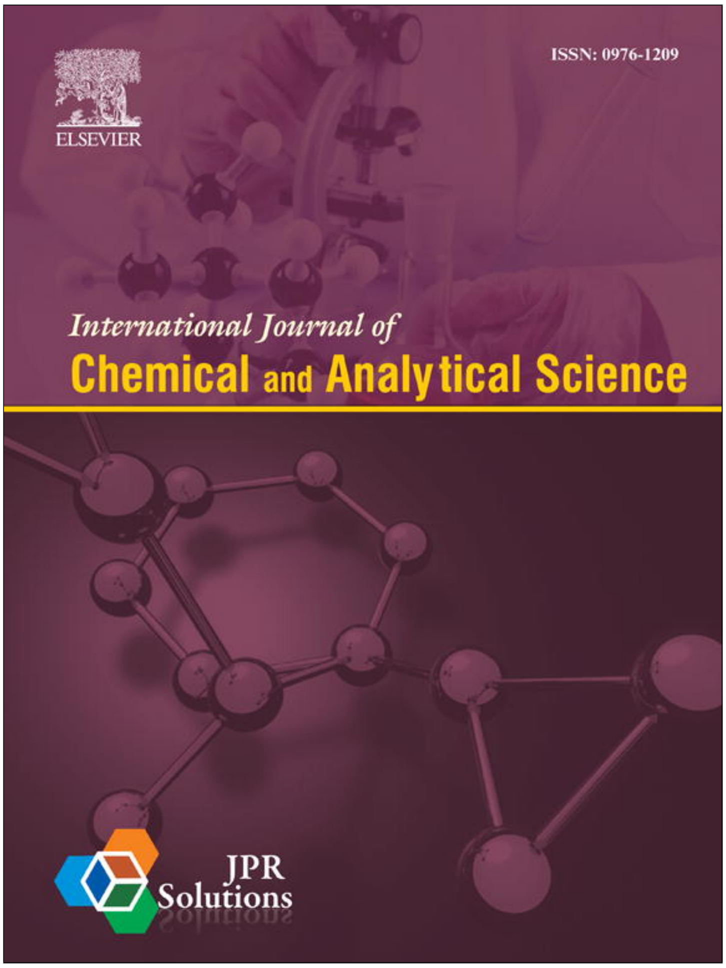
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Original Article

Analysis of Copper, Zinc and Lead using Atomic Absorption Spectrophotometer in ground water of Jimma town of Southwestern Ethiopia

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ABSTRACT

Aims: This study was design to determine the level of heavy metal contamination of ground water in Jimma town of Southwestern Ethiopia.

Methods: The sample had been collected from (6) different sites about (10) well and borehole water. Samples were analyzed using Atomic Absorption Spectrophotometer (AAS). Three heavy metals had been studied were Copper, Zinc and Lead. Their concentration and maximum contaminant levels (MCL) were compared with World Health Organization (WHO) data. The maximum contaminant levels according to WHO, for Copper, Zinc and Lead are 0.5, 3.0 and 0.01 mg/L respectively.

Conclusion: From the results obtained, none of the samples analyzed for Copper (0.025 mg/L) and Zinc (0.15 mg/L) concentration was found above the MCL but for Lead (0.02202 mg/L) concentration found above the MCL. However, the metals were present in 82.86% and 91.23% of the samples analyzed respectively. Almost 86.01% of the sample had detectable level of Lead. All the Lead concentration was above the MCL. In general, 86.70% of all samples analyzed contained one or more of three heavy metals. The results obtained from this study suggest significant risk to this population given for toxicity of these metals, well and borehole water are the only source of their water supply in this environment.

1. Introduction

Water quality is about what is in water and how quality affects its usefulness. Water is one of the essentials that support all living things such as plants and animals.[1] It is obtained from two principal natural sources; surface water (such as fresh water, lakes, river, stream etc) and ground water (such as well and borehole) water.[2] In nature water does not exist as pure, it has contaminants that arise from surrounding by human and animals.[3]

One of the most important environment issues today is ground water contamination and between the diversity of contaminants that affecting water resources.[4] The most contaminants of ground water are heavy metals likes Aluminum, Cadmium, Lead, Mercury, Copper, Zinc and etc. These heavy metals particularly cause strong toxicity even at low concentrations.[5] Lead is a commutative poison and a possible human carcinogen.[6] In addition, Lead causes the development of autoimmunity in which a person's immune system attacks its own cells. This can Lead to joint diseases and ailment of the

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kidneys, circulatory system and neurons. At higher concentrations, Lead can cause irreversible brain damage.

Copper is required for the proper functioning of many important enzyme systems. Copper-containing enzymes include ceruloplasmin, SOD, cytochrome-c oxidase, tyrosinase, monoamine oxidase, lysyl oxidase and phenylalanine hydroxylase.[7] Wilson disease is an autosomal recessive disorder that Leads to Copper toxicity, because Copper accumulates in the liver, brain and eyes. Wilson disease affects the hepatic intracellular transport of Copper and its subsequent inclusion into ceruloplasmin and bile. Because Copper is not incorporated into ceruloplasmin, its normal systemic distribution is impaired, and Copper accumulates in the liver, brain and eyes.[8] Wilson disease generally appears in late childhood and is accompanied by hepatic cirrhosis, neurological degeneration and Copper deposits in the cornea of the eye. Patients with Wilson disease are treated with chelating agents, such as penicillamine, to promote Copper excretion.[9]

The quality of these ground water sources are affected by the characteristics of the media through which the water passes on its way to the ground water zone of saturation,[10] thus, the heavy metals discharged by industries, traffic, municipal wastes, hazardous waste sites as well as from fertilizers for agricultural purposes and accidental oil spillages from tankers can result in a steady rise in contamination of ground water.[4] The World Health Organization has specified the maximum contaminant level for the presence of heavy metals in the ground water the aim of this study is to assess the quality of ground water sources in Jimma town, with aid of Atomic Absorption Spectrophotometer (AAS). The presence and concentration of three heavy metals (Copper, Zinc and Lead) were determined and the results compared to the maximum contaminant level (MCL) specified by the WHO.

2. Materials and methods

Analytical grade reagent and distilled water would used throughout the study. All glass ware and plastic container used were washed with detergent solution followed by 20% nitric acid and then raised with top water and distilled water.

All chemicals and reagents were of the analytical grade and were obtained from RIEDEL-DE HAEN, Germany. Lead Nitrate, Copper Sulfate and Zinc Chloride were used for preparation of Lead, Copper and Zinc standards respectively. Nitric acid was used for sample digestion.

2.1. *Sample collection and area*

Ground water sample were randomly collected from 10 sampling sites (6 well and 4 borehole) water in 6 different area of Jimma town around Jimma University. These areas include Koche, Ajip, Farenge Arada, Mentina, Sare Sefer and Kullobar. The samples were collected during the month March 2012. The following tables give the sample information (Tables 1 and 2).

Table 1 – Specification of samples and area for well water.

Sample sites	Sample type
Koche	WW1
Ajip	WW2
Farenge Arada	WW3
Mentina	WW4
Sare Sefer	WW5
Kullobar	WW6

Table 2 – Specification of sample and area for borehole water.

Sample sites	Sample type
Koche	BH1
Mentina	BH2
Sare Sefer	BH3
Ajip	BH4

2.2. *Sample digestion procedures*

To ensure the removal of organic impurities from the samples and thus prevent the interference in analysis, the samples were digested with concentrated Nitric acid. 5 mL of conc. HNO_3 was added to 100 mL of sampling water into the 250 mL conical flask then heated on a hot plate and evaporated till 20 mL was left. After cooling the flask again 5 mL of conc. HNO_3 was added and heated the flask on the hot plate. The digestion was continued till 10 mL was left and finally filtered and diluted with distilled water into 100 mL of volumetric flask and stored in the refrigerator.

2.3. *Standard preparation*

The stock solution of Lead, Copper and Zinc were prepared by dissolving in a liter volumetric flask 24.62, 1.63 and 1.60 g of Lead nitrate, Copper sulfate and Zinc chloride respectively with 68% of nitric acid. The mixture was shaken and the flask made up to the 1 L mark with the nitric acid for each metal. Calibration solutions of the target metal ions were prepared from the standard stock by serial dilution.

2.4. *Sample analysis*

The digested water samples were analyzed for the presence of Copper, Zinc and Lead using the scientific Nov 300 Atomic Absorption Spectrophotometer. The calibration plot method was used for analysis. The air acetylene was the flame used and hallow cathode lamp of the corresponding element was the resonance. Line source, the wave length for the determination of three elements were 283.31, 324.7 and 213.9 nm for Lead, Copper and Zinc respectively. The digested samples were analyzed in triplicates with the average concentration of metals being displayed in mg/L by the instruments after extrapolation from the standard curve.

3. Results and discussion

Calibration curves were obtained using a series of varying concentrations of the standards for the three metals. All three calibration curves were linear. The concentration level of

Table 3 – Results of Copper in well water sample.

Sample sites	Absorbance	SD	RSD	Conc. (mg/L)	SD	RSD
WW1	0.01429	0.00019	1.321	0.02181	0.00163	7.461
WW2	0.01398	0.00031	2.232	0.01911	0.00269	14.06
WW3	0.01331	0.00042	3.19	0.01337	0.00366	27.36
WW4	0.01468	0.00017	1.189	0.02518	0.0015	5.974
WW5	0.01358	0.00038	2.77	0.01565	0.00324	20.7
WW6	0.01341	0.00019	1.1415	0.01409	0.00163	11.59

metals ranging from 0.0122 mg/L to 0.220 mg/L. There was no detectable heavy metal in the distilled water which served as the control.

Tables 3–8 show the results obtained in this study for Copper, Zinc and Lead respectively. These tables gives the results of their concentration, absorbance, standard deviation of absorbance, standard deviation of concentration and relative standard of concentration of the three heavy metal in ground water well water and borehole water measured by calibration plot method was used for the analysis. For the protection of human health, guide lines for the presence of heavy metals in water have been set by different. International organizations such as EPA, WHO and European Union Commission,[11] thus heavy metal have maximum permissible level in water specified by these organizations. The maximum contaminant level (MLC) is an enforceable standard set at a numerical value with adequate margin of safety to ensure no adverse affect on human health.

The three elements studied in this research were Copper, Zinc and Lead has the maximum contamination levels of 0.5, 3.0 and 0.01 mg/L respectively.[11] From the result obtained, the minimum concentration of Copper detected in the water samples for both borehole and well water was 0.00122 mg/L with maximum concentration being 0.0252 mg/L (Figs. 1 and 2).

Table 4 – Results of Zinc in well water sample.

Sample sites	Absorbance	SD	RSD	Conc. (mg/L)	SD	RSD
WW1	0.01691	0.00012	0.726	0.09128	0.00093	1.015
WW2	0.01605	0.00018	1.105	0.08478	0.00134	1.577
WW3	0.02363	0.00034	1.424	0.1419	0.00254	1.787
WW4	0.01811	0.00058	3.193	0.1003	0.00436	4.346
WW5	0.02017	0.000065	0.325	0.1158	0.00049	0.427
WW6	0.025	0.00045	1.797	0.1522	0.00339	2.224

Table 5 – Results of Lead in well water sample.

Sample sites	Absorbance	SD	RSD	Conc. (mg/L)	SD	RSD
WW1	0.0097	0.00056	5.915	0.1906	0.03044	15.97
WW2	0.00951	0.000091	0.966	0.18	0.00496	2.754
WW3	0.01014	0.00043	4.2	0.2141	0.02299	10.74
WW4	0.01025	0.00024	2.386	0.2202	0.0132	5.996
WW5	0.00984	0.00041	4.131	0.198	0.02194	11.08
WW6	0.00942	0.00031	3.25	0.1757	0.01654	9.413

Table 6 – Results of Copper in borehole water sample.

Sample sites	Absorbance	SD	RSD	Conc. (mg/L)	SD	RSD
BH1	0.01374	0.00014	0.988	0.01707	0.00117	6.856
BH2	0.01318	6.8E-05	0.519	0.01224	0.00059	4.815
BH3	0.01364	0.00022	1.582	0.01621	0.00186	11.47
BH4	0.01337	0.0004	3.025	0.01383	0.00348	25.18

Table 7 – Results of Zinc in borehole water sample.

Sample sites	Absorbance	SD	RSD	Conc. (mg/L)	SD	RSD
BH1	0.02281	0.00027	1.163	0.1357	0.002	1.473
BH2	0.01987	0.00012	0.58	0.1136	0.00087	0.765
BH3	0.02675	0.00074	2.753	0.1654	0.00555	3.356
BH4	0.0286	9.4E-05	0.329	0.1794	0.00071	0.395

None of the water sample above the specified maximum contaminant level (0.5 mg/L). However, Copper was detected in water sample 82.86% (85.71% from well and 80% from borehole water) and since toxicity is associated with continuous low level exposure this can eventually Lead to series health effects. As several epidemiological studies have provided evidence with respect to a possible link between Copper in drinking water.

In the analysis of water samples collected for Zinc 10 of the collected water samples were containing Zinc, all samples detectable 91.23% of them were in concentration below the maximum contaminant level. The minimum concentration of Zinc was 0.0848 mg/L with the maximum concentration 0.179 mg/L. The maximum contaminant level of Zinc was 3.0 mg/L. The concentration of Zinc and Copper in the water samples were within the maximum permissible range however, they are cause for the series human wealth. In the analysis of the water samples collected for Lead metal, 6 of the well water and 4 borehole water samples were shown to contain Lead representing 86.01% of the total contained Lead in levels above the maximum contaminant level (0.01 mg/L) with maximum concentration detected being 0.220 mg/L. These results are of concern as Lead has been recognized for along period as a cumulative general metabolic poison.[12] It is a neurotoxin and is responsible for the most common type of human metals toxicities. Also, studies have linked Lead exposures even at low levels with and increase in blood pressure,[13] as well as with reduced intelligence quotient in children and caused for attention disorders.

Table 8 – Results of Lead in borehole water sample.

Sample sites	Absorbance	SD	RSD	Conc. (mg/L)	SD	RSD
BH1	0.009526	0.00026	2.682	0.1812	0.0138	7.614
BH2	0.008994	0.00414	4.606	0.1524	0.02237	14.67
BH3	0.00937	0.00022	2.358	0.1727	0.01193	6.907
BH4	0.009252	0.00032	3.438	0.1664	0.01718	10.32

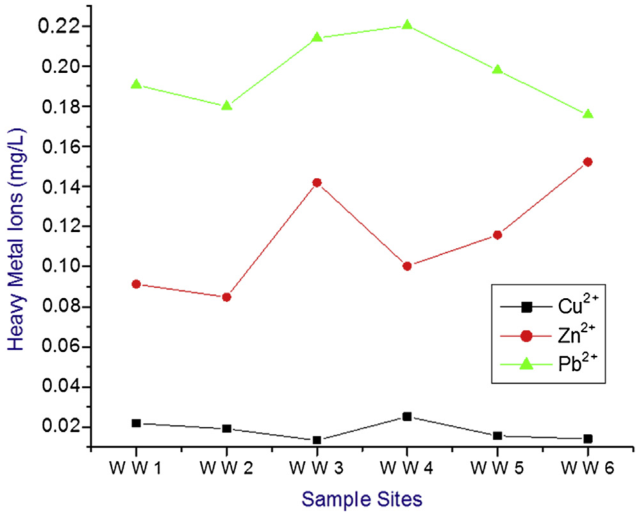

Fig. 1 – Plot of concentrations versus sample sites for three heavy metal ions well water.

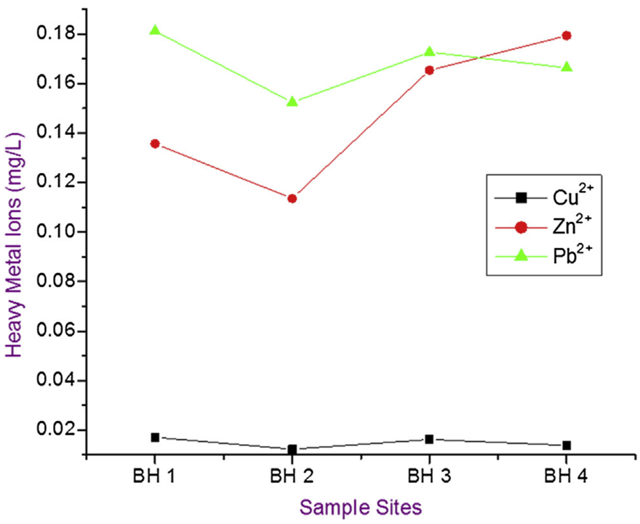

Fig. 2 – Plot of concentrations versus sample sites for three heavy metal ions in borehole water.

Over all, except the distilled water sample which was used as control all other samples contained detectable amounts of the three heavy metals studied with 10 samples containing all 3 metals.

4. Conclusion

These results show the concentration of Cu^{2+} and Zn^{2+} are below the WHO specified maximum contaminant level. But the concentration of Pb^{2+} is of concern as it exceeded the maximum contaminant level of WHO in the targeted area of Jimma Town. This suggests a significant risk to this population given the toxicity of these metals and the fact that for many, hand dug wells and boreholes are the only sources of their water supply in this environment.

Conflicts of interest

All authors have none to declare.

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