allow for the collection of cool water rather than hot water.
- Rinse the bottles with the water to be sampledtwice.
- Gently collect the water sample 2cm below the mouth of the tap and cover it with a tin foil.
- Proper labeling of the samples collected
- Placedthe bottlesinto the kit after labeling and transported to the laboratory for analysis.

During the collection of samplesto the laboratory for analysis, the materials used included: water sampling kits (insulated bag), water sampling bottles, cover (tin foil), lighter, methylated spirit, cotton wool, soap, handkerchief/small clean towel, masking tape, marker,(in the Laboratory for sample Analysis) pH meter, conductivity meter, turbidity meter, spectrophotometer, cuvette, Beaker, probe, Aspirator, syringe, distilled water, scissors, bowl, Reagents for the different Heavy Metals to be studied, Test tubes, Tissue paper.

Before the analysis, the instrument (spectrophotometer) was properly calibrated to ensure accurate reading, the instrument required proper timing before readings starts.

- The samples were properly labeled to avoid misplacement and changes of the water sample
- The test tubes were properly washed and arranged in the test tube rack for proper labeling
- The test tubes and beakers to be used was rinsed with distilled water before each use. The ph meter was properly calibrated before analysis to get accurate results
- The probe was properly rinsed with distilled water after each test before using it for another test.
- The cuvette was cleaned with tissue paper, to clean off the finger print.

Chromium Test in Water Sample

- Prepared sample: one content of chromaver (R) (3) R.power pillow was "added to the sample cell. It was swirled to mix a purple colour was formed showing that hexavalent chromium is presents.

Results and Analysis

Thedatapresented and results analyzedby the researcher. Different tables show how different results analysis conducted through getting the mean of the data from different taps as seen in various wards of the hospital.

Table 4.1:Taps analyzed and the Metals studied

No of Taps	Chromium (mg/l)	Aluminum (mg/l)	Zinc (mg/l)	Copper(mg/l)
TH1	0.016	0.13	0.16	0.05
TH2	0.046	0.09	0.17	0.16
TH3	0.015	0.15	0.18	0.02
FW1	0.009	0.08	0.14	0.05
FW2	0.008	0.09	0.15	0.02
FW3	0.008	0.08	0.16	0.06
MW1	0.013	0.07	0.18	0.05
MW2	0.015	0.07	0.17	0.05
MW3	0.016	0.09	0.16	0.05
CW1	0.009	0.09	0.15	0.13
CW2	0.007	0.12	0.18	0.06
CW3	0.011	0.11	0.16	0.06
FV1	0.010	0.14	0.16	0.12
FV2	0.016	0.13	0.17	0.13
FV3	0.009	0.12	0.16	0.06

Table 4.2 showing the mean of the result of water analysis collected from Theatre section (unit) of General Hospital Calabar

No of Taps	Chromium (mg/l)	Aluminum (mg/l)	Zinc (mg/l)	Copper (mg/l)
TH1	0.016	0.13	0.16	0.05
TH2	0.046	0.09	0.17	0.16
TH3	0.015	0.15	0.18	0.02
Total	0.077	0.37	0.51	0.23
	3	3	3	3
Mean=x= £x/n =	0.02566667	0.12333333	0.17	0.7666667

Table 4.3 showing the mean of the result of water analysis collected from Female Ward of the Hospital

No of taps	Chromium (mg/l)	Aluminum (mg/l)	Zinc (mg/l)	Copper (mg/l)
FW1	0.009	0.08	0.14	0.05
FW2	0.008	0.09	0.15	0.02
FW3	0.008	0.08	0.16	0.06
Total	0.025	0.25	0.45	0.13
Divided (*r)	3	3	3	3
Mean = x = £x/n =	0.0083333	0.0833333	0.15	0.0433333

Table 4.4 showing the mean of the results of water analysis collected from Male Ward of the Hospital

No of Taps	Chromium (mg/l)	Aluminum (mg/l)	Zinc (mg/l)	Copper (mg/l)
MW1	0.013	0.07	0.18	0.05
MW2	0.015	0.07	0.17	0.05
MW3	0.016	0.09	0.16	0.05
Total	0.044	0.23	0.51	0.15
(-)	3	3	3	3
Mean-v =x = £x/n =	0.0146667	0.0766667	0.17	0.05

Table 4.5 showing the mean of the results of water analysis collected from Children Ward of the Hospital

No of taps	Chromium (mg/l)	Aluminum (mg/l)	Zinc (mg/l)	Copper (mg/)
CW1	0.009	0.09	0.15	0.13
CW2	0.Q07	0.12	0.18	0.06
CW3	0.011	0.11	0.16	0.06
Total	0.027	0.32	0.49	0.25
(+)	3	3	3	3
Mean = x = £x/n	0.009	0.1066667	0.163333 3	0,083333 3

Table 4.6 showing the mean of the results of water analysis collected from Food Vendor section of the Hospital

No of taps	Chromium (mg/l)	Aluminum (mg/l)	Zinc (mg/l)	Copper (mg/l)
FV1	0.10	0,14	0.16	0.12
FV2	0.016	0,13	0.17	0.13
FV3	0.009	0,12	0.16	0.06
Total	0.035	0,39	0.49	0.31
(+)	3	3	3	3
Mean= x = £x/n -	0.0116667	0.13	0.1633333	0.1033333

Table 4.7 showing concentrations of Bore-Hole water samples converted into two decimal places (points)

Heavy Metals	SELECTED BORE HOLE SITES				
	Theatre	Female Ward	Male Ward	Children Ward	Food Vendor
Chromium (mg/l)	0.03	0.01	0.01	0.01	0.01
Aluminum (mg/l) '	0.12	0.01	0.08	0.11	0.13
Zinc (mg/l)	0.17	0.15	0.17	0.16	0.16
Copper (mg/D	0.08	0.04	0.05	0.08	0.10

Table 4.8 showing Heavy Metal concentration of bore-hole water samples in General Hospital Calabar comparation with World Health Organization Maximum Acceptable Limit

Heavy metals	Range		Mean	WHO Maximum Acceptable Limits
	Minimum	Maximum		
Chromium	0.01	0.03	0.01	0.05
(mg/l)				
Aluminum	0.01	0.13	0.09	0.09
(mg/l)				
Zinc (mg/l)	0.15	0.17	0.16	3.0
Copper	0.04	0.10	0.07	2.0
(mg/l)			-	

TH - Theatre
Fv - Food vendors
Fw - Female wards
Mw - Male wards
C/w - Children wards

Summaries of Descriptive statistics

Hypothesis One

$_{Ho}$: The level of chromium content in bore hole water used in General Hospital Calabar does not exceed the recommended standard as set by World Health Organization

H_1: The level of chromium in bore hole water used in General Hospital Calabar exceeds the recommended standard as set by World Health Organization

If calculated mean is greater than recommended standard set by World Health Organization, accept $H_1$and reject Ho.

The calculated mean is less than the recommended standard, the researcher rejects H_1 and accepts H_o.

Conclusion: The level of chromium in bore hole water used in General Hospital Calabar does not exceed the recommended standard set by World Health Organization.

Hypothesis Two

H_1: The level of Aluminum in bore hole water used in Genera! Hospital Calabar exceeds the recommended standard as set by World Health Organization.

Ho: The level of Aluminum in bore hole water used in General Hospital Calabar does not exceeds the recommended standard as set by World Health Organization (WHO).

If calculated mean is greater than recommended standard as set by World Health Organization, accept Ha and reject Ho.

Decision Taken: Since the calculated mean of Aluminum is not higher than the recommended set standard by World Health Organization, the researcher rejects Ha and accepts Ho.

Conclusion: The researcher therefore concludes that, the level of Aluminum in borehole water used in General Hospital

Calabar does not exceeds the recommended-standard as set by World Health Organization (WHO).

Hypothesis Three

H_1; The level of zinc in bore hole water used in General Hospital Calabar exceeds the recommended standard set by World Health Organization (WHO).

Ho: The level of zinc in bore hole water used in General Hospital Calabar does not exceed the recommended standard as set by World Health Organization,

Decision Rule: If the calculated mean is greater than recommended standard set by World Health Organization, accept Ha and reject Ho.

The calculated mean is less than the recommended standard, the researcher, rejects H_1 and accepts Ho.

conclusion: the researcher therefore concludes that, the level of chromium in bore-hole water used in General Hospital Calabar, does not exceed the recommended standard as set by World Health Organization (WHO).

Hypothesis Four

H_1: The level of copper in bore-hole water used in General Hospital Calabar exceeds the recommended standard set by World Health Organization.

Ho: The level of copper content in bore-hole water used in General Hospital Calabar- does not exceed the recommended set standard by World Health Organization.

Conclusion: The researcher therefore concludes that, the level of copper in bore hole water used in General Hospital Calabar, does not exceed the recommended set standard by World Health Organization.

Discussion of findings

The research focused on the level ofselected Heavy Metals in bore-hole water used in General Hospital Calabar. Fourhypotheses were formulated and analyses carried out to achieveresults that will form bases for this discussions.

The level of chromium (Cr) in bore-hole water used in General Hospital Calabar does not exceed recommended standards as set by the World Health Organization (WHO).

The laboratory analysis showed that the level of chromium in each of the collection tap was 0.01mg/l,(as the mean), the result varies from 0.01mg/l minimum to0.03mg/l maximum (in range) as shown in table eight (8), the WHO recommended standard (2011) is 0.05mg/l. This result agree to the fact that bore hole water used in General Hospital Calabar does not havechromium which exceed the recommended standard set by World Health Organizationand this is in line with Provin (2002) which said that Chromium within the recommended limit in drinking water is essential in human nutrition to maintain the normal glucose metabolism in human body. WHO (1996) also suggested that ingestion of Chromium in large amount in drinking water cancause stomach upsets and ulcers, convulsion, kidney, and liver damage which can also even lead to deaths of the exposed population.

Findings from hypotheses four showed that the levels of Aluminum (Al) in bore hole-water used in General Hospital Calabar did not exceed recommended standard as set by the World Health Organization.

The laboratory analysis showed that the level of Aluminum in each of the collection tap was 0.09 mg/l (as the mean) the result varies from 0.01mg/l (minimum) to 0.13 (maximum;) as shown in table eight (8).The World Health Organization (WHO) recommended standard (2011) is 0.09mg/l.

The result when compared with World Health Organization recommended standard showed that Aluminum content in borehole water used in General Hospital Calabar did not exceed the recommended standard, rather, it is in line with the stipulated standard from WHO recommendation. This is in support with Driscoll (1988) contribution which says that there is little indication that Aluminum is acutely toxic by oral exposure despite its widespread occurrence in foods, drinking water and many antacid preparations. WHO (1997) stated also that exposure to water supply system containing Aluminum, is attributed to the following health defects including nausea, vomiting, diarrhea, mouth ulcers, skin ulcers, skin rashes and arthritic pain.

The researcher suggests that Aluminum presence in water to be used should not be neglected rather, there should be strict adherence to the recommended standard set by World Health Organization to avoid health effects that results from excessive intake of water highly filled with Aluminum content.

In Hypothesis three, the level of Zinc (Zc) in bore hole water used in General Hospital Calabar did not exceed recommended standard as set by the World Health Organization.

The laboratory analysis carried out showed that the level of zinc in each of the collection tap was 0.16mg/l as the mean, the result varies from 0.15mg/l minimum to 0.17mg/l maximum as shown in table eight (8), the World Health Organization (WHO) recommended standard (2011) is 3.0mg/l

Findings from hypotheses three revealed that bore hole water used in General Hospital Calabar does not have zinc content in large quantity as to exceed the recommended standard set by WHO.The result when compared with World Health Organization recommended standard is in line with Chen (2006) which said that acute toxicity arises from the ingestion of excessive amount of zinc in drinking water, either by accidentally or deliberately. Torrance (2001) also said that mass poisoning has been reported following the drinking of water containing much dose of zinc kept in galvanized containers and stressed that health challenges such as fever, nausea, vomiting, stomach cramps and diarrhea could occur after ingestion of such water and further asserts that issues like death from cancer and cardiovascular disease is not exempted from such trend of exposure. Vavo (2002) also recommended that drinking water containing zinc at levels above 3.00mg/litter tends to be opalescent, develops a greasy film when boiled and has an undesirable astringent taste when drinked into human system.

Based on the results from the analysis and Torrance (2001) contribution, The research suggests overhead tanksthat are used to store borehole water should be periodically analysed to ensure that the content of water in it does not favour the escalation of zinc level found in the bore hole water used which can lead to the above suggested health risks.

In Hypothesis four, the level of Copper (Cu) In bore hole water used in General Hospital Calabar did not exceed recommended standard as set by the World Health Organization.The laboratory analysis carried out showed that the level of Copper in each of the collection taps was 0.07mg/l (as the mean) the result varies from 0.04mg/l minimum to 0.10mg/l maximum as shown in table eight (8), the World Health Organization (WHO) recommended standard (2011) is 2.0mg/l.The result agreed that bore hole water used in General Hospital Calabar does not have copper inlarge quantity as to exceed the recommended standard set by WHO

The result when compared with World Health Organization recommended standard showed that copper contained in bore hole water used in General Hospital Calabar does not exceed the recommended standard, rather it is in line with the imput made by Linder (1999) which said that drinking water contributes O.lmg/day copper intake for adults consumption of standing or partially flushed water from a distribution system that includes copper pipes or fittings can considerably increase total daily copper exposure, especially for infants fed from water reconstituted from the tap. Luza and Speisky (1996) also gave out the places in the body where copper-concentration can be seen; they includes in the hairs, liver, brain, heart, and kidney, with moderate concentrations found in the intestine, lung and spleen.

Conclusion

The implication of the study could be drawn from the fact that the presence of heavy metals in high level as compared to set standard is very dangerous to health and can lead to numerous health problems. The study reveals the levels of Chromium, Aluminum, Zinc, Copper in the bore hole water used by both workers and patients of General Hospital Calabar.

Following the result gotten from the laboratory analysis and recommended set standard by World Health Organization, on chromium, Aluminum, Zinc, Copper, the result shows that non ofthe heavy Metals exceed the set recommended standard, which indicates that the water is not contaminated with any of the above-mentioned chemicals (Heavy Metals) and it fit for consumption and other relevant uses.

Recommendations

Based on the findings, there should be regular analysis of borehole water to ascertain the level of Heavy Metals in the water is maintained to conform to the set standard by World Health Organization.

1. Physical analysis should also be carried out on the bore-hole water to determine the level of physical parameters on the same water in relation to the recommended standard.
2. Wider variables of Heavy Metals should be studied to verify the level of those chemicals (metals) in the bore-hole water, related to World Health Organization set standard for such Heavy Metals.
3. Further studies should be carried on the bore hole water to assess the bacteriological status of the water used in General Hospital Calabar as it will help to ensure that the water is fit forhuman consumption and uses in all ramifications.
4. More research work should be done on the water in subsequent time to check whether it will correlate with the same result gotten form the researcher's result.

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