Poll Res. 40 (3) : 995-1000 (2021)

ISSN 0257–8050

A PRELIMINARY STUDY TO ASSESS HEAVY METAL CONTAMINATION IN WATER RESOURCES OF CHISAMBA TOWN, ZAMBIA

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(Received 19 May, 2021; Accepted 26 June, 2021)

ABSTRACT

With dwindling water resources, increasing anthropogenic pressure and industrialization, an escalating water pollution with conglomerate of varied xenobiotic compounds has been witnessed, globally. Heavy metals have been considered amongst priority pollutants with their presence being evident in industrial effluents. An empirical study was conducted, water samples were collected from three boreholes and two wells in Chisamba town, Zambia for the analysis of heavy metals Chromium (Cr), Lead (Pb), Arsenic (As), Copper (Cu) and Cadmium (Cd) in accordance with standard procedures. Our findings revealed Sample A1 and B1 possesses significant traces of As, C1 was found to be contaminated with As, Cr, Cd and Pb. Sample D1 and E1 were devoid of any significant heavy metal traces, thereby adhering to Zambia Bureau of Standards (ZABS). This pilot study further paves a way for bioremediation based eco-friendly interventions to mitigate the problem before it escalates further and impose eco-toxicological hazards.

KEY WORDS : Anthropogenic, Eco-toxicological, Heavy metals, Xenobiotics, Zambia Bureau of Standards (ZABS)

INTRODUCTION

Environment has been constantly under exposure of different environmental contaminants attributed to an unprecedented rise in anthropogenic activities, urbanization and population explosion. Heavy metals are one of the toxic contaminants which by virtue of their bio-accumulation have endangered the ecosystem at large (Adout *et al*., 2007) posing adverse health hazards for biotic resources (Salzano and Angelone, 2013; Klaassen, 2013). The most common route of transmission of xenobiotic compounds like heavy metals, synthetic dyes, nitrates, phosphates, chlorinated compounds, bleaching agents into surface waters are industrial effluents (Sharma *et al*., 2020). Following the same, these industrial effluents adversely affect agricultural practices (Kalavrouziotis and Koukoulakis, 2016). A recent report suggests a co-relation between heavy metal acquisition and anti-microbial resistance by micro-flora indigenous to hospital effluents (Sharma and Sharma, 2021). A similar study in Kenya had been conducted on heavy metal analysis in soil, waste water and open drainage systems (Kinuthia *et al*., 2020). Heavy metals have been known to possess high solubility in aquatic habitats which makes them exhibit bio-sorption by gills, liver and muscular tissue of fishes (Sobhanardakani *et al*., 2011). Interestingly, analyzing pollutants in living organisms is more lucrative option as it suffices about indices of bioavailability, bio magnification and bio-transference of contaminants (Muralidharan, 2018). Birds have been considered both as potential bio-indicators and bio monitors of heavy metal accumulation spanning across divergent geographical, historical and global boundaries as they occupy a wide range of trophic levels in different food chains (Abdullah *et al*., 2015). Heavy metals have relatively high density and are toxic even at low concentration (Lenntech, 2004). The toxicity level of heavy metals humans is of the order Co < Al < Cr < Pb < Ni < Zn < Cu < Cd < Hg (Mansourri and Madani, 2016). As a surface run-off or leachate from soil, heavy metals find their way into potable waters (Morais *et al*., 2012). Factors contributing to toxicological health hazards of heavy metals on account of consuming contaminated water (Vetrimurugan *et al*., 2017) include dosage, emission rate and exposure period (Kinuthia *et al*., 2020). Heavy metal pollution in Zambia is one of the daunting tasks which call for immediate attention to minimise eco-toxicological implications (Yoshinori *et al*., 2010). Figure 1 elucidates toxicological implications of heavy metals on human health (Jaishankar *et al*., 2014).

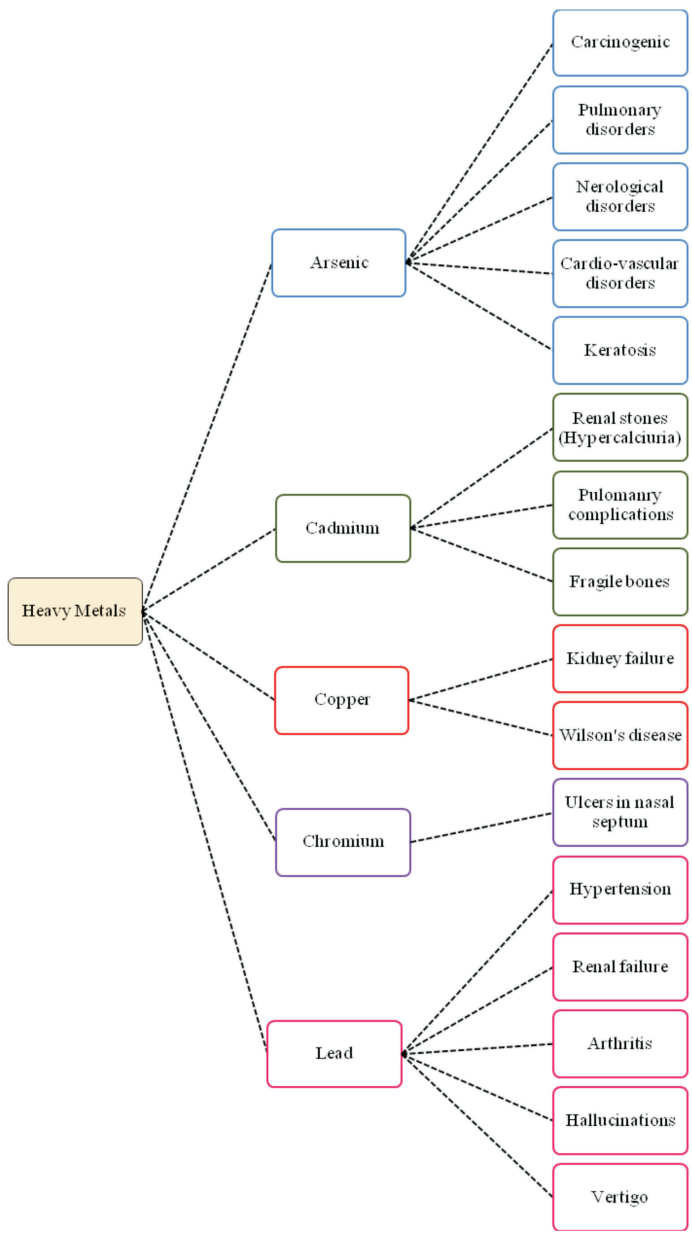

Fig. 1. Toxicological Impact of Heavy Metals on Human Health

Inspired by similar studies in African region and a need to address environmental challenge, the study was aimed to assess heavy metal contamination of underground water from William Compound, Chisamba District, Zambia.

MATERIALS AND METHODS

Sampling

Chisamba, small centrally located town in Central province of Zambia was earmarked as our study location (Figure 2). All the chemicals and reagents used in the study were of analytical grade. Five sampling sites were chosen to collect and analyse requisite water samples for heavy metal contamination.

1. Zambeef (A1)
2. Kelly compound (B1)
3. Mwakasanda (C1)
4. Mwayasunka (D1)
5. Fringila (E1) were chosen to collect respective samples (1000 ml) each by Grab methodology in pre-sterile plastic bottles designated as A1, B1, C1, D1 and E1 respectively. The samples were transferred and stored under refrigerated conditions until further analysis (APHA, 2005).

Preparation and Analysis

We adopted method devised by Choi *et al*., 2018. Briefly, microwave digestion was used, following the same samples were run on the Inductively Coupled Plasma – Mass Spectrometry (ICP-MS) for determination of heavy metal elements; Arsenic (As), Cadmium (Cd), Copper (Cu), Chromium (Cr) and Lead (Pb).

RESULTS AND DISCUSSION

Figure 3 depicts a comparative account of heavy metal (As, Cd, Cu, Cr and Pb) analysis in five samples (A1, B1, C1, D1 and E1) expressed as mg/l. Our findings were compared and contrasted ($p<0.05$) with reference range prescribed by ZABS.

Arsenic: For sample A1, B1 and CI, the observed values were 0.05 mg/l, 0.023 mg/l and 0.04 mg/l respectively and were found to be non-significant ($p<0.05$) with respect to permissible standards and. For D1 and E1, the values were 0.01 mg/l and were found to be significant ($p<005$).

Cadmium: For sample A1, B1, D1 and E1, the observed values (0.001 mg/l) were found to be significant ($p<0.05$) with respect to permissible standards and. We reported non-significant values (0.19 mg/l) for sample C1.

Copper: For sample A1, B1, CI, D1 and E1 the observed values were (0.01 mg/l, 0.01 mg/l, 0.1 mg/l, 0.02 mg/l and 0.01 mg/l respectively. All were found to be significant ($p<0.05$) with respect to permissible standards.

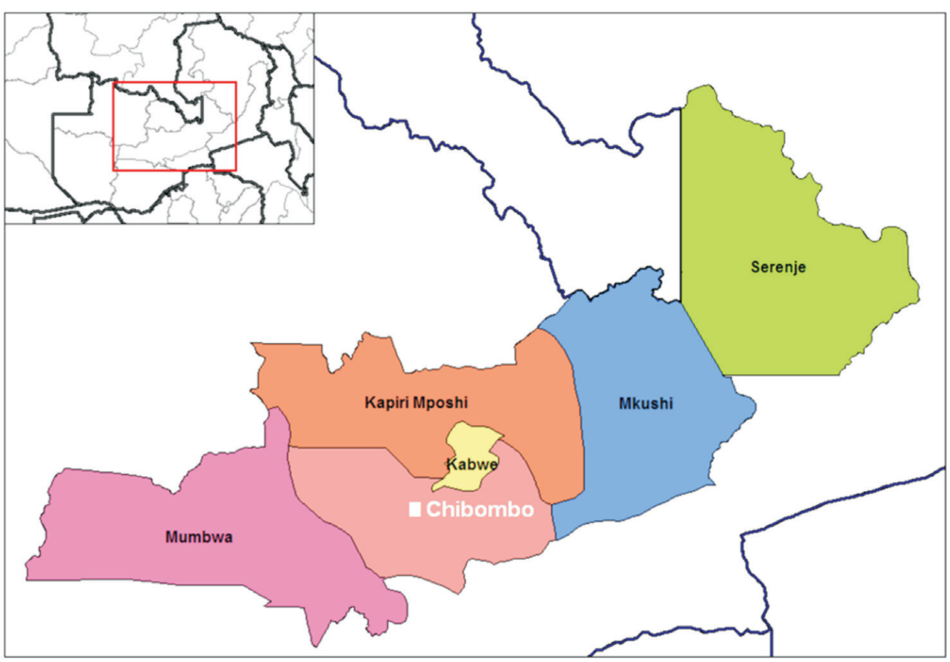

Fig. 2. Sampling location

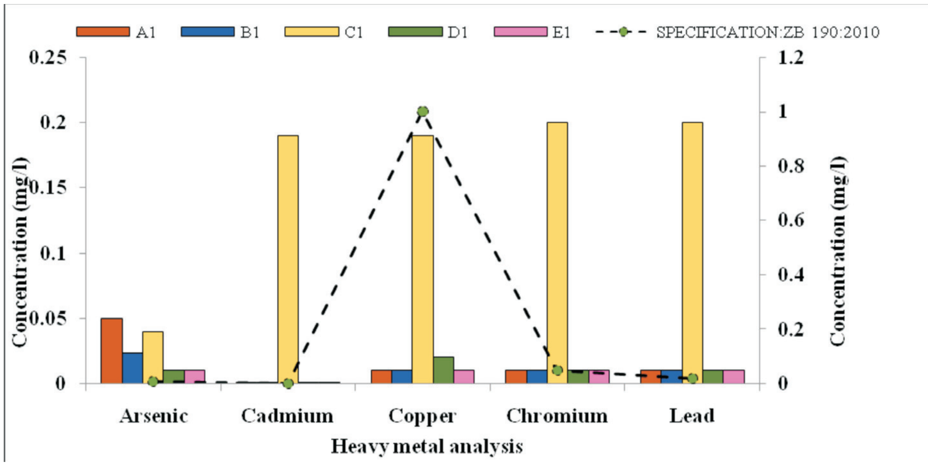

Fig. 3. Comparative account of heavy metal analysis in different water samples Chisamba Dist., Zambia

Chromium and Lead: For sample A1, B1, D1 and E1, the observed values (0.01 mg/l) were found to be ($p<0.05$) with respect to permissible standards and. We reported non-significant values (0.2 mg/l) for sample C1. From the results, it was observed that concentration of heavy metals such as As was above the permissible limits of Zambia bureau of standards (ZS 190: 2010). The concentration of Cd was only found unsatisfactory in sample C1 with the concentration of 0.19 mg/l. The concentrations of the four remaining samples were within the acceptable range, i.e. <0.001, <0.001, <0.001 and <0.001. The concentration of Cu and Cr were satisfactory in all samples except in sample C1 where the concentration (0.20 mg/l) was higher than the permissible value. The Pb concentration was also found unsatisfactory in sample C1 (0.20 mg/l). Previous studies revealed elevated levels of Pb above permissible levels in various water samples in Nigeria (Itodo *et al*., 2011). Previous findings by Kapungwe, 2013 indicated high levels of chromium in water at Chilumba Gardens than New Farm with a possible contaminating source being nearby tannery industry. The concentrations of As, Cd, Cr and Pb in sample C1 exceeded the permissible standards attributed to corroded inland pipes or higher concentrations of the heavy metals in ground water. Overall, the ground water of the town with respect to heavy metals contamination is a serious issue especially the water collected at point C1. Results from this sample showed high concentrations of As, Cd, Cr and Pb which could be attributed to ground water contamination of the area. Other studies conducted by Phan *et al*., 2010 in Cambodia also reported high levels of As in groundwater and well water in the Mekong River basin of Cambodia. The observed metal contamination might be taking place due to severe farming activities near the compounds that involve use of various inorganic chemicals used on the farms as well as from the small-scale mining activities that take place near the area under study. However, the main source of what could cause the heavy metal contamination in the water was not identified in this study. In another study conducted by Tembo *et al*., 2006, concentrations of Zn, As, Cd, Pb were significantly higher in Kabwe district. The maximum values of Cd and As in Kabwe were 18.7 and 51.5 mg/kg dry-wt, respectively. Above reported concentrations of Cd and As could have the potential for poisoning, as the trigger values for Cd and As are reported to be 3.0 and 10.0 mg/kg (ICRCL, 1987), respectively. The open well water samples collected at sampling point A1, B1, C1, D1 and E1 show that none of the water samples is having higher concentration of any heavy metals under study. The monitored data of ground water samples of the same study carried out earlier and HPI calculated for Dhanbad township (India), ground water was 11.2531 (Karim, 2000). Some important anthropogenic sources that significantly contribute to the heavy metal contamination in the environment include automobile exhaust, which releases lead; smelting which releases As, Cu and Zn; insecticides that release As and burning of fossil fuels that release Ni, V, Hg, Se and Sn (Biswas *et al*., 2017). The most common heavy metals are Pb, Ni, Cr, Cd, As, Hg, Zn and Cu. Although the aforementioned heavy metals traces can be found, they still cause serious health problems to human and other mammals (Musa *et al*., 2013).

CONCLUSION

As expressed, the concentrations of As, Cs, Cu, Cr, and Pb were studied at five sampling points in William compound of Chisamba District, all concentrations of the parameters except Cu was higher than the standard specifications of Zambia bureau of standards (ZABS), which is unsafe for drinking water. This indicates the potential of heavy metal pollution in the area. Therefore, this sets a benchmark for further research.

ACKNOWLEDGEMENTS

Authors would like to thank authorities of Department of Science Engineering and Technology, School of Science, Engineering and Technology, Mulungushi University, Kabwe.80415, Zambia for providing necessary resources to conduct the research and Research and Development Centre, Maharishi Markandeshwar Medical College and Hospital, Maharishi Markandeshwar University-Solan-173229 (Himachal Pradesh) for providing adequate resources for content writing, data validation, statistical analysis and plagiarism

Conflict of Interest

Authors declare no competing/ conflict of interests

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