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Quality Analysis of Potable Water in Dowhan, Erop Wereda, Tigrai, Ethiopia

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Abstract
One of the important UN Millennium Development Goals is to reduce by half the proportion of people without sustainable access to safe drinking water by the year 2015. Quality analysis of drinking water is less studied even though peoples are consuming or drinking water day to day that may result the accumulation of unwanted materials in human body. A study was carried out to assess the suitability of potable water used for domestic activities in Dawhan, Erope wereda, tigray Ethiopia. some water quality parameters such as total dissolved solids (TDS), Hardness, Chlorides, Sulphate. The results of the physical parameters revealed the following: total dissolved solids, 2500 mg/L exceeds the permissible value of WHO (500-2000mg/l), chloride, 200.293 mg/L, Hardness, 275.8 mg/L and sulphate, 490.085mg/L. Therefore, the concentration of sulphate exceeds the permissible value of WHO (200-400 mg/L).
Key words: Total Dissolved Solids, Water Hardness, Sulphate, Chlorides. Water Quality

1. INTRODUCTIONS

Water is one of the vital components of the physical environment. The quality of drinking water is closely associated with human health, and providing safe drinking water is one of important public health priorities. Estimated 80 % of all diseases and over none third of deaths in developing countries are caused by the consumption of contaminated water, and on an average as much as one tenth of each person's productive time is sacrificed to water-related diseases (UNCED, 1992) as reported by[1]. Potable water is the water of sufficiently high quality that can be consumed or used with low risk of immediate or long-term harm. Water has always been an important and life-sustaining drink to humans and is essential to the survival of all organisms. Excluding fat, water composes approximately 70% of the human body by mass. It is a crucial component of metabolic processes and serves as a solvent for many bodily solutes. Water is essential for the growth and maintenance of our bodies, as it is involved in a number of biological processes [2].

In recent times, there has been an increasing health related concern associated with the quality of drinking water in developing countries. According to a recent report by WHO/UNICEF, about 780 million people in the developing world lack access to potable water due largely to microbiological and chemical contaminations. Drinking water sources in these so-called developing countries are under increasing threat from contaminations by chemical, physical and microbial pollutants [3].

One of the important UN Millennium Development Goals is to reduce by half the proportion of people without sustainable access to safe drinking water by the year 2015. The United Nations Convention on the Rights of the Child stipulates that states and their partners have the obligation to provide clean drinking water to all children. The consumption of water containing pathogenic organisms or toxic chemicals and the use of inadequate volumes of water, resulting in poor hygiene, pose serious risks to human health. In addition, the physical condition of water (colour, taste and odour) might render it undrinkable as it can be rejected by end-users. For this reason, water quality assessment and continuous monitoring are of utmost importance [4].

Quality analysis of drinking water is less studied even though peoples are consuming or drinking water day to day that may result the accumulation of unwanted materials in human body. However, to the extent of assessment done, there is no literature report on the physico-chemical properties of drinking water in Dawhan, Erope Wereda. Hence, this research is intended to determine on the physico-chemical properties of drinking water in Dawhan, Erope wereda, Tigray, Ethiopia.

1.1 OBJECTIVES

The general objective of this work was to determine quantitatively of some physical and chemical parameters drinking water with the following specific objectives:

- To characterize drinking water samples for their physico-chemical properties
- To compare the collected drinking water samples analysis results with that of international quality standards and WHO guide line value
- To aware the local people on the health risk of drinking water

2. LITERATURE REVIEW

2.1. Total dissolved solids (TDS)

Total dissolves solids (TDS) are naturally present in water or are the result of mining or some industrial treatment of water. TDS contain minerals and organic molecules that provide benefits such as nutrients or contaminants such as toxic metals and organic pollutants. Current regulations require the periodic monitoring of TDS, which is a measurement of inorganic salts, organic matter and other dissolved materials in water. Measurements of TDS do not differentiate among ions [5, 6].

According World Health Organization (WHO), a total dissolved solid (TDS) is the term used to describe the inorganic salts and small amounts of organic matter present in solution in water. The principal constituents are usually calcium, magnesium, sodium, and potassium cations and carbonate, hydrogen carbonate, chloride, sulfate, and nitrate anions. Concentrations of TDS from natural sources have been found to vary from less than 30mg/liter to as much as 6000 mg/litre, depending on the solubility of minerals in different geological regions. The presence of dissolved solids in water may affect its taste. The palatability of drinking-water has been rated by panels of tasters in relation to its TDS level as follows: excellent, less than 300 mg/litre; good, between 300 and 600 mg/litre; fair, between 600 and 900 mg/litre; poor, between 900 and 1200 mg/litre; and unacceptable, greater than 1200 mg/litre. Water with extremely low concentrations of TDS may also be unacceptable because of its flat, insipid taste [7]. No recent data on health effects associated with the ingestion of TDS in drinking-water appear to exist; however, associations between various health effects and hardness. Certain components of TDS, such as chlorides, sulfates, magnesium, calcium, and carbonates, affect corrosion or encrustation in water-distribution systems. High TDS levels (>500mg/liter) result in excessive scaling in water pipes, water heaters, boilers, and household appliances such as kettles and steam irons. Such scaling can shorten the service life of these appliances [8].

2.2. Water Hardness

According world health organization (WHO), Water hardness is the traditional measure of the capacity of water to react with soap, hard water requiring considerably more soap to produce lather. It is not caused by a single substance but by a variety of dissolved polyvalent metallic ions, predominantly calcium and magnesium cations, although other cations, e.g. barium, iron, manganese, strontium and zinc, also contribute [9]. The principal natural sources of hardness in water are dissolved polyvalent metallic ions from sedimentary rocks, seepage, and run-off from soils. Calcium and magnesium, the two principal ions, are present in many sedimentary rocks, the most common being limestone and chalk. They are also present in a wide variety of industrial products and are common constituents of food. As mentioned above, a minor contribution to the total hardness of water is also made by other polyvalent ions, e.g. Aluminum, Barium, Iron, Manganese, Strontium, and Zinc. Hardness levels above 500 mg/litre are generally considered aesthetically unacceptable, although this level is tolerated in some communities. Drinking water with less hardness may have adverse effects on mineral balance in the body [7].

There does not appear to be any convincing evidence that water hardness causes adverse health effects in humans. In contrast, the results of a number of epidemiological studies have suggested that water hardness may protect against disease. However, the available data are inadequate to prove any causal association. The results of several studies have suggested that varieties of other diseases are also inversely correlated with the hardness of water, including anencephaly and various types of cancer. However, the significance of these results is unclear, and it has been suggested that the associations may reflect disease patterns that can be explained by social, climatologically, and environmental factors, rather than by the hardness of the water. Depending on the interaction of other factors, such as pH and alkalinity, water with hardness above approximately 200 mg/litre may cause scale deposition in the distribution system, as well as increased soap consumption. In contrast, soft water, with hardness less than about 100 mg/litre, has a greater tendency to cause corrosion of pipes, resulting in the presence of certain heavy metals, such as cadmium, copper, lead, and zinc, in drinking-water. The degree to which this corrosion and solubilization of metals occurs also depends on the pH, alkalinity, and dissolved oxygen concentration [8]. The World Health Organization (WHO) International Standard for Drinking Water (1998) classified water with a total hardness of $CaCO_3$ less than 50 mg/l as soft water, 50 to 150 mg/l as moderately hard water and water hardness above 150 mg/l as hard $CaCO_3$ as reported [10].

2.3. Chlorides

Chloride is the major anions in water. Chlorides are present as sodium chloride (NaCl, common salt) and to lesser extent as calcium and magnesium chlorides. The salty taste is produced by the chloride concentrations. There is no known evidence that chlorides constitute any human health hazard. For this reason, chlorides are generally limited to 250 mg/l in supplies intended for public use (WHO). The main problem caused by excessive chloride in water concerns the acceptability of the supply. Concentration above 250 mg/L can impart a distinctly salty taste to water. For people suffering from heart and kidney diseases, high chloride water usage has to be restricted. Excessive chlorides concentration increase rates of corrosion of metals in the distribution system [2, 6].

Chloride concentrations in excess of about 250 mg/litre can give rise to detectable taste in water, but the threshold depends upon the associated cations. Consumers can, however, become accustomed to concentrations in excess of 250 mg/litre. No health-based guideline value is proposed for chloride in drinking water [8]. Other researcher reported that Chlorides are found in water as mineral solvents said that huge ingestion of chlorides may results in several health effects including tooth decay [9].

2.4. Sulphate

The concentration of sulphate in natural water can be found in various ranges from a few mg/L to several thousand mg/L. the highest level usually occurs in ground water. The sources of sulphate are the solutions of minerals containing sulphates and oxides of sulphur, sulphides and thiosulphates. The presence of sulphate in drinking water can cause noticeable taste. The taste varies with the associated cation. Taste threshold has been found to range from 250 mg/L for sodium sulphats to 1000 mg/L for calcium sulphate [11] Geneva. Sulphate in domestic water contributes the major source for permanent hardness. High levels can impart taste and when combined with magnesium or sodium can have laxative effective effect [6]

According the world health organization (WHO), the existing data do not identify a level of sulfate in drinking-water that is likely to cause adverse human health effects. The data from the liquid diet piglet study and from tap water studies with human volunteers indicate a laxative effect at concentrations of 1000–1200 mg/liter, but no increase in diarrhea, dehydration or weight loss. The presence of sulfate in drinking-water can also result in a noticeable taste; the lowest taste threshold concentration for sulfate is approximately 250 mg/litre as the sodium salt. Sulfate may also contribute to the corrosion of distribution systems. In the light of the above considerations, no health-based guideline value for sulfate in drinking water is proposed. However, there is an increasing likelihood of complaints arising from a noticeable taste as concentrations in water increase above 500 mg/liter [8]. Some researcher argues that Sulphate, one of the major anions in natural waters, is of importance due to its cathartic effect in some human when present in excessive amount. Sulphate may occur due to industrial discharge, contaminant from mines, tanneries, paper mills, etc. Sulferdioxide from combustion is converted in the atmosphere to sulphuric acid. The sulphuric acid is then driven by wind and eventually comes down to the earth, either directly (dry precipitation) or with rain (wet precipitation, also referred to as acid rain), many miles from its origin. Excessively high concentrations of sulphate may decrease pH of the water and increase its bacterial load, for example, sulphate reducing bacteria [12].

Table 1: Water Quality Parameter and WHO Drinking Water Standard

No.	Water Quality Parameter	WHO	References
1.	Total dissolved solids(mg/L)	500-2000	[13]
		600-1000	[14]
2.	Chlorides (mg/L)	250	[6,14]
3	Sulphates (mg/L)	200-400	[13]
		250	[6,14]
4	Hardness (mg/L)	300-600	[13]
		200-500	[14]
5	pH	6.5-8.5	[13,14]
6	Alkalinity(mg/L)	200	[13]
7	Phosphate(mg/L)	5	[10]

3.Methodology

3.1.Chemicals and materials

The chemicals were used Potassium chromate purchesed from UNI-CHEM-chemical reagents, Silver Nitrate purchesed from Blulux laboratory P.ltd,Ammonium chloride purchesed from Fine chem.-Industries, India,Ammonia purchesed from Rashmi Diagrwstic, Di sodium salt EDTA ,Barium chlorides &Sodium hydroxide purchesed from Ace-laby laboratory reagents,India,Erichrome black T and Sodium salphate (EBT) purchesed from FINKEM Lab Reagent,n-Propanol purchesed from chemicals UPYOG.India, Glycerol purchesed from Okhia induatrial area,India,Hydrochloric acid 35% purchesed from Himedia laboratory Pvt.Ltd,India andSodium Chloride purchesed from Abron chemicals and reagents.

The apparatus and instruments used for this study were beakers (SUNLEX), Burrate (Reli glass India),Pipette 5ml (borosilicate glass ,india),Conical flask (BOMEX,B.J,China),Volumetric flask (BOMEX,B.J,China),Uv visible spectrometer (721 visible spectrometer)

3.2. Sampling

Meaningful and reliable sampling assures the validity of analytical findings. Therefore, greatest care was exercised to ensure that the analyses were representative of the actual composition of the water samples. The samples were collected from different locations of Dawhan town in sterilized bottles and prior to filling the sample bottles were rinsed two to three times with the water to be collected. The collected samples were promptly carried to the analytical chemistry laboratory of the Department of Chemistry, Adigrat University and almost all the important water quality parameters were measured.

3.3 .Total Dissolved Solids (TDS)

The dissolved solids in water comprise inorganic salts and a small amount of organic matter. The principal anions contributing to the TDS include: carbonate, bicarbonate, chloride, sulphate and nitrates. Also TDS includes the cations: calcium, magnesium, potassium and sodium. TDS water influences other qualities of drinking water, such as; taste hardness and corrosion properties. 100 ml of water sample was transferred to weighted beaker and evaporated to dryness by heating for 4- 5 hours at 180^0C [6,10].

3.4. Determination of Total Hardness

3.4.1. Buffer Solution preparation

Weigh 16.9g of ammonium chloride add it to the contents in the beaker. Dissolve it thoroughly then Weigh 780mg of magnesium salphates and transfer it to the beaker. Measure 143 mL of ammonium hydroxide solution using measuring cylinder and add it to the contents in the beaker. place the funnel over the 250 mL standard flask and transfer the dissolved contents from beaker, make the volume up to 250mL then mark by adding distilled water. Transfer the buffer solution to a clean reagent bottle labeled as buffer solution. This buffer solution is used to maintain the pH of water sample between 9 and 10.

3.4.2. Erichrome Black T

Weigh 0.5g of Erichrome black T then Transfer it to 100mL standard flask using funnel. Add distilled water in the standard flask and make the volume exactly up to 100 mL mark. Put the lid and shake the contents well finally, Transfer the solution to a clean reagent bottle named EBT.

3.4.3. Standard EDTA Solution (0.02 M)

Switch on the Electronic balance, keep the weighing pan, and set the reading to zero. Weigh 3.723g of EDTA sodium salt and Transfer the entire content to 1000mL standard flask, then Fill with distilled water up to 1000mL. Mark Put the lid and shakes the contents well. For easy handling, take the EDTA solution in a 250 mL beaker.

3.4.4. Testing of Water Sample

Pipette 20mL of water sample and transfer it to a clean 250 mL conical flask. Add 2mL of Ammonia buffer solution to the water sample so that the pH will be maintained between 9 and 10.then Add few drops of EBT indicator to the conical flask and the sample turns to wine red in color. Before starting the titration rinse the burette with few mL of EDTA. Fill the burette with 0.02M EDTA solution and adjust to zero then fix it in burette stand. Titrate the sample against the EDTA solution in the burette till all calcium and magnesium ions present in the sample reacts with the EDTA. The appearance of blue colour indicates that all Ca & Mg ions are complexes with EDTA and forms a metal EDTA complex i.e., the end point of the titration. Note down the burette reading and repeat the titration for concordant values [10].

3.5.Determination of Chlorides

The Mohr Method uses silver nitrate for titration (normality: 0.0141) (method applicability: 0.15 to 10 mg/L chloride ions). This corresponds to 1 mL of 0.0141 equals to 1 mg chloride in solution. The silver nitrate solution is standardized against standard chloride solution, prepared from sodium chloride (NaCl). During the titration, chloride ion is precipitated as white silver chloride (Eq.1):

$Ag^+ + Cl^- \Leftrightarrow AgCl$ (Solubility product constant, Ksp=3×10-10) ---------------------------- (1)

The indicator (potassium chromate) is added to visualize the endpoint, demonstrating presence of excess silver ions. In the presence of excess silver ions, solubility product of silver chromate exceeded and it forms a reddish-brown precipitate (Eq.2). This stage is taken as evidence that all chloride ions have been consumed and only excess silver ions have reacted with chromate ions:

$2Ag^+ + CrO_4^{2-} \Leftrightarrow Ag_2CrO_4$ (Ksp=5×10-12) ------------------------------------ (2) Take 25 ml sample in a conical flask. Add 1.0ml indicator solution, Titrate with standard silver nitrate solution to pinkish yellow end point and note down volume of titrant used. Also measure sample pH. Calculate chloride ion concentration using Eq. (3):

$$\text{Chloride Ion Concentration } (^{mg}/_{L}) = \frac{A \times N \times 35.45 \times 1000}{V_{Sample}} \quad \text{-------------------------------- (3)}$$

Where: A = volume of titrant used, N is normality of silver nitrate (here we used N/71 or 0.0141 N), and V sample is volume of sample used (mL).

3.6. Determination of Sulphate

3.6.1 Preparation of Conditioning Reagent

Measure exactly 25 ml glycerol and pour it to a dry clean beaker. Then, measure 15 mL of concentrated hydrochloric acid and add it to the same beaker. To the same beaker, add exactly 50 mL of 95 % isopropyl alcohol and mix well. Accurate weigh 37.5 g sodium chloride and dissolve it in distilled water. Then mix all the contents and make up the final volume to 250 mL using distilled water.

3.6.2. Standard sulphate solution

Weigh accurately 1.479 g anhydrous sodium sulphate and dissolve it in distilled water. Take 1000 mL standard measuring flask and place a funnel over it. Transfer it to the 1000 mL standard flask and make up to 1000 mL using distilled water (1mL = 1.0 mg SO_4^{2-}).

3.6.3. Preparation of Blank, Standards and sample for Testing

Take six 50 mL glass stoppered standard flask (four for standards, one for the sample and one for the blank). Add 10 mL of the standard sulphate solution to the first standard flask, 20 mL to the second, 30 mL to the third and 40 mL to the fourth. To the fifth standard flask, add 20 mL of the sample water. The sixth standard flask is for the blank; to this standard flask add distilled water alone. Add 5 mL of conditioning reagent to all the standard flasks. Then make up the volume to the 100 mL mark using distilled water.

$$\text{Concentration of sulphate in mg/l} = \frac{x.1000}{ml\ of\ sampletaken} \quad (4)$$

3.7. Data analysis

Finally, the data was statistically analyzed using Axel and Origin

4.RESULT AND DISCUSSION

4.1. Total dissolved solids (TDS)

The average value of TDS in the water was 2500 mg/L prescribed as desirable limit of TDS is 500 mg/L. The maximum permissible level is 2000 mg/L. TDS values observed in Dawhan were above the desirable limit. However, High TDS in ground water may be due to ground water pollution when the leaching of the inorganic salts from the rock to the water. The study area has the high probability of leaching because of covered by hard and soft rocks and it may makes high TDS value [15].

4.2. Water Hardness

The total hardness value of the Dawhan town was 275.8 which is hard and has positive impact for the health since the presence excess calcium important for building of bones and teeth [9] and in the permissible value (200-500 mg/L) of global drinking water quality index. But water with hardness above approximately 200 mg/liter may cause scale deposition in the distribution system, as well as increased soap consumption but higher concentrations are acceptable to consumers [8]. The reason water make hard is due to the leaching of polyvalent metallic ions from sedimentary rocks, seepage, since the study area is highly covered by the hard and soft rocks.

4.3. Chlorides

Chloride in water may be considerably increased by treatment processes in which chlorine or chloride is used. The average value of chloride obtained from the experiment was 200.293mg/L.The data showed that the concentration of chloride for the samples were in agreement with the WHO standards (250mg/L) [6, 13].

4.4. Sulphates:

The average value of sulphate concentration in a given sample was 490.085mg/L from the calabration curve using the values read by the Uv-visible spectrometer ()and R value of the calibration curve was 0.99 which indicated measurement agreements. This is above the maximum permissible limit of WHO (1984) 200-400mg/L [12] and WHO (2007)250mg/L [13].The presence of high levels of sulphate in water may contribute to the corrosion of distribution system. A side given drinking water a bad taste, it can also act as a purgative in humans. The high level of sulphate also contributed to the appearance of permanent hardness of water.

Table 3: Absorption Measurement of Sulphate Standard and Water Sampleusing Uv visible spectrometer at 420nm

Sample no.	Volume of Sample/ Standard(Ml)	Absorbance	
std1	10	0.0929	
std2	20	0.128	
std3	30	0.217	
std4	40	0.317	
std5	50	0.411	
1	sample	0.089	**0.0867**
2	sample	0.082	
3	sample	0.089	

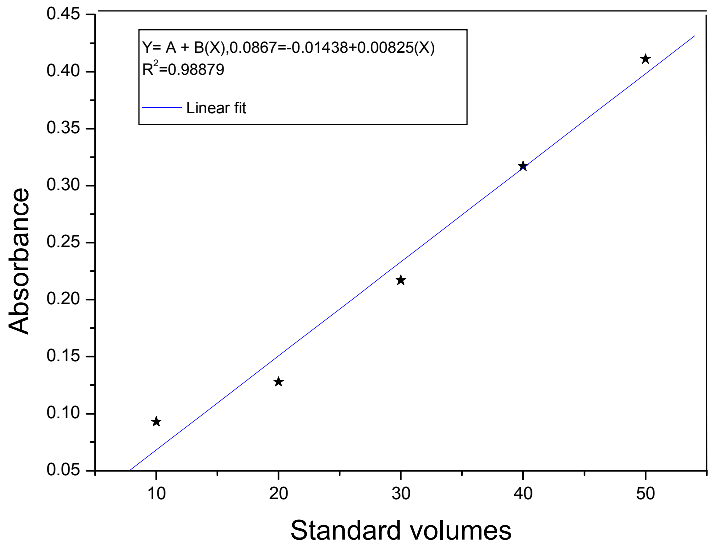

Fig.1: A calibration Curve for sulphate

5.Conclusions and Recommendations

The study was conducted to assess the physicochemical quality of water such as Total dissolved solids (TDS), Hardness, chlorides, sulphate and trace metals. The average value of the dissolved solids (TDS), Hardness, chlorides, sulphate were 2500mg/L, 275.8 mg/L,200.293mg/L and 490.085mg/L respectively. The TDS and sulphate content of water were above the permissible limits while the chlorides content of water was obtained below the permissible limit which is 250mg/L.the water hardness was obtained with range of permissible limit which is 200-500 mg/L.Eventhough the hardness was in between permissible value, it has the probability of to cause corrosion of the materials consumption of soaps during laundry. The high content of sulphate also contributes for the existence of permanent hardness.In conclusion from the results of the present study it may be said that the groundwater of Dawhan is though fit for domestic and drinking purpose need treatments to minimize the contamination especially the TDS, sulphate content.

Recommendations

As author I would like to recommend the following main points.

- The authorized body should be give special attention to remove the high level of TDS, sulfate and the Copper and Cadmium.
- The level of essential and non essential metals must analyzed for next
- Besides of this research, other researchers shall assess water quality area by using other parameters.

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