Short communication

Comparative analysis of some trace metals in municipal and spring water from Makerere University and selected springs in Bunga, Uganda

ABSTRACT

Aims: Access to clean and safe water is a challenge globally. This study assessed the levels of three trace metals (iron, copper and chromium) and chlorine in water samples from municipal water supply points in Makerere University and springs from Bunga, Uganda.

Study design: This research employed a quantitative research method.

Place and duration of study: Samples were collected from five different sites of Makerere University halls and Bunga springs, Kampala. This study was undertaken between May 2021 and October 2021.

Methodology: Trace metal content and free chlorine of the water samples were determined and calibrated using multiparameter Palintest 7100 photometer.

Results: Analytical results indicated that the average iron, copper and chromium and chlorine content of the tap water samples from the municipal supply system were 0.0125 ± 0.00433 mg/L, 0.155 ± 0.0384 mg/L, 0.0325 ± 0.01479 mg/L and 3.045 ± 0.180623 mg/L, respectively. The corresponding mean values for water samples from Bunga springs were 0.0080 ± 0.0109 mg/L, 0.0124 ± 0.2019 mg/L, 0.056 ± 0.02073 mg/L and 0.00 ± 0.00 mg/L, respectively. These average values were within the maximum permissible limits of 0.3 mg/L, 0.5 mg/L and 0.05 mg/L for iron, copper and chromium in drinking water as recommended by the World Health Organization.

However, springs A and B had chromium concentrations above the recommended value of 0.05 mg/L.

Conclusion:

Trace metal and chlorine content of the sampled water were within compliance limits except for chromium which exceeded at springs A and B in Bunga, Kampala.

Keywords: **Iron, portable water, drinking water, Makerere University**

1. INTRODUCTION

Access to clean and safe water has remained a global challenge [1, 2]. The underlying causes of water scarcity are the ever increasing demand by the agricultural sector, industrialization and poor water management practices [3]. Specifically, pollution of water resources by legacy contaminants presents a great threat to clean water supply and sanitation. Pollutants such as heavy metals, pharmaceutical products and plastics enter the water supply system mostly through anthropogenic sources [4]. However, contamination may also occur during distribution of water through pipes, due to weathering of rocks and leaching of soils, mining processing, industrial wastes, municipal wastes and agrochemicals.

Africa is one of the continents with evident water scarcity. Ugandan being one of the African countries with water scarcity challenge has endeavored to provide water through private companies. In most cases, such water is treated with chlorine to treat it against microbial contaminants. However, several instances may occur that can expose the water to contamination along the distribution lines. Several contaminants such as heavy metals and microbial contaminants may have adverse health effects on humans. Thus, understanding water quality and its probable impacts necessitates collecting and monitoring water quality from time to time [5].

Several studies have reported on the contamination of surface water sources (lakes, rivers, irrigation canals and ponds) and springs in Uganda [2, 6-12]. However, few of them have examined the trace metal content and free chlorine content of municipal water supply, yet unsafe water is a global public health threat, placing persons at risk for chemical intoxication, which results into the development of the different forms of cancer and damages to the human organs [6]. In this study, the concentration of three trace metals (iron, copper and chromium) and free chlorine in municipal water and Bunga springs in Kampala, Uganda were determined.

2. MATERIAL AND METHODS

2.1Equipment and reagents

The following were the apparatus, instruments and reagents used for the analysis of the different parameters in the corresponding samples (tape water and spring water); sample bottles, beakers (250 ml), measuring cylinder (50 ml), multiparameter Palintest 7100 photometer (Palintest®, UK), Electronic weighing balance, diphenyl carbazide, iron tablets, copper tablets, chromium tablets, N,N-diethyl-p-phenylenediamine (DPD) tablets.

2.2 Sampling

Water samples were collected from four different sites of Makerere University (Mary Stuart, Nkrumah, Africa and Mitchell halls) with the coordinates; 0.3326° N, 32.5686° E, and Bunga springs (labelled A, B, C, D and E) located next to Ggaba in Kasanga Parish, Makindye Division, Kampala, Uganda. The coordinates for Bunga is Latitude: 0°16'26.71''N, and Longitude: 32°37'29.71''E. For municipal water, tap water from Mary Stuart, Nkrumah, Africa and Mitchell halls were sampled directly into sterilized polypropylene bottles after rinsing thrice with the tap water. They were immediately taken to the laboratory for analyses. Spring water samples were collected in sterilized containers. Attachments that could cause splashing out of water at the mouth of the springs were removed and the water allowed to flow for one minute. With the container held at the mouth of the spring with one hand, the containers were carefully opened with the other hand and placed below the pipe and filled with water [6].

2.3 Analysis of water samples

Trace metal content and free chlorine of the water samples were determined using a calibrated multiparameter Palintest 7100 photometer (Palintest®, UK). Trace metals: iron (Fe), copper (Cu) and chromium (Cr) and free chlorine were determined. In each case, the instrument was blanked using distilled water (10 ml).

For iron, a 10 ml test tube was filled with the sample and one iron tablet was added to the test tube, crushed and mixed to dissolve. The test tube was left to stand for 1 minute and allowed to stand full colour development. The test tube was then transferred into the photometer and analyzed using Program 018. The results were read directly in mg/L of iron.

The test for copper followed the same procedure but using copper tablet and the results were read in mg/L of copper using program 010. For chromium, 0.5ml of diphenyl carbazide was used and the sample was allowed to stand for 10 minutes. The analysis was performed using program 055, with the obtained results expressed in mg/L of chromium. Free chlorine determination used N, N-diethyl-p-phenylenediamine (DPD) tablets and the concentration was read in mg/L using program 007 of the photometer.

2.4 Data Analysis

Analytical data were presented as means with errors as standard deviations attached. One-way ANOVA was done followed by Tukey pairwise test (P = .05) using GraphPad Prism (v9, Systat GraphPad software Inc., USA).

3. RESULTS AND DISCUSSION

3.1 Trace metal and residual chlorine content of water samples

In natural water, ionic composition of natural water depends on factors such as the chemistry of atmospheric precipitation, mineralogy of the rocks encountered along the flow path, residence time of the water, topography and climate [13, 14]. The results of water analyses in this study are given in **Table 1**. Analytical results indicated that the average iron, copper and chromium and chlorine content of the tap water samples from the municipal supply system were 0.0125 ± 0.00433 mg/L, 0.155 ± 0.0384 mg/L, 0.0325 ± 0.01479 mg/L and 3.045 ± 0.180623 mg/L, respectively. The corresponding mean values for water samples from Bunga springs (A to E) were 0.0080 ± 0.0109 mg/L, 0.0124 ± 0.2019 mg/L, 0.056 ± 0.02073 mg/L and 0.00 ± 0.00 mg/L, respectively. These values were within the maximum permissible limits of 0.3 mg/L, 0.5 mg/L and 0.05 mg/L for iron, copper and chromium in drinking water recommended by the World Health Organization. However, chromium occurred at concentrations above the permissible limit in water from springs A and B (**Table 1**).

In reference to previous studies, the trace metal contents obtained from tap water were comparable to 0.00687 mg/L and 0.03 mg/L for copper and iron reported in Chuho springs, Kisoro district [7]. Similarly, spring water samples in this study had comparable concentrations to preceding reports. For example, 0.0085 mg/L to 0.01117 mg/L and 0.01 to 0.09 mg/L for copper and iron reported in Chuho springs, Kisoro district (Uganda) [7], 0.0036 mg/L for copper in Kitagata hot springs water, Uganda [12]. Similar results were reported by Moulodi and Thorsell [8] where water samples from Katalina, Bukuuku and Katoogo springs had iron and copper contents of 0.01421 mg/L and undetected, 0.01195 mg/L and 0.00075 mg/L, 0.00998 mg/L and 0.00084 mg/L, respectively.

Table 1. Trace metal and chlorine content of water from tap water from Makerere University and Bunga springs, Uganda

Sampling location	Iron (mg/L)	Copper (mg/L)	Chromium (mg/L)	Free chlorine (mg/L)
Mary Stuart hall	0.01± 0.00	0.22 ± 0.04	0.05 ± 0.01	3.34 ± 0.01
Nkrumah hall	0.02 ± 0.05	0.12± 0.02	0.03 ± 0.02	2.98 ± 0.01
Africa hall	0.01± 0.00	0.14 ± 0.05	0.04 ± 0.50	2.85 ± 0.00
Mitchell hall	0.01± 0.00	0.14 ± 0.00	0.01 ± 0.00	3.01 ± 0.01
Spring A	0.02± 0.00	0.12 ± 0.10	0.06 ± 0.00	ND
Spring B	ND	0.16 ± 0.05	0.09 ± 0.02	ND
Spring C	ND	0.12 ± 0.00	0.04 ± 0.00	ND
Spring D	ND	0.10 ± 0.00	0.05 ± 0.02	ND
Spring E	0.02 ± 0.00	0.12 ± 0.00	0.04 ± 0.01	ND
WHO guidelines [15]	0.3	0.5	0.05	5.00

Values are presented as means ± standard deviation of triplicates. ND = Not detected.

Iron is found in natural fresh water at levels ranging from 0.5 to 50 mg/L [16]. It is reported that iron is an inorganic water quality contaminant that is primarily transported in groundwater in the reduced ferrous form [17]. Thus, the relatively higher concentration of iron observed for spring water samples is plausibly due to the geological composition of rocks and soil structure, and the depth of the aquifer of an area that are known to influence its ground water iron levels [18, 19]. Though not of great concern, excessive dissolved ferrous iron confers upon water metallic taste and promotes undesirable growth of ''iron bacteria''. In addition, high iron content can damage the liver, pancreas and heart or cause diabetes, hemochromatosis, stomach problems, nausea and vomiting [20].

For copper, the high concentrations observed in municipal (tap) water samples could be attributed to agricultural chemicals of copper compounds at the source or from corrosion of copper into water in the pipe system [7]. Though uncommon, copper intake at high concentrations causes copper poisoning, a condition characterized by vomiting (usually hematemesis) and gastrointestinal distress [21].

On the other hand, chromium occurred at concentrations above the permissible limit in water from springs A and B (**Table 1**). While it has not been reported by most studies examining water samples, exposure to hexavalent chromium is known to cause skin irritation and lung cancer [22]. Its main source in water is due to washing of chromium-based preservatives such as chromated copper arsenate into water bodies [23, 24]. The physicochemical parameters such as pH, redox potential and salinity affect the mobility of metals in water [25-27]. As seen in this study, spring waters were less mineralized with compositions approaching those of the surface waters (treated municipal water) which indicate that groundwater in the shallow aquifers discharges fast with minimum chemical interactions with aquifer minerals [12].

For residual chlorine, its presence in water is a measure of how much disinfectant was initially added to inactive pathogenic bacteria and viruses and ensures that water is protected from recontamination during transport or storage. However, too much chlorine in water may cause changes in its taste. In most stored water however, such excess residual chlorine tends to decay over time [28].

4. CONCLUSION

Based on the results of the trace metals and chlorine content of the sampled water, they were found within compliance limits except for chromium which exceeded at springs A and B in Bunga, Kampala.

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