

The Status and Quality of Water Supply and Its Related Problems in Tula, Sidama, Ethiopia

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Abstract
Background: Water is central to human life as it supports existence and vital prerequisite to create a healthy and stable community. Water related diseases caused by unsafe water and poor sanitation are major reason of death throughout the world. This study aimed at examining the status of water supply, its quality and related challenges in Tula.Methods: Household survey was used to elicit data on the status of water supply and related handling as well as management problems. However, field and laboratory measurement and analysis supplied data about quality of water in the study area. The parameters were finally compared to WHO standards. Results: It was observed that 55% of the sampled respondents were not satisfied with the water supply in the area due to quality, quantity and accessibility of the water. More than half of the sampled respondents did not practice household level water treatments such as boiling and filtration. Regarding quality, some of water parameters measured was found within the WHO permissible range and the others were in non-compliance. The measured average temperature of water samples across different sources ranged between 26–29 °C and the mean pH values in each source was still in compliance with WHO range (6.5–8.5). The turbidity of water in the study area averaged 1.16 NTU far lower than the WHO recommendation of 5.00 NTU. The mean TDS values of samples from tap, ground, spring and river water sources were; 120.15, 145.8, 139.025, 129.53 mg/l respectively. There was a considerable difference in the concentration of chloride among different sources. The total coliform bacteria results ranged from 2 to 6/100 ml with an average value of 0.97 colony/100 ml and found to be within low risk level of WHO standards (1-10 count/100ml).Conclusion: There is an indication of high risk of pathogens being present in the water from sources namely river, spring and ground in Tula. The contamination of water was not harmful as some residents practiced household level treatment such as boiling however, the increasing deterioration of environment, urbanization and industrial expansion emerged as a threat to water quality in the area.
Keywords: water quality, WHO, permissible, compliance, safe water

1. Introduction

Water is the basic necessity and so central for human life next to an air. Social and economic development is closely tied to water. Apart from its support for human life existence, water is essential prerequisite for the establishment of stable community (MOH, 2011). Poverty is more prevalent mostly in areas that face water shortage.

According to WHO (2005), the scarcity of water is one of the most significant issue that policy makers face in developing countries. Water related diseases caused by an unsafe drinking water and the absence of proper sanitation facilities are among the main causes of death in developing world (salmon et al, 2004). About one tenth of the disease throughout the world could be prevented with improved access to safe water, sanitation and hygiene, and improved water management as a whole (WHO, 2010)

Continuity of water supply is a guarantee in most developed countries but it is severe problem in developing nations including Ethiopia where sometimes water is only provided a few hours every day or few days a week. It's estimated that about half of the population of developing countries receive water on an intermittent basis (Arms, 2006).Ethiopia, the second mostly populated nation with over 90 million people have one of Africa's lowest rate of access to improved water supply, sanitation and hygiene. The figures on access to safe water in 2015 by the government and the WHO contradict as they claimed 40 % and 22% percent respectively.

Although water is considered as the soul of existence, this basic necessity is still a luxury for many of the world's poor. Increasing the number of people with access to safe water supply, sanitation and hygiene has become a burning challenge throughout the developing world including Ethiopia (UNICEF, 2009).

Access to safe and adequate water is a key to health and healthiness in turn is a prerequisite for progress, social equity and human dignity (William P. and Cunningham M., 2013). According to (MOH, 2011)Access to safe drinking water supplies and sanitation services in Ethiopia are among the lowest in sub Saharan Africa.Over 60 % of the communicable diseases are caused due to unsafe and inadequate water supply and poor hygienic and sanitation practices that result in poor environmental health (Abera et. al, 2011).The study area (Tula sub city) water supply is inadequate due to rise of population (consumers) and inefficiency of water supply system. Water consumption in the area is directly linked to socio economic factors such as economic level, population density and the cost of water. The quality of water in the area is a big issue that needs to be investigated while, the sources of water also influences its safety.

There is also a growing concern that the problem will get more complicated tide with rapidly growing urbanization in the area. The imbalance between supply and demand forced the people to use different sources of water such as rivers, ponds and unsafe wells that expose the people to different water borne diseases. In the existing situation it is important to have an insight about the quality/safety of drinking water and its availability to reach at wise solution of mitigating the challenge. Hence, this study aimed at examining the status and quality of water in the study area.

Both an adequate amount of water and water quality are essential for public health and hygiene (WHO, 2006). Moreover, the supply of adequate and safe water has a direct contribution in the economic and social wellbeing of the society(Abler et.al (2002).Therefore, examining the status of water supply and analyzing its safety became vital. Thus, this study made emphasis to assess the availability and quality of the water to explore ways for sound improvement in the future.

2. Materials and methods

2.1 The study area

The study area namely Tula subcity of Hawassa is located in Hawassa city administration,Sidama,Ethiopia. Hawassa city, the capital city Southern region is located 275k.m from Addis Ababa Capital city of Ethiopia. It is surrounded by the Lake Hawassa in west, HawassaZuriaworeda in the south east, Melgaworeda in the north east & Oromia region in the north. It is located at 7'30" latitude north & 33'30" east longitude with an altitude of 168meter above sea level (www.southinvest.gov.et/potential Hawassa.Htm).

Hawassa city administration comprises 8 sub cities namely :-hayekdare,Tabor, Menaheria, Misrak, Mehalketema, Bahiladerash, Addis ketema and Hawela Tula. Tula sub city is surrounded by Hawassazuriaworeda in the south east, Tabor sub city in the west Melgaworeda in the north, Addis ketema in the North West& Oromia regional state in the north. According to Tula sub city administration, Tula sub city has a total population of 129,507 of whom 65,018 are men & where 64,499 are women. The study area experiences moderate types of tropical climate. Although it is situated in rift valley it has relatively high altitudes about 1800 above sea level means that the climate is mild round. The land form is plain with reddish volcano soil.

2.2 Sampling Techniques & Sample Size

Hawela Tula subcity was selected purposively as water problem is more severe in tula. Hawela tula sub city (the study area) comprises twelve kebeles(kebele is the smallest administrative unit under district)and the entire subcity has the problem of water both quantity and safety wise.Cluster sampling was used as people were clustered in their kebeles and respondents were selected from each kebele. Simple random sampling was employed to select respondents from each kebele. The random sampling was preferred because of uniformity of the problem throughout the sub city and the residents have homogenous characteristics such as the same agro ecological zone, they belong to the same ethnic group, they have the same language and they all face the same water problem. It is well known that whenever we have homogenous population the sample size should be small because the result will not be affected as the sample size increases so, due to uniformity in so many socio-economic factors mentioned above only 5% from the total population was selected randomly. The total households of the sub city were 4200 at the time of data collection and accordingly 216 households selected. The sample size was supposed to be 210 but to have the same number of respondents from each kebele 18 respondents were taken from each of 12 kebeles. The house head was the main target of the study.

2.3 Data Collection and Analysis

Both primary & secondary data were used in this study. The Primary data was obtained through observation, questioner surveys and personal interview (semi-structured interview). Close ended question were used the questionnaire was translated in to local community language (Sidamic) to help those respondents who cannot understand English. The Secondary data was elicited from published materials and books in the library. Moreover, past reports and unpublished materials of water office were reviewed to supplement the primary data.

The obtained data was organized and analyzed both quantitatively and qualitatively. The numerical data was analyzed using descriptive statistics such as frequency, percentage,averages and presented by tables,graphs and etc. Content analysis was used for qualitative data in which the data was checked,organized, and coded. Afterwards the data were put in to the same themes as comments, suggestions or concerns.

2.4 Water sampling and sampleAnalysis

Water sources were identified and twelve water samples were taken from each source. Tula sub city has 12 kebeles and four water sources namely tap, ground, spring and river were identified and 12 samples were collected from each source. Twelve samples were taken to get representative sample. Samples were taken from each source at different locations. The samples were collected and placed in clean containers and nitric acid was used to preserve the sample for heavy metal analysis. The quality indicators of the water sample such as

Electrical conductivity,PH,Temperature were measured in the field using portable devices.

2.41 PH measurement

PH measurement is determination of hydrogen ion activity in a sample (Standard Method 4500-H+ B, APHA *et al*., 1998). About 20 mL of sample water was poured in to a beaker and the PH and temperature probes were suspended inside the water until the PH meter indicated a stable reading was achieved. A pH meter was calibrated before use with 4.00, 7.00 and 10.01buffer solutions.

2.42 Determination of conductivity and Temperature

Jenway conductivity meter was used to measure the Electrical conductivity. Several readings were taken until a stable reading was recorded. Buffer solution within the standard range was used to calibrate the device. The temperature however was measured using thermometer during sampling.

2.43 Turbidity

Turbidity was measured using Hachturbidimeter 2100N. The turbidimeter was calibrated using Stabl Cal Calibration standards of less than 0.1, 20, 200, 1000 and 4000 ntu (Hach Calibration Standards Catalog Number 26621-05). The water samples were allowed to warm to room temperature and gently inverted before transferred in to cleaned sample cell. The cell was placed in the trubidimeter and the measurement was recorded in units of NTU.

2.44 Total dissolved solids (TDS) determination

The gravimetric method by which a portion of water is filtered out and thefilter measured in to pre-weighed evaporating dish was used for determining the total dissolved solids (TDS). The filtrate was oven dried at a temperature of 105℃.Then transfer of the dish into dessicators was done and allowed to cool to be weighed. The following formula was used to obtain total dissolved solids.

$TDS = [(A-B) \times 1000] / \text{ml sample}$

Where:A= the weight of the evaporating dish + filtrate and

B= the weight of the evaporating dish

2.45 Determination of major chemicals

Argonometric method by which the samples were titrated with silver nitrate was utilized to indicate the chloride amount in the sample. Colorimetric and EDTA titrimetric methods were used to determine sulphate ions and calcium ions concentrations respectively.

2.46 Analysis of microorganism

Membrane filtration method in which 100ml water filtered using hand pump was used. Once filtration was made the bacteria remained on the filter paper was placed on petri dish with agar. The Petri dishes were placed in an incubator at a specific temperature and time based on the type of indicator bacteria and culture media. When the incubation was over the bacterial colonies were seen using a magnifying glass.

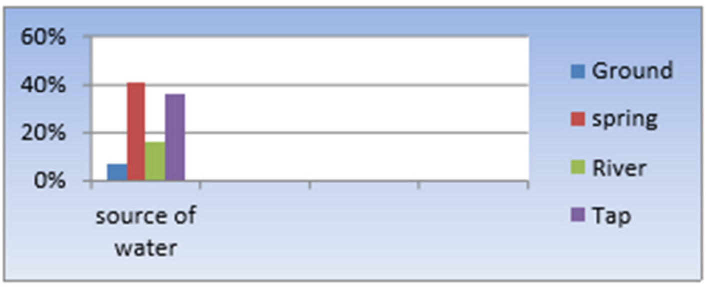
3. Result and Discussion

3.1 Socio economic status of the sample respondents

Majority of respondents to this study (65%) were male and 35% were female .Most of them (40%) laid in the age range between 36-45 ,30% laid in the age range between 26-35,13% laid in age range between 46-55, 12 % laid in age range less than or equal to 25 and (5%) laid in age range above 55 years. Regarding educational level, most of the respondents (36%) were illiterate, followed by primary education (27%), and the rest of respondents were diploma holder and above. About 38% of the respondents were farmers, 34% of the respondents were businessmen and the remaining 28% of the respondents were government workers. The income level of the respondents reflected that about 14% of them had monthly income of less than 1000 Ethiopian Birr. The rest 40%, 26% and 14% of the respondents fall under the income range of 1000- 3000,3000-5000, above 5000 respectively.

3.2. Household Water Supply and Sanitation Status

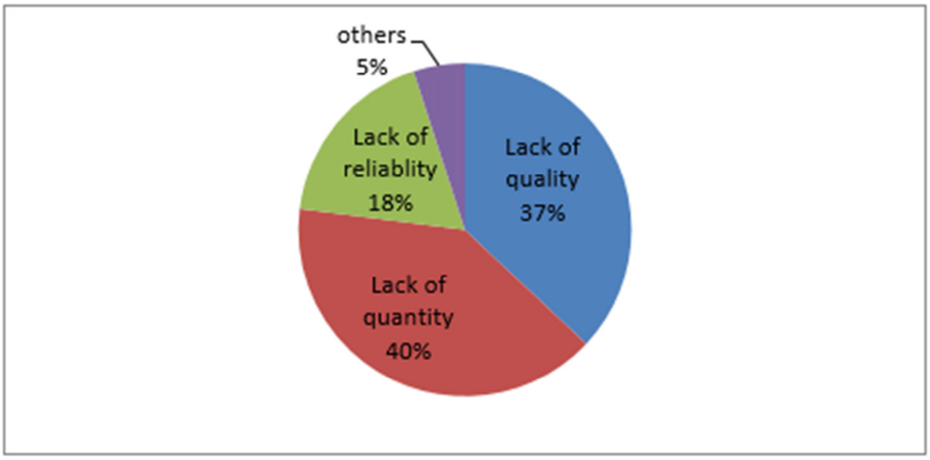
Figure 1: Source of potable water of the sample household



From figure (1) majority of respondents (41%) rely on spring water, only 36% were using tap as water source. There were people(16%) who use river as source of potable water and about 7% rely on ground water .The responses of the households indicate that majority of sampled household rely on spring water because most of them have not their own tape water.The respondents were asked about whether they are satisfied with their water sources,accordingly 55% of them replied thatthey were not satisfied with their water sources, whereas 42% were satisfied with their water sources. On the other hand the respondents were asked to provide the reasons for non-satisfaction with their water sources; 49% of them noted the quality of water, 15%, and 36% of the respondents mentioned amount of water and accessibility of water as the reason respectively.

Respondents were asked about whether there was sufficient water supply in the area**.** Majority of respondents (64%) replied that there was not sufficient water supply in their area, whereas (36%) responded that there was sufficient water supply in their area.

3.3 Reasons for insufficient water supply (Why sufficient water supply was not applicable in the area?).
Figure 2: Reasons for insufficiency of water supply



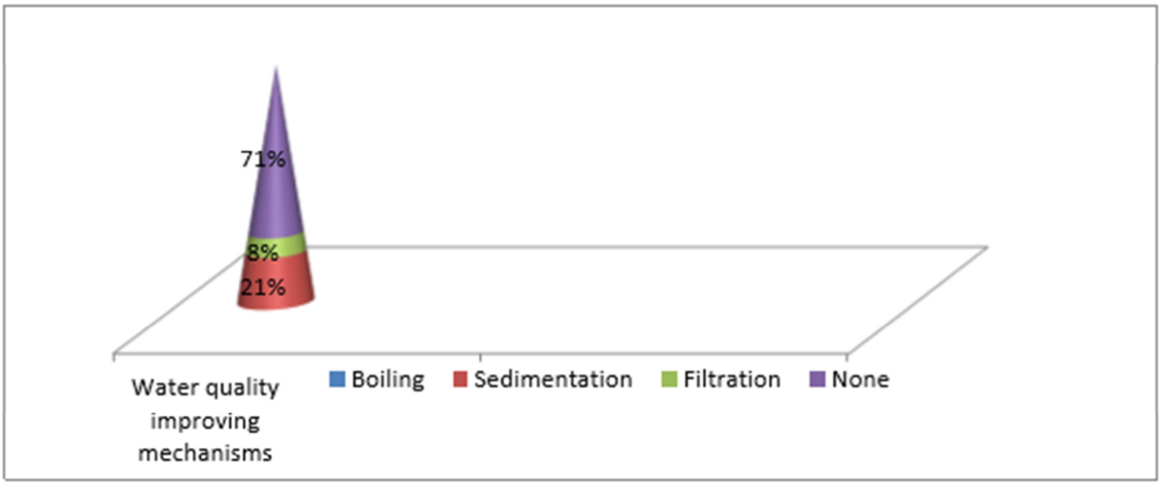
As described in figure (2) Most of the residents believe that there was not sufficient water supply because of low water supplement, however lack of quality was also a factor alongside low reliability.

Table 1: Major causes for insufficient water

Major problem affecting the water supplement	Percentage
Accessibility	47
Cost of distribution	30
Low supply sources capacity	13
Other	10

Accessibility was identified as primary problem affecting the water supplement(Table 1). Cost of distribution thought major problem by one third of the sample respondents and the low supply sources capacity also contribute its own.

Figure 3: Household mechanisms to improve water quality



More than half of the respondents didn't use any mechanisms at household level to treat water, while (23%) of the respondents used sedimentation mechanisms to improve water quality .Only a few residents use filtration mechanism to improve water quality. None of the respondents used to boil water before they use to treat so this seems to have a major impact on the health of the residents (Figure 3). The cultural belief regarding water is also another bottleneck as some of the residents believe water is naturally blessed and allowed to use without prohibition. They believe that "water is made to clean; the cleaner is not to be cleaned".

Table 2: Sources of water associated with sanitation problem and victims.

Water sources with sanitation problem	Percentage	Victimized person (%)
Ground water	25	53
Spring water	6	26
River water	48	3
Stream water	21	18
Others	0	
Total	100	100

Based on the result (table 2) river water was mostly associated with sanitation problem. Ground and stream sources of water were also noted as responsible for almost half of problems associated with sanitation.

3.4 Quality of drinking water in Tula sub city

3.41Turbidity

The turbidity values measured were varied widely across all samples, from 0.7 to 10.2 NTU, with a Mean value of 1.16 NTU. The turbidity determines light emitted by water and it indicates the waste discharge in respect to colloidal matter. The WHO recommended figure of turbidity for quality water is 5.00 NTU, however the turbidity of water in Tula sub town averaged 1.16 that is far lower than the WHO recommendation (WHO, 2011).

3.42 pH

The pH compliance (pH range of 6.5–8.5) was included in the analysis to evaluate whether the drinking water at different sources have acceptable acidity and salinity balance. The measured pH values varied across different sources. The most saline value was obtained in the ground source ((pH = 9.3) and the most acidic was obtained river (pH value of 5.4). However, the average of pH values in each source was still in compliance with WHO range (WHO, 2004) and most of the samples ranged in neutral level.

3.43 Temperature and Conductivity

The WHO guideline (WHO, 2011) suggests that, drinking water to be safe should possess maximum temperature of 30 °C. The measured average temperature of water samples across different sources ranged between 26–29 °C. Conductivity was measured for all water samples from four sources and in general compliance with the WHO suggested value of 400 µS/cm. The mean conductivity for all water supplies was 220.32 µS/cm, but conductivity was lower for tape source water supplies (average of 193.45 µS/cm) and higher for ground source averages of 276.44 (table 3).

Table 3: Temperature and conductivity value of samples at different sources

Water sources/parameters	Values of each samples at different sources											
Tape T °C	27.1	26.3	26	26.4	26	26.3	26	26.3	26.1	26	26.1	26.2
EC (µS/cm)	209.3	188	187.4	199.7	190.2	177.9	196.7	189.1	198.3	194.9	194.7	195.3
Ground T °C	28.4	28.1	28	28.7	29	28	26	26.5	27	29	26.2	28.8
EC (µS/cm)	294.1	287.2	259.7	269.9	372.5	299.9	214.7	219.2	234.8	376.3	217.7	271.3
Spring T °C	27.8	27.3	26.9	27.7	28	26.9	26.4	26.1	26.3	27.8	26	26.2
EC (µS/cm)	238.5	226.6	203.1	197.4	211.9	192.8	196.3	207.9	205.4	203.7	200.7	214.3
River T °C	27.4	26.1	26.6	27	26.5	26.5	27	26.7	26.6	27.1	26.2	26.2
EC (µS/cm)	233.3	208.4	197.4	196.7	203.2	187.9	206.7	209.1	198.3	194.9	194.9	207.3

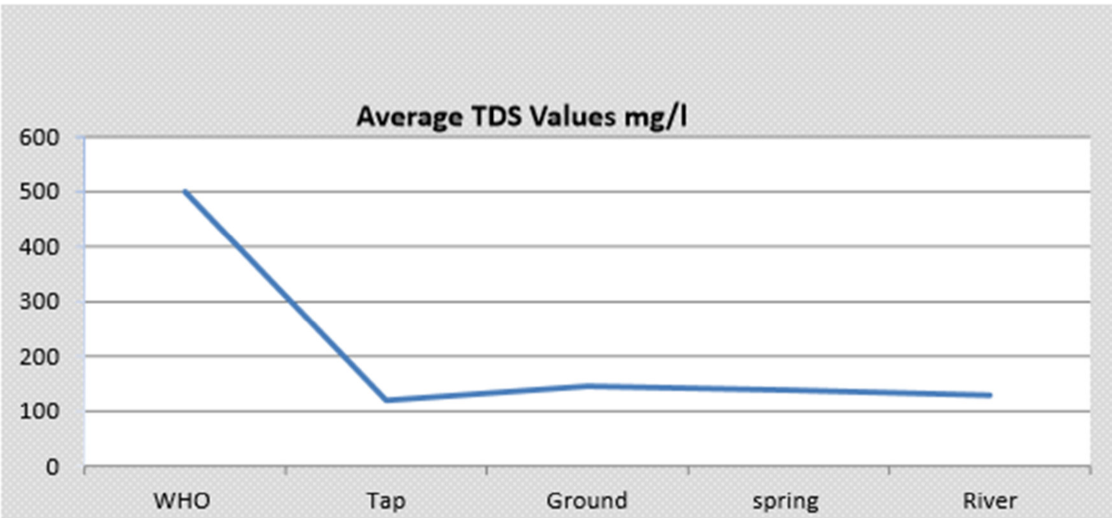
3.44 Total dissolved solids (TDS)

The amount of TDS of water might not be dreadful for human use but there are a group of people with problems of kidney and heart who can suffer from water with high TDS. TDS can also affect the smell and color of water. The presence of mineralized solids in water determines its suitability especially for drinking. The WHO standard (WHO, 2011) for water to be safe for drinking indicates 500mg/l and the maximum limit is 1000mg/l. The high amount of solid in water may make a person inactive, immobile and dull. The average values of TDS for all water sources in Tula shown that it is in compliance with WHO standards(Figure 4). The mean values of tap, ground, spring and river are 120.15, 145.8, 139.025, 129.53 mg/l respectively. Thus the mean values of all samples from four sources have acceptable TDS under normal circumstances (table 4).

Table 4: TDS values of Water sample under different sources

Water source	TDS (mg/l)											
Tape water	124.7	119	116.5	121	117.8	121.9	115.2	123.1	123.6	121.9	118.3	118.8
Ground	150.5	151.3	144.7	139.6	147.5	142.3	141.2	149.8	150.7	140.3	145.6	146.1
Spring	138.8	137.3	134.2	135.6	138.9	140.3	142.1	143.6	139.7	141.4	138.9	137.5
River	126.1	119.7	131.8	133.6	127.9	129.2	129.6	128.4	132.3	133.1	135.5	127.2

Figure 4: Comparison of average TDS values of water sources to WHO recommendation



3.45 Nitrate

All of the water sources in each kebele were analyzed for nitrate. The obtained nitrate levels had variation by source and sampling point. Average nitrate levels were lowest for tap water (1.63mg/l) and highest for ground water source (33.11 mg/l).

Use of Nitrogen rich fertilizers and industrial waste are the major sources for nitrate concentration. According to the WHO, the permissible level of nitrate for safe drinking water is 5 mg/l. In the study site the nitrate level at two sources namely tap and river sources are within acceptable limit however there is excess nitrate level in the ground and spring sources with an average value of 33.11 and 28 mg/l respectively (Table 5).

Table 5: Nitrate concentration of water at different sources

Water sources	**Nitrate level(Mg/l) of each sample**												**Mean Value mg/l**
tap	2.2	1.4	1.9	1.1	2.3	2.07	1.92	1.3	0.96	1.12	1.4	1.98	1.63
ground	37.7	33.2	34.7	28.9	39.78	37.2	29.9	29.5	27.3	29.31	32..6	36.8	33.11
spring	32.01	27.6	28.7	26.1	32.1	29.9	28.01	26.4	25.3	26.6	27.14	27.6	28.12
River	7.2	4.9	5.2	2.9	6.4	5.78	6.03	3.9	3.37	4.12	3.71	5.4	4.9

3.46 Chloride (Cl)

The concentration of Chloride is often higher in ground water than surface water. Among others, intrusion of sea water, waste materials carried away from homes and industries are often referred as major sources of chlorides in water.

The (WHO, 2011) standards suggest that chloride the concentration in water is acceptable if it doesn't exceed 250mg/l. The higher chloride concentration in water would result in physiological discomfort and distort human health. The chloride concentration in the study area was lowest in tape source averaged 4.3mg/l in twelve samples and the mean value of ground water sources was highest with mean value of 46.4mg/l. Although the chloride level was observed within WHO permissible range but there exist a considerable difference in the concentration of chloride among different sources (table 6).

Table 6: chemical constituents of water samples at different sources in the study area

Water sources	**Mean values**			
	Cl− (mg/l)	SO4 (mg/l)	Ca (mg/l)	Mg (mg/l)
Tape	4.3	3.3	6.91	17.8
Ground	46.4	5	9.42	27.4
Spring	25.8	4.1	8.34	22.6
River	11.9	4	7.45	19.33

3.47 Chemical constituents of water

Cleavage of sulfuric acid in water results in sulfate which relatively has insignificant negative impact on human health. The values of sulfate can range from 0 to hundreds of mg/l however WHO recommends (WHO, 2011) water with sulfate concentration below 250mg/l. From results of table 6 the sulfate concentration in Tula sub city is in compliance with the standard value. Calcium concentration in the study area was also observed as far lower than the maximum limit suggested by WHO (75mg/l) and the same was true for magnesium.

3.48 Bacterial contamination

The most basic test for bacterial contamination is the test for total coliform bacteria. The suitability of water for drinking is also determined based on its bacterial contamination level. The pathogenic bacteria or organisms found to be larger in number if the water is contaminated and coliforms also tend to be high in number within water containing disease causing organisms. It is recommended that people who use wells and other surface and subsurface water sources should test their water for coliform bacteria at least once in a year. Increased levels of fecal coliforms provide a possible contamination with pathogens.

The sample water from all sources in Tula sub city were analyzed for total coliform bacteria and the results ranged from 2 to 6/100 ml with an average value of 0.97 colony/100 ml. The WHO standards (WHO,2011) for safe water supply is to be totally free of total coliform however, water supplies with 1-10 count/100ml have low risk and the study area shows it is in compliance to the low risk level.

In Tula sub city there was no fecal coliform bacteria in tap water sources but the presence was detected in river, spring and ground water sources. The study area comprises one urban kebele and human sewage from this kebele was believed to be the main source of contamination. The discharge of wastes from animals and birds, and agricultural activity mainly livestock manure and fertilizers were major sources in the surrounding rural kebeles. The quantity of fecal coliform in the study area is not harmful as residents boil the water they use for drinking but there is an indication of high risk of pathogens being present in the water from sources namely river, spring and ground.

Conclusion

The findings of this study identified four types of water sources in Tula sub city and the vast majority of residents rely on river source. The residents were not satisfied with their water supply due to problems in the quality, quantity and accessibility of water sources. Despite, the poor quality of water, more than half of the respondents didn't use any mechanisms at household level to treat water either due to lack of awareness and negligence. Surprisingly the study has come to known that there is a traditional belief which says “water is naturally blessed so, no prohibition due to quality or anything else” this is one of factors hindering safe water effort in the study area.

The physico-chemical parameters of water sample from different sources were analyzed and shown either compliance or non-compliance with the standards of the WHO guidelines. The temperature, pH and conductivity of the water samples were found to be within permissible range. The turbidity values were far lower than the WHO recommendation. The water samples were analyzed for chemical constituents and accordingly samples from two sources namely spring and ground had excess nitrate levels. The chloride concentration in the study area was lowest in tape source averaged 4.3mg/l in twelve samples and the mean value of ground water sources was highest with mean value of 46.4mg/l. The bacterial contamination level of water in the study area was found to be under low risk range. The study area comprises mixed water supply problems from quality to quantity and handling to treatment so, further investigations and action plan seems necessary to overcome the bottlenecks and come up with better solution.

Abbreviations

EDTA: ethylene dinitrilo tetra acetic acid; MOH: Minstor of Health; NTU: nephelometric turbidity units; TDS: total dissolved solid; UNECA: United Nations Economic Commission of Africa; UNICEF: United Nations international Children’s Emergency Fund; WHO: World HealthOrganization.

Declaration

Ethics Approval and Consent to Participate: Not applicable

Consent for publication: Not applicable

Availability of data and supporting materials section: Data sharing not applicable to this article as no datasets were generated or analyzed during the current study

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