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International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Heavy Metal Assessment in Domestic Water at Chalimbana University and Surrounding Areas

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DOI : https://doi.org/10.55248/gengpi.6.0125.0606

A B S T R A C T

The study investigated the concentration of selected heavy metals in domestic water at Chalimbana University and its surrounding area. Water was sampled from three bores and samples were tested and results show that the concentration of lead in the three samples was higher than the WHO permissible limit of 0.015ppm. As for cadmium, sample A was more than the threshold by only 0.0011ppm. Samples B and C's concentrations were both lower than the WHO threshold. Copper had all the three samples within the permissible limits, 0.0068, 0.2532 and 0.0766 respectively. Finally, chromium had all the samples (0.0198. 0.004 and 0,0039) beyond the threshold (0.003). Chromium is next though the difference with the WHO threshold is smaller than lead. Copper was below the permissible limit in all the three samples. Considering the threshold values, the water at Chalimbana University and surrounding area is not fit for human consumption on account that lead and chromium that were beyond the WHO permissible limit.

Keywords: Heavy metals, concentration, threshold.

1. Introduction

Access to safe drinking water across the globe remains a major public health concern. A Joint report by World Health Organization and United Nations' Children Fund (WHO/UNICEF., 2017) report that 2.1 billion people do not have access to safe water on a global scale. One of the factors impeding access to safe drinking water is heavy metal contamination of water bodies. Heavy metals exist in rocks under the ground. They are exposed to the environment by human activities through farming, mining, industrial activities, among others. They are introduced into drinking water via runoffs and seepage from the soil into the water bodies and finally groundwater (Morais et al., 2012). Among the most dangerous heavy metal contaminants of ground water is arsenic, cadmium, chromium, mercury and lead. Therefore, monitoring these metals in water is important for public health safety.

Effects of heavy metals in drinking water to human health

Lead: Lead is a highly toxic metal that can cause serious health problems, especially in children. It can affect the development of the brain and nervous system, leading to learning disabilities, decreased IQ, and unacceptable behavioral issues. In adults, lead exposure can cause kidney damage, high blood pressure, reproductive problems, and an increased risk of cardiovascular diseases.

Cadmium: Cadmium is a cumulative toxicant that primarily affects the kidneys. Prolonged exposure to cadmium in drinking water can lead to kidney damage and increase the risk of kidney diseases. It may also cause bone demineralization, leading to osteoporosis, and has been associate

Chromium: Hexavalent chromium (Cr (VI)) is a known carcinogen that can increase the risk of lung cancer when ingested through drinking water. It can also cause respiratory problems, skin irritation, and liver and kidney damage. International Agency for Research on Cancer. (2012).

Copper: Copper is an essential mineral for human health and at the same time can be toxic, depending upon the amounts ingested. It is associated with bone health, immune function and increased frequency of infections, cardiovascular risk, reproductive problems/child development and alterations in cholesterol metabolism (EPE, 1998).

Chalimbana university is in Chongwe district where mining activities of different minerals are emerging. Therefore, researchers saw need to investigate the quality of domestic water at the institution in order to ascertain the water quality. Review of related literature showed that there was no published study on this topic that was conducted at the institution.

1.1 Statement of the problem

The status of domestic water at Chalimbana University and the surrounding area is unknown since there is no published information. Therefore, this study investigated the concentration levels of lead, cadmium, copper and chromium in order to ascertain the safety of the water consumed by students,

and villages around the university. Therefore, the purpose of the study is to determine the concentration of heavy metals in drinking water sources of Chalimbana area and their potential human health risks.

1.2 Objectives of the study

1. To determine the concentrations of copper, cadmium, chromium and lead
2. To assess the potential human Health risks associated with heavy metal exposure through drinking water consumption.

1.3 Delimitation of the study

This research will confide itself to the assessment of the heavy metals in drinking water in Chalimbana university area. Chalimbana university area is an area that is occupied mostly by university students hence, the water has to be assessed because some heavy metals like Lead (Pd) is very toxic and it affects mostly the brain which leads to dullness

1.4 Significance of the study

This study is important because it ascertained the safety of drinking water drinking water at Chalimbana University. By investigating the heavy metal levels and their potential human health risks in Chalimbana area, this study may provide valuable insights into what remains to be done by relevant authority in this area. This study may also help policy makers and other agencies concerned with standards of water such as the National Water and Sanitation Council (NWASCO) and Ministry of Health (MOH) to make relevant decisions on drinking water in Chalimbana university area, Zambia, thereby improving the health of the students at Chalimbana University and the surrounding area at large.

2. Review related literature

Heavy metals are metals whose density is five times greater than the density of water. They are natural components of the earth's which mainly includes some transition metals. Because of their high degree of toxicity, arsenic, cadmium, chromium, lead, and mercury are the metals of concern in this study. These are systemic toxicants that damage organs even at lower levels of exposure, hence, the need to assess the drinking water.

2.1 Distribution of heavy metals in underground water

Heavy metals are found in surface water bodies such as rivers, dams and lakes from mines, industries and farms. From here, they may leach into the soil to pollute underground water. Some underground water sources maybe found already polluted with heavy metals due to presence of these metals under the ground. Lusaka province is one of the most polluted provinces due to urbanization and industries that fail to manage their effluents. These effluents may filter into groundwater or be carried to nearby districts through rivers and streams. Residents of Chongwe have been complaining about the deteriorating quality of water of Chongwe River to disposal of chemicals in the river. Some of these chemicals may contain some heavy metals which later leach into the ground water. Therefore, this study is a precautionary measure taken to prevent some diseases associated with heavy metal exposure.

Studies on underground water have shown concentrations of heavy metals beyond permissible limits. For example, Nadeem-ul-Hag. Et al. (2009) reported high levels of chromium and lead in almost all ground water sources and extremely high concentrations were found in industrial areas of Karachi. Khan et al. (2013) reported high levels of lead, cadmium, Iron, nickel and zinc contamination in drinking water in Pakistan. Kavcar et al. (2009) reported high levels of nickel and arsenic in drinking water in Turkey. Mora et al. (2009) revealed significantly high level of copper in drinking water of the eastern Lianos of Venezuela.

For underground water sources: Elinge et al. (2011) reported higher concentrations of heavy Metals in the order Copper > Lead > Chromium > Nickel > Cobalt from borehole water in Nigeria. Momodu and Anyakora (2010) reported Cadmium and Lead contamination in Nigeria. Cobbina et al. (2015) reported higher levels of Mercury, Arsenic, Lead, Zinc, and Cadmium in drinking water from a small-scale mining community of Ghana. Eruola et al. (2011) highlighted elevated levels of cadmium, lead and iron in hand dug wells in Ilaro and Aiyetoro area of Ogun State of Nigeria. In a study by Ekpo et al. (2012), borehole water in Cross river state of Nigeria Reported higher content of manganese in landfill areas than that of the non-landfill areas.

Majority of studies on heavy metals in Zambia concentrated on samples from water bodies and soil while information on heavy metal contamination of drinking water is very inadequate. Hence a research gap has been identified.

3. Materials and Methods

3.1 Study design, location and sampling techniques

The study was conducted at Chalimbana University and surrounding area, through an analytical descriptive study using primary data from the samples collected. Three boreholes were sampled for underground water. One borehole supply water to the university community while two bores are within a radius of 5km from the university. These boreholes were important to the study because students use the water from the boreholes for domestic purpose. Sampling involved use of new polyethene bottles were cleaned with acid and rinsed with deionized water before putting the samples. Samples were taken to National Food and Drug Laboratory for chemical analysis.

3.2 Sample preparation and chemical analysis

Sample preparation of involved preparation of analyte by reducing it smaller size for ease handling, then digestion extraction and analysis. Mass spectrometer was used to analyze the sample contents and their concentrations.

3.3 Results and discussion

Table 1 shows results for sampled boreholes at Chalimbana University and surrounding villages. From the table, results show that the concentration of lead in the three samples was higher than the WHO permissible limit of 0.015ppm. Concentration was alarmingly highest in borehole C, with a difference of 0.1194ppm. for cadmium, sample A was more than the threshold by only 0.0011ppm. Samples B and C's concentrations were both lower than the WHO threshold. Copper had all the three samples within the permissible limits, 0.0068, 0.2532 and 0.0766 respectively. Finally, chromium had all the samples (0.0198. 0.004 and 0,0039) beyond the threshold (0.003). Generally, results show that lead has the highest concentration of all the heavy metals analysed in all the three bores. Chromium is next though the diference with the WHO threshold is smaller than lead. Cadmium was only higher than the threshold in sample A while samples B and C had lower concentrations. Copper was below the permissible limit in all the three samples. However, for heavy metals that were above the threshold, it remains to be established whether or not, the difference of the concentration of the sample and the threshold was statistically different. But considering the threshold values, one would simply conclude that the water at Chalimbana University and surrounding area is not fit for human consumption on account of lead and chromium that are beyond the WHO permissible limit.

Table 1: Concentration of heavy metals in sampled boreholes

S/N0	Heavy metal	unit	Water A	Water B	Water C	WHO standard
1	Lead	ppm	0.0606	0.049	0.1345	0.015
2	Cadmium	ppm	0.0064	0.0017	0.0032	0.005
3	Copper	ppm	0.0068	0.2532	0.0766	1.3
4	Chromium	ppm	0.0198	0.004	0.0039	0.003

3.4 Conclusion

The purpose of the study was to determine the concentration of heavy metals in drinking water from boreholes at Chalimbana University and the surrounding area, in order to assess the safety of the water. Specific objectives were: (i) To determine the concentrations of cadmium, chromium, lead and copper, (ii) To assess the safety of water. The concentration of lead in all the three samples was alarming higher than the WHO threshold, while that of chromium was only slight higher than the acceptable limit. Copper and cadmium had their concentrations with the acceptable limits. Therefore, going the concentrations of lead and chromium, the people taking this water may be at risk of poisoning or suffering from diseases associated with such metals. All in all, local authorities must move in to find solutions to this problem.

Acknowledgement

Authors would like to thank Chalimbana University for sponsoring student research activities. Also, we wish to thank the Dean for School of Technology, Science and Mathematics for supporting this noble activity.

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