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Full Length Research Paper

Assessment of irrigation water quality of lowlands in the Bale Zone, South Eastern Oromia, Ethiopia

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Water quality concerns have been very crucial because good quality water supplies in abundance and readily available for production and productivity is of great importance. Therefore, the study was conducted to assess irrigation water quality of the lowlands of Delo Menna and Berbere districts. The samples were collected from the upstream and downstream of the canals along the farms of the districts during the medium and low peaks of the rivers' flow. About 1 L of water sample was collected from each site. Likewise, the sampling date was on the 15th of designated months. Accordingly, the results reveal that the surface irrigation water has less salinity, sodium hazard and residual sodium carbonate hazard in the irrigated canals and canals along the farms. The electrical conductivity ranges from 0.17 to 0.49 ds/m at lower peak and from 0.06 to 0.24 ds/m at medium peak in Delo Menna district. Moreover, the residual sodium carbonate ranges from 1.34 to 2.57 at lower peak flow and 0.79 to 1.30 at medium peak flows; sodium concentration ranges from 0.36 to 0.46 meq/L at lower peak of the river flow and very small concentrations at the medium peak flow period in Berbere district. The salinity indicator parameters such as all cations and anions, total dissolved solid, adjusted sodium ratio, residual sodium carbonates in the irrigated rivers were low in Delo Menna and Berbere. Therefore, the rivers in both districts are normal for agricultural production of all types of crops which are grown in the low lands of Bale.

Key words: Cation, anion, assessment, conductivity, irrigation, water quality.

INTRODUCTION

Water quality issues have often been neglected because there are quite a number of good quality water supplies (Islam et al., 2004). Hydrochemical study reveals the quality of water that is suitable for drinking, agriculture and industrial purposes. The chemical parameters of groundwater play a significant role in assessing water quality which is suitable for irrigation (Sadashaiah et al., 2008). Most of Ethiopian irrigable lands are affected by soil salinity problem. As indicated by Massoud (1997) in Ethiopia, saline soils cover about 11,608,000 ha, and

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sodic soils, about 425,000 ha, and these are found in arid and semi-arid climate where most irrigable lands are found. Irrigation with poor quality waters may bring undesirable elements to the soil in excessive quantities, affecting its fertility. The quality of groundwater has definite command over yield of crops through its effect on soil environment which is the soul of infinite life (Latha et al., 2002).

In irrigation, poor water quality with excess salts affects plants in many ways, but the most common problems are caused by salts which influence the osmotic relationship between roots and soil moisture (Malash et al., 2005). Irrigation water must have appropriate salt concentrations and be free of chemical and biological pollutants. High salts in irrigation water reduce plant growth and affect the structure, aeration, permeability and texture of soil (Singh et al., 2010; Ackah et al., 2011). The aridity of the study area could raise irrigation water impact on soil through the concentration of minerals in soil during evaporation (Al-Rashdi and Sulaiman, 2015). Salt water increases the osmotic pressure in soil solution and accordingly restricts water uptake by plants (Singh et al., 2010; Embaby and El-Barbary, 2011).

The main sources of salts in these regions are rainfall, mineral weathering, "fossil" salts, and various surface and ground waters which redistribute accumulated salts, often the result of anthropogenic activities (Bresler et al., 1982). For instance, soil saturated with high sodium, especially heavy textured, and high swelling clay soils cause increased hydration, swelling, dispersion and peptization of the soil colloids, structural destruction, and aggregate failure. Therefore, this study was undertaken with the objectives of assessing irrigation water quality.

MATERIALS AND METHODS

Study area

The study area is located in the Southeastern part of Oromia Regional State in Bale Zone which lies at latitude 060° 24" N and longitude 390° 50"E in Delo Menna District, with 1278 m altitudes and an average rainfall of 986.2 mm and at latitude 06° 49" N and longitude 040° 11"E in Bebere District, with 1234 m altitudes and an average rainfall of 725 mm. The districts were purposively selected where irrigation has frequently been used.

Procedure for water sample collection

Water samples were collected from four rivers per district from which the canals were constructed for irrigation purpose, and the three water samples were taken from each river at Delo Menna and Berbere in 2011 during the medium and low peaks of river flow. Water samples were collected in one-liter plastic bottle and were drawn from midstream at 0 to 15 cm depth below the surface of the canal water and along the canal. The collected water samples were tightly sealed as early as possible to avoid exposure to air and immediately analyzed for sensitive parameters like pH, electrical conductivity and total dissolved solids (TDS).

Assessment activities were carried out along the rivers from upstream and downstream of the canals along the farms in the districts. About one litre of water sample was collected from each site. The sampling date was on the 15th of designated months. Water sampling techniques were followed as outlined by Hunt and Wilson (1986) and APHA (1989). The chemical analyses were conducted at the Sinana Agricultural Research Center (SARC) and JIJE Laboglass PVT Limited Company.

Methods used for chemical analyses

The pH and electrical conductivity (EC) values were determined electrometrically using digital pH and digital conductivity meter (Ghosh et al., 1983). Residual sodium carbonate (RSC) and adjusted residuals sodium (Adj.Ran.) were calculated using standard equation procedures. Total dissolved solids (TDSs) were estimated by weighing the solid residue obtained by the evaporation of a measured volume of water samples to dryness (Chopra and Kanwar, 1980). Potassium and sodium were determined by flame emission spectrophotometer (Golterman, 1971). Calcium and magnesium were analyzed directly by atomic absorption spectrophotometer (APHA, 1989). Carbonate and bicarbonate were determined by acidimetric titration (Chopra and Kanwar, 1980) while chloride was determined by argentometric titration (APHA, 1989); whereas sulphate was analyzed turbidimetrically (Wolf, 1982) as was analyzed directly by atomic absorption spectrophotometer with hydride generator (APHA, 1989). Accordingly, the generated data were presented in tabulated form.

RESULTS AND DISCUSSION

Salinity hazard of irrigated rivers

Water quality is determined according to the purpose for which it was used. Regarding irrigation water, for instance, the usual criteria including salinity, sodicity, and ion toxicities has been indicated for quality of water. Likewise, the concentration of soluble salts in irrigation water can be classified in terms of electrical conductivity (EC), total dissolved solids (TDS) and pH. Therefore, the analyzed results show quality of irrigation water in Delo Menna district. Thus, the pH ranges in both peaks were found the same which is near neutral from 6.77 to 7.79 at lower peak (Table 1) and from 7.50 to 7.95 at medium peak (Table 2). Likewise, electrical conductivity at lower peak was higher than the medium peaks flows of rivers, thus indicating non saline which ranges from 0.17 to 0.49 ds/m at lower peak and from 0.06 to 0.24 ds/m at medium peak in Yadot and Gomgoma Rivers, respectively. Similarly, total dissolved solids at lower peak was higher than the medium peak flow which range from 113.00 mg/L at Yadot to 352.00 mg/L at Gomgoma River at lower peak and 133 mg/L at Dayu to 164 mg/L at Gomgoma River at medium peak of the river flow (Table 2).

Table 1. The Irrigation water quality of Delo Menna Districts at low peaks flow of the rivers.

Lab. No.	EC(ds/m)	pH	adj. R_{Na+}	RSC	$\%Na^{+}$	Cations (meq/L)				Anions (meq/L)				TDS (mg/l)
						Na^{+}	K^{+}	Ca^{2+}	Mg^{2+}	CO_3^{2-}	HCO_3^{1-}	Cl^{-}	SO_4^{2-}	
DL1-1	0.37	7.79	0.38	Trace	8.73	0.44	0.07	4.18	0.35	Trace	3.51	0.35	5.92	251.00
GL1-2	0.49	7.70	0.96	Trace	15.10	1.09	0.10	5.39	0.64	Trace	5.34	0.58	2.28	352.00
CL1-3	0.28	7.05	0.48	Trace	14.72	0.53	0.04	2.50	0.53	Trace	2.76	0.35	2.78	180.00
YL1-4	0.17	6.77	0.45	Trace	19.92	0.48	0.05	1.84	0.04	Trace	1.60	0.24	4.96	113.00
Mean	0.33	7.33	0.57	Trace	14.62	0.64	0.07	3.48	0.39	Trace	3.30	0.38	3.98	224.00

Letters within the same column of the respective treatments are EC = Electrical Conductivity, PH = Power of Hydrogen, Adj. R Na+ = Adjusted Residuals Sodium, TDS = Total Dissolved Solids, RSC = Residual Sodium Carbonate, mg/L = milli gram per liter.

Table 2. The Irrigation water quality of Delo Menna Districts at medium peaks of the rivers.

Lab. No.	EC(ds/m)	pH	adj.R_{Na+}	RSC	$\%Na^{+}$	Cation (meq/L)				Anion(meq/L)				TDS (mg/l)
						Na^{+}	K^{+}	Ca^{++}	Mg^{++}	CO_3^{2-}	HCO_3^{1-}	Cl^{-}	SO_4^{2-}	
DM2-1	0.20	7.83	0.04	1.13	2.54	0.03	0.16	0.62	0.37	Trace	2.12	0.61	1.64	133.00
GM2-2	0.24	7.95	0.08	2.88	2.22	0.08	0.82	1.26	1.45	Trace	5.59	0.79	0.73	164.00
CM2-3	0.23	7.50	0.05	1.59	2.68	0.04	0.37	0.36	0.72	Trace	2.67	0.96	0.60	153.00
YM2-4	0.06	7.50	0.04	0.84	5.71	0.02	0.13	0.04	0.16	Trace	1.04	0.75	0.38	139.40
Mean	0.18	7.70	0.05	1.61	3.29	0.04	0.37	0.57	0.68	Trace	2.86	0.78	0.84	147.35

Letters within the same column of the respective treatments are EC = Electrical Conductivity, PH = Power of Hydrogen, Adj. R Na+ = Adjusted Residuals Sodium, TDS = Total Dissolved Solids, RSC = Residual Sodium Carbonate, mg/L = milli gram per liter.

Sodium hazard of irrigated rivers

Among the soluble constituents of irrigation water like sodium, magnesium and calcium is considered most hazardous. Therefore, sodium soils are relatively impermeable to air and water; making both soils and plants adversely affected by high sodium irrigation water. Accordingly, the results reveal that the sodium percent varies from time to time with high percentage at lower peak flows that ranges from 8.73 to 19.92% at lower peak and 2.22 to 5.71% at medium peak (Table 2). Likewise, residual sodium carbonate was found in trace amount at lower peak flow and 0.84 to 2.88 meq/L at medium peak flow and that of sodium concentration ranges from 0.44 to 1.09 meq/L at lower peak flow and 0.02 to 0.08 meq/L at medium peak of the river flow (Table 2).

Bicarbonate hazard of irrigated rivers

In water having a high concentration of bicarbonate, there is a tendency for calcium and magnesium to precipitate. When this happens, there is a reduction in the concentration of calcium and magnesium and a relative increase in sodium. Accordingly, the results reveal that the bicarbonate concentration at lower peak and medium peak river flow were found in the same and trace amount. Likewise, bicarbonate ranges from 1.60 to 5.34 meq/L at lower peak flow and 1.04 to 5.59 meq/L at medium peak flow in Yadot and Gomgoma Rivers, respectively of Delo Menna District (Table 2).

Chemical properties of irrigated rivers

The water quality during the assessment of each

Table 3. The irrigation water quality of Berber District at low peak flow of the rivers.

Lab. No.	EC(ds/m)	pH	adj.R_{Na+}	RSC	%Na^+	Cation (meq/L)				Anion (meq/L)				TDS (mg/l)
						Na^+	K^+	Ca^{++}	Mg^{++}	CO_3^{2-}	HCO_3^{1-}	Cl^-	SO_4^{2-}	
SL2-1	0.15	7.55	0.68	2.47	34.85	0.46	0.03	0.15	0.68	Trace	3.30	0.35	0.04	113.00
HL2-2	0.22	7.72	0.39	1.92	12.20	0.36	0.04	1.93	0.62	Trace	4.47	0.35	0.78	162.00
GL2-3	0.08	7.72	0.60	1.34	38.78	0.38	0.06	0.24	0.30	Trace	1.88	0.24	0.42	62.70
HNL2-4	0.16	7.56	0.64	2.57	34.43	0.42	0.03	0.16	0.61	Trace	3.34	0.32	0.32	112.00
Mean	0.15	7.64	0.58	2.08	30.07	0.41	0.04	0.62	0.55	Trace	3.25	0.32	0.39	112.43

Letters within the same column of the respective treatments are EC = Electrical Conductivity, pH = Power of Hydrogen, Adj. R Na+ = Adjusted Residuals Sodium, TDS = Total Dissolved Solids, RSC = Residual Sodium Carbonate, mg/L = milli gram per liter.

Table 4. The irrigation water quality of Berber District at medium peak flow of the rivers.

Lab. No.	EC(ds/m)	pH	adj.R_{Na+}	RSC	%Na^+	Cation (meq/L)				Anion (meq/L)				TDS (mg/l)
						Na^+	K^+	Ca^{++}	Mg^{++}	CO_3^{2-}	HCO_3^{1-}	Cl^-	SO_4^{2-}	
SM1-1	0.13	7.69	0.05	0.95	4.29	0.03	0.17	0.25	0.25	Trace	1.45	0.73	0.60	83.90
HM1-2	0.26	7.96	0.02	1.30	1.05	0.02	0.21	1.31	0.37	Trace	2.98	0.88	2.47	189.00
GM1-3	0.10	7.45	0.06	0.84	6.00	0.03	0.18	0.10	0.19	Trace	1.13	0.86	0.32	63.10
HNM1-4	0.14	7.34	0.02	0.79	3.45	0.01	0.10	0.07	0.11	Trace	0.97	0.89	0.24	88.50
Mean	0.16	7.61	0.04	0.97	3.70	0.02	0.17	0.43	0.23	Trace	1.63	0.84	0.91	106.13

Letters within the same column of the respective treatments are EC = Electrical Conductivity, PH = Power of Hydrogen, Adj. R Na+ = Adjusted Residuals Sodium, TDS = Total Dissolved Solids, RSC = Residual Sodium Carbonate, mg/l = milli gram per liter.

indicator displayed recommendations for the farmers. Moreover, the analyzed results show that the cations such as potassium, calcium and magnesium were found in small amount which could not affect the growth and developments of all crops grown in the area. Anions such as chlorine were also found in small amount at lower and medium peak, while sulphate was very small at medium flow and 2.28 to 5.92 meq/L at lower peak flow rivers of Delo Menna district.

Salinity hazard of irrigated rivers

The analyzed results show the quality of irrigation water in Berbere District which were collected from rivers of Gabe, Hambala, Sirima and Hara Nano. Thus, the pH of most of the irrigation water of four rivers ranges from 7.34 to 7.96 at medium stream flow and 7.55 to 7.72 at low stream flows (Table 3), and is within the safe limit for irrigation water quality. Likewise, the electrical conductivity ranges from 0.08 ds/m in Gabe to 0.22 ds/m in Hambala at low stream flow and 0.10 ds/m in Gabe to 0.26 ds/m in Hambala at medium stream flow; total dissolved solids range from 62.70 mg/L in Gabe River to 162.00 mg/L in Hambala River at lower peak and 63.10 mg/L in Gabe River to 189 mg/L in Hambala at medium peak of the river flow (Table 4).

The study is in line with the finding of Raghunath (1987). The amount of total dissolved solids (TDS) ranged from 130 to 359 mgL^{-1} water containing TDS less than 1000 mgL^{-1} considered to be of 'fresh water category. According to Mohammed (2011), irrigation being used had the most influential water quality guideline on crop productivity; the extent of salinity hazard could be measured by the ability of water to conduct an electric current since conductance is a strong function of the electrical conductivity (EC) measurement. In general, the amount of water available to the crop gets lower when the electrical conductivity is higher. The pH of water samples varied from 7.50 to 7.95 at medium stream flow and 6.77 to 7.79 at low stream flows, indicating slightly acidic to slightly alkaline in nature and is within the safe limit recommended for irrigation water quality. The recommended pH limit of irrigation water is 6.0 to 8.5 (Ayers and Westcot, 1985).

Sodium hazard of irrigated rivers

The results reveal that the sodium percent ranges from 12.20% in Hambala to 38.78% in Gabe River at lower peak and 1.05% in Hambala to 6% in Gabe at medium peak of the river flow (Table 4). Likewise, residual sodium carbonate ranges from 1.34 in Gabe to 2.57 in Hara Nano at lower peak flow and 0.79 meq/L in Hara Nano to 1.30 meq/L Hambala at medium peak flow (Table 4); sodium concentration ranges from 0.36 meq/L in Hambala to 0.46 meq/L in Sirima Rivers at lower peak of the river flow (Table 3) and very small concentrations in Sirima, Hambala, Gabe and Hara Nano at the medium peak flow. The study is in line with the finding of Vasanthavigar et al. (2009) higher sodium concentrations observed in (May 2010) because increase river water level that leads to dissolution of minerals from lithological composition.

Bicarbonate hazard of irrigated rivers

The results reveal that the carbonate at lower and medium peak was found in a trace amount in all rivers in Berbere District. Likewise, bicarbonate ranges from 1.88 meq/L in Gabe to 4.47 meq/L in Hambala at lower peak river flow and that of Hara Nano 0.97 meq/L to 2.98 meq/L in Hambala at medium peak flows of the river. As a result, the relative proportion of sodium in the water is increased in the form of sodium bicarbonate (Sadashaiah et al., 2008). Continuous use of waters having residual sodium carbonate of more than 2.5 meq/L leads to salt build up which may hinder air and water movement by clogging the soil pores. This leads to the degradation of the physical condition of soil (Latha et al., 2002).

Chemical properties of irrigated rivers

The analyzed results show that the cations such as potassium, calcium and magnesium were found in small amount which could not affect the growth and developments of all crops. Anions such as chlorine were also found in small amount at lower and medium peak. Sulphate was very small at medium and lower peak flow in all the rivers in Berbere District. Accordingly, the study, in line with some of the soluble constituents, Ca^{2+}, Mg^{2+}, Na^{-}, Cl^{-}, SO_4^{2-}, HCO_3^{1-} and B are of prime importance in judging the water quality for irrigation (Michael, 1978). Likewise, some of these ions are beneficial and few ions in excess amounts are more or less detrimental to plant growth and soil properties (Quddus and Zaman, 1996). Similarly, the relatively high concentration of calcium cations may limit the hazardous effect of sodium which later causes the dispersion of the soil aggregates eventually creating water problem and movement in the soil systems (Mathess, 1982).

Generally, the irrigation water qualities in both districts were identified as a good condition for production and productivity. Moreover, Delo Menna is relatively more saline than the Berbere district. Accordingly, salinity, sodium, bicarbonate and chemical properties of the districts were found to be in normal concentration which does not need reclamation for the crops grown in area.

Conclusion

Irrigation is an important practice for farmers to increase their production and productivity, especially where moisture stress is found in lowlands of Oromia. In the area, fruits and vegetables are majorly produced under irrigation where the mode of irrigation is canal from flowing rivers. Accordingly, assessments of irrigation water quality parameters reveal that the percentages of sodium at the low stream flow were higher than those at the medium stream flow of irrigated rivers and that of the carbonate ions in all the kebeles were in trace amounts.

Analysis of the results showed that the relative concentrations of all cations and anions in both districts were very low at medium and lower stream flow of all rivers. Generally, the irrigation water qualities in both districts were identified as a good condition for production and productivity. Moreover, Delo Menna is relatively more saline than the Berbere district. Accordingly salinity, sodium, bicarbonate and chemical properties of the districts were found to be in normal concentration which does not need reclamation for the crops grown in the area. Therefore, the rivers in both Woreda are normal for the agricultural production of all types of crops which are grown in the low lands.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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Water supply and demand scenario of Dilla Town, Southern Ethiopia

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Access to and use of safe drinking water can contribute enormously to health, productivity and social development. This study was conducted to assess the existing water supply and demand scenario of Dilla Town, Southern Ethiopia. To achieve the objective of the study, a total of 187 households were randomly selected and interviewed by using semi structured questionnaire. To collect the required data, interview schedule, observation, focus group discussions and key informant interviews were used. In addition, different documents were reviewed. The collected data were analyzed using descriptive statistics. The survey result revealed that the town water supply cannot fulfill consumer demand for water. Obsolete supply system, electric power supply problem, lack of institutional capacity and budget shortage are the basic factors for this imbalance. According to the survey results, the average per capita consumption was found to be less than the recommended standard, which is approximately at least 20 L of water per person per day. In line with this, the most frequent complaints by water customers were regular interruption of water supply and unfair water distribution. The collected data also showed that there is prolonged water shortage in the town. Consequently, in order to narrow the supply and demand gap, expansion of water supply services that match with the town development must be carried out, the town water supply service enterprise should devise a mechanism so as to assure the equitable distribution of water among the residents and the concerned stakeholders should discharge their respective responsibilities properly.

Key words: Dilla town, water distribution, drinking water, supply and demand gap.

INTRODUCTION

Many countries in both the developed and developing world face significant problems in maintaining reliable water supplies and this is expected to continue in future years due in part to the impacts of global climate change. Growing populations will further increase the demand for water, with limited cost-effective water supply augmentation options (Dharmaratna and Harris, 2010).

No other single intervention is more likely to have a significant impact on global poverty than the provision of safe water. Water is a central theme which can be used

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to achieve millennium development goals (MDGs) (Schuster-Wallace et al., 2008). As reported by Helena (2010), the current challenges facing the water supply sector includes keeping pace with net population growth, closing the coverage and service gap and ensuring sustainability of existing and new services with improved quality of services.

A good water supply system should fulfill two primary requirements, viz; adequacy and reliability. Budget constraints, low revenues and shortfalls in operation and maintenance have resulted in insufficient expansion of the system and gradual degradation of the service; at the same time the water demands increased and scarcity worsened (Hickey, 2008). According to World Health Organization, 75 L of drinking water per day is necessary to be able to prevent household disease and also 50 L a day for basic parent's sanitation (Abaje et al., 2009).

Currently, majority of the existing Ethiopian urban water supply and sanitation system designs are obsolete but the rate of rehabilitation and expansion has been lagging behind. Most urban water utilities do not fulfill the principle of cost recovery and self-reliance, which has undermined the interests of the external borrowers. On the other hand, contrary to its huge investment requirement of urban water supply, the flow of funds has remained very low (Ministry of Finance and Economic Development - MoFED, 2007). Estimate reveals that about 52% of the population in Ethiopia traveled half an hour or more to collect water every day (Central Statistical Agency - CSA, 2006). This long travel distance to the nearest water source directly affects women and children who are mainly responsible for fetching water. Most girls and children find it too difficult to attend and succeed in school because a considerable amount of their time is used for domestic chores including fetching water. This has an implication on the productivity of women.

According to the report of Ministry of Health and Water and Energy, access to safe drinking water increased from 23.1% in 1998 to 68.5% in 2012. However, millions of people in urban and rural areas have not been getting safe drinking water from an improved water source. In the case of Southern Nation, Nationalities and Peoples' Regional State ($SNNPR_S$), clean water supply access in terms of coverage has reached 53.9% (BoWRD, 2008). According to Edward (2010), major problems of water supply in urban centers of Ethiopia include low production levels, inadequate distribution systems and leakages in many areas.

The administrative center of Gedeo zone, Dilla town, is growing rapidly in recent years as a result of increased trade and being a major transit center, main passage of goods from Kenya. On the other hand, the provision of urban water is clearly observed as a critical challenge in the town. Therefore, these conditions necessitated a research work in order to assess the existing water supply and demand status of the town.

METHODS

Study site description

Dilla town is located in Southern Ethiopia at a distance of 359 km from the capital city, Addis Ababa, on the way from Addis Ababa to Moyale. It is located at 6° 22´ to 6° 42´ N and 38° 21´ to 38° 41´ E longitude with an altitude of about 1476 m.a.s.l (Figure 1). The mean annual daily maximum and minimum air temperature is 28.4 and 12.8°C, respectively (Demelash, 2010). According to the Ethiopian Central Statistical Agency, the town has a total population of 86,069 out of which 45,207 are males and 40,862 are females. However, Dilla Town Administration Population Affairs, Coordination and Implementation Core Work Process (DTAPA) reported that the projected population of the town is estimated to be above one hundred thousand (Dilla Town Administration Population Affairs - DTAPA, 2016).

The town is bounded by Legedara, Walame and Chichu Rivers. Presently, the town is supplied with water by two different water sources. The first one is Legedara River and the other one is ground water from which six boreholes are developed. The data obtained from Dilla Town Water Supply Service Enterprise (DTWSSE) showed that the production capacities of the boreholes are 13.5 l/s (Millennium), 5 l/s (Chichu number 1), 6 l/s (Chichu number 2) with the three new ones producing 8 l/s each. In addition, there are 36 public stand pipes in the different parts of the town that supply water for those households that do not have access to piped connections (DTWSSE, 2016).

Data source and method of data collection

The survey utilized both quantitative and qualitative methods to explain concepts and measures to demonstrate implications of the issue under question. Primary data was collected from respondents using questionnaires and personal field observation was employed to supplement respondents' response. Secondary data was collected from related literatures. Structured and semi structured questionnaire were prepared for the survey. The questionnaire included an introductory part, questions on the characteristics of the respondents, water sources and accessibility, potable water coverage and water supply satisfaction. Data collection was undertaken by both the researcher and enumerators.

Sample size and sampling method

In order to determine the sample size that represents the population, a mathematical formula suggested by Fink and Kosecoff (1995) was employed as presented:

$$N = \frac{z^2 pq}{d^2} \quad (1)$$

Where N = Sample size;

Z = 95% confidence level corresponds to the value 1.96;

p = 0.61 (the 2015 water supply coverage of the town);

q = 1-p;

d = proportion of sampling error tolerated at 0.07.

Therefore, 187 households were taken as sample respondents. Since the town is classified into three sub cities, sample households were randomly selected from the three sub-cites purposively based on their population number.

Data analysis and presentation

Qualitative data was analyzed and presented through description,

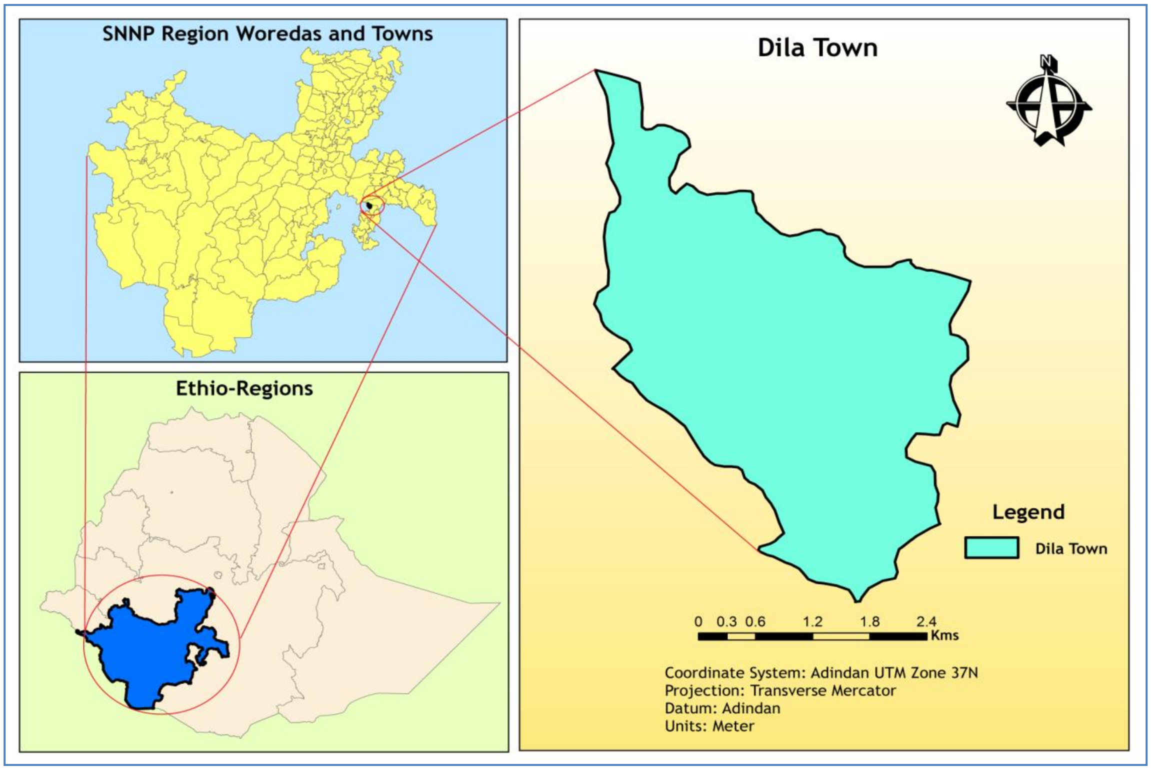

Figure 1. Location of the study area.

narration and interpretation of the situations contextually. Whereas quantitative data were analyzed and presented using tables, frequency and percentages were used to give clear understanding of the issue quantitatively. The computer software applications SPSS (Statistical Program for Social Science) and Micro soft Excel were used to analyze the data.

RESULTS AND DISCUSSION

Characteristics of survey respondents

As depicted in Table 1, out of 187 interviewed sample households, 60% were female and the rest are male. The age range distribution of the respondents showed that 18% of them were in 20 to 30 age groups, 31% were in 31 to 40 age groups and the remaining were above 41. With regards to marital status, 68% were married, 2% were divorced and the rest were unmarried. Concerning the educational level of the respondents, 2% were illiterate, 76% had formal education and 22% had informal education.

Table 1. Sample households' characteristics.

Item category	Variables	Frequency	Percent
Sex	Female	112	60
	Male	75	40
Age	20-30	33	18
	31-40	58	31
	>41	96	51
Marital status	Married	128	68
	Divorced	4	2
	Unmarried	55	29
Educational level	Literate/formal	142	76
	Illiterate	3	2
	Informal	42	22

Source: Sample survey (2015).

Status of drinking water supply

Water sources and accessibility

Safe drinking water is the birthright of all humankind (as much a birthright as clean air) (Rao, 2002), while access to clean water can be considered one of the basic needs and rights of a human being. The two main water sources of Dilla town are river and ground water. Legedara River is diverted to a treatment plant and distributed to urban residents through a piped system. The non-piped system

Table 2. Water supply connection (Sample survey, 2015).

Description	Variable	Frequency	Percent
Primary water source for the household	Pipeline connection	92	49
	Public tap	73	39
	Water vendors	22	12
Distance from the water source to residence (m)	Up to 10	7	4
	10-50	13	7
	50-100	26	14
	100-200	43	23
	>200	97	52
Average time spent to collect water (min)	<5	24	13
	5-30	73	39
	>3	90	48
How much water do you use on average per person per day in liter	<20	125	67
	20-30	56	30
	30-50	6	3

includes rivers and hand dug wells. With regard to water accessibility, distance and time traveled to fetch water are considered. To most communities of Africa, long distance travel to fetch water is common. According to World Health Organization (WHO, 2006), only 16% of people in sub Saharan Africa had access to drinking water through a household connection (an indoor tap or a tap in the yard).

Out of the total interviewed sample households, 49% obtained water from private tap connection regardless of its frequency, 39% used water from public tap and the remaining got water from water venders. The survey result revealed that majority of the respondents (52%) travelled more than 200 m to collect water from public tap. Some of them (4%) reported distances up to 10 m, 7% from 10 to 50 m, and 14% from 50 to 100 m while the remaining (23%) reported distances from 100 to 200 m from their residence. Similarly, majority of the respondents (48%) spent more than 30 min to collect drinking water, 13% of them < 5 min, the rest 39% spent from 5 to 30 min (Table 2). An estimate reveals that about 52% of Ethiopian population traveled half an hour or more to collect water every day (CSA, 2006).

Regarding the per capita water requirement, majority (67%) of the respondents reported that they use less than 20 L of water per capita per day which is less than the recommended standard. African Water Development Report (2006) estimated that to ensure the basic water needs of humans, 20 to 50 L of water free from harmful contaminants are needed every day. According to Ministry of Water, Irrigation and Energy (MoWIE) (2011), basic access of water for urban dweller is 20 L per capita per day within 0.5 km service radius in universal access plan. On the other hand, as per WHO (2008), the basic access of water is 20 L per capita per day within 100 m to 1 km and the average time spent to collect water is 5 to 30 min. More than 1 km of traveling distant in search of water is said to be no access. Thus, majority of households did not have basic access of water for their domestic needs. It implies that water accessibility standards are not well exercised in the town.

Bartram and Howard (2003) underlined that adequate and reliable water supply is critical for coping with every day urban life. Poor access to potable water has negative impact on development. Challa (2011) also indicated that, poor access to water supply and sanitation limits opportunities to escape poverty and exacerbates the problems of vulnerable and marginalized groups. As depicted in Figure 2, the towns' residences use donkey carts and yellow plastic jars 'Jerikans' to fetch water from long distances and some organizations and hotels also use lorries to meet their water demand from public taps.

Potable water coverage

The WHO/UNICEF JMP report of 2015 indicated that the improved water coverage in Ethiopia was found to be 93 and 49% in urban and rural areas, respectively. The country coverage of improved water source usage reached 57%. On the other hand, 30% of the total Ethiopian citizens rely on unimproved drinking water sources. In 2015, the potable water coverage of Dilla Town was reported to be 61% (DTWSSE, 2016). Water supply systems in urban areas are often unable to meet existing demands and are not available to everyone,

Figure 2. Fetching water from public taps (2015).

rather some consumers take disproportionate amounts of water and the poor is the first victim of the problem (Bereket, 2006).

The total numbers of potable water customers of Dilla town are 7001 out of which 6596 are private customers and 19 and 194 are commercial and government customers, respectively. There are two jails in the town. As reported by the key informant, there is chronic water shortage in the jail and as a result they complement their water need from ground and river water. As depicted in Table 3, the piped water coverage increment is very small as compared to the population growth. As reported by DTWSSE, financial constraint and poor management of the existing water supply are the main challenges for the low coverage of the water supply.

Some of the respondents also reported that due to water shortage they incur additional costs and face health problems like diarrhea as they are forced to use alternative sources of water of poor quality. Hunter et al. (2010) reported that a poor water supply impacts human health by causing diarrhea and non-diarrheal disease, limiting productivity and the maintenance of personal hygiene.

According to WHO and UNICEF (2013), there is a considerable funding gap to achieve full coverage; hence, more has to be invested in developing sector capacity through strengthening institutional structures especially at regional, district and community levels. Based on Schuster-Wallace et al. (2008), water has suffered from severe under financing. This result from inadequate

Table 3. Dilla town 5 years water coverage.

Description	2011	2012	2013	2014	2015
Total population	73,361	78,360	82,127	86,071	91,029
Population served with potable water	22,505	25,005	27,505	30,505	32,505
Potable water coverage (%)	30.7	31.9	33.5	35.44	35.7

Source: DTAPA and DTWSSE (2016).

Table 4. Drinking water supply service situation.

Items	Variables	Frequency	Percent
Are you satisfied in the current water supply of the town?	Yes	7	4
	No	180	96
How often do you get water for your consumption?	Once in 1-2 days	6	3
	Once in 3-4 days	22	12
	Once in 4-5 days	26	14
	Once in a week	60	32
	More than 1 week	73	39
Is there fair water distribution.	Yes	13	7
	No	174	93

Source: Field Survey (2015).

internal financial capacity in the poor countries to achieve water goals, poor political decisions for allocation of development aid, an overall reduction over time in development aid, and the limited cost recovery potential in poverty stricken regions.

Evidence from empirical research (Vasquez et al., 2009) indicates that improved water supply schemes in many developing countries are not functioning properly. There have been similar studies carried out in some of Ethiopian towns. Generally, the studies revealed that the water demand is more than the supply. For instance, Tizazu (2012) at Yirgalem town showed that, water supply service could not meet water demands of the town with existing capacity. Challa (2011) and Reda (2012) reported that there is low water coverage and frequent interruption. To expand water supply to urban areas, implementing proper demand management strategies is required. Pertinent information on the residential water demand of households is necessary to properly assess the factors that affect residential water demand (Arbués et al., 2003).

Water supply satisfaction

Most countries give first priority to satisfaction of basic human needs for water. The service deficiencies primarily affect the poorest segments of the population in developing countries. This survey result showed that out of the total respondents, about 96% are dissatisfied with the current service due to frequent interruption and unfair distribution of water whereas the rest reported that they are satisfied with the services. Of the total interviewed respondents, 39% obtained tap water once a week. In some cases, the water may not be available for two weeks and even more (Table 4). The interruption is attributed to malfunction of submersible pumps and power supply interruption. While expanding improved water source schemes is generally essential, it is equally important to ensure that the schemes have increased users' satisfaction with water quality and availability for everyday use (UNICEF, 2010). The majority of the sample households replied that the water distribution is unfair and variable. As reported by respondents, some area may be served water frequently while other areas stay without water service at all. Consequently, the town water supply service enterprise should devise a mechanism so as to minimize the inequitable distribution of water among the residents of the town.

Conclusions

This study has attempted to examine the water supply and demand scenario of Dilla Town. The water demand of the town is increasing due to urbanization and population growth. The survey revealed that the town water supply cannot fulfill consumer demand for water. Long age of the system, electric power supply problem, lack of institutional capacity, lack of finance and malfunction of submersible pumps are the basic limitations.

The average per capita consumption was found to be less than 20 L/person/day which is less than the recommended standard. In line with this, according to the survey results, the most frequent complaints by water customers are regular interruption of water supply and unfair water distribution. The findings of the data lead to the conclusion that there is a huge gap between the water supply and demand of the town. Consequently, in order to satisfy the water demand of the town the following measures should be taken.

1) Expansion activities that match with the town development must be carried out to meet the water requirements of the town.
2) The concerned stakeholders (DTWSSE, Gedio Zone Water and Irrigation Office, Electric and Power Authority, Dilla branch) should discharge their respective responsibility properly.
3) DTWSSE should devise a mechanism so as to minimize the inequitable distribution of water among the residents of the town.
4) Additional study should be conducted to find out other possible causes for water shortage so as to act accordingly.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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