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Assessment of Physicochemical Quality of Spring Water in Arbaminch, Ethiopia

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Abstract

Spring water is a major source of water for drinking, agricultural, and industrial desires. The availability of water determines the location and activities of humans in an area and our growing population is placing great demands upon natural fresh water resources. However, they are sometimes exposed to various forms of pollution such as agricultural, industrial and residential. In the present study spring water samples were collected from Arbaminch spring and have been analyzed for physico-chemical parameters pH, electrical conductivity (EC), total dissolved solids (TDS), total suspended solids (TSS), total alkalinity, total hardness (TH), Cl^-, F^-, NO_3^-, NO_2^-, Na^+, K^+, Ca^{2+}, SO_4^{2-} and Mg^{2+}. The obtained values of each parameter were compared with the standard values set by the World Health Organization (WHO), standards organization of Nigeria (SON), Indian standards institution (ISI) and United nations environmental protection agency (USEPA) drinking water quality standards. The values of each parameter were found to be within the safe limit values except Cl^- , total alkalinity and F^-. But the concentration of Cl^- was found higher than the permissible levels of Cl^- for safe drinking water set by WHO and SON. Total alkalinity have been found to be high as compared to desired limit value, but little higher compared to maximum permissible limit values of ISI. The average value of F^- was also found above the maximum standard values of WHO and SON, but within the maximum standard values of US-EPA.

Keywords: Arbaminch; Spring water; Physio-chemical parameters; Water quality

Introduction

Water is essential for life on earth. Because of its importance, the pattern of human settlement throughout history has often been determined by its availability [1]. Next to oxygen, water is the most important substance for human existence [2]. Human existence mainly depends on fresh water supply which is less than 1% of the water available on earth [3]. Ground or spring water represents an important source of drinking water and its quality is currently threatened by a combination of over-abstraction and microbiological and chemical contamination [4]. In addition to the process of desertification, pollution is also reducing the volume of safe drinking water. Drinking water is water pure enough to be consumed or used with low risk of immediate or long term harm. In most developed countries water supplied to households, commercial and industry is all of drinking water standard even though only a very small proportion is actually consumed in food preparation [5].

But the majority of the population in developing countries is not adequately supplied with potable water and is thus compelled to use water from sources like shallow wells, boreholes, springs and streams that render the water unsafe for domestic and drinking purposes due to high possibilities of contamination [6,7]. In order to ensure a safe public health, water supply for human consumption must be free from pathogens, free from chemical toxins and must be physically clear and appealing to taste [8]. It is also important that water for domestic, agricultural or industrial uses should not be acidic or alkaline than is required by standards for the purpose. Ethiopia is also one of the developing countries, have suffered from a lack of access to safe drinking water from improved sources and to adequate sanitation services [6]. As a result, people are still dependent on unprotected water sources such as rivers, streams, springs and hand dug wells.

Peoples living around the study area are also seeking the spring water as drinking and other domestic purposes. Considering this situation a good knowledge of the qualities of spring water is necessary to guide its suitability for use [9] also stated that physicochemical characteristics are vital water quality monitoring parameters and affect the quality of a water resource. Therefore; the present study was formulated to determine the potability of the spring water by assessing the levels of some physicochemical parameters, which justifies the quality of a drinking water.

Materials and Methods

General description of sampling site

Spring water samples were collected from Arbaminch called Forty springs. Arbaminch is an administrative town and trading center of the Gamogofa zone, located at 505 kms from Addis Ababa, the capital city of Ethiopia. The total area of the town is estimated about 1095 hectares and it lies at an altitude of 1300 meters above sea level, its average temperature is 29°C and the average annual rainfall is 900 mm [10].

Samples and sampling techniques

Spring water samples were collected in two litres capacity polythene bottles separately, without any air bubbles and prior to the collection, bottles were thoroughly washed and rinsed with sample to avoid any possible contamination in bottling and every precautionary measure was taken. Finally the samples collected were kept in refrigerator (4°C) during transportation to Arbaminch University for analysis.

Physicochemical analyzes

The analyses of various physicochemical parameters were carried out following the method described by [11]. The temperature, potential of hydrogen (pH) and electrical conductivity were measured at the time of sample collection. pH was measured with portable field pH meter,

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type (WTW pH 330i/SET), total dissolved solids (TDS) and electrical conductivity (EC) were measured with Handheld Conductivity Meter, Model 4510 by shifting one of the four buttons of the instrument. Total Hardness (TH), calcium (Ca^{2+}) and magnesium (Mg^{2+}) were determined by the volumetric method with EDTA (Ethylenediaminetetraacetic acid). Total Alkalinity was analyzed by volumetric method with 0.4 N H_2SO_4 solutions. Chlorides (Cl^-) was determined by the volumetric method with dinitrate mercury Hg $(NO_3)_2$ in the presence of a pH indicator and total suspended solid (TSS) using gravimetric analysis. Nitrate (NO_3^-), nitrite (NO_2^-), sulphate (SO_4^{2-}) were determined by a colorimetric method using a UV-Visible spectrophotometer type (JASCO V-530). Sodium (Na^+) and potassium (K^+) were also determined by excitation of the atoms by flame photometer type (AFP-100).

Results and Discussion

pH

The pH is a measure of the hydrogen ion concentration in water (Tables 1 and 2). The pH value of water indicates whether the water is acidic or alkaline. Drinking water with a pH between 6.5 to 8.5 is generally considered satisfactory. In this study, the concentration of hydrogen ion (pH) ranges between 7.13 to 7.5 and all the water samples analyzed have concentration within the safe limit of 6.5 to 8.5 standard set by the WHO and SON.

Total hardness as $CaCO_3$

Total hardness of water mainly depends upon the amount of calcium and magnesium salts or both. The permissible limits of total hardness in potable water ranged within 300 mg/L as given by Indian standards for drinking water. In the present study the values of total hardness in all sampling sites ranged from 220 to 238 mg/L. The water quality analysis showed the hardness values of the spring water samples were within permissible limit and is safe for drinking and other domestic uses.

Chloride (Cl^-)

Cl^- is normally the most dominant anion in water and it imparts salty taste to the water. The permissible limit of chloride in drinking water is 250 mg/L as given by WHO and SON. In present study, the results of chlorides in all sampling sites, S1, S2 and S3 were 260 mg/L, 264.33 and 271.8 mg/L respectively. The chloride level recorded in the entire sampling points of the spring water was higher than the permissible levels of chloride for safe drinking water set by WHO (250 mg/L) and SON (250 mg/L). According to the USEPA guideline high level of Cl^- results eye/nose irritation; stomach discomfort and increase corrosive character of water.

Total suspended solids (TSS)

Regarding the values of the TSS, the water samples showed much presence of contaminants, as the values ranged from 62.3 mg/L to 21.1 mg/L in the spring water samples. Conversely, TSS value is usually taken as an index of contamination potential of drinking water. This may introduce different diseases which affect all living things especial human beings.

Total dissolved solids (TDS)

TDS can also be taken as an indicator for the general water quality because it directly affects the aesthetic value of the water by increasing turbidity. High concentrations of TDS limit the suitability of water as a drinking source and irrigation supply [12].

In the present study, the concentrations of TDS in all sampling sites were ranged from 150.76 to 155.54 mg/L. These values were within the standard limits of drinking water quality set by WHO (500 mg/L) and SON (500 mg/L). Thus a low level of TDS contents of the spring water allows the water for drinking and other domestic uses.

Electrical conductivity (EC)

It is known that EC is a measure of the ability of aqueous solution to carry an electric current that depends on the presence and total concentration of ions, their mobility and valance and on the temperature [13]. The EC is a valuable measure of the amount of metal ions dissolved in wastewater and water.

In present study, the values of EC in all sampling points were ranged from 150.76 to 154.96 µS/cm. The values obtained in all sampling sites were within the standard value of SON drinking water quality which is 1000 µS/cm. So they are good for use.

Total alkalinity

Alkalinity of water is defined as the ionic concentration, which can neutralize the hydrogen ions. In the present study the total of the S1, S2 and S3 were 680.33 mg/L, 666.67 mg/L and 711.11 mg/L respectively.

Parameters	Sampling Sites Mean ± SD		
	S1	S2	S3
pH	7.13 ± 0.499	7.70 ± 0.65	7.50
Total alkalinity	680.33 ± 1.47	666.67 ± 1.50	711.11 ± 1.23
TH	220 ± 0.001	238 ± 0.001	222 ± 0.002
TDS	150.76 ± 1.66	154.96 ± 0.64	155.54 ± 1.01
TSS	62.3 ± 2.17	21.1 ± 1.40	33 ± 1.88
EC	150.76 ± 1.66	154.96 ± 0.64	158.23 ± 1.0
Cl^-	271.8 ± 2.4	260 ± 1.99	264.33 ± 2.2
F^-	4.415 ± 0.59	2.048 ± 1.79	2.5 ± 1.2
NO_3^-	20.17 ± 0.55	18.03 ± 0.66	19.57 ± 0.67
NO_2^-	ND	ND	ND
Na^+	33.00 ± 0.001	29.77 ± 0.002	30.57 ± 0.002
K^+	3.45 ± 0.22	3.68 ± 0.34	2.88 ± 0.15
Ca^{2+}	67.54 ± 0.33	70.16 ± 0.45	72.81 ± 0.44
SO_4^{2-}	10.33 ± 0.67	16.73 ± 0.47	13.60 ± 0.54
Mg^{2+}	60.44 ± 0.59	59.23 ± 0.32	63.55 ± 0.37

Table 1: Average concentration (mean ± SD, n=3) values of physicochemical parameters of spring water. All values are means of three determinations and are in mg/L except pH and EC (µS/cm). ND: Not detected.

Types of parameter	Standard values
pH	6.5-8.5*,**
TDS	500 mg/L*, 500 mg/L**
Cl^-	250 mg/L*
EC	1000 µS/cm**
TH (as $CaCO_3$)	300 mg/L***
Alkalinity	200 mg/L***, 150 mg/L**
F^-	1.5 mg/L*, 1.5 **, 4.0 mg/L****
Mg^{2+}	0.2 mg/L**
NO_3^-	50 mg/L**
NO_2^-	0.2 mg/L**
Na^+	200 mg/L**
Ca^{2+}	75*, 75-100***
SO_4^{2-}	100 mg/L**

Table 2: Some international standard values of drinking water quality. Sources: *WHO, **SON, *** ISI, ****US EPA.

According to ISI the desired limit and the maximum permissible limit for alkalinity in drinking water is 200 and 600 mg/L respectively. Therefore, the value of total alkalinity content in all sampling points have been found to be high as compared to desired limit value, but little higher compared to maximum permissible limit. Thus, high value of alkalinity might be due to the presence of bicarbonates as total alkalinity is caused by bicarbonates. However, little abnormal value of alkalinity is not harmful to human beings [14].

Fluoride (F^-)

The measured values of F^- ion in all sampling sites S1, S2 and S3 were 4.415, 2.048 and 2.5 mg/L respectively. The average value of F^- which is 2.98 mg/L was above the maximum standard values of F^- in drinking water set by WHO and SON which is 1.5 mg/L but within the maximum standard values of F^- in drinking water set by US-EPA which is 4 mg/L. High values of F^- in drinking water also results in Fluorosis, skeletal tissue (bones and teeth) morbidity [15].

Sulphate (SO_4^{2-})

The sulphate naturally present in water, very variable concentration (major in contact with gypsum or and other common minerals) [16]. Discharge of industrial wastes and domestic sewage tends to increase its concentration. For the present study the levels of SO_4^{3-} in all sampling sites S1, S2 and S3 were 10.33, 16.73 and 13.6 respectively. And these measured results were within the standard values of SON which is 100 mg/L. This result also confirms the acceptability of the spring water for drinking and other domestic uses in terms of their sulphate contents.

Calcium (Ca^{2+})

Ca^{2+} has no effect on human health in water, but it can cause hardness problem risk and directly related to hardness [6]. The concentrations of Ca^{2+} recorded in S1, S2 and S3 were 67.54, 70.16 and 72.81 mg/L respectively. Mean value was 63.6 mg/L. All the values of Ca^{2+} were within the standard values of WHO (75 mg/L) and US-EPA (75-100 mg/L). This indicated that in terms of the Ca^{2+} content the spring water is safe for drinking and other domestic purposes.

Magnesium (Mg^{2+})

Mg^{2+} is the most abundant elements in nature and it is a significant member in water hardness, it gives an unpleasant taste to water [17]. The content of Mg^{2+} in the investigated water samples S1, S2 and S3 were 60.44 mg/L, 59.23 mg/L and 63.55 mg/L respectively, with mean value 61.07 mg/L. The level of Mg^{2+} in all these water samples is very low. This makes it good for drinking and domestic uses.

Nitrates (NO_3^-)

Follett RF et al. [18] stated that low levels of nitrogen (in the form of nitrate) are normal in groundwater and surface water. However, elevated nitrate caused by human activity is a pollutant in the water. Nitrate enters ground or spring water from many sources, including nitrogen-rich geologic deposits, wild-animal wastes, precipitation, septic system drainage, feedlot drainage, dairy and poultry production, municipal and industrial waste, and fertilizer.

In the present study the levels of nitrate in all the sampling sites S1, S2 and S3 were 20.17 mg/L, 18.03 mg/L and 19.57 mg/L respectively and all these values were found within the prescribed limit value of SON which is 50 mg/L which shows the water is safe in terms of its NO_3^- content for drinking and other domestic uses.

Conclusion

In this study physico-chemical parameters such as pH, EC, TDS, TSS, total alkalinity, total hardness, Cl^-, F^-, NO_3^-, NO_2^-, Na^+, K^+, Ca^{2+}, SO_4^{2-} and Mg^{2+} of the spring water were measured. And from the experimental data it was found that the concentration of Cl^- was higher than the permissible levels of Cl^- for safe drinking water set by WHO and SON. Water containing Cl^- more than 250 mg/L has detectable salty taste. Total alkalinity have been found to be high as compared to desired limit value, but little higher compared to maximum permissible limit values of ISI standards. The average value of F^- was also found above the maximum standard value of WHO and SON, but within the maximum standard value of USEPA. But all the rest parameters were found within the safe limit drinking water quality standards and are found to be safe for dirking and other domestic purposes at the physicochemical level. However, it is also important to investigate other potential water contaminations such as chemicals, microbial and radiological materials for a longer period of time, in order to assess the overall of the spring water quality.

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