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Physico-chemical analysis of drinking water quality at Jigjiga City, Ethiopia

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Abstract: Water is one of the most important of all natural resources known on the earth. The safety of drinking water is important for the health. The safety of drinking water is affected by various contaminants which included chemical and microbiological. Such contaminants cause serious health problems. The physico-chemical analyses of drinking water quality at Jigjiga city, Somali Region, Ethiopia were studied. Temperature, pH, electrical conductivity, total dissolved solids, Total hardness have been determined along various water quality profiles. The experimental procedures were set according to the international drinking water standards set by WHO (1999). Average temperature, pH, electrical conductivity, total dissolved solids and total hardness values are 13.6 ^{o}C, 7.4, 1.143 S/m, 571.67 mg/l and 362.67 mg/l in $CaCO_3$ respectively. The result shows that, except the total hardness and electrical conductivity all the parameters fulfill the minimum and maximum permissible limit for drinking water guidelines.

Keywords: Physico-Chemical Parameters, Groundwater, Water Quality

1. Introduction

Water quality is a critical factor affecting human health and welfare. Studies showed that approximately 3.1% of deaths (1.7 million) and 3.7% of disability-adjusted-life-years [1] (54.2 million) worldwide are attributable to unsafe water, poor sanitation and hygiene [1]. The problem is the backward socio-economic development resulting in one of the lowest standard of living, poor environmental conditions and low level of social services [1], [2].

The functioning of an aquatic ecosystem and its stability to support life forms depend to a great extent, on the physico-chemical characteristics of its water. Physico-chemical parameters are highly important with respect to the occurrence and abundance of species. Ground water is by far more abundant than surface water and its quality is as important quantity. Water meant for drinking must therefore meet quality standards. Water quality is essentially determined by its physical and chemical characteristics [1]. Naturally, ground water contains mineral ions. These ions slowly dissolves from soil particles, sediments, and rocks as the water travels along mineral surfaces in the pores or fractures of the unsaturated zone and aquifer.

Good quality of water resources depends on a large number of physico-chemical parameters and biological characteristics. To asses that monitoring of these parameters is essential to identify magnitude and source of any pollution load [3].

The only source of water for drinking and agricultural purpose throughout the Ethiopian Somali regional state is the underground water. In nature, the hydrochemistry of the water sources were affected by a rich of metal ions and other physical factors that leads the water more polluted.

In this work, the physico-chemical analysis of drinking water quality was studied at Jigjiga city, Ethiopia. The main aim of this study was to carried out different physco-chemical parameters of water samples collected from different sites of Jigjiga City and to recommend the whether it is potable or not. The major water quality parameters considered for the examination in this study are like pH, temperature, total dissolved solids (TDS), dissolved oxygen (DO), total hardness and alkalinity.

2. Materials and Methods

2.1. Description of Sampling Locations

Jigjiga is a city in eastern Ethiopia and the capital of the Somali Region of the country. The city is located in the Jigjiga Zone approximately 106 km east of Harar and 628 km from Addis Ababa. This city has an elevation of 1,609 meters above sea level. Based on figures from the central statistical agencyin 2005, Jigjiga has an estimated total population of 98,076 of whom 50,355 are men and 47,721 are women. The climate of Jigjiga is a subtropical highland climate with the influence of mountain climate, with hot and dry summers and cold winters. This is attributed to the fact that Jigjiga is located on a plain surrounded by mountains and to its distance to the sea and its effects. The average temperature and rainfall range are between 25 to 31 °C and 11 to 712 mm respectively. The % humidity was in the range of 45 to 70% [Wikipedia).

2.2. Sampling and Preservation

Tap water samples were collected from three activesites across the Jigjiga city in April 8, 2014. All the samples collected were colorless and odorless. Samples were drawn with the aid of plastic drawer into three same types of polyethylene bottles i.e.1.5 L for physic -chemical parameters in the two sites. The plastics bottles were previous washed and soaked overnight with 5% HNO_3 solution [4]. To avoid any kind of contamination during sampling extra care was taken and the bottles were rinsed several times with the water being collected or filled. However, on-site analyses was comprised for temperature; electrical conductivity (EC) and pH were urgently determined when receive the sample in the laboratory because of their unstable nature. A 0.75 L of the sample was acidified with 1.5 ml concentrated HNO_3 (Analytical grade). Samples were then transported to laboratory and kept at 4^oC prior the time of analyses.

2.3. Materials and Chemicals

Apparatus and instruments: Polyethylene bottle, pH meter, oven, balance, glass bottles, Thermometer, desiccators, Conductivity Meter, Measuring Cylinder, Filter paper, Conical flask, Burette, Pipette, Beaker, Measuring flask.

Reagents and Chemicals: 0.1 MEDTA solution, EBT indicator, Basic buffer solution (NH_4OH and NH_4Cl), Standard hard water, given water sample.

2.4. Experimental Analysis

2.4.1. Temperature, Conductivity and pH Measurements

Parameter like temperature was determined in the field due to their unstable nature. A mercury filled centigrade thermometer calibrated from 0^0c to 100^0C was used for temperature measurements. The pH of the water sample was measured with a pH meter. The electrical conductivity was measured using digital conductivity meter. All analyses were carried out at a standardized laboratory using international regulatory methods. The evaluation of water quality was in accordance with regulatory standard. The approach ensures that the samples collected were tested in accordance with agreed requirements using competent personnel as well as appropriate equipment and materials. For physco-chemical analysis all the chemicals used were analytical grade. Temperature, pH and EC were measured by universal water analysis kit and manual method. Total hardness of water was estimated by complexometric titration with EDTA.

2.4.2. Determinations of Total Dissolved Solids

A clear dry glass beaker was taken (which was kept at 103^0Cin an oven for 1 hour) of 150ml capacity and put appropriate identification mark on it. Weight of the beaker was noted. Take a 100 ml. of sample and filter it through a double layered filter paper and collect the filtrate in a beaker. Place the beaker in an oven maintained at 103^0C for 24hours. After 24 hours, cool the beaker and weight. Find out the weight of solids in the beaker by subtracting the weight of the clean beaker determined in the first step. Total dissolved solids (TDS) can be determined as follows:

Calculating total dissolved solids concentration:

$$\text{Mg dissolved solids/l} = \frac{(A-B)}{mLofsample} \text{ x } 1000$$

A = weight of dried residue + dish, mg

B = weight of dish, mg

2.4.3. Total Hardness Determination of Water Samples Standardization of EDTA Solution with Standard Hard Water

20 ml of standard hard water was pipetted out in a washed conical flask. 5ml of basic buffer solution and 2-3 drops of Eriochrome Black-T indicator were added, the colour of the solution turns to wine red. This solution was titrated against EDTA solution which was taken in the burette until the color changes from wine red to clear blue at the end. The final reading of the burette was noted and the titration was repeated to get a concordant value

Estimation of Total Hardness of Given Water Sample:

20 ml of given hard water was pipette out in a washed conical flask. 5ml basic buffer solution and 2-3 drops of Eriochrome Black-T indicator were added, the colour of the solution turns wine red. This solution was titrated against EDTA solution taken in the burette until the colour changes from wine red to clear blue at the end. The final reading of the burette was noted and the titration was repeated to get concordant value. Finally using the analytical calculation, total hardness of given water sample was determined in terms of ppm of $CaCO_3$.

3. Results and Discussion

The mean values of different selected physico-chemical parameters have been tabulated below in the table.

Table 1. *Physco-chemical parameters for tap water from ground water sources at Jigjiga town*

No	Parameters	Values obtained			WHO value
		JJU tap water	04 kebele tap water	05 kebele water sample	
1	Temperature	13.5°c	13.6°c	13.8°c	Not exceed 15°c
2	pH	7.2	7.6	7.4	6.5 to 8.5
3	Total dissolved Solids	570 mg/l	580 mg/l	565 mg/l	500/1000 mg/l
4	Total hardness	350 mg/l of $CaCO_3$	378 mg/l$CaCO_3$	360 mg/l $CaCO_3$	500 mg/l
5	Electrical conductivity	1.12S/m	1.23S/m	1.08 S/m	3S/m

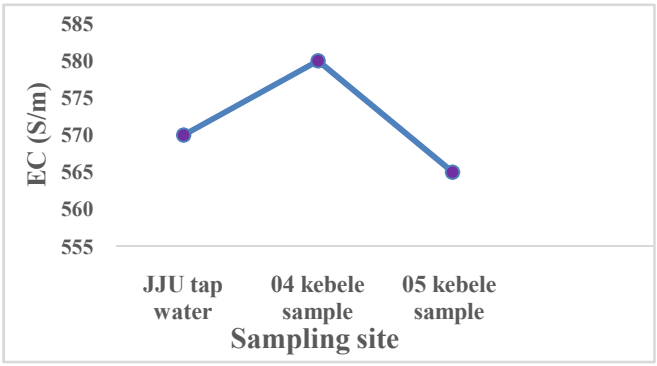

Fig 3.1. *Total dissolved solids (mg/l) values of various water samples*

Temperature: As shown in fig 3.2 below, the temperatures of the samples were noted at the sampling point itself. As indicated in graph below, the temperature was 13.5, 13.6 and 13.8°C in the three sites. During the present investigation, there was no great difference between the temperatures of the tap water from different sources of ground water and it is related to the WHO standards i.e. 15 °c.

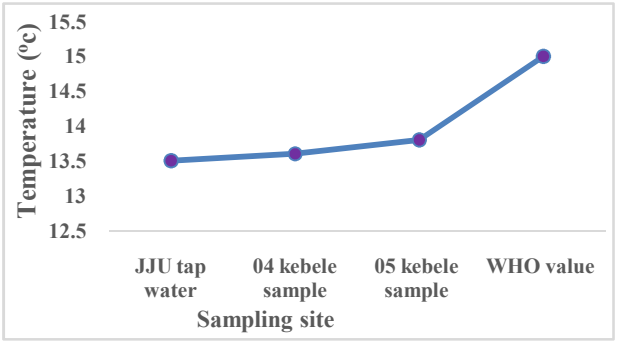

Fig 3.2. *Temperature (°c) values of various water samples*

Hydrogen Ion concentration (pH): is an important parameter which is important in evaluating the acid-base balance of water. Also it is the indicator of acidic or alkaline condition of water status. WHO has recommended maximum permissible limit of pH from 6.5 to 8.5.As shown in fig 3.3 the current investigation were 7.2, 7.6, and 7.4 which are in the range of WHO standards. The overall result indicates that the water sources are within the desirable and suitable range. Basically, the pH is determined by the amount of dissolved carbon dioxide [CO_2], which forms carbonic acid in water. According to [6], pH of ground water can also be lowered by organic acids from decaying vegetation, or the dissolution of sulfide minerals. The slight basic nature of the bore well water may be mainly due to the limestone basin of the all the locations.

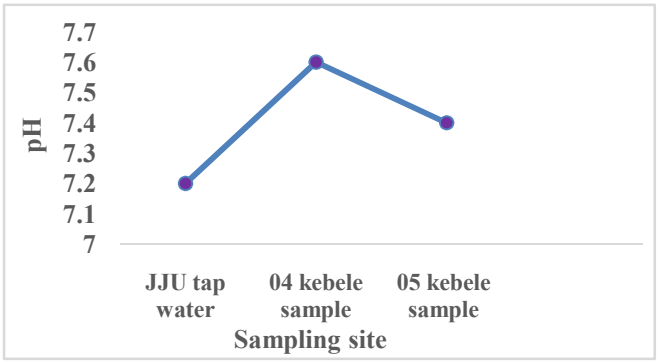

Fig 3.3. *pH values of various water samples*

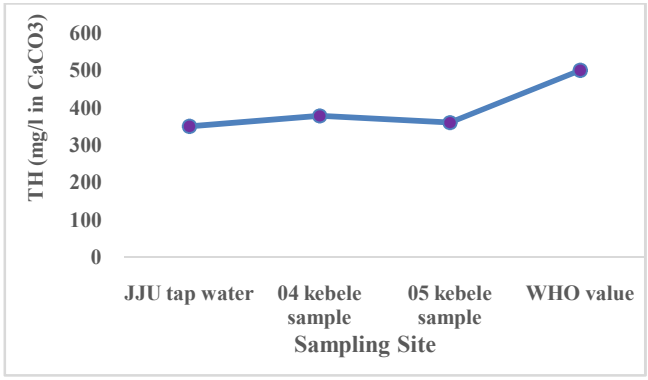

Fig 3.4. *Total hardness (mg/l in $CaCO_3$) values of various water samples*

Electrical Conductivity (EC): The result was shown in fig 3.5 below. EC measurement is an excellent indicator of TDS, which is a measure of salinity that affects the taste of potable water. The conductivity of water is a measure of capacity of a solution to conduct electrical current through it and depends on the concentration of ions and load of nutrients. Electrical conductivity is used to indicate the total ionized constituent of water. It is directly related to sum of the cations and anions. As most of the salts in water are present in ionic forms, they make water capable for conducting current. The conductivity, thus serves as a good and rapid measure of the total dissolved solids in water. EC measurement is an excellent indicator of TDS, which is a measure of salinity that affects the taste of potable water.

As shown in fig 3.5, the mean electrical conductivity (EC) of the tap water samples are 1.12, 1.23 and 1.08 respectively;

which is above the standard limit of 0.8 S/m.

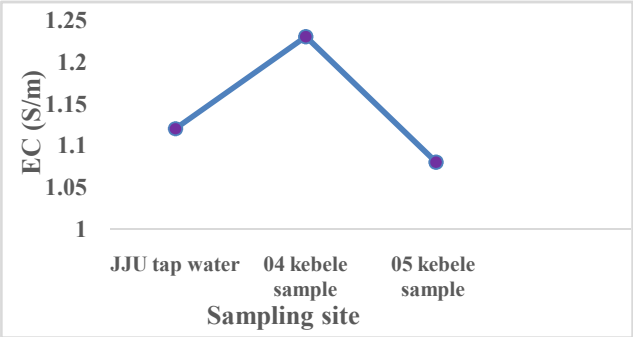

Fig 3.5. *Electircal conductivity (S/m) values of various water samples*

Thus the water has very high electrical conductivity, implying the presence of reduced level of ionic species.

Total Dissolved Solids (TDS): The result was shown in figure 3.1 above. This is the important parameter for the use of water. The water with high TDS value indicates that water is highly mineralized. Desirable limit for TDS is 500 mg/l and maximum limit is 1000 mg/l prescribed for drinking purpose. The concentration of TDS in present study is observed in the range of 647 and 537 mg/l. The mean total dissolved solids concentration in Jigjiga town tap water was found to be 592 mg/L and it is within the limit. High values of TDS in ground water are generally not harmful to human beings but high concentration of these may affect persons, who are suffering from kidney and heart diseases. Water containing high solid may cause laxative or constipation effects. According to [12], potable water should not contain more than 1000 mg/l of total dissolved solids (TDS).

Total Hardness: Hardness is a very important parameter in decreasing the toxic effect of poisonous element. As shown in fig 3.4, the hardness was found to be in the range of 350, 378 and 360 mg/L in $CaCO_3$ and with average value of 373.5 mg/l in CaCO3 in all the sampling sites. This value is within the hard level. None of the samples cross the maximum permissible limits of 500 of WHO and standards [13].

4. Conclusions

The result obtained during study was compared with ISI standards. Potable water is water safe enough to be consumed by humans or used with low risk of immediate or long term harm. The study assessed the evolution of water quality in tap water from a groundwater source of Jigjiga town. A comparative study of both type of bore well water and surface water was carried out by taking certain important parameters like temperature, pH, total dissolved solid, conductivity and total hardness. In this present investigation it was found that the maximum parameters were not at a level of pollution.

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