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(Research Article)

Soil Salinity Assessment and Irrigation Water Quality of Humbo woreda, Wolaita Zone, South Ethiopia

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Abstract

Soil salinity affects the majority of Ethiopia's irrigated farmland and chemical properties of irrigation water quality has major role in assessing the irrigation land salinity. The study had objective of determining the soil salinity and irrigation water quality. The study was conducted south peoples regional state wolaita zone Humbo a woreda. The study used standard analytical techniques and methods to analysis different physiochemical parameter of both irrigation water and soil of irrigated areas. The mean analysis result of irrigated soil parameter like pH, ECe, TDS, Ca, OC, TN, CEC Na, and SAR 7.9 to 9.5 for pH, 5.97 to 8.96 dS/m for ECe, 180 to 794 ppm for TDS, 1.3 to 1.6g/cm^3 for BD, 1.2 to 1.75 % for OC, 0.083 to 0.14% for TN, 4.2 to 6.54 meq/100g for Na and 2.13 to 2.96 for SAR respectively. The mean analysis results of irrigation water used at study site physiochemical parameter for pH, EC_e, TDS, Ca^{+2}, Mg^{+2}, Na^{+}, K^{+}, SAR, $HCO3^{-2}$, $CO3^{-}$, $SO4^{-2}$ and Cl^{-} were 7.77±0.12, 2.51±0.22dS/m, 1241.5±56.95 mg/l, (5.15±0.52, 3.06±0.56, 2.28±0.36 , 0.15±0.02) meq/100g, 1.13±0.2, 5.4±0.34, (0.56±0.06, 0.05±0.01 and 2.79±0.61) ppm respectively. From Analysis result of soil physiochemical parameter indicate the irrigated soil of study was moderate to strongly saline and from water analysis also shows the irrigated water also moderately saline. The study conclude that the irrigated land was moderate saline due to irrigation water salinity and better to treat irrigation water before irrigating land. Study recommends that irrigation water better to treat and plant salinity tolerates grass to treat soil salinity.

Keywords: Water Quality; Irrigation Land; Chemical Analysis; Salinity; South Ethiopia

1. Introduction

Water quality issues are frequently overlooked because there are numerous high-quality water sources (Islam et al., 2004). A hydro chemical analysis determines the quality of water acceptable for consumption, agriculture, and industry. According to Sadaash.et al(2008) assessing water quality analyses of chemical parameter was suitable and play great significant role. Soil salinity affects the majority of Ethiopia's irrigated farmland. According to Massoud (1997), saline soils cover approximately 11,608,000 hectares in Ethiopia, while sodic soils cover around 425,000 hectares, both of which are located in dry and semi-arid climates, where the majority of irrigable lands are found.

Water used for irrigation needs to contain the right amount of salt and be free of chemical and biological contaminants. According to Singh.et al. (2010) and Ackah.et al. (2011), irrigation water with high salt content inhibits plant growth and alters the soil's structure, aeration, permeability, and texture. The concentration of minerals in the soil during evaporation due to the research area's aridity may increase the influence of irrigation water on the soil (Al-Rashid and Suleiman, 2015). Irrigation water must be free from chemical and biological pollutants and must had appropriate salt concentration. The concentration of salt in irrigation water can reduce plant growth and affect the structure, aeration, permeability and texture of soil (Singh et al., 2010; Ackah.et al., 2011).

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The aridity of study area could raise irrigation water impacts on soil through the concentration of mineral in during evaporation (Al-Rashdi and Sulaiman.et al., 2015). Poor water quality and excessive salts in irrigation have a variety of effects on plants, but the most frequent issues are brought on by salts that alter the osmotic interaction between roots and soil moisture (Malash.et al., 2005). In most irrigation situation, the primary concern for water quality is salinity level since salts can affect both the soil structure and crop yield(Longenecker & Lawyerly, 1994) .Osmotic pressure increased y effect of salt water in soil solution and accordingly restrict 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 that redistribute accumulated salts, often the result of anthropogenic activities (Besler.et al., 1982). For instance, soil saturated with high sodium, especially heavy-textured and high-swelling clay soils, causes increased hydration, swelling, dispersion, and potentization of the soil colloids, structural destruction, and aggregate failure.

High salinity content water is toxic to plants and poses a salinity hazard. Soils with high level of salinity total salinity are called saline soils. High concentration of salts in the soil can results in physiological drought conditions and plants wilt because the roots are unable to absorb the water. The water salinity was measure by TDS, EC and sodium hazard. Concentration of sodium in irrigation water were high, it's special concern due to sodium effect on the soil and poses a sodium hazards. SAR of irrigation water had significant effect on the water transmission properties of soil (El-Morsy.et al., 1991). Sodium hazards are usually expressed in terms of SAR (sodium adsorption ratio) and calculated as from the ratio of sodium to calcium and magnesium using the following equation (Suarez et al., 2006):

$$SAR = \frac{\mathrm{Na}^{+}}{\sqrt{\frac{1}{2}(\mathrm{Ca}^{+} + \mathrm{Mg}^{++})}}$$

Where Na+, Ca2+, and Mg2+ are the concentrations expressed in meq/L. The latter two ions are important since they tend to counteract the effect of sodium. Salinity hazards affect plants and can lead to saline soil conditions, while sodium hazards affect soil and can lead to sodic soil conditions. The second phase is due to the accumulation of salts in the shoot at toxic levels and is very slow.

The standard criteria developed by USSL (United States Salinity Laboratory, 1954) still has worldwide acceptance for irrigation water quality evaluation (Kirda C., 1997). However, the most internationally acceptable standard guidelines for irrigation water quality evaluation are given by FAO (Ayers R.S., 1985). The main aim of this is to find the information of irrigation water quality and examine the salinity level of irrigated water and soil.

1.1. Statement of the Problem

Salinity is major problem affecting crop production all over the world: 20% of cultivated land in the world and 33% of irrigated land are affected by salt and degraded. About 20% (45 million hectare) of irrigated land which produce one third of world food is affected by salt (Saudi and Biol, 2015). Salinity affects photosynthesis by decreasing the CO2 availability as results of duiffusion limitation (Flexa s, 2007) and reduction of the contents of photosynthetic pigments (Delfin, Alvino, 1999; Ashraf, Hrris, 2013). A significant amount of literature has dealt with the problems of salinity and its management. But, there were no studies conducted concerning the salinity level of soil at irrigated water, and how it can be managed in the Wolaita zone in the sampling area. The gap in the study is the unavailability of a study concerning the salinity of irrigated soil and water quality, and the aridity of the study area. So, the study was conducted to identify the problem and initiate further studies closely related to problems in the area. The current study was focus on measuring the soil salinity, determining SAR, TDS, and irrigated water quality.

In soils with high concentrations of sodium, calcium and magnesium adsorbed on the soil exchange complex was replaced by sodium, which has low flocculating power (Table 1), causing dispersion of soil particles. The damage to soil structure is accompanied by an increase in compactness, a decrease in filterability, hydraulic conductivity, and oxygen availability in the root zone. Another effect of a high concentration of sodium is increased PH (alkalization), which is produced by the presence of HCO3. There is a linear relationship between the exchangeable sodium percentage (ESP) and the pH of the soil (Khajanchi, 2008).

1.2. Soil salinity management

The key to producing vegetable crop is control salinity in the root zone to value equal to or smaller than EC of crop. In order to control salinity level, managements must be included soil reclimination of the saline and sodic soil, and practice of fertilization and irrigation should aim to prevents soil salinization and mitigate the effect of salinity.

1.3. Soil reclamation

Soil sodality and salinity are problem too difficult to overcome, require salt remove from the root zone (reclamation). Reclamation is the most effective and long-lasting way to minimize or even eliminate the detrimental effects of salinity (Munns, Husain, and Ravalli, 2002).Irrigation waters could contain high nutrient levels (e.g., nitrate N, calcium, magnesium, sulfur, and boron) sufficient to partially or completely satisfy crop needs (Machado, 2008).Ca2+, Mg2+ and SO4-2concentrations in irrigation water may easily exceed apparent uptake concentrations (Sonneveld.et al., 2009). In arid regions, soils are commonly alkaline, with high concentrations of free calcium carbonate (CaCO3). In this case, sulfuric acid can be applied by fertigation, with a consequent release and leaching of the Na+ existing in the soil profile (Silvertooth.et al., 2005).

1.4. Leaching

The leaching is absolute necessary to achieve long term success in irrigation (Hoffman, 1990). The volume of water applied with irrigation was must include an amount that drain down the root zone, which is in addition to the amount of required for normal irrigation and this additional water is defined as Leaching fraction (LF) (Hoffman, 2011). The management of water for irrigation is often based on the application of excess water maintains a root zone salinity that avoid salinity induced yield reduction. The amount of additional water required to maintain a target salinity level the leaching requirement LR, is a function of crop salinity and irrigation water salinity (Ayers and Westcott, 1985).

1.5. Fertilization

Crop fertilization is one of the sources of soil salinization. To reduce this negative impact, the fertilizer characteristic's, the methods of fertilization application, irrigation water quality, fertilization scheduling, etc. must be considered. Excessive nutrient application must be avoided, and high purity, chloride free, low saline fertilizers should be selected. In irrigated vegetable crops; the crop's nutritional requirements must be met by the soil, fertilization, and nutrient content of the irrigation water. Irrigation waters could contain high nutrient levels (e.g., nitrate-N, calcium, magnesium, sulfur, and boron) sufficient to partially or completely satisfy crop needs (Grattan, 2002; Machado, Oliver, 2008). Many agricultural regions in the world have high amounts of N in the groundwater due to NO3- leaching from fertilizers (Olivares, 2008), and concentrations in irrigation water may easily exceed apparent uptake concentrations (Sonneveld, Voogt, 2009).

1.6. Irrigation

The way of management, irrigation method and artificial drainage can prevent and mitigate the effect of soil and water salinity by influencing water use efficiency and nutrient use efficiency NUE, salinity accumulation and distributions and salt leaching. Folia damaged by salt in irrigation water is a concern, method of irrigation such as surface drip irrigation, d drip irrigation, furrow irrigation and low energy precision application i. must be used Both drip and surface drip irrigation, was better when compared to others salinity management by increasing water use efficiency and nutrient use efficiency (Machado, 2008).

1.7. Cultivating salt tolerant plant

The capacity of any crop to tolerate salinity is ability to endure the effect of excess salt in root zone. Tolerance of salt for crop was described by model that related the decrease oin relative production with the increase in soil salinity (Maas, Hoffman, 1977; Genuchten, 1984). Also salt tolerance was complex quantitative genetic character controlled by many genes (Shannon and Noble, 1990; Shannon, 1996). Interims of its measurement: salt tolerance is described as a complex function of yield claims across a range of salt concentrations (Maas and Hoffman, 1977; van Genuchten and Hoffman, 1984).

2. Methodology

2.1. Description of study area.

The study was conducted at Wolaita zone Humbo woreda Abala Faracho town in South Ethiopia.The town located about 349km from capital city of Ethiopia which adis Ababa at south parts and 30km away from sodo town which administrative center of south Ethiopian people. The geo reference of Abala Faracho town was in altitude of 1378m above sea level and latitude and latitude of 6055` N and 37039`00``E respectively (Abala Farcho location elevation map.net). Abala Faracho receives an annual rainfall of 50 to 300 mm. The monthly mean maximum temperature of the area is 32 degrees Celsius, while its minimum temperature is 15.5 degrees Celsius. The soil type of the area is silt clay (Down loads hindawi.com). Humbo woerda is bordered on the south by Lake Abaya (''direction to Humbo a Woreda'', Wolaita Times.com.et.), located as west of of offa woerda, North of Humbo woreda and East of Hobicha woreda. Based on climate variability areas had four different season which was summer dry and winter, spring and autumn rain season and different crop such as miaze, tomato, headcabbage, common bean, teff, cassava and taro was adaptable and produced by farmers with irrigation and rainfall.

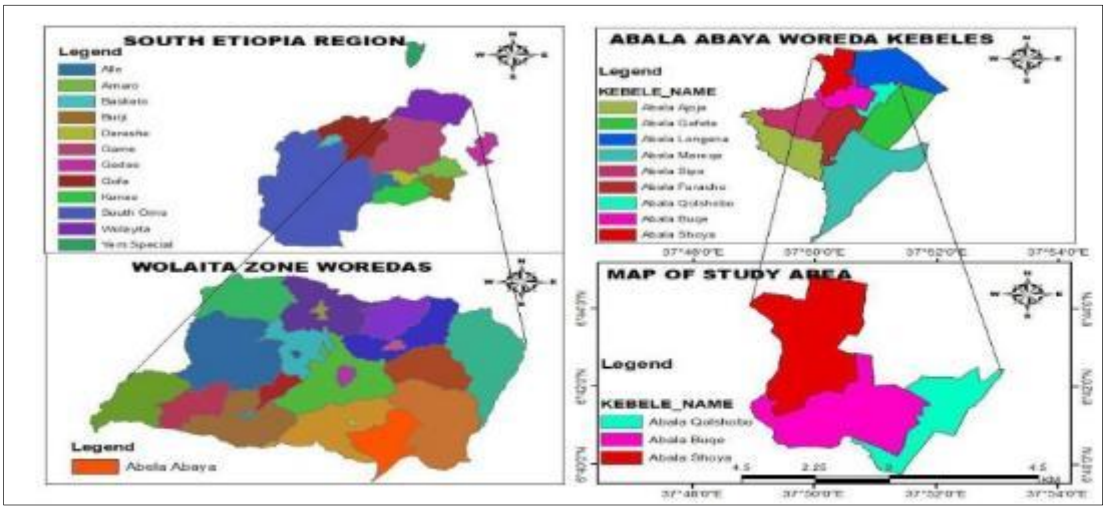

Figure 1 ArcGIS map of Humbo woreda wolaita zone south Ethiopia

2.2. Sample collection and size

The soil and water samples were collected for this study from Humbo woreda Abala Faracho irrigation schemes. The composite soil was collected from three different locations of study areas based on topography. The total twelve composite sample of soil were collected from experimental site with depth. The water sample also collected from irrigation river sources and different place at irrigation canal. Different 4 composite water samples were collected from irrigation scheme at different location on canal from source, upper, middle and lower catchments. The water sample collected were transferred to plastic bottle which cleaned with 1% HCl to prevent contamination

2.3. Soil Sample Preparation

The soil samples were collected from the surface of the Abala Faracho irrigation schemes and brought to laboratory of Areka agricultural research center at south Ethiopia. The water sample also collected from irrigation water source which is Abala Abay River. Then about 0.5kg of soil samples was taken from the surface and was dried air, ground by grinder or mortar and sieved to a size of 2 mm. These were stored in a polyethylene bottle and then it was sent to EC determination.

2.4. Soil Analysis

The soil pH and EC values was determined electrometrically using a digital pH meter and conductivity meter/probe (Ghosh.et al., 1983). Total dissolved solid was determined by weighing soil residual obtained by evaporation of measured volume of water sample to dryness (Chopra and Kanwar.et al, 1980). Level of sodium and potassium was estimated by instrument flame photometer using emission. And Potassium and sodium was determined by a flame emission spectrophotometer (Golterman.et al, 1971). Other exchangeable base such as Ca and Mg, trace elements such as Cu and Zn were determined by using FAAS with acetylene flame system using an external calibration curve from the digested sample (APHA, 1989, Demirel.et al., 2008). Carbonates and bicarbonates were determined by acidimetric titration (Chopra and Kanwar.et al, 1980). Chloride was determined by argent metric titration (APHA, 1989), while sulfates was analyzed turbid metrically (Wolf, 1982) and directly by AAS with a hydride generator (APHA, 1989).

2.5. Procedure for water sample collection

Water samples was collected from the three sites of Faracho irrigation water from which the canals are constructed for irrigation purpose, and the three water samples was taken from each site. Water samples were collected in one-liter plastic bottle from the surface of the canal water and along the canal. The sampling date was designated. Water sampling techniques were followed as outlined by Hunt and Wilson (1986) and APHA (1989). The collected water samples was 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).

2.6. Statistical analysis

The mean separations between sample categories were computed using the least significant difference (LSD) at a 95% confidence interval. The one-way ANOVA (analysis of variance) was used to determine whether the data were significance difference or not within and between sample.

3. Results and discussion

3.1. Determination of selected physicochemical characteristic of irrigated soil and irrigation water

The physiochemical properties of soil and water was analyzed by standard analytical techniques and procedure and read by standard analytical instruments for each parameter at Areka Agricultural research center soil, plant and water analysis laboratory.

3.2. Physical characteristics of Soil

The physical properties of soil at irrigated and non-irrigated land of study site were analyzed by standard analytical techniques. Those physical parameters are electric conductivity (EC), bulk density (BD), texture, total dissolved solute, TDS and Moisture. The soil electric conductivity was analyzed by conduct meter and the results of irrigated land ranged from 2.5dS/m to 3.6 dS/m; the non-irrigated soil ranges from 1.9dS/m to 2.4 dS/m. The electric conductivity of both irrigated and non-irrigated land shows the soil was saline because the EC of soil > 2dS/m saline and below 2dS/m are normal for most agricultural crop (ETHIOSIS, 2017). The soil bulk density of study site was analyzed by oven dry base and cylindrical shaped core sample (Hazelton and Murphy, 2007). The bulky density of soil at irrigated and non-irrigated areas was ranges from 1.4-1.56 g/cm3 and 1.3-1.45 g/cm3 respectively. The lower bulky density at non-irrigated land was due to lower sand percentage and high BD of irrigated land was due to high percentage of Sand and silt. The overall data of BD for both irrigated and non-irrigated soil of study site was high and implies the soil was compacted and well aerated areas (USDA, 2008). The total dissolved solute o salt was analyzed by macro-processor pH meter and implies total solute or anion and cation concentration that found at soil. The level of TDS at irrigated and non-irrigated areas at study site was ranges from 1200ppm to 1800ppm and 700-1050 ppm respectively. The average value of TDS at irrigated land was higher than non-irrigated land which implies the irrigated land had high cation and anion or soluble salt than non-irrigated land due to irrigation water effects. The particle size distribution is one of physical properties of soil and analyzed by hydrometric methods of analysis using NaPO3 as dispersing agents and read by hydrometer. The particle size distribution of soil indicates percentage of sand, silt and clay. The average sand, clay and silt concentration of irrigated land soil was 38, 34, 28 and non-irrigated and was 35, 36 and 29 % respectively. The soil irrigated land felled under sandy clay loam textural class according to agricultural textural triangle (FAO, 2000). The soil moisture content of both irrigated and non-irrigated soil was analyzed by oven dry bases at dry 105oC. The average result of moisture content of soil was 10-20% and 20-25% for irrigated and non-irrigated soil respectively. The low moisture content both irrigated and non-irrigated soil low due to low organic carbon and low

3.3. Chemical properties of soil

The chemical properties of irrigated soil at study areas were analyzed by standard analytical techniques and procedure. The pH or soil reaction was analyzed by soil to water suspension read in macro-processor pH meter 2000 model. The level pH implies that soil was moderately saline to strongly saline soil according to ETHIOSIS soil map (ATA, 2017). The concentration level of pH was ranges from 8.1 to 9.2 which found at saline soil ranges. The electrical conductivity soil was read by conduct meter and its concentration ranges from 2 dS/m to 7.1dS/m in concentration and the results shows that the soil was in saline to moderately saline soil. The soil organic carbon was analyzed by wackily and blackly methods and its concentration ranges from %1.54 to %2.17(Wackily and blackly, 1934). The results of organic carbon of irrigated soil of study areas were low to medium according to Tekalign rating and total nitrogen of irrigated soil at Humbo woreda was analyzed by keldjal digestion and distillation methods and the result of total nitrogen shows that the soil had low total nitrogen due to high salinity level of soil (Tekalign, 1991).The cation exchange capacity of irrigated soil at study areas was analyzed by 1N ammonium acetate leachate followed distillation and titration. The concentration of CEC ranges from 23meq/100g to 36 meq/100g which implies that the CEC of soil was felt at optimum to high ranges according to Beranu and Tekalign rating (Beranu, 1980, Tekalign,1991).

3.4. Physiochemical properties of irrigation water

The physicochemical properties of irrigation water source were taken from Humbo a Rivers and the result was stated as table 2 below. The irrigation water taken at three different location which main source, middle and lower catchment. The pH of irrigation water ranges from 7.6 to 7.89 which was slightly to moderately alkaline according to ETHIOSIS and Yara rating (2014, Yara, 2021) and the highest pH recorded at main source of irrigation water and lowest was at lower catchment of irrigation schemes which was 7.89 and 7.6. The electrical conductivity of irrigation water of Abala Faracho ranges from 2.18 to 2.68dS/m and its average electric conductivity was 7.77 dS/m which moderately alkaline according to classification US salinity laboratory manual (USSLS,1954). The TDS of irrigation water at Humbo irrigation water at irrigation scheme of Abala Faracho was analyzed by macro-processor pH meter and the result ranges from 1210 ppm to 1310 ppm which indicate the irrigation water source had different solute and solvent in water from natural or artificial. The TDS analysis implies there were a lot of dissolved solutes was existed on it those includes Ca+2, Mg+2, Na+, K+, HCO3-, CO3-2, SO4-2, Cl- and so on. The average TDS of irrigation water used in Abala Farcho areas was 1241.5 ppm which was high relative to y study and according to US salinity classification laboratory manual, the result was high and may necessary to treat irrigation water (USSLS] (1954).

The chemical properties of irrigation water source were analysis for different parameter such as Ca+2, Mg+2, Na+, K+, HCO3-, CO3-2, SO4-2, Cl- and SAR. The concentration level of exchangeable base and some anion of irrigation water were analyzed by standard analytical techniques and procedure. The level of Ca and Mg in Humbo Irrigation River were ranges from 7.8 to 10.8 mg/l for Ca and 3.4 to 4.7 mg/l for Mg respectively. The concentration level of soluble potassium and sodium was read in FAAS or flame photometer at 588nm and 766nm and the concentration ranges from 0.35 to 0.94 mg/l for potassium and 18.4 to 26.8 mg/l for Na respectively. The average concentration of soluble cations Ca+2, Mg+2, Na+ and K+ were 4.08±0.4, 8.93±0.2, 22.8 ±0.14 and 0.6±0.13 mg/l respectively for Abala Abaya River (table 6).

The Sodium absorption ration concentration ranges from 9.34 to 14.3 and average concentration was 12.03 ± 0.4, which implies the water has moderate to high SAR level and this due to high concentration sodium level. The soluble anion of Humbo irrigation water at Abala Faracho areas were HCO3-, CO3-2, Cl- and SO4-2 and analyzed by standard analytical procedure and instrument. The concentration of bicarbonate and carbonate level ranges from 5.21 to 5.89 HCO3-, 0.49 to 0.62 for carbonate. The average concentration of bicarbonate and carbonate in Abala Abaya Irrigation River were 5.4± 0.34 and 0.56 ± 0.06 respectively. Also, the concentration of sulfate and chloride ion in this study areas irrigation water were 0.043 to 0.06 and 2.04 to 3.5 and average concentration level for two soluble ions were 0.053±0.01 and 2.79±0.61 for both sulfate and chloride ion respectively.

When comparing the irrigation water quality of this study with former study at wolaita zone, the irrigation water has higher Na and Mg content than former studies but lower concentration in Calcium and potassium contents (A. Chinasho.et al., 2023). The alkaline reactions of these water sources are the reflections of the relatively higher concentrations of bicarbonates. Among the dissolved cations, Ca2+ followed by Mg2+ and among the anions Cl− followed by HCO3− were the highest both in the Abala Abay sources (Table 5). The Abala Abay River sources were found to be in the medium (C2) (341.7 μS/cm) and high (C3) (1452.9 μS/cm) salinity hazards, respectively, based on the classification of US Salinity Laboratory Staff [USSLS] (1954). Both irrigation water sources investigated were found to be safe with regards to RSC hazard for irrigating crops. Similarly, with regards to the sodocity hazard criteria of the US Salinity Laboratory Staff [USSLS] (1954) classification, the abala abay river sources were found to be high (S1) in their sodocity hazards for irrigation (Table 6). Due to greater than >3. Selected soil physical and exchangeable cation properties of the soils irrigated by abala abay river.

Table 1 The mean separation of physic-Chemical parameters of Irrigation Water in the Study Area

S/Code	pH	EC(dSm^{-1})	TDS (ppm)	Mg^{+2}	Ca^{+2}	Na^{+}	K^{+}	SAR	HCO_3^-	CO_3^{-2}	SO_4^{-2}	Cl^-
W1	7.89	2.68	1310	4.7	7.8	26.8	0.71	14.3	5.89	0.59	0.055	2.04
W2	7.78	2.54	1210	3.4	8.8	24.1	0.43	12.9	5.34	0.49	0.043	2.64
W3	7.81	2.61	1264	3.9	8.5	21.8	0.94	11.6	5.14	0.54	0.051	2.98
W4	7.6	2.18	1182	4.3	10.8	18.4	0.35	9.34	5.21	0.62	0.06	3.5
Mean	7.77±0.03	2.51±0.2	1241.5±28.9	4.08±0.4	8.98±0.2	22.8±0.14	0.6±0.13	1.13±0.2	5.4±0.2	0.56±0.06	0.053±0.01	2.79±0.26
CV	0.73	2.89	4.03	21.46	5.83	10.98	150.95	17.85	7.231	8.921	13.75	21.95
pV(<0.05)	0.075	0.034	0.3	0.73	0.12	0.18	0.42		0.63	0.42	0.58	0.67

W: water, CV: coefficient of variation, SAR: Sodium absorption ratio, TDS: total dissolved solute; Ca, Mg, Na and K in unit of mg/l

3.5. The soluble cation contents of Abala Abay Irrigation River water (calcium, magnesium, potassium, and sodium)

The highest contents of calcium ion Ca2+ (10.8 mg l − 1) and magnesium-Mg2+ (4.7 mg l − 1) were observed in the water of Abala Abaya irrigation scheme (Table 4). Former parameters showed above in table 4 were low spatiotemporal variability in the studied area.On the other hand irrigation water used in study site schemes were higher content of sodium (Na+) 26.8mgl-1 with low spatiotemporal variability. According to FAo 1985 rating na content in water was in the acceptable ranges for irrigation uses. And the cation level in suitable irrigation water was in order of Ca2+ > Mg2+ > K+ > Na+ (C.J. Smith.et al, 2014). However, in case of study site cation was in order of Ca2+ > Na+ > Mg2+ > K+. Moreover, Abala Abay irrigation water has highest sodium sorption ratio (SAR) of 1.32 during the rainy season. Despite the acceptable level of Na+ content in water, its SAR value indicate that it dominated the contents of Ca+2 and Na+ (Table 6) As results, the irrigation water of Abala Abaya irrigation schemes has a cation imbalance which also affects soil quality and water availability to crops (C.J. Smith.et al, 2014, A. Dejene,2018), which limits maize productivity.

3.6. Mean separation and ANOVA table of soil physiochemical parameters of irrigated land

The mean separation and ANOVA table below show that the selected chemical physical parameter was statistically significant or not across depth at 95% confident interval. The average mean value for pH of irrigated land at study areas was 8.93±0.21 and statistically non -significant at p<0.05with 11 degree of freedom. The physical parameter such as electric conductivity, total dissolved solute and particle size distribution sand, clay and silt percentage was statistically n0n significant at 95 % confidence interval and 11 degrees of freedom across depth. The chemical parameter such as organic matter, cation exchange capacity, total nitrogen, exchangeable base such as calcium, magnesium and sodium was statistically significant at 95 % confidence interval because of p<0.05. But chemical properties like organic carbon and potassium was not statistically significant across depth at 95 CI due to P>0.05.

Table 2 Mean separation table of soil physic-chemical parameter of study site

Sample depth (cm)	**pH**	**ECe dS/m**	**TDS (ppm)**	**BD g/cm3**	**% OC**	**% TN**	**% OM**	**CEC**
0-20	8.82	6.9	400.17	1.38	1.64	0.13	2.95	31.33
20-40	9.05	7.38	422	1.513	1.44	0.106	2.33	26.28
Mean	8.93±0.21	7.19±0.47	411±80.2	1.45±0.029	1.54±0.07	0.118±0.0075	2.64±0.17	28.8±0.95
CV	5.88	15.83	47.79	4.93	13.2	15.54	13.46	8.05
P value (95%CI)	0.46	0.564	0.85	0.0096	0.074	0.0497	0.0128	0.0037
S/ depth (cm)	Ca	Mg	Na	K	%sand	%clay	%silt	
0-20	16.38	4.69	5.98	2.73	37.83	34.2	28.17	
20-40	13.2	3.99	4.9	2.42	39.83	32	28.33	
Mean	14.8±0.5	4.3±0.2	5.44±0.2	2.57±0.2	38.83±0.9	33.08±1.1	28.25±1.5	
CV	8.88	8.29	8.19	15.53	6.08	8.16	12.53	
Pval(95%CI)	0.0019	0.003	0.0018	0.218	0.17	0.19	0.93	

CEC, Ca, Mg, Na and K measured in unit of meq/100g

3.6.1. Correlation of some selected physiochemical parameter f irrigated soil of study site

The Pearson correlation for some selected physiochemical parameter of soil sample was done to describe relation between each variable and which relation was significant. The pH has strong and positive correlation with ECe, TDS, Ca, and Na; moderate and positive relation with OC, TN, Mg, CEC and K. pH has strong and positive correlation with ECe, TDS, Ca, and Na and significant at 95% CI and 13 degree of freedom for p < 0.05 from table 4.1 9 with Pearson correlation coefficients (R^2 = 0.93, 0.91,0.84, p<0.05, df= 15) and moderate ones (R^2= 0.73, 0.65, 0.59,0.68, p<0.05, df = 15) significant correlation at 95% CI respectively. The ECe has strong and positive Pearson correlation with TDS, CEC, Ca, Na and silt with correlation coefficient of (R^2 = 0.95, 0.88, 0.8, 0.79; p<0.05, df = 13) But moderate and positive with other parameters. The bulk density has positive and strong correlation with sand percentage and Na with Pearson correlation coefficient (R^2 = 0.84 and 72, p<0.05, df = 13); moderate and negative correlation with OC, TN, CEC and Clay percentage with Pearson correlation coefficient of (R2 = -0.58, -0.55, -0.69, -0.61, p<0.05, df= 13). And organic carbon has strong and positive correlation with total nitrogen, CEC, Ca and clay percentage with Pearson correlation coefficient of and moderate and positive with others except sand percentage, BD and TDS of soil with negative and moderate respectively.

Table 3 Soil physiochemical parameter Pearson correlation

	pH	ECe	TDS	BD	OC	TN	CEC	Ca	Mg	Na	K	sand	clay
pH	1												
Ece	0.93	1											
TDS	0.73	0.95	1										
BD	0.65	0.49	0.92	1									
OC	0.74	0.52	0.57	-0.58	1								
TN	0.68	0.5	0.54	-0.55	0.88	1							
CEC	0.59	0.88	0.82	-0.69	0.9	0.81	1						
Ca	0.91	0.8	0.91	0.65	0.75	0.58	0.80	1					
Mg	0.77	0.72	0.72	0.59	0.69	0.51	0.72	0.92	1				
Na	0.84	0.79	0.92	0.72	0.59	0.48	0.68	0.90	0.61	1			
K	0.78	0.78	0.93	0.48	0.64	0.67	0.85	0.950	0.63	0.66	1		
SD	0.46	0.65	0.58	0.84	0.54	0.51	0.63	0.68	0.56	0.7	0.98	1	
CL	0.51	0.59	0.53	-0.61	0.95	0.85	0.90	0.81	0.6	0.70	1.00	-0.59	1
Silt	0.44	0.72	0.61	0.51	0.63	0.57	0.76	0.75	0.69	0.8	0.97	0.69	0.58

The graphical representation of cation exchange capacity and exchangeable base Ca, Mg, Na and potassium as well as TEB, SAR and ESP follow the same trend in graph below.

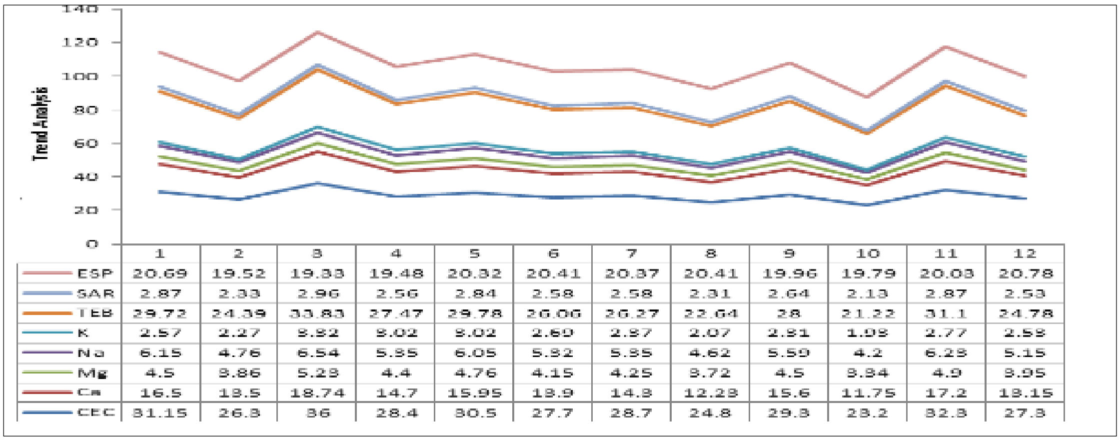

Figure 2 Graphical representation of CEC and exchangeable base with data table

3.7. Correlation of some selected physiochemical parameter f irrigated water of Abala Abaya rivers of study site

The Pearson correlation of irrigated water parameter indicates the relation between two parameter and shows variance and covariance of two variables. The positive relation or coefficient of two variable shows that one variable increases with second variable and cognitive character of two variable and negative correlation shows that two variable was inverse proportional with each other's one increases but second decreases.

The physiochemical parameter of irrigation water was correlated positively with each other and level of relation was different. The pH of irrigation water was correlated positively and strongly with EC, TDS, CA, Na, SAR, and chloride ion but moderate and positively with sulfate, magnesium and potassium. The correlation coefficient for strongly correlated parameters wore R^2 greater than 0.75 and for moderately correlated ranges of R^2 was between 0.5 to 0.75.

Electric conductivity (EC) has strong and positive correlation coefficient greater than R2>0.75 and the EC was also perfectly correlated with TDS and Ca in which R^2 is 1 and have moderate correlation with potassium, pH and anions such as $HCO3^-$, $Co3^{-2}$, $SO4^{-2}$ and Cl^- in the r2 script value between 0.5 and 0.75.

Table 4 Pearson correlation of some selected physic-chemical properties of irrigation water of Abala Abaya River

	pH	ECw	TDS	Ca^{+2}	Mg^{+2}	Na^+	K^+	SAR	$HCO3^-$	$CO3^{-2}$	$SO4^{-2}$
pH	1										
ECw	0.93	0.95									
TDS	0.89	1.00	1								
Ca	0.85	0.91	0.83	1							
Mg	0.79	0.99	0.75	0.89	1						
Na	0.91	0.73	0.79	0.78	0.71	1					
K	0.66	0.68	0.67	0.63	0.63	0.64	1				
SAR	0.79	0.80	0.99	0.78	0.77	0.95	0.64	1			
HCO3	0.83	0.70	0.59	0.89	0.79	0.59	0.64	0.69	1		
CO3	0.86	0.67	0.61	0.88	0.85	0.64	0.64	0.68	0.80	1	
SO4	0.72	0.69	0.69	0.90	0.89	0.68	0.64	0.71	0.77	0.66	1
Cl	0.88	0.81	0.72	0.86	0.99	0.95	0.66	0.94	0.7	0.8	0.68

4. Conclusion

The chemical and physical properties of soil and irrigation water were analyzed in this study at Abala Abay woreda using standard analytical techniques. The chemical and physical analysis of irrigation water and soil at study site shows the water and soil was slightly alkaline and moderately salt affected soil. The pH, EC, TDS, Ca and Na concentration of irrigation water at study site revealed that the water was slightly to moderately alkaline. The basic cations of irrigation water had order with Ca^{+2} >Na^+ > Mg^{+2} >K^+; indicate nutrient imbalance in soil and shows poor soil quality at study site cause low crop productivity.

Based on physical properties of soil, soil of site was fell on clay loam to clay textural class and slow infiltration rate and less compacted and suitable for crop grow due to better root penetration zone and better water holding capacity. Also based on chemical properties soil of study categorized on neutral to moderately alkaline, low organic carbon, phosphorus, total nitrogen and sulfur content. And site had low exchange base and low Ca+2: Mg+2 ratios which indicate imbalance of nutrient in soil that affect production of crop productivity in study areas. The concentration of micronutrient in soil was optimum at study site. So, study concludes that irrigation water used in Humbo wored at abala faracho schemes is moderately alkaline and have salinity problem. Therefore, irrigation water and soil of study site was saline which limiting the crop productivity, so better to amend soil by using organic source of fertilizer to overcomes nutrient imbalance and salinity as well as to improve crop productivity and fertility of soil.

Compliance with ethical standards

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No conflict of interest to be disclosed.

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