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Analysis of Selected Physico-Chemical Parameters, Nutrients, and Heavy Metals in Drinking Water Samples in Halaba Town, SNNPR, Ethiopia

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Abstract

Residents in the Halaba town, SNNPR, Ethiopia have used tap water as the main source of water for their drinking and domestic purposes. However, the Physico-chemical parameters of tap water in Halaba town have not been studied and this study was aimed to investigate some Physico-chemical parameters and selected heavy metals in tap water samples collected from two sampling sites in Halaba town. All the samples were analyzed for selected heavy metals such as Zn, Cu, Pb Ni, Cr, Fe, Mn, and some Physico-chemical parameters such as EC, pH, TDS, TH, turbidity, K, Ca, Mg, nitrate, and sulfate using Flame Atomic Absorption Spectrometer (FAAS) and Paline test methods, respectively. The mean results of the physicochemical parameters investigated in tap water samples collected from two sampling sites were found to be in the range: EC (193.3–323.3) μS/cm, pH (7.88–7.9), TDS (96.7–175) mg/L, TH (24-30) mg/L, turbidity (3.93–4.53) NTUs, NO3-1(1.64–1.75) mg/L, SO4-2(1.3–3.3) mg/L. The mean concentrations of heavy metals were found to be in the range: Zn (0.05–0.30) mg/L, Fe (0.25–0.50) mg/L, Cu (0.01–0.04) mg/L, Pb (0.01–0.02) mg/L, Ni (1.86–2.4) mg/L, Cr (0.08–0.14) mg/L, Mn (0.001) mg/L, K (44.3–88.7) mg/L, Ca (180–204) mg/L, Mg (6.3–13) mg/L. The study showed that the concentrations of Pb, Ni, and Cr were slightly higher than the maximum permissible limits recommended by WHO, USEPA, and EU standards whereas concentrations of K and Ca were found to be higher than the maximum permissible limits recommended by WHO. All the other selected physicochemical parameters considered were below the maximum permissible limits recommended by WHO. Furthermore, the concentration of Zn, Cu, Fe, and Mn were found to be below the maximum permissible limits recommended by WHO, USEPA, EU, Australian, Iranian, Indian, Malaysian, Newzlandian, and Ethiopian standards. Therefore, citizens in the Halaba town that uses tap water for their day-to-day domestic activities and drinking purpose could potentially expose to health risks due to high levels of Pb, Ni, Cr, K and Ca. So, it is recommended that the tap water in the study area should be treated before being used for drinking and domestic purposes.

Keywords: Physico-Chemical Parameters; Safe drinking water

Abbreviations: SNNPR: South Nation Nationality People Region; WHO: World Health Organization; EC: Electrical Conductivity; TDS: Total Dissolved Solids; TH: Total Hardness; Ca: Calcium; Mg: Magnesium;

Introduction

Water is the most important substance for the existence of life on earth. It is a prime component of aquatic life to be flourished. Freshwater is essential to human health,

agriculture, industry, and natural ecosystems [1]. Human being uses water mainly for drinking purposes, to sustain agriculture, to support various industries, to produce hydroelectric power, to carry out aquatic transport, to ensure personal hygiene, and maintain a clean environment.

Safe drinking water or potable water should be free from disease-producing microorganisms and chemical substances that are dangerous to human health [2,3]. However, the majority of the world's population does not have access to potable water and depends on well, stream, and river waters for domestic use [4]. As a matter of fact, in most African countries such as Ethiopia and Asia countries such as India, safe drinking water is not easily available [4]. Of the six billion people on the earth, more than one billion lack access to safe drinking water, and, about 2.5 billion do not have access to adequate sanitation services [4]. Recently, the availability and access to safe drinking water have been the most critical issue worldwide because it could have serious consequences for the health and well-being of billions of people.

Safe drinking water should be free from disease-producing microorganisms and chemical substances that are dangerous to human health [2,3]. The desirable properties of potable water include transparent, colorless, odorless, relatively low organic content, pH value near neutrality, moderate temperature, and being free from infectious agents, toxic substances, and mineral matter [5]. However, the dominant source of drinking water used to supply major urban and rural communities may be contaminated through the disposal of various industrial effluents, human wastes, heavy metals, etc., [6-8]. Heavy metals, and pesticides, particularly, tend to accumulate in human organs and the nervous system and may interfere with normal body functions [7]. In recent years, heavy metals such as lead (Pb), nickel (Ni), copper (Cu), and Zinc (Zn) have received significant attention because these heavy metals can cause health problems [2].

In Ethiopia, the dominant source of drinking water used to supply major urban and rural communities is from rivers, wells, and springs [9]. Halaba administrative town is located in Halaba zone, South Nation Nationality People Region (SNNPR), Ethiopia, and it is approximately 245 km far from Addis Ababa, the capital city of Ethiopia. In this town, residents use tap water, pumped from underground, stored, and distributed using water pipes, as the main source of water for their drinking and domestic purposes even though there were no systematic and comprehensive studies about the water quality parameters of the sources. Thus, this study was aimed to investigate selected Physico-chemical parameters, nutrients, and heavy metals in tap water samples collected from two sampling sites and check whether the results obtained are in line with standards set by World Health Organization (WHO) and other officials.

Materials and Methods

Description of the Study Area

The study was conducted in Halaba administrative town, SNNPR, Ethiopia. It is located approximately 245 km far from Addis Ababa, the capital city of Ethiopia.

Sample Collection and Preparation

Samples collection, handling, preservation, and analysis were carried out according to standard methods described by APHA [10]. Tap water samples were collected from two selected sampling sites. Three water samples were collected from each selected sampling site. The samples were collected in one-liter capacity plastic bottles after being rinsed with 0.02 M HNO3 and distilled water. The plastic bottles were rinsed with the water samples before filling each with the sample. Then, the bottles were labeled and kept in an icebox, and transferred to the laboratory for analysis.

Chemicals and Reagents

The reagents used in the study were all analytical grades. Nitric acid (69-72%) and H_2O_2 (30%) were used for the digestion of the samples. The stock standard solutions containing 1000 mg/L in 2% HNO_3 of metals such as Cu, Zn, Fe, Pb, Mn, Ni, and Cr were used for the preparation of calibration standards. Deionized water was used throughout the experiment for sample preparation and dilution and rinsing of apparatus before analysis [10]. Palintest tablets were used to determine the concentration of selected metals, nutrients, and Physico-chemical parameters.

Instruments

The instrument used in the study were sample digester, conductivity meter, portable digital pH meter, Flame Atomic Absorption Spectrometer (Buck Scientific, Model 210 VGP Atomic absorption spectrophotometer, USA), and a Palintest photometer. 7100 integrated with the Palintest system of water analysis.

Preparation of samples for heavy metal analysis using FAAS

Samples were digested by taking 100 mL of water samples in a 250 mL beaker and then 5 mL of HNO_3 (69-72%) and 5 mL of H_2O_2 (30%) were added [10]. Then, the beakers were covered with a watch glass and then heated on a hot plate until the volume of the sample approximately reached 20 mL. Then, the contents of the beaker were cooled, filtered

with Whatman No 42 into a 100 mL volumetric flask, and the flask was filled with distilled water up to the mark. Likewise, the digestions of the blanks were done.

Preparation of Samples for Analysis Using Palintest Photometer

The analysis of NO_3^-, SO_4^{2-}, K, Ca, and Mg were done using a Palintest photometer after the collected water samples were filtered using glass fiber filter paper. However, the analyses of the other water quality parameters were done using unfiltered and undigested water samples.

Data Analysis

Simple descriptive statistics were used to summarize the values of the selected physic-chemical parameters, nutrients, and heavy metals in tap water samples. One-way analyses of variance (ANOVA) tests were used to compare the mean values of results obtained for each sampling site. The results were also compared with WHO, US Environmental Protection Agency (USEPA), European Union Commission (EU), Australian, Iranian, Indian, Malaysian, Newzlandian, and Ethiopian standards.

Results and Discussion

Physicochemical characteristics of tap water sample

A statistical summary of the selected physic-chemical parameters of tap water at two sampling sites is shown in Table 1. The mean concentrations of the different parameters analyzed in the samples were compared with the WHO standards.

Parameters	Sample site 1	Sample site 2	WHO (2008/2011)
pH	7.9 ± 0.002	7.88 ± 0.021	6.5 to 8.5
EC	323.3 ± 67.62	193.3 ± 2.3	750
TDS	175 ± 0.81	96.7 ± 1.25	500
TH	30 ± 0.81	24 ± 0.81	300
Turbidity	3.93 ± 0.002	4.53 ± 0.02	5
Ca	204 ± 3.32	180 ± 0.81	75
Mg	13 ± 0.81	6.3 ± 0.82	30
K	88.7 ± 1.3	44.3 ± 0.5	
NO_3^-	1.64 ± 0.01	1.75 ± 0.81	45
SO_4^{2-}	1.3 ± 0.5	3.3 ± 0.5	250

Table 1: Results of the selected Physico-chemical parameters (Mean ± SD, n=3) found in tap water samples at the two sampling sites. All units are in mg/L except pH (pH scale), turbidity (NTUs), and EC (μS/cm).

pH

The mean pH value was 7.9 at sample site 1 and 7.88 at sample site 2 which showed that the tap water was slightly basic and it was within the permissible limit of WHO [2]. Analysis of variance indicated that the mean pH values were not significant ($p < 0.05$) different among the two sampling sites.

Electrical Conductivity (EC)

Electrical conductivity is a measure of water's ability to conduct an electric current and is related to the total concentration of dissolved ions in water samples. The high EC value is a good indicator of the presence of a high amount of ions such as Na^+, K^+, Cl^- and $SO4^{2-}$ [11]. In this study, a high mean EC value (323.3 ± 67.62 µS/cm) was observed in sample site 1, while a low mean EC value (193.3 ± 2.3 µS/cm) was recorded in Sample site 2.

All EC values recorded, in this study, were below the maximum permissible limit recommended by WHO [2]. The EC result of sample site 1 was significantly different from that of sample site 2 at $p < 0.05$.

Total Dissolved Solids (TDS)

The observed mean TDS value was 175 mg/L for sample site 1 and 96.7 mg/L for Sample site 2. Both results were below the maximum permissible limit set by [2,12]. According to WHO [4], there is no health-based limit for TDS in drinking water, but drinking water becomes unpalatable if the TDS level is greater than 1000 mg/L. There was a significant variation of TDS values among the sampling sites at $p < 0.05$.

Total Hardness (TH)

The total hardness mean values were 30 mg/L and 24 mg/L for sample site 1 and sample site 2 respectively. Both results were below the maximum limit (500 mg/L) given by

WHO [2]. According to WHO classification, Halaba town tap water was moderately soft.

Turbidity

The turbidity of water depends on the quantity of solid matter present in the suspended state. It is a measure of the light-emitting properties of water and the test is used to indicate the quality of waste discharge concerning the colloidal matter. The mean turbidity values obtained were 3.93 NTUs for sample site 1 and 4.53 NTUs for sample site 2. Both results were lower than the WHO [2] recommended value of 5.00 NTUs.

Calcium (Ca)

Calcium is the fifth most abundant element on the earth's crust and is very important for human cell physiology and bones. About 95% of the calcium in the human body is stored in bones and teeth. The high deficiency of calcium in humans may cause rickets, poor blood clotting, bones fracture, etc., and the exceeding limit of calcium-produced cardiovascular diseases. The mean calcium concentration obtained was 204 mg/L for sample site 1 and 180 mg/L for sample site 2. Both results were higher than the WHO standard [2].

Magnesium (Mg)

Magnesium is the 8th most abundant element on earth's crust and a natural constituent of water. It is essential for the proper functioning of living organisms and is found in minerals like dolomite, magnetite, etc. The human body contains about 25 g of magnesium (60% in bones and 40% in muscles and tissues). In the study, the mean magnesium concentration obtained was 13 mg/L for sample site 1 and 6.3 mg/L for sample site 2. Both results were lower than the WHO standards [2].

Potassium (K)

Potassium is a silver-white alkali that is highly reactive with water. Potassium is necessary for living organisms functioning hence found in all human and animal tissues, particularly in plants cells. The total potassium amount in the human body lies between 110 and 140 g. It is vital for the human body functions like heart protection, regulation of blood pressure, protein dissolution, muscle contraction, nerve stimulus, etc. Potassium is deficient in rare but may lead to depression, muscle weakness, heart rhythm disorder, etc. The mean concentration of potassium was 88.7 mg/L in sample site 1 and 44.3 mg/L in sample site 2.

Nitrate (NO_3^-)

Nitrate is one of the most important diseases causing parameters of water quality particularly blue baby syndrome in infants. The sources of nitrate are nitrogen cycle, industrial waste, nitrogenous fertilizers, etc. The mean concentration of nitrate was 1.64 mg/L in sample site 1 and 1.75 mg/L in sample site 2. Both results were below WHO standards [2].

Sulfate (SO_4^{-2})

Sulfate mainly is derived from the dissolution of salts of sulfuric acid and is abundantly found in almost all water bodies. A high concentration of sulfate may be due to oxidation of pyrite and mine drainage etc. Sulfate concentration in natural water ranges from a few to several 100 mg/L, but no major negative impact of sulfate on human health is reported. In the study area, the mean concentration of sulfate was 1.3 mg/L in samples site 1 and 3.3 mg/L in sample site 2. Both results were below WHO standards [2].

Heavy Metal Concentration in the Tap Water Sample

The mean concentration of the selected heavy metals determined in tap water samples collected from the two sampling sites is shown in Table 2. The mean concentrations of the selected heavy metals in the samples were compared with the WHO [2], USEPA [13], EU [14], Australian [15], Iranian [16], Indian, [17] Malaysian [18], Newzlandian [19], and Ethiopian [12] standards.

Heavy metals	Sample site 1	Sample site 2	WHO (2011)	USEPA (2008)	EU (2011)	Australian (2011)	Iranian (2010)	Indian (2012)	Malaysian (2004)	Newzlandian (2005)	Ethiopian (2003)
Zn	0.05 ± 0.02	0.30 ± 0.002	3	5	---	3	---	5	3	1.5	5
Cu	0.01 ± 0	0.04 ± 0.005	1	1.5	---	2	1	1.5	1.5	2	1
Pb	0.01 ± 0.01	0.02 ± 0.005	0.01	0.015	0.01	0.01	0.05	0.1	0.05	0.1	0.01
Ni	1.86 ± 0.1	2.4 ± 0.01	0.02	0.1	0.02	0.02	---	0.02	---	0.08	---
Cr	0.08 ± 0.01	0.14 ± 0.02	0.05	0.1	0.05	0.05	0.05	0.05	0.05	0.05	0.1
Fe	0.25 ± 0.0002	0.50 ± 0.01	---	---	---	---	---	--	---	---	---
Mn	0.001 ± 0	0.001 ± 0	0.1	0.5	--	0.5	0.5	0.1	0.5	0.4	--

Table 2: Concentration of heavy metals (Mean ± SD, n=3 in mg/L) found in tap water samples at the two sampling sites.

Zinc (Zn)

The mean concentration of Zn was found to be 0.05 mg/L for sample site 1 and 0.30 mg/L for sample site 2. The concentration of Zn in both sample sites was within the permissible limit reported by WHO, USEPA, Australian, Iranian, Indian, Malaysian, Newzlandian, and Ethiopian standards. Analysis of variance showed that the concentration of Zn was significantly different among sample site 1 and sample site 2 at a 95% confidence level.

Copper (Cu)

The mean concentration of Cu was found to be 0.01 mg/L for sample site 1 and 0.04 mg/L for sample site 2. A higher concentration of Cu (0.04 mg/L) was observed in the tap water sample taken from sample site 2 and a lower concentration of Cu (0.01 mg/L) was found in the water sample taken from sample site 1. However, the mean concentration of Cu for both sample sites was below the maximum permissible level reported by WHO, USEPA, Australian, Iranian, Indian, Malaysian, Newzlandian standards. Analysis of variance showed that the concentration of Cu was significantly different between sample site 1 and sample site 2 at a 95% confidence level.

Lead (Pb)

A higher concentration of Pb (0.02 mg/L) was observed in sample site 2 tap water samples and a lower concentration of Pb (0.01 mg/L) was found in sample site 1 tap water sample. The mean concentrations of Pb found in both sample sites were above the maximum permissible level recommended by WHO, EU, Australian, and Ethiopia standards. However, the mean concentrations of Pb found in both sample sites were below the maximum permissive level set by USEPA. Iranian, Indian, Malaysian, Newzlandian standards. This high amount of Pb might be due to Pb leaks from the old water pipes. Analysis of variance showed that the concentration of Pb was significantly different between sample site 1 and sample site 2 at a 95% confidence level.

Nickel (Ni)

The mean concentration of Ni was found to be 1.86 mg/L for sample site 1 and 2.4 mg/L for sample site 2. The mean concentrations of Ni in the sample sites were found to be above the maximum permissible level recommended by USEPA, WHO, EU, Australian, Indian, Newzlandian standards. Analysis of variance showed that the concentration of Ni was significantly different between sample site 1 and sample site 2 at a 95% confidence level.

Chromium (Cr)

The mean concentration of Cr was found to be 0.08 mg/L for sample site 1 and 0.14 mg/L for sample site 2. These Cr values were higher than the maximum permissible level stated by WHO, USEPA, EU, Australian, Iranian, Indian, Malaysian, Newzlandian, and Ethiopian standards. Analysis of variance showed that the concentration of Cr was significantly different between sample site 1 and sample site 2 at a 95% confidence level.

Iron

The mean concentration of Fe was found to be 0.25 mg/L for sample site 1 and 0.50 mg/L for sample site 2. These Fe results were found to be below the maximum permissible limit set by WHO. Analysis of variance showed that the concentration of Fe was significantly different between sample site 1 and sample site 2 at a 95% confidence level.

Manganese

The mean concentrations of Mn were found to be 0.001 mg/L for sample site 1 and sample site 2. This concentration of Mn was below the maximum permissible level recommended by WHO, USEPA, Australian, Iranian, Malaysian, and Newzlandian standards. Analysis of variance showed that the concentration of Mn was significantly different between sample site 1 and sample site 2 at a 95% confidence level.

Conclusion

In this study, selected Physico-chemical parameters and heavy metals were determined in tap water collected from two sampling sites in Halaba town. The result of the study showed that there was variation in the concentrations of selected heavy metals (Zn, Cu, Pb, Ni, Cr, and Mn) between the two sampling sites. The concentration of Cr and Ni has slightly exceeded the recommended limit set by WHO, USEPA, EU, and other countries' standards. Therefore, the tap water used in the Halaba town needs to be treated for these heavy metals before it is distributed to the community for drinking purposes and domestic activities. The increased level of heavy metals such as Cr and Ni could be due to the use of agricultural chemicals such as fertilizers, pesticides, herbicides, etc., which find a way to pollute the sources of the tap water. Thus, comprehensive studies of the presence of heavy metals in environmental samples near the town need to be investigated.

Data Availability

All the data used to support the findings of this study are available from the corresponding author upon request.

- **Conflicts of Interest:** The authors declare that there is no conflict of interest regarding the publication of this paper.

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References

1. WWF (1998) Living planet report: Overconsumption in driving the rapid decline of the world's environments. WWF International, Avenue Du Mont-blanc CH-1196 Gland Switzerland.

2. World Health Organization (2011) Guidelines for drinking water quality, WHO press, Geneva, Switzerland, 4th (Edn.).

3. Lamikanra A (1999) Essential Microbiology for students and practitioners of pharmacy, medicine and microbiology, 2nd (Edn.), Amkra Books.

4. TWAS (2002) Safe drinking water–the need, the problem, solutions and an action plan. Third World Academy of Sciences, Trieste, Italy.

5. Oluyemi EA, Adekunle AS, Adenuga AA, Makinde WO (2010) Physico-Chemical Properties and Heavy Metal Content of Water Sources in Ife North Local Government Area of Osun State, Nigeria. African Journal of Environmental Science and Technology 4(10): 691-697.

6. Singh S, Mosley LM (2003) Trace metal levels in drinking water on Viti Levu, Fiji Islands. S Pac J Nat Sci 21: 31- 34.

7. Bartram J, Ballance R (1996) Water Quality Monitoring: A Practical Guide to the Design and Implementation of Freshwater Quality Studies and Monitoring Programmes. CRC Press, New York.

8. Goel PK (2006) Water pollution, causes, effects and control. Y.C. College of Science, Vidyanaga, Maharashtra, 2nd (Edn.).

9. Ministry of Water Resource (MoWR) (2002) Federal Democratic Republic of Ethiopia Ministry of Water Resources Water Sector Development Program Main Report Volume II.

10. APHA (2005) Standard methods for the examination of water and wastewater. American Public Health Association 21st (Edn.), Washington DC, USA.

11. Gebrekidan M, Samuel Z (2011) Concentration of heavy metals in drinking water from urban areas of the Tigray region, Northern Ethiopia. Momona Ethiopian Journal of Science 3(1): 105-121.

12. EEPA (2003) Guideline Ambient Environmental Standards for Ethiopian. Prepared by Ethiopian Environmental protection Authority in collaboration with the United Nations Industrial Development Organization, Addis Ababa.

13. USEPA (2008) Drinking water standards and health advisories. EPA822-R-04-005, Office of Water, US Environmental Protection Agency, Washington D.C.

14. European Union (2011) European standard for drinking water, World Health Organization, Geneva.

15. NRMMC (2011) Australian Drinking Water Guidelines Paper 6 National Water Quality Management Strategy. National Health and Medical Research Council, National Resource Management Ministerial Council, Commonwealth of Australia, Canberra.

16. ISIRI 1053 (2010) Institute of Standards and Industrial Research of Iran. Drinking water -Physical and chemical specifications, 5th revision.

17. BIS (2012) Indian Standard for Drinking Water-Specification IS 10500: 2012.

18. National Drinking Water Quality Standards for Malaysia (2004) Drinking Water Quality Surveillance Unit, Engineering Services Division, Ministry of Health Malaysia.

19. Ministry of Health (2005) Drinking-water Standards for New Zealand. Wellington: Ministry of Health.