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Assessment of the Quality of Drinking Water Supply, and the Status of Sanitation and Hygiene in Mudulla Town, Tembaro Woreda, Southern Ethiopia

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Abstract
Limited access associated with poor water supply, hygiene and sanitation is widening the poverty gap, gender inequality and prevalence of water born diseases. This research work is aimed to examine the quality of existing water supply, sanitation and hygiene status of Mudula Town. To achieve this objective, the household survey and Water samples were collected from three water sources (spring), storage and taps. With the exception of Kalahiwot spring for Turbidity (7.75NTU), all others were within the standards. For bacteriological analysis, Gofore spring is within the standard. But samples tested from Bada and Kalahiwot did not meet the WHO and EPA bacteriological standards for drinking water. The correlation result of physical parameters shows that for all sources turbidity, TDS and EC has strong positive correlation with each other. With the exception of Gofere spring source, fecal coliform (E.coli) is negatively correlated with Temperature and positivity correlated with Total coliform for both spring water sources. The current average per capital water converge in the area is 68% and its consumption is strongly correlated with house hold income amount. Similarly for sanitation, from total respondents 5% use pit latrine without house, 10% pit latrine with house and remain 85% use pit latrine with wall and roof. Regarding to solid waste, 55% dispose solid waste on garden and 45% have sanitary pit. From total respondents, up to 55% do not use water after defecating. The rest also have a gap on using soap continuously. Therefore, to overcome the problems regular chlorination of water, sanitation and hygiene practicing awareness may be required.
Keywords: Water Supply, Coverage, Water Quality, Sanitation and Hygiene practices

1 INTRODUCTION

Access to clean water and sanitation is a universal need and a basic human right. As a matter of fact, people around the globe face a problem of water scarcity. Today, close to a billion people living in the developing world does not have access to safe and adequate water [1]. This scarcity of water forced people around the world to use unsafe water for drinking and other domestic uses [2]. According to world health organization more than 80% of diseases in the world are attributed to unsafe drinking water [2].

Likewise, lack of proper sanitation is a serious health risk and an affront to human dignity. UNICEF by its 2012 report [1] estimate that about two-fifths of the global population did not have access to improved sanitation. The majority of these people live in Asia and Africa. Africa has the lowest sanitation coverage of the global regions. In Africa, only 60% of the population have access to improved sanitation, but the situation is worse in rural areas only 45% of the rural population have access to improved sanitation. Thus, as WHO [3] stated people are forced to defecate in open fields, in rivers or near areas where children play and food is prepared because they do not have access to improved sanitation.

On the other hand, Ethiopia has an estimated annual runoff of 122 billion m^3 and 28 billion m^3 of ground water potential [4]. This corresponds to an average of 1,732 m^3 of physically available water per person per year, a relatively large volume. However, due to large spatial and temporal variations in rainfall and lack of storage, water is often not available where and when needed [5]. Only about 3% of water resources are used, of which only about 11% (0.3% of the total) is used for domestic water supply. Due to this, the access to water supply and sanitation in Ethiopia is amongst the lowest in Sub- Saharan Africa and the entire world [4; 6; 7]. As a result, people are still dependent on unprotected water sources such as rivers, streams, springs and hand dug wells.

In 2010, an Ethiopia government presented the equally ambitious Growth and Transformation Plan that aims at increasing drinking water coverage in rural area from 65.8% (baseline at 2010) to 98% at 15 l/p/d day within the radius of 1.5km and to increase Urban Water Supply coverage from 91.5% to 100% at 20 l/p/d within the radius of 0.5km and thereby increase national water supply from 68.5% to 98.5% in the year 2015 [8]. GTP also targeted to improve sanitation by 84% at 2015. Accordingly WHO [9] estimated that the country's water coverage rate for urban areas is up to 97% with per capita consumption rate of 20 liter/capita/day within 0.5 km, and the sanitation coverage as 69%. But the report of the study area [10] reveals that, in Mudula town the water and sanitation coverage is below the national average. Besides, most of Mudula town residents indicated that they are still using unimproved water sources. An area's Health Office [11] approved as the impact of unimproved sources of water up on the users is identified. The report shows that, number of patients related with water born diseases increase during dry season when the people use different water sources. Therefore, this study was designed to examine the quality of all water sources used by the community, their sanitation and hygienic practices.

2. MATERIALS AND METHODS

2.1. Description of the Study Area

The study was conducted at Mudula town in Tembaro Woreda, Kembata Tembaro Zone, Southern Ethiopia. It is located at about 400km south of Addis Ababa (Figure 1). Geographically, Mudula town is located between 32°98' E to 34°29'E and 8°08'N to 8°9'N. The town is composed of three administrative Kebeles namely Mudula 01, Mudula 02 and Mudula 03 and has the total area of about 1,050 hectares [12].

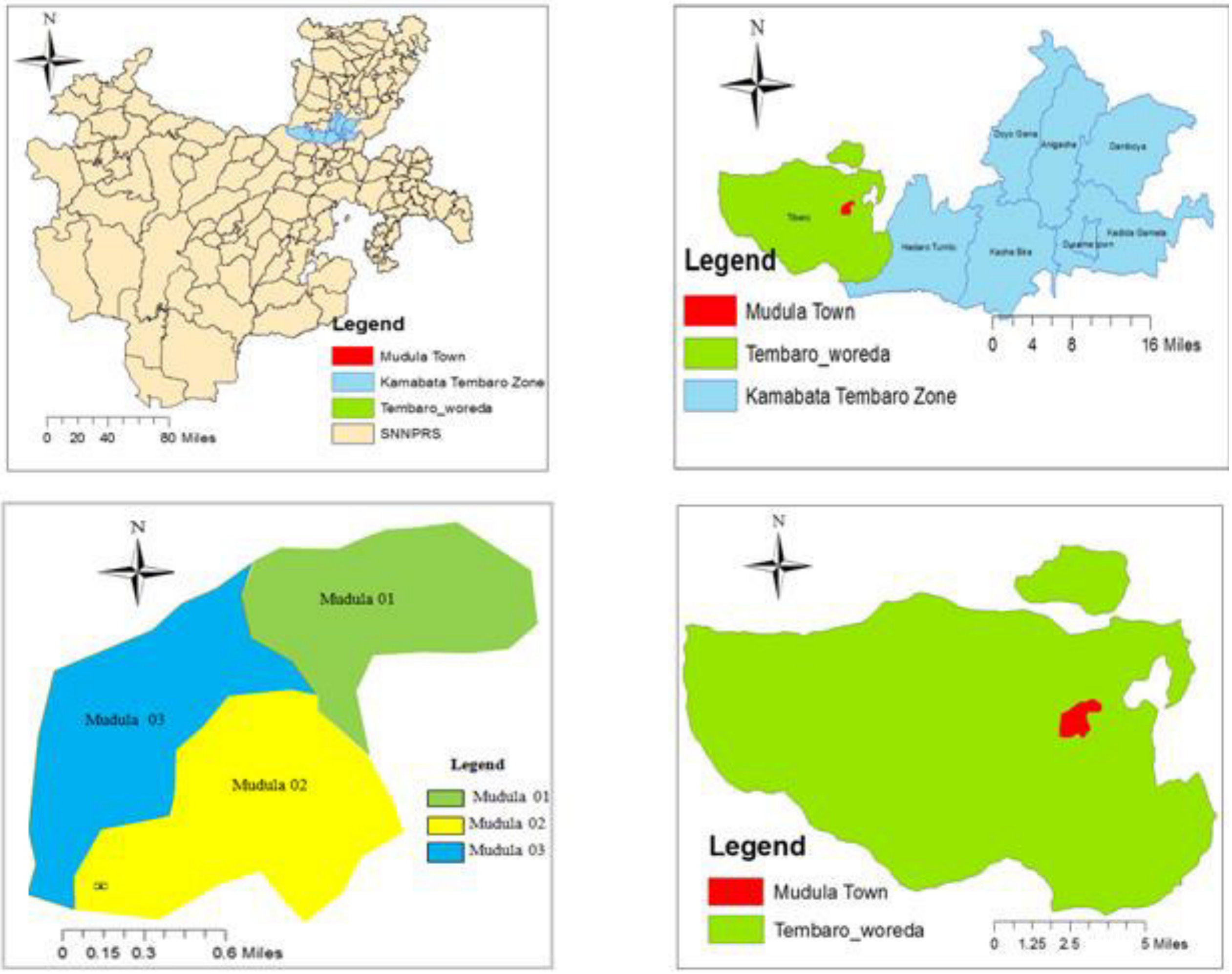

Figure 6: The map of study area

The Climate The study area belongs to the "Weyna Dega" agro-climatic zone with bimodal rainfall distribution "Belg" and "Kiremt". For the study area "Belg" is the short rainy season that lasts between January and April. During this period, the area receives a monthly average rainfall of 170 mm. The "Kiremt" season, which is the longest rainy period, lasts between May and October, with a monthly average rainfall of about 206.4 mm [13].

Regarding to populations, in the year 2013 the total population of the woreda is estimated to be 175,050 and out of this, Mudula town accounts 14,380 [12]. Like that, the potable water sources of town are three Natural Springs namely, Kaliwot, Bada and Gofore Springs. Out of the three Springs, Kaliwot Spring is found inside the town and it serves as a Tap Water (Bono) and has an average discharge of 0.2 l/s. Due to this the principal source of the town's water sources are springs of Bada spring with an average flow rate of 3 l/s and Gofore with an average discharge of 20 l/s. From Bada spring sources, flow of water is by gravity but in case of Gofore spring. it needs pump and generator to overcome an elevation difference of 315 meters. Here the pump is located 4 km from the town and an electric energy is not used instead of generator. Beside the water tariff of the area is not enough to cover its fuel cost. In addition to this, the fluctuation of price of fuel and frequent damaging of the internal-part of the pump makes great difficulty on this water supply system [10]. Consequently in dry season, all sources of the water supply of the town decreases and the peoples of the town is forced to use Lamo river that pass near to the town. Both TWWMO [10] and Mudula municipal [12] argue that the problem of potable water supply is still very critical in the town.

2.2 Data Collection

Both primary and secondary data collection techniques were employed. The primary data gathering technique was including, household survey questionnaires, focus group discussion, personal observation and water quality laboratory test while secondary data collection method was document review, on water supply and sanitation of the town, woreda, zone and the country. For household survey, samples were decide to select by using equation of Cochran (1977) as cited by [14].

$$n' = \frac{z^2 pq}{d^2} \quad \text{.......eq. (2.1)} \qquad \text{and} \qquad n = \frac{n'}{1+\frac{n'-1}{N}} \text{......eq. (2.2)}$$

Where, n′ = desired sample size when the population is greater than 10,000
n= № of samples size when population is less than 10,000
Z=95 % confidence limit (z-value at 0.05 is 1.96)
P= 0.05 (proportion of the population to be included in the sample i.e. 5 %)
q= 1-0.05 i.e. (0.95), N= total No of population for each kebele
d= margin of error or degree of accuracy (0.05).
Since the population (HHs) of the Kebeles would have been involved in the study are less than 10,000 in number i.e. 1053, 884 and 807 for kebele 01,02 and 03 respectively; both equations (1 & 2) are used to determine sample size required in this study as follow:

$$n' = \frac{z^2 pq}{d^2} = (1.95)^2 \times (0.05) \times (0.95) / (0.05)^2 = 72.990 \text{ then}$$

$$n = \frac{n'}{1+\frac{n'-1}{N}} = 72.990 / (1 + (71.990) / \text{No population}) = 68, 66 \text{ and } 67\text{HH}$$

But the calculated value obtained is so small to have a high accuracy for an study. Due to that, stratified random sampling technique based on the different administrative kebele was employed. To determine sample size for household survey, stratified random sampling was applied to 2744 households of the town from which to select 13% of the households. In three administrative kebele's namely, Mudula 01,02 and 03 there are 1,053, 884, 807 HHs; and beside 137, 115 and 105HH were selected from kebele 01,02 and 03 respectively for an interview.

To assess the Physicochemical and Bacteriological parameters of the water, Drinking Water Program [15], Denele Analytical laboratory [16] and WHO [17] advises that samples must be taken from locations that are representative of the water source, treatment plant, storage facilities, distribution network, points at which water is delivered to the consumer, and points of use. Based on this, the sample for this study was taken from the source, reservoirs and sampled water taps.

As Kaliwot spring have no storage, one sample was taken from eye of the spring and one from the tap. For Bada spring there is one reservoir located in the town and there are 10 tap (Bono) constructed and functional in the area. To assess the water quality standard of this source, total of five samples were taken. One sample from source, one from reservoir and three samples was taken from 3 tap (Bono) from out of 10 (which is 30%), and was taken from 3rd 7th and 10th tap of water starting from reservoir.

From Gofore spring there are 12 tap water points and is connected with house blocks. In addition to main reservoir, there are two tanks sited at Mudula health center and World Vision OAD Project Office in the town. To assess the water quality standard of this source, total of seven samples was taken. One sample from source, one from reservoir, two from each tanks and three from three tap water points. For this study to take samples from tap water sources, 25% of tap water points were selected and purposely the 4th, 8th and 12th tap (Bono) starting from the reservoir was selected. This is because as the water is tasted from the reservoir; to minimize the errors each of the 4th water points was sampled and tasted (Fig 2).

Based on the above sampling methods, total of 14 samples were taken and examined for both Physicochemical and Bacteriological parameters. When taking the sample from the pipe, the water was run at full force for 4 minutes to clear the line as advised by Analytical laboratory [16].

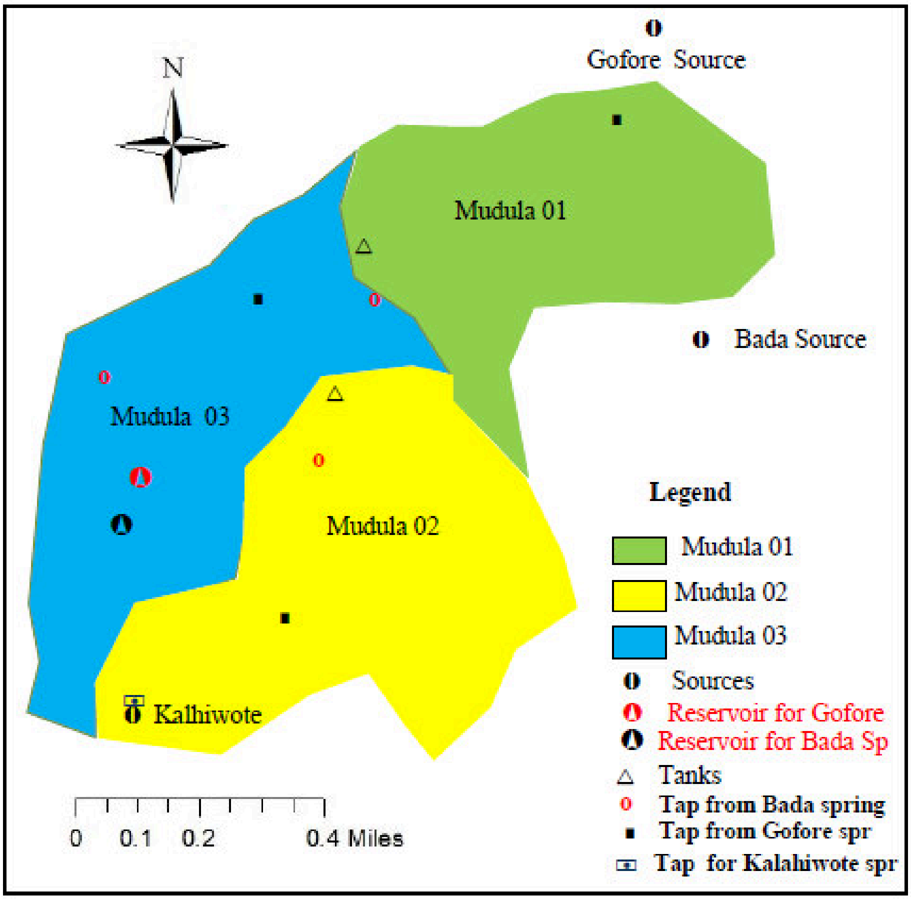

Figure 2: Points where Samples were taken

Water samples were collected in four consecutive days from the beginning of April, 2014. A water quality analyst, with a complete set of water quality analysis kit (Potalab ® WAG-WE10010) was contracted from the SNNPRS Water and Energy Bureau water quality analysis laboratory. Water samples were analyzed both onsite and offsite for selected water quality parameters. Temperature, pH, total dissolved solids (TDS), Electrical Conductivity (EC) and turbidity were analyzed onsite. The temperature of the sample was analysis using digital thermometer, turbidity by using spectrometer and pH of the sample was determined by using pH meter. Like that Electrical Conductivity (EC) and total dissolved solids (TDS) was determined by conductivity meter and TDS meter onsite respectively. WHO (2006) advice, the bacteriological tests should be undertaken within 6 hours after collection to avoid the growth or death of microorganisms in the samples. Based to this, total coliform, and *Escherichia coli (E.coli)* bacteria were analyzed onsite using membrane filter method which reads the result after 24 hours. Calcium Hardness, Magnesium Hardness, Total hardness (TH), Fluorine, Iron, Nitrate, Sodium, Chloride, Potassium, Manganese, Chromium, Iron, Calcium, Magnesium and Copper was analyzed in SNNPRS Water and Energy Bureau water quality analysis laboratory by using a pre-cleaned 1L plastic containers in an ice box to transport samples from the site to Hawassa.

Sample container preparation, storage and transport procedures were followed the recommendations of Standard Methods for the Examination of Water and Wastewater manual [18]. Analysis of Fluorine, Iron, Nitrate, Sodium, Chloride, Potassium, Manganese, Chromium, Iron, Calcium, Magnesium and Copper was carried out by using HACH DR 500 instrument (UV-visible spectrophotometer) in accord with the procedures of the HACH manual [19]. In addition, Calcium Hardness, Magnesium Hardness, Total hardness (TH) were determined by using titration method.

To Analysis data, SPSS 16 for windows version and MS Excel were used; and Coverage and accessibility of domestic Water Supply of Urban Population that is provided with access to 20 l/p/d was computed as:

$$\textit{Capital consumption (l/p/d)} = \frac{A \times 1000}{B \times 365} \quad \text{........................e q. (2.3)}$$

A = Annual consumption (M^3) and B = Population number of town

3. RESULT AND DISCUSION

3.1 PHYSICAL PARAMETERS OF WATER QUALITY

TEMPERATURE

The result for Temperature of the springs had a range of 7.5–13°C, which corresponds to the minimum and maximum temperature of Gofore spring. On the other hand, the mean and standard deviation values for the Temperature were 9.93±2.0, 9.8±1.5, and 11±1.4, for Gofore, Bada, Kalehiwot, respectively.

The result shows that all of the temperature values for the sources are within the limit of WHO guideline [7]. According to this guideline, the maximum permissible limit for drinking water should be within 15 C^o. In addition to this, for all sources the temperature recorded were not have significant difference with the mean temperature analyzed during the test. Temperature is one of the physico-chemical parameters used to evaluate the quality of potable water. When water temperature increases, disinfectant demand and microbial activity will also increase so that palatability of water quality decreases. WHO [7] argue that high water temperature enhances the growth of microorganisms and may increase taste, odour, colour, corrosion problems and makes difficult to drink. Apart from this, the amount of any gas, including oxygen, dissolved in water is inversely proportional to the temperature of the water; as temperature increases, the amount of dissolved oxygen (gas) decreases and vice versa.

TURBIDITY

The mean turbidity level of Gofore water source is 1.97 with its maximum and minimum of 2.3 by 1.7 with standard deviation of 0.18 and Bada source has mean turbidity of 2.22 with its maximum and minimum of 2.6 by 2 and with standard deviation of 0.23. Similarly Kalahiwot spring source has a maximum and minimum turbidity level of 8.00 and 7.5 with its standard deviation of 0.3.

The turbidity level of Gofore and Bada water samples (1.97 and 2.22 NTU) were compliant with WHO of less than 5NTU [7], [20] that recommend less than 5NTU, Indian Standard Specifications for Drinking Water [21] which advises less than 5NTU and [22] which advises maximum value of 4 NTU. However, the mean turbidity recorded of Kalahiwot spring (7.75NTU) did not meet the standards give above. Based to those guide line, this source can't be effective for the consumption of the people. Because, the colloidal material exerts turbidity provides adsorption sites for chemicals that may be harmful or cause undesirable tastes and odors. Desinfection of turbid water is difficult because of the adsorptive characteristics of some colloids and because the solids may partly shield organisms from desinfectant.

TOTAL DISSOLVED SOLID (TDS) AND ELECTRICAL CONDUCTIVITY (EC)

The mean TDS level of Gofore water source is 133.71 (mg/l) ± 2.44 with its maximum and minimum of 135.8 by 130.1 and Bada water source had the mean TDS of 101.82 (mg/l) ± 5.04 with its maximum and minimum of 106.1 by 93.8 (mg/l). Similarly, Kalahiwot spring had the mean TDS of 51.25 (mg/l) ± 0.49 with its maximum and minimum of 51.60 by 50.90 (mg/l). In WHO [17] there is no health based limit for TDS in drinking water, as TDS occurs in drinking water at concentrations well below toxic effects may occur, but according to [22] and [23] the palatability of water with TDS level of less than 500 mg/L is generally considered to be good. Of the samples analyzed all of the water sources found to contain TDS value of less than 500 mg/L. Based on this the water used in the study area is within acceptable limits base to guide lines [22] and [23].

Electrical conductivity (EC) which is a measure of water's ability to conduct an electric current is related to the amount of dissolved minerals in water, but it does not give an indication of which element is present but higher value of EC is a good indicator of the presence of contaminants such as sodium, potassium or chloride [24]. Analysis of the results show that, the samples from the Gofore water source have the mean EC value of 267.64 ± 5.02 with maximum and minimum value of 271.32 and 260.20 (µS/cm). Similarly, EC for Bada water source have the mean value of 201.80 ± 9.66 within the range of 211.68 to 187.40 µS/cm. Like that Kalahiwot spring source have mean value of 101.90 ± 0.14 within the range of 102.0 to 101.8 µS/cm.

When compared to WHO [17] standard, the analyzed results for Bada and Kalahiwot spring source have less than the maximum admissible limit that allow to consume water with EC up to 250 µS/cm.

As shown in Table 3.1 below, from physical parameters of the water in all sources TDS and EC has strong positive correlation with r^2 =0.828 for Gofore and for Bada sources for $P < 0.01$. On the other hand for Gofore spring source turbidity and TDS is positively correlated (r^2 = 0.857) with significance level of 95% confidential interval. Similarly for the same source, turbidity and EC has positively correlation (r^2 =0.825) for $P< 0.05$.

Table 3. 1 Paired samples correlations of physical water quality parameters

Parameters	Gofore spring source				Bada spring source			
	Temp.	Turbidity	TDS	EC	Temp.	Turbidity	TDS	EC
Temp.	1	0.433	0.406	0.444	1	0.754	-0.150	-0.145
Turbidity	0.433	1	0.857*	0.828*	0.754	1	0.282	0.292
TDS	0.406	0.857*	1	0.995**	-0.150	0.282	1	1.000**
EC	0.444	0.828*	0.995**	1	-0.145	0.292	1.000**	1

*. Correlation is significant at the 0.05 level (2-tailed).
**. Correlation is significant at the 0.01 level (2-tailed).

3.2 CHEMICAL PARAMETERS OF WATER

P^H

The pH of the Springs assayed in the study area had a pH range of 6.51–7.60 (Slightly Acidic to Moderately Alkaline) with a Mean ± SD pH Values of 7.15 ± 0.40, 6.98 ± 0.27, and 6.65 ± 0.21 observed for Gofore, Bada, and Kalahiwot Springs, in that order. Compared to the common pH range for Natural Water of 6.5–8.5 [21; 20], the samples collected from the study area had pH within this general range. pH is one of the most important operational parameters for water treatment such as disinfection or coagulation-flocculation and pH adjustment is a common practice in water treatment (Cerdic *et al.,* 2005 as cited by [14]). Besides, even though the latest guideline for drinking water quality [17] does not recommend any health-based guideline for pH, the adverse effects of pH result from the Solubilization of Toxic Heavy Metals in low pH (Copper, Lead, Zinc and Cadmium) and the Protonation or Deprotonation of other ions [25] Danger to Health would result primarily from the presence of Metal Ions, which are more likely to influence selection than the pH value.

HARDNESS OF WATER

The samples libratory analysis shows that, the total hardness of Gofore water source and Bada water source were 119.84 ± 1.7 between the range 117.8 to 122.0 and 83.34 ± 1.98 between the range 80 to 85 mg /l respectively. Similarly, the other water sources of the town Kalahiwot spring had mean total hardness of 49.75 ± 0.35 with the range of 49.5 to 50 mg/l.

According to WHO (2006), depending up on P^H and alkalinity, hardness above about 200 mg/liter can result in scale deposition, particularly on heating. Like that, Ethiopian Drinking Waster Specification (2003) advice that water with hardness above 300$CaCO_3$ mg/l is unsuitable for drinking. According to [26] & [20] classification, Gofore spring water source will be categorized under Slightly hard water (100 - 150 $CaCO_3$ mg/l) while Bada and Kalahiwot spring sources will be categorized under Moderately soft (50 - 100 $CaCO_3$ mg/l) and Soft (< 50 $CaCO_3$ mg/l) respectively.

FLUORIDE

There was no fluoride content detected from all water sources. The standard for Fluoride is recommended in WHO 1.5 mg/l and according to Ethiopia drinking water guideline it should be below 3 mg/l. But in the area, the maximum fluoride concentration of the sources Gofore, Bada and Kalahiwot is 0.55, 0.08 and 0.53 mg/l. Standards like Ethiopian Bottled drinking water standard [27], [17] and [28] allow the maximum permissible level of 1.5 mg/l and Ethiopian drinking water quality guidelines [29] allows 3 mg/l for portable water. Based to that, the researchers conclude that all sources of the town it is within the standards.

NITRATE

The major sources of nitrates in drinking water are runoff from fertilizer use; leaking from septic tanks, sewage; and erosion of natural deposits. The libratory result shows that, the mean nitrate level of Gofore water source is 3.94 mg/l with its maximum and minimum of 4.2 mg/l by 3.7 mg/l and with standard deviation of 0.181. On the other hand the second water supply source of the town Bada source has mean Nitrate (NO_3^-) of 0.4860 mg/l with its maximum and minimum of 0.50 mg/l by 0.45 mg/l and with standard deviation of 0.02. Similarly the third source Kalahiwot spring has means Nitrate level of 1.51 with its standard deviation of 0.01. To say the water has a problem of nitrate, [17, 22, 27, 28, 29 and 21] state that its concentration in the portable water should be above 10 mg/l nitrate-N. Similarly [20] guideline advice water with nitrate concentration above 10 mg/l nitrate - N will cause Methaemoglobinaemia up on the users. Base to these standards the researcher obtained that there is no any the nitrate problem in the study area.

DISSOLVED METALS AND SALTS

SODIUM (NA^+) AND CHLORIDE (CL^-)

The mean Sodium (Na) level of Gofore water source is 17.04 (mg/l) ± 0.05 with its maximum and minimum of 17.15 by 17.00 and Bada water source had the mean Sodium (Na) of 7.112 (mg/l) ± 0.46 with its maximum and minimum of 7.6 by 6.46 (mg/l). On the other hand, Kalahiwot spring had the mean Sodium (Na) of 4.31(mg/l) ± 0.07 with its maximum and minimum of 4.36 by 4.26 (mg/l).

Similarly, mean chloride (Cl^-) level of Gofore water source is 2.86 (mg/l) ± 0.08mg/l with its maximum and minimum of 3.0 by 2.75 and Bada water source had the mean Chloride (Cl^-) of 3.98 (mg/l) ± 0.08mg/l with its maximum and minimum of 4.1 by 3.9 (mg/l). Similarly, Kalahiwote spring had the mean Chloride (Cl^-) of 12.25 (mg/l) ± 0.35 with its maximum and minimum of 12.5 by 12.00 (mg/l).

The guideline developed in Ethiopia Ministry of Water & Energy allows water with sodium concentration up to 358 mg/l and guideline developed by Quality and Standards authority of Ethiopia Bottled drinking water specification (2001) advice the maximum permissible level of sodium up to 200 mg/l. Based to this, all sources of the town water supply are within acceptable limit. [17], [28] and [20] standards advise also maximum permissible level of sodium in drinking water up to 200 mg/l. Similarly the laboratory result of chloride for the sources is within the limit given by [29, 28, 17, 20 and 21] guidelines those recommend the portable water should have Cl^- concentration below 250mg/l.

POTASSIUM (K) AND MANGANESE (MN $^{2+}$)

According to the laboratory result of Potassium and manganese concentration of the three water sources of the town, Potassium in Gofore water source has a mean level of 2.05 (mg/l) ± 0.010 with its maximum and minimum of 2.20 by 1.90 and Bada water source 2.22 (mg/l) ± 0.16 with its maximum and minimum of 2.4 by 2.0 (mg/l). Similarly, Kalahiwot spring had the mean of 3.05(mg/l) ± 0.07with its maximum and minimum of 3.10 by 3.00 (mg/l). When compared to international standard, all of the water sources of the town is less than the upper limited.

In case of manganese, the mean manganese level of Gofore water source is 11.66 (mg/l) ± 0.11 with its maximum and minimum of 11.8 by 11.5 (mg/l) and Kalahiwot spring had the mean manganese of 0.39 (mg/l) ± 0.01with its maximum and minimum of 0.40 by 0.38 (mg/l). On the other hand, Bada water source had equal level of manganese concentration 0.1 (mg/l) ± 0.0.

When the libratory result of the town water sources is compared with some international standard, Bada and Kalahiwot spring source are within the limit. Because their average manganese concentration is less than 0.4mg/l. On other hand, Gofore spring source is above the limited value. Due to that, based up on the concentration of manganese, the two sources Bada and Kalahiwote springs are on acceptable limit for portable water. [17] advise that manganese concentration in the portable water should have 0.4 mg/liter in mass. Like that, [21] also counsel Mn in portable water to be 0.3 mg/liter. Beyond this limit taste/appearance are affected, has adverse effect on domestic uses and water supply structures.

Manganese is an essential element for humans and animals, but is neurotoxic in excessive amounts [20]. Similarly [17] report that, manganese is an essential element for humans and other animals. Adverse effects can result from both deficiency and overexposure.

Heavy Metals

According to American Public Health Association, American Water Works Association, Water Pollution Control Federation, WHO (2008) the most common heavy metals that have been identified in polluted water include Chromium (Cr^{6+}), Iron (Fe^{2+}), Calcium (Ca^{2+}) , Magnesium (Mg^{2+}) , Copper (Cu^{2+}).

CHROMIUM AND IRON

In Gofore water source, the mean Chromium (Cr^{6+}) level is 0.032 (mg/l) with its standard-division of 0.04 and, with maximum and minimum level of 0.12 by 0.01(mg/l). In Bada water source the mean Chromium (Cr^{6+}) is 0.0062 (mg/l) ± 0.003 with its maximum and minimum of 0.007 by 0.006 (mg/l) and in Kalahiwot spring its mean is 0.01(mg/l) ± 0.00 with maximum and minimum of 0.01 by 0.01 (mg/l). When compared to [28] and [29] that order in drinking water to have maximum Chromium concentration of 0.10 mg/l, the analyzed sources of the town are within the acceptable limit and are safe for the portable water.

The shortage of iron causes disease called "anemia'' and prolonged consumption of drinking water with high concentration of iron may lead to liver disease called as haermosiderosis (Rajappa et al., 2010; Bhaskar et al., 2010). In the areas studied, iron content varies in Gofore water source from 0.16 to 0.05 (mg/l) with its mean of 0.12 (mg/l) ± 0.04 of and Bada water source from 0.085 by 0.076 (mg/l) with its mean of 0.07 (mg/l) ± 0.05 and, in third water sources of the town (Kalahiwot spring) there was no variation of an iron concentration (0.053 mg/l) in all sampling points. Based on the concentration of the iron the all sources of the town is inacceptable limit. Because [17, 27, 28 and 29] recommend that the maximum permissible level of iron in drinking water should be up to 0.3 mg/L only.

CALCIUM, MAGNESIUM AND COPPER (CU^{2+})

The result showed that the mean Calcium level of Gofore water source is 30.68 (mg/l) ± 1.300 with its maximum and minimum of 33.00 by 28.80 (mg/l) and Bada water source had the mean Calcium of 24 (mg/l) ± 0 with its maximum and minimum of 24 by 24 (mg/l). Similarly, Kalahiwot spring had the mean Calcium of 16 (mg/l) ± 0 with its maximum and minimum of 16 by 16 (mg/l). Analysis result is compared with the Guidelines for Drinking-water Quality, World Health Organization and Ethiopian Bottled drinking water standard [17 and 27] No health effects.

The average Magnesium value of Gofore water source is 11.75(mg/l) ± 0.08 with its maximum and minimum by 11.90 to 11.67(mg/l) and Bada water source had the average magnesium of 4.972 (mg/l) ± 0.063 with its maximum and minimum of 5.00 to 4.86 (mg/l). Similarly, Kalahiwot spring had the average Magnesium of 2.42(mg/l) ± 0.02 with its maximum and minimum of 2.43 to 2.4 (mg/l).

Laboratory analysis result is compeered with the National Academy of Sciences [30]. *The Contribution of Drinking Water to Mineral Nutrition in Humans*, US National Research Council limited that Target Water Quality Range 0-30 mg/l has no bitter taste no scaling problems. And also it recommends that, no health effects magnesium in portable water range 30 - 100 mg/l.

A result obtained from laboratory water quality analysis, the copper value in both Gofore and Bada source is 0. Similarly, Kalahiwot spring had the average Copper value of 0.038 mg/l ± 0.004 with its maximum and minimum of 0.04 by 0.03 (mg/l). Contamination of drinking water with high level of copper may lead to chronic anemia [31]. In this study, copper is the only metal that was not detected at most the sampling areas presumably due to the low cupper related industrial and mining activities in the sampling areas. The maximum permissible limit of copper in portable water is recommended by [29] 1 mg/l, by [28] 1.3 mg/l and by [27] 5 mg/l.

Since the [17] maximum admissible limit of copper in drinking water was well above the method detection limit; there was no health related risk due to the presence of copper in drinking water of the study areas.

3.3 BACTERIOLOGICAL QUALITY

The analysis of the biological drinking water quality parameters of the study area results was presented in table 3.2 with comparison of [17] and [28] guideline standard. From out of three sources, Gofore spring has no bacteriological problem. But the two sources (Bada and Kalahiwot) are not suitable for drinking.

Table 3.2 Bacteriological water quality of the study area

Water Sources	Mean values		[17]		[28]	
	Total Coliform	E. coli	T.coliform	E. coli	T. coliform	E. coli
Gofore Spring	1.82	0	3	0	3	0
Bada Spring	26.4	11.4	3	0	3	0
Kalahiwot Spring	21	10	3	0	3	0

The bacteriological and physico chemical parameters strongly negatively correlated for each other for instance temperature and E.coli values was -0.851 ($P<0.05$) and P^H and E.coli was also negative correlation . On the other hand, the positively correlated values for P^H and TDS, P^H and EC the values were 0.914 and 0.918 for $P<0.05$ respectively. Correlation also observed between P^H and TC was value 0.851 (Table 3.3).

Table 3.3 Paired samples correlations of physico-chemical and bacteriological indicators

Parameters	Gofore Spring Source						Bada Spring Source						
	Temp.	Turbidity	TDS	EC	TC	P^H	Temp	Turbidity	TDS	EC	TC	P^H	E.coli
Temp.	1	0.433	0.406	0.444	0.853*	0.770*	1	0.754	-0.150	-0.145	-0.421	-0.011	-0.815*
Turbidity	0.433	1	0.857*	0.828*	0.473	-0.045	0.754	1	0.282	0.292	0.217	0.561	-0.320
TDS	0.406	0.857*	1	0.995**	0.445	-0.228	- 0.150	0.282	1	1.0**	0.765	0.914*	0.110
EC	0.444	0.828*	0.995**	1	0.466	-0.208	- 0.145	0.292	1.0**	1	0.764	0.918*	0.110
TC	0.853*	0.473	0.445	0.466	1	0.610	- 0.421	0.217	0.765	0.764	1	0.851	0.629
P^H	0.770*	-0.045	-0.228	-0.208	0.610	1	- 0.011	0.561	0.914*	0.918*	0.851	1	0.220
E.coli							-.815	-0.320	0.110	0.110	0.629	-0.220	1

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

3.4 Sanitation and Hygiene

Sanitation behaviors

Three types of latrines are constructed in the study area: 5% open pit latrine/without house, 10 % constructed pit latrine without closed wall but with roof and 85 % of the latrines had a wall and roof. Accordingly the latrine coverage in the study area seems encouraging as traditional latrines, which do not meet official standards, are taken in to consideration in the arithmetic. The sanitation technologies said to be improved if those sanitation facilities prevent humans, animals and insects from coming in contact with human excreta [32]. Accordingly, above 80% of the people in the study are under unimproved sanitation. Therefore, lack of proper sanitation is the major cause of spreading diseases which are harmful to human life in the study area as they do not have access to improved sanitation.

Regarding to solid waste management, the researcher observed in the study area children are not expected to go far or to use toilet to defecate, rather they are expected to defecate in a place near to their houses and may be in a place where they play. This habit of children is not only limited to those who do not have toilets but also it works for those that have toilets as well as it is not safe for children to use. It has been reported that baby feces that is not properly disposed might put household members at risk of diarrhea [33].

Similarly in case of solid waste collection, 55% of the households were disposing solid wastes in the open field (dispose at garden) and 45% used private sanitary pit. As the town is rural town there is no communal land fill. Because of this they refuse the wastes at household vicinities. The condition is, therefore, likely to present a high risk for the continued transmission of communicable diseases despite the efforts made by the Woreda health office to alleviate the existing solid waste management problems. This was able to indicate the condition of environmental sanitation in Mudula town is mainly in relation to water supply and sanitation. The situation in most cases was very poor. There is a need to educate the people to dispose off the waste in proper places.

Hygienic behaviors

More than 55% of respondents in all the study area don't use water at all for hand washing after defecating. 20.1% of the respondents were using water and soap; and 24.7% were using water only for hand washing after attending toilet. Use of soap was limited because soap was reportedly expensive and was only used for laundry purposes. Poor health awareness and poor level of personal hygiene might explain lesser amount of water consumption. Hand-washing with soap can result in major health improvements: one review of studies worldwide documented a 45% reduction in diarrheal morbidity from improved hand-washing [34] and another documented over 50% reductions in the incidence of both diarrhea and pneumonia when children washed their hands with soap [35].

3.5 SANITARY SURVEY ON HOUSE HOLD WATER CONTAINER AND DISTRIBUTION SYSTEM (PIPE)

When water is not piped directly into a house or yard, it needs to be stored in containers (Jarkan). Even when water is piped to the house, if the flow is not regular it will have to be stored. This can provide a number of opportunities for contamination.

As indicated table 3.4, 99 % household water containers were plastic containers. 48.6% of storage containers were not narrow mouth containers.

Table 3. 4 : Result of sanitary inspection of house hold water containers in Mudula Town 2014

Sanitary risk inspection of house hold water container	Risk frequency
Is drinking water in separate containers?	5%
Is drinking water container kept above floor level and away from contamination?	0
Do water containers have a narrow mouth/opening?	50.3 %
Do containers have a lid/cover?	10 %
Is it plastic?	99.2 %
Is the utensil used to draw from the containers clean?	30.7 %
Is the utensil used to draw water the container kept away from surfaces and stored in a hygienic manner?	49.5
Is the inside of the drinking water container clean?	29.2%
Is the outside of the drinking containers clean?	38.5%

The storage container washing frequency among the households has been assessed and it was found that only 10 households wash every day. During the time of house visiting the researcher observe that from the "Jarkan" that they store water 30% is physically clean but the remain 70% of "Jarkan" observed was unlearned and some have no shutter. In addition to this, the water stored is near to children. So there may be probability of contamination of water by the children face. Study in *Rural Malawi* by [36] and [37] show that contamination of water in the storage is a particular problem in households with young children, who may dip dirty hands into a storage bucket, or leave water scoops on the floor, contributing to contamination and disease. The prevalence of diarrhea for small boys in Ethiopia, for instance, was found to be significantly associated with drinking water obtained by dipping from storage containers; by contrast, the water source and the amount of water consumed were not significant risk factors [38].

One of the appealing features of water piped directly and regularly into the house is the fact that there is no need for a storage tank, and that those using the water cannot contaminate the supply. According to the sanitary survey conducted, there were pipe water interconnection with the sewerage lines which may cause contamination of disinfected water distribution systems. Pipeline leakage was observed and attracted people to utilize for laundry and personal hygiene practice that might be possible cause contamination. In addition to this the reservoir area the collect Bada spring water source as more that 28 years age and physically it is non cleaning and deferent types of vegetation is growing up on it.

3.6 ACCESSIBILITY AND COVERAGE OF WATER SERVICES

As per the official data of Mudula municipal there are 250 domestic, 8 private or commercial organizations 15 governmental & non-governmental organizations and institutional (Churches) connections and 21 public points. They are estimated to serve 2494 HHs or 12470 people.

The water supply coverage of the town was evaluated based on the average per capital consumption and by the level of connection. The average per capital consumption was derived from the yearly consumption of the town that has been aggregated from the individual domestic water meters and Bono site water meters. For evaluating the amount of water consumption, the annual water consumption is converted to average daily per capital consumption using the population data of the town. The average daily per capital consumption of town was derived using the equation 2.3.

Table 3.5 Water production and consumption at the study area

Year	Population	No. of domestic connection	No. Bono	Amount of water sold by billed (M^3)/year	Consumption l/person/day	Coverage (%)
2010	11,987	190	21	50315.43	11.5	57.5
2011	12,825	220	21	56,922.48	12.16	60.8
2012	13, 327	232	21	58,372.26	12.0	60
2013	14,380	250	21	71,382.32	13.6	68

As shown in the table 3.5 above, the water converge of the study area in the past four years starting from 2010 to 2013 was 57.5 %, 60.8 %, 60 % and 68 % by dividing the calculated average capital consumption to 20 l/p/day (recommended average per capital demand in Ethiopia). This result does not include coverage of Kalahiwot spring due to lack of water meter. Based to that the coverage of portable water for the area in the year 2013 E.C will be increased to 69 % because according to the standard set by World Food Organization one stand pipes can serve maximum of 200 people or 40 HHs.

As the survey result shown above the most of those inhabitants who do not have access to the piped system draw their water from private hand dug wells or collect from rivers or springs or buy from vendors who collect water from nearby river on donkey's Gari.

The household survey result for the study area shows that, the average domestic water consumption of the sample households excluding non domestic water use is 9.2 liters per person per day, which is less than half of the 20 l/d recommended by the WHO for urban community. This indicates that the amount of safe water consumption of households in the study area is very low as per the standard. As shown in table 3.6, static correlation for monthly income and water consumption shows that as there is a positive correlation between the monthly income and amount of water used per day. The 2- tailed Pearson correlation result shows as, it is strongly correlate with R^2 value of 0.9 with significant level of 0.05.

Table 3. 6 : Correlation between monthly income and water consumption

Pearson correlation	Monthly income		Water consumption l/c/d	
(2- tailed)	Correlation	Significance	Correlation	Significance
Monthly income	1	-	0.9(*)	0.04
Water consumption l/c/d	0.9(*)	0.04	1	-

Based to accessibility, the households claimed that Tape Water opening hours are not convenient (55%). Service (Tape Water) is available only for three hours per day, which is 8:00am to 10:00am in the morning, and from 5:00pm to 6:00pm in the afternoon. The respondents were asked about the continuity of water supply and 80 percent has claimed that water interruption occurred once a week and the time to maintain takes 1 to 2 days, while 12% of the respondents said that there is interruption of water twice in week, the rest 8% respond that there is interruption at least 2 times per a month, and it takes a 3 days to maintain which confirms how the water interruption problem is serious in the study area.

Similarly, the key informants were also agreed on the problem of water supply interruption of the town, the pipe line problems and electro-mechanical work problems. All key informants inform about water supply and sanitation problem at the first stage. The key informants who were selected from different disciplines reported that the town has no shortage of water sources but the only problem for the town is distribution system.

4. CONCLUSION

In the study area, People have largely depended on improved water sources for drinking and other domestic activities. Continues chlorination of the water sources might help to reduce pathogens and other improper activities around the water points that cause for higher levels of coliform bacteria. By acceptability aspects of drinking water quality, With the exception of Kalahiwot spring for Turbidity, all others were good set for Temperature, TDS, EC, P^H , Calcium Hardness, Magnesium Hardness, Total hardness, Fluorine, Nitrate, Na^+, Cl^-, K, Cr^{6+}, Fe^{2+}, Ca^{2+}, Mg and Cu^{2+}. The presence of higher Total coliform and fecal coliform in Bada and Kalahiwot water sources may affect their continued use unless regular chlorination will not be undertaken. The current average per capital water converge of 68% is so small compared with the country (Ethiopia) standards and sanitation coverage is also so low. The main water source of the town (Gofore) needs pump and generator to elevate. As the result, the existing accessibility is highly depending on the electro -mechanical functionally of the system. Due to this it is recommended that, to pump water there should be a transformer to have continues electric power instead of generator and; Water, sanitation and hygiene education programs should carry out be in a place.

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