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Exploring the Usability of Guangua Badiya River Water for Agricultural Purposes

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Abstract

The quality of irrigation water directly influences the quality of soil and the crops grown in the soil. Quality of water used for agricultural purposes is directly proportional to the yield. The present study was conducted to find the quality of Gungua Badiya river water and its usability for agricultural purposes in Abaya district, West Gujji Zone, Oromiya Region, Ethiopia. To analyze the physicochemical parameters of the river water, nine samples were collected from upper, middle and lower parts of the river. The physicochemical parameters are analyzed to explore the usability of the river water are: pH, Electrical conductivity (EC), Total dissolved solids (TDS), Calcium (Ca^{2+}), Magnisium (Mg^{2+}), Sodium (Na^{+}), Chloride (Cl^{-}) and Residual Sodium Carbonate (RSC), Sodium adsorption ratio (SAR) and Soluble Sodium Percent (SSP)**.** After evaluating the parameters, it is found that the river water is usable to agricultural purposes and meet the standards directed by UCCC, WHO and FAO.

Keywords: Water quality, Gungua Badiya River, agricultural purposes, physicochemical parameters.

Introduction

Ethiopia is predominantly an agricultural country with potentialities of fertile land and abundant water resources. The food habits of people and the weather in Ethiopia also favours agriculture to be the major profession. Quality of water and quality of soil are major natural resources for crop production on which agriculturalists invest their time, resources and energy. However, in Ethiopia, surface water sources are affected by many anthropogenic factors such as pollution from industrial, commercial and residential areas, as a result reduction of agricultural crops, human health problem and aquatic ecosystems disturbance observed in different areas (Ranjeeta, Ratwani and Vishwakarma, 2011). Therefore, to improve the sustainable use of water resources for agriculture and satisfy the food demand of the everincreasing population of Ethiopia, attention is given to explore the available water resources that have quality to use for agricultural purposes.

Surface water quality is affected by natural and anthropogenic factors such as: geology, hydrology, natural hazards, sedimentation/erosion, agricultural activities, industrial, mining, fishing, sewage discharging/disposal, deforestation, and other commercial activities (Chaterjee and Raziuddin, 2002). The water quality is to be analyzed before we use it for the crops, as these factors aggravate the pollution of water body and greatly influence the agricultural yield. Muthana also opined in his research that the poor irrigation water quality has resulted in a negative effect on crop productivity, crop product quality, public health of consumers and farmers who are direct contact with the irrigation water.

Abaya district has many perennial rivers and most of these water sources are polluted, due to the discharge of untreated sewage, waste water from coffee processing industries and other industrial effluents. Simsek and Gunduz, (2007) pointed out that poor quality of river water has an effect on agriculture then, surface water resources have been polluted above the permissible limits that could no longer be used in agricultural uses. In the study area no data is documented about the quality Guangua Badiya River for agricultural use. Thus, the researcher felt to collect water samples from the river and to analyze systematically to find the quality of water to explore whether the river water is usable for agricultural purposes. Therefore, the main objective of this research is to evaluate water quality of Guangua Badiya River and to explore whether it is suitable for agricultural purposes.

The study findings will help the stake holders of Guangua Badiya River to take decisions based on the water quality for sustainable use. Moreover, the study will provide baseline information to woreda agricultural officials, experts and development agents plan to manage waste disposal from industries and agricultural activities, so as to maintain the quality of the river water for agricultural usage.

Materials and Method

Description of the Study Area

The experiment was conducted in Guangua Badia River, Abaya district, West Gujii Zone, Ethiopia in 2015/16 irrigation period. Abaya district is in Oroma Regional state, 06°11' 56''- 06°25'06''Latitude and 38°06'00''Longitude, and is located at about 430 km east of Addis Ababa. It has bimodal rain fall pattern, with annual average rain fall of 700 to 1200 mm and daily mean temperature of 27°C. A total population of 103,348, of whom 52,015 were men and 51,333 were women are residing in the place according to 2007 national census of Ethiopia. The district has a total area of 187134 ha of land, out of which, 60728 ha is cultivated land, 45275 ha is grazing land, 12404 ha is forest and bush land, 62925 ha is covered by Lake Abaya, and 5801 ha is allotted for other activities with 26 rural kebeles and 3 semi urban kebeles. Maize, Teff, haricot bean, groundnut, tomato, onion, potato, pepper, cabbage, coffee and Enset are the major crops grown in the area. Moreover, the district has more than twelve perennial rivers including the Gelana and Gidabo (ADBOA, 2014).

Location Map of the Study Area

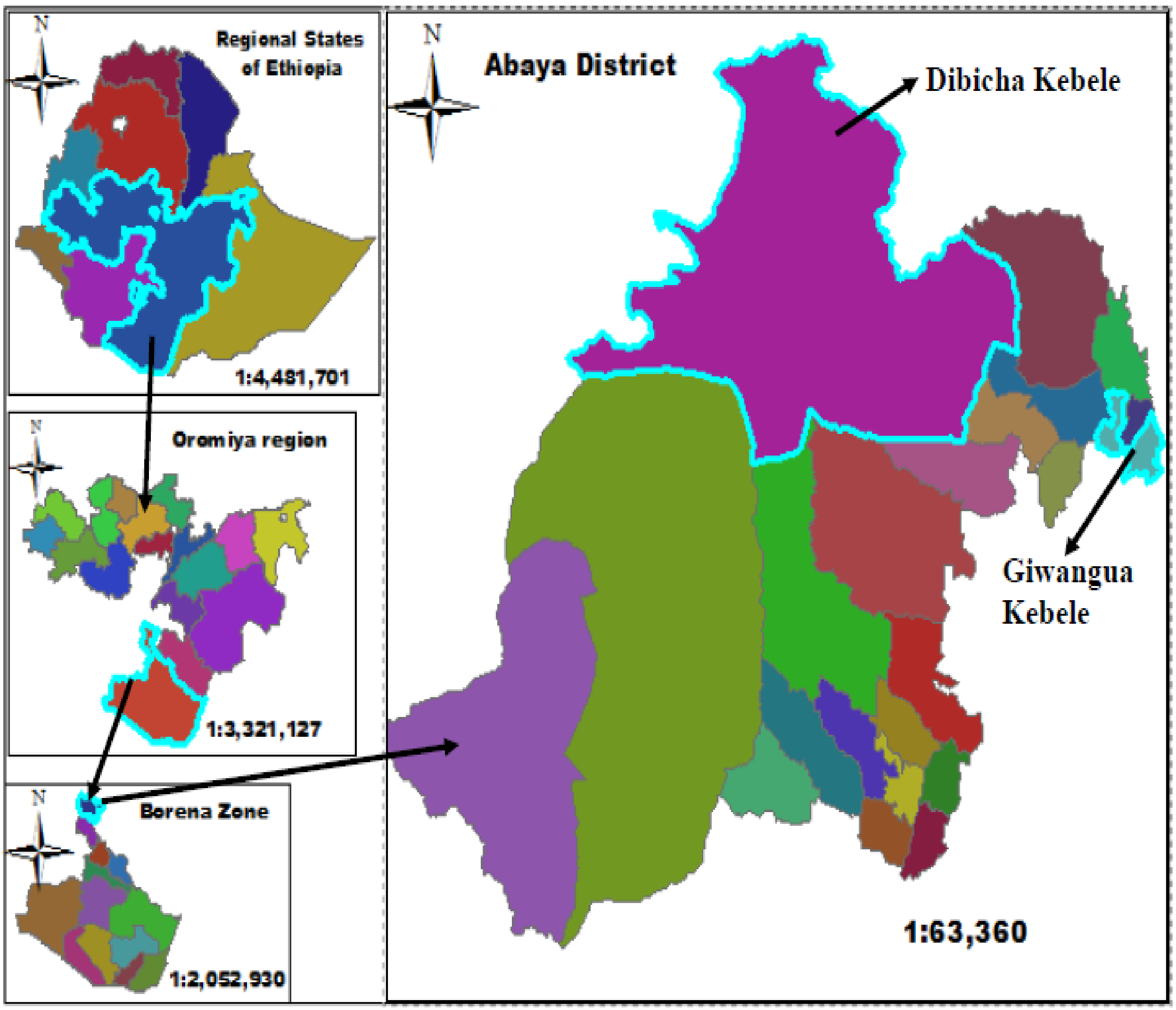

Figure 1. Location map of the study area

Water quality determination

Representative sampling points were purposively selected based on the use of river for agricultural purposes. The study was conducted strategically between December and February, 2015/16 during peak farming period. Samples were collected three times with a month's interval from upper, middle and lower selected sites. A total of nine water samples, with a depth of 30 cm were collected from the river sites which was predominantly utilized for agricultural use by the farmers.

Analysis of water chemical properties

The water samples were analyzed all physicochemical parameters viz. pH (H_2O), Electrical conductivity (EC) , Total Dissolved Solids (TDS), Calcium (Ca^{2+}), Magnesium (Mg^{2+}), Sodium (Na^{+}), Potassium (K^{+}), Chloride (Cl^{-}) and Residual Sodium Carbonate (RSC**)**. Furthermore, the quality of the water samples were assessed using Sodium adsorption ratio (SAR) and Soluble Sodium Percent (SSP). Then, ionic concentrations of Na^{+}, Ca^{2+}, Mg^{2+} and K^{+}. EC and pH (H_2O) were determined using electrical conductivity meter and pH meter as described by (Carter and Gregorich 2008). TDS were indicated by weighting the solid residue obtained by evaporation of a measured volume of water samples to dryness (Chopra and Karnwar, 1980). Soluble Na^{+} and K^{+} were determined by flame-photometer after proper calibration with combined Na-K standard solutions (Carter and Gregorich 2008). While soluble Ca^{+2} and Mg^{+2}, were analyzed directly by atomic absorption spectrophotometer (APHA, 1998). $C1^{-}$ ion was measured by the argentometric method, by titrating against silver nitrate standard solution with potassium chromate indicator (Greenbergs et al., 1992). SAR, RSC and SSP of water sources were calculated as suggested by Muthanna.

Statistical Analysis

The physical and chemical properties of the river water was subjected to analysis by using SPSS version 20 software and Microsoft Excel. The physicochemical parameters of the river water was compared with standard guideline values recommended by the UCCC, WHO, FAO, Ayers and Westcot, Eaton, Wilcox, Todd, Richards and Wilcox.

Results and Discussion

Irrigation water quality for the Gwangwa Badiya River

The quality of river water may be affected by salt that could eventually contributing to the accumulation of salinity. Irrigation must be accompanied by sufficient system of salt removal (Hergert and Knudsen, 1997). The summary of statistical parameters such as minimum, maximum and mean concentrations of physicochemical parameters are tabulated in Table 1.

Table 1. Statistical description of physicochemical parameters of Guangua Badiya River water (Mean±SE, n=9)

Parameter	Minimum	Maximum	Mean±SE
PH	6.55	7.25	6.85 ± 0.2
EC(dS/m)	0.07	0.27	0.16±0.0
TDS(mg/l)	131	146	139± 4.1
Na(meq/l)	0.24	0.30	0.26±0.0
Ca(meq/l)	0.38	0.47	0.43±0.0
Mg(meq/l)	0.37	0.51	0.44±0.0
K(meq/l)	0.26	0.29	0.27±0.0
Cl (meq/l)	0.14	0.25	0.19±0.3
SAR	0.37	0.43	0.40±0.0
SSP %	18.02	19.16	18.71±0.4
RSC(meq/l)	0.55	0.93	0.75±0.1

Water PH

The pH of the river water ranged from 6.55 to 7.25 with an average value of 6.85. High value of pH is due to high amount of waste water from coffee processing industries, which may dilute the alkaline substances or the dissolution of the atmospheric carbon dioxide (Sheikh Nisar and Yaregi, 2003). This value is considered to be safe for agricultural activities when compared with the standard value given by (UCCC, 1974, FAO, 1985 and WHO, 2006). The results are also within the values as determined by Vudhivanich, (1998) for agricultural water use (6.5-8.5).

Salinity hazard

The measurement of EC is directly related to the concentration of ionized substances in water and may also be related to the problems of excessive hardness and other mineral contamination. Excess salt induces artificial physiological drought condition by increasing the osmotic pressure of the soil water and produces conditions that withhold the roots from absorbing water. Even though the field appears to have plenty of moisture, the plants may wilt because the roots could not absorb enough water to replace water lost by transpiration.

The EC value of irrigation water of the study river ranges with a maximum 0.27 dS/m and minimum 0.07 dS/m, and with the mean value of 0.16 dS/m. Total dissolved salts in the river water ranges from 146 to 131 mg/l and the mean value is 139 mg/l. According to FAO (1985), UCCC (1974) and Wilcox (1955) the result of EC and TDS fall within the irrigation water quality classification of excellent category (Table 2). Furthermore, Hergert and Knudsen's (1997) thresholds for the classification of irrigation water shows into low, medium, high and very high salinity are < 0.75 dS/m, 0.75-1.5 dS/m, 1.5-3.00 dS/m and > 3.00 dS/m, respectively. Therefore, river water salinity level is excellent for agricultural purposes.

Table 2. University of California Committee of Consultants (UCCC) classification of water for irrigation use based on EC and TDS values (UCCC, 1974)

Parameters	***Excellent***	***Good***	***Permissible***	***Unsuitable***
EC (dS/m)	< 0.25	0.25-0.75	0.75-2.25	> 2.25
TDS(mg/l)	< 200	200-500	500-1500	>1500

Sodium hazard and Sodium Absorption Ratio (SAR)

Effects on soil permeability, infiltration, and aeration and tillage properties of soils are the main problems with high sodium concentration. Sodium toxicity is recorded as a result of high sodium in water as sodium percentage and SAR ratios. The sodium hazard of irrigation water is estimated by the sodium adsorption ratio - SAR. High SAR in any irrigation water implies hazard of sodium (Alkali) replacing Ca and Mg of the soil through cation exchange process, a situation eventually damaging to soil structure, namely permeability which ultimately affects the fertility status of the soil and reduce crop yield (Gupta, 2005). The SAR value obtained in the study area ranges from 0.43 meq/l to 0.37 meq/l with an average value of 0.40 meq/l (Table 1). According to the standard depicted by Ayers and Westcot

(1985); Eaton, 1950; Wilcox, 1950; Todd, 1980) and Richards (1954), the result obtained falls under the category C1S1 (Tables 3 and 4). That means the result indicating low alkali hazards and excellent irrigation water. The findings are also agreed with Sadashivaiah et al. (2008), who classified the water samples based on SAR as low (<10), medium (10-18), high (18-26) and very high (> 26). Thus the river water is suitable for agricultural purposes.

Table 3. Classification of water for irrigation use based on SAR and EC value (Richard, 1954)

Water class	**SAR**	**Index**	**EC(µS/cm)**	**Index**	**Category**
Excellent	≤10	S1	100–250	C1	C1S1
Good	10–18	S2	250–750	C2	C2S2
Fair	18–26	S3	750–2250	C3	C3S3
Poor	≥26	S4	≥2250	C4	C4S4

Soluble Sodium Percent (SSP)

Soluble Sodium percent is another important factor to study sodium hazard. It is calculated as the percentage of sodium and potassium against all cationic concentration. High percentage of sodium on irrigation water may stunt the plant growth, deflocculating and reduces the soil permeability (Joshi et al., 2009; Singh et al., 2008). It is also used for considering the quality of water for use of agricultural purposes. The analyzed water samples value ranged between 18.02% and 19.16% with an average value of 18.71% in the present study. According to the standards pointed out by Ayers and Westcot (1985); Eaton, (1950); Wilcox, (1950); Todd, (1980) and Richards (1954), Wilcox (1955), irrigation water is grouped under excellent category. Hence, based on the values of SSP, Gungua Badiya river water is usable for agricultural purposes.

Table 4. Limits of some parameter indices for rating water quality and its sustainability in irrigation (Ayers and Westcot, 1985;Eaton, 1950;Wilox,1950;Todd, 1980)

Category	***EC(µS/cm)***	***RSC(meq/l)***	***SAR***	***SSP (%)***	***Sustainability for Irrigation***
I	<117.509	<1.25	<10	<20	Excellent
II	117.509-508.61	1.25-2.5	10-18	20-40	Good
III	>508.61	>2.5	16-26	40-80	Fair
IV	_	_	>26	>80	Poor

Residual Sodium Carbonate

Residual sodium carbonate (RSC) indicates the amount of sodium carbonate and sodium bicarbonate in water. It is changing the quality of water through the precipitation of alkali earth elements (Ca^{2+}, Mg^{2+}) thereby increase the percentage of sodium (Eaton 1950). The irrigation water quality is influenced by the presence of high amount of RSC. The value of RSC of the river water samples ranges from 0.55 to 0.93 meq/l and mean value of 0.75 meq/l. According to the standard pointed out by Ayers and Westcot (1985); Eaton, (1950); Wilcox, (1950); Todd, (1980) and Richards (1954), Wilcox (1955), the suitability of RSC value less than 1.25 meq/l. Thus, river water is safe for agricultural purposes.

Magnesium content

Magnesium content in water is considered as one of the most important qualitative criteria in determining the water quality for agriculture. Generally, calcium and magnesium maintain a state of equilibrium in most waters. More magnesium in water will adversely affect crop yield, as the soil become more alkaline. In the present study, the magnesium content of river water samples values ranges 0.44 meq/l to 0.51 meq/l with an average value of 0.37 meq/l (Table 1). Therefore, according to the standard of FAO (1985), 0-5 meq/l this river water in terms of magnesium content is suitable for agricultural purposes.

Chloride Hazard

Chloride is essential to plant in very low amount and should be considered in irrigation water. Although chloride is essential to plant in very low amount, if it is present in excess amount can cause toxicity to sensitive crops. High amount of chloride contamination in leaves results leaf burn or drying of leaf tissue. Chloride in surface water may be from soil, and domestic and municipal effluents (Sarath Prasanth et al. 2012; Krishna Kumar et al. 2014). In the study area chloride found in the river water varies between 0.14 meq/l (4.97 mg/l) and 0.25 meq/l (8.875 mg/l). WHO (2011) and UCCC (1974) suggests the desirable limit and permissible limit for chloride are 250 and 1000 mg/l, respectively. It is evident that the values of Cl of the study area fall within desirable limit (less than 250 mg/l). Therefore, river water categorized as excellent for agricultural purposes.

Conclusions

The study was carried out to evaluate the physicochemical properties of Gungua Badiya river water to explore the suitability for agricultural purposes. The major ion concentration (pH, EC, TDS, SAR, SSP, Mg^{2+}, Cl^{1-} and RSC) suggest that the river water samples belong to the suitable category for agricultural purposes. The samples meet the standards of UCCC, WHO, FAO, Ayers and Westcot, Eaton, Wilcox, Todd, Richards and Wilcox. The statistical data, also show that the association of ions and they are very less influenced by the anthropogenic activities. The results show that proper management of the river water and periodic monitoring of quality parameters are required for the sustainable usage of the river water for agricultural purposes. Hence, further work is needed to investigate the detail water quality status of the river through taking more intensive sampling for a longer period and studies to measure any change of physicochemical properties of the river water in the soil and crop.

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