EFFECT OF MIXED RATIO OF AWASH WATER WITH THE WATER OF BESEKA LAKE ON YIELD OF TOMATO (*LYCPERSICON ESCULENTUM MILL*) IN THE CENTRAL RIFT VALLEY OF ETHIOPIA

By:

Mohammed Ebrahim Roble

A Thesis Submitted to the Department of Water Resources Engineering,
School of Civil Engineering and Architecture

Presented in Partial Fulfillment of the Requirement for the Degree of Masters in Water Resources Engineering (Specialization in Irrigation Engineering)

Office of Graduate Studies
Adam Science and Technology University

January, 2021
Adam Ethiopia

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Co-Advisor: Tilahun Hordofa (Ph.D.)

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We, the undersigned, members of the Board of Examiners of the final open defense by Mr. Mohammed Ebrahim Roble have read and evaluated his thesis entitled "**Effect of Mixed Ratio of Awash Water with The Water of Beseka Lake on Yield of Tomato (*LYCPERSICON ESCULENTUM MILL*) In The Central Rift Valley of Ethiopia**" prepared, presented and defeated by Mr. Mohammed Ebrahim Roble.

This is, therefore, to certify that the thesis has been accepted in partial fulfillment of the requirement of the Degree of Master's in Water Resources Engineering (Specialization in Irrigation Engineering)

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DECLARATION

I hereby declare that this MSc Thesis is my original work and has not been presented for a degree in any other university, and all sources of material used for this thesis/ dissertation have been duly acknowledged.

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This MSc Thesis has been submitted for examination with my approval as thesis advisor.

Name: Zelalem Biru (Ph.D.)

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Date of submission: ___________________

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To: Water Resources Engineering Department

Subject: Thesis/Dissertation Submission

This is to certify that the thesis entitled "Effect of Mixed Ratio of Awash Water with The Water of Beseka Lake on Yield of Tomato (*LYCPERSICON ESCULENTUM MILL*) In The Central Rift Valley of Ethiopia" submitted in partial fulfillment of the requirements for the degree of Master's in Irrigation Engineering, the Graduate program of the department of Water Resources Engineering, and has been carried out by Mohammed Ebrahim **[ID Nº: PGR/18131/11]** under our supervision. Therefore, we recommend that the student has fulfilled the requirements and hence hereby he can submit the thesis to the department.

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Co -Advisor	Signature	Date

ACKNOWLEDGEMENTS

The author deeply indebted and would like to express sincere gratitude to his advisor Dr. Zelalem Biru and Dr. Tilahun Hordofa for all the wealth of knowledge they passed on to him during his thesis research work. Their useful comments and corrections during the proposal development and thesis manuscript preparation and completion in the form of the present condition deserve much credit and gratitude.

The Adam Science and Technology University and the financial assistance from the Ministry of Education (MoE) which jointly made this study possible are highly appreciated.

The author appreciates the continuous encouragement and concern made by his mother Mrs. Zahara Roble and the family as a whole. His truly friends, Mr. Abdelaziz Chane, Mr. Alemayehu Getachew, Mr. Eyaasu and Mr. Abdi Mohammed did a lot through their profound support and friendly hospitality which otherwise life would have not been easy and enjoyable. The author is grateful to the staff of Melkassa Agricultural Research Center and Werer Agricultural Research Center, particularly Mr. Katama, Mr. Mesefine and Mrs.Mese Birehanu, with whom they shared scarce office resources in the course of the research work and Laboratory accessories. Last but not least, take me this opportunity to give words of thanks to all other individuals and organizations, numerous to mention for their contribution in this work in various ways.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDIX TABLES

LIST OF APPENDIX FIGURES

ABBREVIATIONS AND ACRONYMS

ABA	Awash Basin Authority
CEC	Cation Exchangeable Capacity
dS/m	Deci Siemens per meter
ESP	Exchangeable Sodium Percentage
EC	Electrical Conductivity
ETa	Actual Evapotranspiration
ETc	Crop Evapotranspiration
FC	Field Capacity
FAO	Food and Agricultural Organization
GIS	Geographic Information System
LSD	Least Significance Difference
masl	Meter above sea level
MARC	Melkessa Agricultural Research Center
MSE	Metehara Sugar Estate
MoA	Ministry of Agriculture
MoWR	Ministry of Water Resources
mg/L	Milli grams per liter
meq/L	Milli equivalents per liter
mmho/cm	Millimhos per centimeter
NBPP	Number of branches per plant
NFPP	Number of fruits per plant
PH	Plant Height
pH	Hydropower
ppm	Parts Per Million
PWP	Permanent Wilting Point
RAW	Readily Available Water
RCBD	Randomized Complete Block Design
RSC	Residual Sodium Carbonate
SAS	Statistical Analysis System
SAR	Sodium Adsorption Ratio
TDS	Total Dissolved Solid

USDA	United States Department of Agriculture
WARC	Werer Agricultural Research Centre
t/ha	Ton per hectare
µS/cm	Micro Siemens per centimeter
USDA	United States Department of Agriculture

ABSTRACT

Irrigation water is an essential element in agricultural practice for the availability of irrigation water, pasture, and fiber production, particularly in the semi-arid and arid regions. Quality of irrigation water has an adverse effect on soil and crop performance. This study was undertaken to evaluate and identify a suitable mixed ratios of Lake Beseka water with Awash River water on growth, yield, and quality of tomato. Five mixed irrigation levels of Lake Beseka and Awash River water (2:98, 3:97, 5:95, 8:92, and 10:90) and a control (0:100), respectively were used as a treatment. The treatments were arranged in a randomized complete block design with three replications. The water analyses for the Awash River water during the cropping season indicated an ECw with 0.30 dS/m, SAR with 7.06, pH with 7.64, and RSC with 0.24 meq/l which was within the safe limit for irrigation purpose. While Beseka water quality had an ECw with 5dS/m, pH with 9.50, SAR with 103.06, and RSC with 21.40 which was not safe for irrigation purposes. Each treatment was replicated three times and arranged in Randomized Complete Block Design. Plant height, number of branches per plant, number fruit per plant, and yield at harvest time were recorded. The different blended irrigation water had a highly significant ($p< 0.01$) effect on plant growth and yield of tomatoes. Control treatment gave the highest plant height, yield, and yield parameters and had no significant difference with the blended irrigation water up to 5% lake Beseka water. The lowest crop yield and yield parameters were obtained from the mix ratio of 10:90 and 8:92 Beseka to Awash River water, respectively. soil salinity increased with increasing the amount of saline water with irrigation water i.e., increasing Lake Beseka in mixed ratio. The max soil quality parameter was obtained from 10:90 and 8:92 Beseka water with Awash River water applied plot (ESP=14.5%,14.2% and pH=8.6,8.5). This might decrease nutrients availability with increasing soil solution which decreases the quality of crop yield, degrading soil structure sod-city effect. Hence, mixing Lake Beseka with Awash River up to 5:95% respectively is safe for growing tomatoes and on soil propriety in the central rift valley of Ethiopia.

Key Words: Awash River, Lake Beseka, Water quality, mix ratio, Tomato, Salinity

1. INTRODUCTION

1.1 Background

Water is a universal source, very important for all life. It is vital to the survival of ecosystems, animal, and plant that lives in them and in turn, ecosystem helps to regulate the quantity and quality of water (Rose *et al*., 2002). Water never exists alone, but it is a part of the ecological unit consisting of land, substrate structure, flora, and fauna. Streams and rivers are the major sources of water to satisfy human needs such as domestic uses, agriculture, transport, industries, power production, and recreation.

Over 97% of the world's water resources is in the oceans and sea and is too salty for most productive uses. Two thirds of the remainder are locked up in ice caps, glaciers, permafrost, swamps, and deep aquifers (Seckler *et al*., 1998). At global level, the withdrawal ratios are 70% agricultural, 11% municipal and 19% industrial (FAO, 2014). Based upon the various river basin master plans, net irrigation potentials of Ethiopia have been estimated as 2.6 million hectares and the gross irrigation potential is about 3.7 million hectares (Selehsi and Makonnen, 2011).

Ethiopia has 12 river basins that provide an estimated annual run-off of 122 billion m^3, with the Abbay basins (in central and northwest Ethiopia) accounting for 45 percent of this amount. Hence,it has 11 fresh and 9 saline lakes, 4 crater lakes and over 12 major swamps or wetlands. Majority of the lakes are found in the Rift Valley Basin. The total surface area of these natural and artificial lakes in Ethiopia is about 7,500 km^2 (Awulachew *et al*., 2007).

Awash River basin has a catchment area of 112,696 km^2 and originates from Central West part of Ethiopia, flowing 1200 km long, and provides a number of benefits to Ethiopia. Relatively, the most utilized river basin and the only river entirely in the country. The total mean annual flow from the river basins is estimated to be 4.9 billion cubic meters (Awulachew *et al*., 2007).

The increasing demand for water in the world, especially in the arid and semi-arid regions, has forced farmers to use low quality water for irrigation, such as agricultural drainage water (Abdel Gawad *et al*., 2002 and Ragab, 2002). Although saline water irrigation relieves shortages of water resources to various degrees, the improper use of saline water, such as the use of saline water with excessive salt content and the use of in sufficient amounts of saline waters for irrigation, may cause both the water and the salinity stress, lead to a secondary salinization of cultivated soils, and bring a series of serious consequences to the agricultural environment and the ecosystem (Kumar, 2015). Similarly, the Awash river faces a great environmental concern; mainly the saline water of Beseka lake expansion affects the surface, ground water dynamics, the soil properties of the region and the condition is specifically dangerous for the sustainability of Matahara Sugar Estate and Matahara town in particular, and the Awash river basin in general (Megersa *et al.,* 2009).

The expanding of Beseka Lake is in less than 3 km from the River Awash, which is the source of drinking water and irrigation for millions of people downstream. If the lake continues to expand at the current rate and other influencing factors remain the same, the lake will cross the natural water divide and join the River Awash. This would be disastrous, as the quality of the river water will be polluted and agricultural development of downstream such as Amibara irrigation scheme would be at risk (Eleni, 2009; Megersa *et. al*., 2009). Hence it was decided to discharge water of Beseka lake into Awash River and reduced its volume to certain level. The blending proportion is fixed to 2% of the Awash River flow rate, during peak flow, which was studied by the water resource authority as harmless (MOEW, 2014).

Tomato is one of the major vegetable crops cultivated by small-scale and large-scale commercial growers and state enterprise growers particularly in the central rift valley of Ethiopia. The production has been expanding to commercial level and used for home consumption, export and processing industries. The homestead production is also becoming important in urban and rural gardens as a source of nutrient and additional source for family income (Lemma, 2002). It is produced both during the rainy and dry seasons under irrigation (Lemma *et al*., 1994).

The important of tomato is increasingly rapid in Ethiopia. However, in arid and semi-arid regions of the country, availability of water is the most limiting factor for tomato production and hence it is important to consider the use of limited irrigation water with saline water through suitable mix ratio. This study identified the effect of mixed Awash irrigation water with Beseka lake water on soil physico-chemical properties and yield of tomato, and suitable mix ratio for control of the expansion of the lake horizontally of the water and land resources.

1.2 Statement of the Problem

The increasing demand for water in the world, especially in the arid and semi-arid regions, has forced farmers to use low quality water for irrigation, such as agricultural drainage water (Abdel Gawad *et al*., 2002). Salinity is one of the major abiotic factors affecting agricultural productivity worldwide (Meena *et al*.,2018).

Salinity is widespread environmental stress for crop plants in arid coastal regions of the world in more than 100 countries. The salinity reduced the crop yield by upsetting the water and nutritional balance of the plant. The use of saline irrigated water and application of fertilizer are the main factors for increasing soil salinity (Patel *et al*., 2010). Excess salinity in the soil water can decrease water availability to plant and can cause plant stress. A high level of soil salinity can significantly inhibit seed germination and seedling growth, due to the combined effects of high osmotic potential and specific ion toxicity (Munns, 2002). Salinity levels adversely affected the growth and yield parameters of tomato and many important crops (Silva *et al*., 2003). Tomato is considered a moderate to sensitive salt-tolerant crop with a threshold level of 2.5 (mhos/cm)2 (FAO, 1985).

In Awash Basin mixing of Lake Beseka's water with Awash River (relatively fresh water) was carried out not only to control of the rapid expansion of Lake Beseka before upsetting the surrounding environment rather than reduce the problem of water scarcity in the basin. Yet, in the basin, mixing Lake Beseka water with the Awash River has been taking place in the customary way, which is not based on scientific methods with the gauged and calibrated stations from 2007 up to now (Yimer and Jin., 2020).

If the Lake water continuously drains at its current rate, it would be difficult to control its water quality effects and environmental disasters and soil salinity downstream of the lake, human habitats, and the irrigation farms. Therefore, an in-depth study is required to understand the effect of mixed irrigation water quality for yield of tomato.

1.1. Objectives of the Study

1.1.1. General objective

The general objective of this research was to the effect of mixed irrigation water quality on soil physico-chemical property and yield of tomato (*Lycopersicon Esculentum Mill*) in the central rift valley of Ethiopia.

1.1.2. Specific objectives

The specific objectives of this study were:

- ✓ To determine the physico-chemical properties of soil, Beseka Lake, and Awash water quality before treatment and status of soil chemical properties end of the experiment
- ✓ To evaluate the effect of mix ratios of Beseka Lake water with Awash River water on growth, the yield of tomato
- ✓ To identify suitable mix ratios of the Lake Beseka water and Awash River water for irrigation.

1.2.Research Question

- ✓ What are the physico-chemical properties of soil, with mix of Beseka Lake, and Awash River quality before treatment?
- ✓ To what extent do the mix ratios affect the growth and yield of tomato production and soil physio-chemical properties?
- ✓ What is the appropriate mix ratio of Lake Beseka with Awash River water for tomato crop production?

1.3.Scope of the Study

This study was demarcated to assess of Beseka Lake and Awash River, mix ratios of Lake Beseka and Awash River water for yield of tomato and also focused on chemicals properties of soil after harvesting of tomato in study area.

1.4.Significance of the Study

Research is concerned with new scientific information on quality of the mixed water of Lake Beseka and Awash River. It was investigating its extent, contribution and impacts on tomato yields and soil physico-chemical properties of the study area. This study is intended to classify suitability of mixed irrigation water for growth, yield of tomato, characterize physico-chemical constituents of achieve the knowledge, information necessary for sustainable use of land and water resources. It is also beneficial for a better understanding of how to increase the yield of tomato under different irrigation mixed ratio of saline water with fresh water in case of limited water resources, increase water productivity and help to identify the suitable mixed ratio of irrigation level where saline water stress significantly reduce yield. On the other hand, it is not only helpful for the study area but also helpful to other places with similar agro-climatic and soil condition.

1.5.Limitation of the Research

The Research has the following limitations:

- One cropping season experiment which lack a strong scientific conclusion.
- Distance between Lake Beseka and experiment field was far and trip for fetching water was very laborious

2. LITERATURE REVIEW

2.1.Irrigation Water Quality

Water used for irrigation can vary greatly in quality depending upon type and quantity of dissolved salts. Salts are present in irrigation water in relatively small but significant amounts. They originate from dissolution or weathering of the rocks and soil, including dissolution of lime, gypsum and other slowly dissolved soil minerals. These salts are carried with the water to wherever it is used. In the case of irrigation, the salts are applied with the water and remain behind in the soil as water evaporates or is used by the crop (FAO, 1985)

Irrigation with saline water led to an increase in ESP and a degradation of the soil physical properties that were estimated indirectly by measuring aggregate stability in water (Anna and Dell, 2005). The effect of mixed water management alternate and mixed supply of fresh (0.55 dS/m) and saline (drainage water 4.2-4.8 dS/m) water on tomato yield and growth. Salt concentration in the root zone were investigated in the Nile Delta, Egypt which shows highest yield obtained (3.2 kg/plant) using a ratio of 60% fresh water with 40% saline water (Malash *et.al*., 2005).

Irrigation with high saline water affected cotton development and growth was reduced in comparison with that in the subplot irrigated only with fresh water and Direct effects of sodicity on cotton plant nutrition did not appear to play a significant effect in yield reduction, are attributed to other factors such as variable irrigation rates (Moreno et al., 2001). The TSS and acidity of tomato fruits increased with increase in the saline water ratios of irrigation water compared to 100 % fresh water treatment, the mixing of 75% fresh and 25% saline water reduced tomato yield by 11% (Nangare *et al*., 2013).

Effects of salt accumulation on the soil physical–chemicals properties decrease with decreasing salinity of irrigation water. The ECe increases with the increasing salinity of irrigation water especially in the surface soil (Choudhary *et al.,* 2001). The water-holding capacity (WHC) of soil also increases with the increasing salinity of irrigation water. The pH, EC, OM and N, P and K concentrations changed due to the blended and straight applications of fertilizers. Growth and yield of sugarcane were improved by all the fertilizer treatments (Hashmi *et al*., 2020). Increase in soil pH (8.9–9.1), salinity (4.7–5.1dS/m) and sodicity (ESP 25–41) as a consequence of irrigation with alkali water affected the growth and yields of all the crops (Choudhary *et al*., 2006).

2.2.Mixing Condition of Saline and Fresh Water

Mixing of saline water with fresh water used to solve water scarcity which an estimated 60% of the world's population is expected to face by the year 2025 is causing increasing reliance on various higher-salinity water sources as substitutes for freshwater irrigation (Kan and Rapaport-rom, 2012). Mixing of waters to an acceptable quality also results in improving the stream size and thus the uniformity in irrigation especially for the surface method practiced on sandy soils (Minhas, 2014). According to Elisa Kebede *et al.* (2016) and Leandro *et al.* (2015) the replacement of good quality water by the high salinity water, without negative impacts on crop yield was possible for irrigation purpose by mixing saline and fresh water to maximize water scarcity.

Competition for fresh water increases, water of better quality is primarily used for domestic purposes, whereas water of lower quality is often used for irrigation. Therefore, one challenge for the future will be to maintain or even increase crop production with less water that may often be of poor quality (Karlberg, 2007).

There are a number of factors to be considered when using fresh with saline water. These are plant tolerance, irrigation system, water management strategies, irrigation frequency and soil properties. Moreover, growth and yield were high only in fresh water, whereas moderate saline irrigation water in mixed practice gave the highest values of yield productions and growth of crops (Malash *et al*., 2005). Therefore, mixing agricultural irrigation and saline water with good quality water in ratios to keep the salinity of the irrigation water below the threshold of the target crop is an acceptable practice (Al-ain *et al*., 2017). In fact, mixing of the Lake water with Awash River without pertinent technology and regulated manner is a very complex action, however, MoWIE tried to discharge the lake water into Awash River using selected water quality parameters and mixing standards (Yimer and Jin., 2020).

2.3.Lake Beseka and Impact on Awash River Water

The Ethiopian Rift is characterized by a chain of lakes varying in size, hydrological and hydro geological settings. The rift lakes and Feeder Rivers are used for irrigation, soda extraction, commercial fish farming and recreation, and support a wide variety of endemic birds and wild animals. The level of Lake Beseka has expanded from an area of 2.5–40 km2 over the same span of time. Changes in Lake Levels are accompanied by dilution in ionic concentration of Lake Beseka. Although the principal hydro geochemical process in the rift lakes is controlled by the input and output conditions and carbonate precipitation, anthropogenic factors such as water diversion for irrigation and soda ash extraction played important role. The recent changes appear to have grave environmental consequences on the fragile rift ecosystem, which demands an integrated basin-wide water management practice (Alemayehu *et al*., 2006).

Water level fluctuation of Lake Beseka due to climatic variability, climatic change as well as land use change impact, total discharge from agricultural land, surface runoff from different area, soil erosion which affect the quality of irrigation water and the impact of sedimentation on the storage capacity of the lakes (Belete *et al.*, 2016). Lake Beseka presents a completely different hydro chemical picture; from an extremely saline water body, it has changed to a nearly fresh lake over the last 40 years. The electrical conductivity has gone down from 74,170 to 7440 mS/cm between 1961 and 1991 corresponding to a change in size from 5 to 40 km2 (Alemayehu e*t al.*, 2006).

Due to poor quality of Lake Beseka, the Awash River Basin is facing environmental problems of unprecedented magnitude due to degradation of the water quality of Awash River. This is due to of disposal of industrial effluents, municipal sewage, solid wastes, agricultural runoff, dumping of domestic wastes and natural agents like unregulated Lake Beseka's water discharge in to Awash River and it also deteriorated the water quality of the Awash River such as soil structure deformation, soil salinity, and sod-city effect (Kebede and Zewdu, 2019). The water quality degradation effect of Lake Beseka on Awash River was assessed using the last ten years water quality data from 2008 to 2017 (Yimer and Jin., 2020).

Lake Beseka water has excessively high salinity (EC $\sim$ 6.3 dS/m), alkalinity (RSC $\sim$ 80, pH $\sim$9.5) and sodicity (SAR $\sim$ 300). Lake Beseka are found to have relatively higher concentration of major ions dissolved constituents (Na$\cong$ 160 me/l). The excessively high Na content of Lake Beseka has a potential to destroy soil structure and aggregates ability to soil structure (Olumana and Loiskandl, 2015).

2.4.Effect of Using Saline and Non-Saline Water on Crop Production and Soil

Several crops are sensitive to salinity and the negative effect on growth leads to the decrease in potential profits. Irrigating saline water can also result in salt accumulation in soil, leading to the decrease in yield and deterioration in soil resource, in tomato production in leading to the decrease in yield parameters, number of fruits per plant, number of branches per plant, and numbers of seeds were affected significantly when compared with the control. In the cultivated tomato, moderate salinity decreased fruit yield by affecting the fruit weight more than the fruit number, while high salinity dramatically decreased both parameters (Bolarin *et al*., 2001). Tomato fruit is mainly composed of water, carbohydrates, and salts, in the manner that fruit growth is closely associated with the relative accumulation of water, inorganic ions and assimilates so that dry matter production, leaf osmotic potential and leaf ion accumulation were highly correlated (Alian *et al*., 2000).

Salinity generally creates the following conditions for plants: a) ionic stress; b) osmotic stress; and c) disrupted homeostasis. In addition, a combination of different morphological, physiological and biochemical effects may occur, negatively affecting nutrient acquisition, transpiration and the photosynthetic function of plants and resulting in stunted growth or potential plant loss. The tomato plat yield with blended water with TDS 750 ppm (20 kg per plant) followed by blended water with TDS 1600 ppm (18.8 kg/plant), then using raw saline water with TDS 4500 ppm (13 kg/plant), and the lowest value using desalinated water with 200 TDS ppm (12 kg/plant), the research results about the production are aligned with the production quantities documented by MOA. According to PCBS (2007-2010) their reports, the average productivity for the tomato seedling under same conditions in terms of the availability irrigation water and nutrients is 25-28 kg per seedlings.

Blended or mixed irrigation water had impact on soil properties, such as electrical conductivity (EC), exchangeable sodium percentage (ESP), as well as pH, increased due to blending effect of Beseka water to fresh water (Elisa Kebede *et al.,* 2016). Furthermore, the water quality of Lake Beseka is not suitable for irrigation due to extremely high values of pH (10) and other parameters dominating in salt lakes (Fito *et al*., 2019). Researchers and farmers have established that these effects can be largely mitigated by incorporation of gypsum or other amendments that liberate free Ca2+ in the upper portion of the soil profile (Grattan *et al*., 2012).

The salt content of soils which plant growth is affected depends upon several factors, among which are the texture of soil, the distribution of salt in the profile, the composition of the salt, and the species of plant. Several arbitrary limits for salinity have been suggested for distinguishing saline from non-saline soils. In the case of irrigation, the salts are applied with the water and remain behind in the soil as water evaporates or is used by the crop. They originate from dissolution or weathering of the rocks and soil, including dissolution of lime, gypsum and other slowly dissolved soil minerals. These salts are carried with the water to wherever it is used (Brown *et al*., 1990).

Yield reduction of some crops for various levels of soil salinity as measured by EC under normal growing conditions and gives potential yield reduction due to water salinity levels. The tolerance of crops to sodium is as measured by the exchangeable sodium percentage (ESP). Sodium Adsorption Ratio is also used to evaluate the suitability of water for irrigation. A high sodium ion in irrigation water affects the hydraulic conductivity (permeability) of soil and creates water infiltration problems. Due high value of SAR, the soil becomes hard and compact when dry and resultantly, reduces the infiltration rates of water and air into the soil affecting its structure If the chloride contamination in the leaves exceeds the tolerance of the crop, injury symptoms develop such as leaf burn or during leaf tissue. These symptoms occur when leaves accumulate from 0.3 to 1.0 percent chloride (FAO, 1985).

Sodium toxicity is not diagnosed quite easily as chloride toxicity. Typical toxicity symptoms are leaf burn, scorch and dead tissues along the outside edges of leaves in contrast to symptoms of chloride toxicity, which normally occur initially at the extreme leaf tip. For tree crops, sodium in the leaf tissue exceeding 0.25 – 0.50 percent is often associated with sodium toxicity. Boron is an essential element for plant growth. Boron is needed in relatively small amounts, however, and if present in amounts appreciably greater than needed, it becomes toxic (FAO, 1976).

2.5.Tests to Salinity Quantification

There are several tests to quantify or qualify soil salinity. It is important to understand the differences among these tests because each provides a specific type of information.

2.5.1. Electrical conductivity

Electrical conductivity describes the amount of electrical current conducted by extracting solution (water containing ions) from a saturated soil sample at a fixed temperature (Joe, 2002). The higher the moisture content, the easier it will be to obtain the extract. The greater the concentration of ions or soluble salts in the saturation extract, the more electricity the solution will conduct, the greater the EC reading, and the greater the toxicity to plants (Karimi, 2005). This test does not distinguish between one type of salt and another; it simply provides an overall measure of water-soluble salts.

The electrical conductivity of the saturation extract is often referred to by the abbreviation ECe. Units of measurement include Deci siemens per meter (dS/m). According to (Joe, 2002), soils can have different level of salinity based on the saturation paste of electrical conductivity. A soil with ECe of 0-2 dS/m can be referred as non-saline, 2-4 dS/m as very slightly saline, 4-8 dS/m as slightly saline, 8-16 dS/m as moderately saline and above 16 dS/m as strongly saline.

2.5.2. Exchangeable sodium percentage, ESP

Exchangeable sodium percentage provides a measure of the amount of exchangeable Na^+ relative to the total cation exchange capacity of the soil expressed as a percentage. As the ESP goes up, more exchangeable Na^+ is available, and the greater the potential to be toxic to plants. Its unit is percent (Chinnusamy, 2005).

Soil sodicity often leads to soil structural degradation, drainage, runoff, and erosion problems and indirectly, to poor plant growth and productivity (Denise, 2003). Sodic (high Na+) soils are characterized as unstable, exhibiting poor physical and chemical properties that impede water availability and water infiltration. Sodicity can cause soil dispersal because of the relatively large size, single electrical charge, and hydration status of the Na+ ion. Soils with high clay contents are especially susceptible to soil dispersion. The Na+ induced dispersion can cause loss of soil structure, plug soil pores, and create surface crusting, which subsequently reduces hydraulic conductivity and water infiltration, and increases water runoff (Murtaza, 2009). According to (Joe, 2002) , soil sodicity level can be classified on the bases of ESP as; soils with ESP <6 is referred as non-sodic, 6-10 as sodic, 10-15 as moderately sodic, 15-25 as strongly sodic and a soil with ESP >25 as very strongly sodic.

2.5.3. Sodium adsorption ratio, SAR

Sodium adsorption ratio (SAR) describes the ratio of the concentration of soluble sodium (Na^+) ion in the soil solution to the square root of the soluble calcium (Ca^{2+}) and magnesium (Mg^{2+}) ion concentration; that moderate the adverse effects of Na^+ (Gemechu, 2010).It is calculated from concentration of cations (meq/l) in the saturation extract. This measure is important, because Mg^{2+} and Ca^{2+} provide a buffering effect on the impacts of high Na+ that means where Na+ ions favor dispersion and Ca^{2+} and

Mg^{2+} favor flocculation of soils. However, the presence of high Mg^{2+} has the same problem with Na+ (Qadir, 2002). Excess exchangeable Mg^{2+} alone or in combination with excess exchangeable Na^+ may behave like Na^+ in soil degradation (Qadir, 2002). The greater the SAR, the more Na^+ relative to Ca^{2+} and Mg^{2+}, the greater the toxicity to plants and indicates a sodic soil. It is unit less. At equivalent solution concentrations, the amounts of Ca^{2+} and Mg^{2+} adsorbed are several times that of Na^+ (Conway, 2001). According to (Joe, 2002), a soil can have different sodicity level based on the sodium adsorption ratio. A soil with SAR less than 13 can be referred as non-sodic, 13-25 as slightly sodic, 25-45 as moderately sodic and a soil with SAR greater than 45 as strongly sodic. Additional, According to Kryzanowski *et al*. (1988), the sodium hazard can be classified based on SAR as; the Soil pH value >8.5 and ECe <4 dS/m, SAR>13 as referred as sodic soil it is poor soil physical condition; the soil pH<8.5, ECe>4 dS/m, SAR>13 as Sodic saline its normal soil physical condition; pH>7.8, ECe<4 dS/m, SAR<13 as High pH it is varies soil properties, and Ph<8.5, ECe>4 dS/m, SAR<13 as saline, its normal condition.

2.5.4. Soil reaction, pH

Another important soil measure even though it does not directly measure salinity. It is a measure of the hydrogen ion concentration in soil solution. This is an important indication of the chemical status of the soil. According to Kryzanowski *et al*., (1988), soil pH ranges can be classified on qualitative and quantitative descriptive as; soils pH values within 3.0-5.6 is referred as strongly acidic, 5.6-6.2 as Moderately acidic, 6.2–6.7 as Slightly acidic, 6.7-7.3 as Neutral,7.3-7.9 as Slightly alkaline,7.9-8.5 as Moderately alkaline, and a soil pH >8.5 as very strongly alkaline.

Since soluble salts affect soil pH and vice versa, it is often included in evaluations and discussions of soil saltiness. Under low pH conditions, some nutrients bind tightly to soil particles and as a result are unavailable to plants. In addition, chemical structures of some nutrients, particularly P, can change under low pH making them less available to crops. Low pH conditions also impact the growth and survival of soil microorganisms, some of which are instrumental in releasing nutrients bound in organic matter for crop use (AAF,2008). A main implication of changing the soil pH is plant nutrient availability (Mohammed Seid and Genenew, 2013).

2.5.5. Cation exchange capacity, CEC

Cation exchange capacity (CEC) is the capacity of a soil to adsorb and exchange cations. It is commonly expressed in cmolc/kg of soil (Dohrmann, 2006). Cation adsorption being a surface phenomenon is identified mainly with the fine silt, clay, and OM fractions of soils and it occurs as a consequence of the electrical charges at the surface of the soil particles. The Na+, Ca^{2+} and Mg^{2+} cations are always readily exchangeable. Other cations like K^+ and $NH4^+$, may be held at certain positions on the particles in some soils so that they are exchanged with great difficulty and, hence, are said to be fixed (Fabrice, 2003).The CEC of the soil is primarily influenced by soil texture and organic matter content. Among mineral component of soil, clay particle generally has the highest CEC.

2.6.Measuring Major Parameters of Irrigation Water Quality

The guidelines are practical and have been used successfully in general irrigated agriculture for evaluation of the common constituents in surface water, groundwater, drainage water, sewage effluent and wastewater (FAO, 1980). The chemical constituents of irrigation water can affect plant growth directly through toxicity or deficiency, or indirectly by altering plant availability of nutrients (Bartram *et al*., 1996). The suitability of water for irrigation is not dependent on soluble salts. Because, the low solubility salts precipitate in the soil and accumulate with each successive irrigation, the concentration of highly soluble salts increases the soil salinity (Doneen, 1964). Various measurements are used to characterize the salinity of irrigation water. The main parameters tested are:

2.6.1. Electrical conductivity, EC

Soluble salts are present in soils at all times; however, when the concentration of salts is high, the soil is considered saline and crop growth can be reduced. EC is a measure of the total soluble salt concentration in a soil (i.e., salinity). It is determined by measuring the ability of a small current to be transmitted through saturated soil between two electrodes of a conductivity meter that are fixed distance apart. The units commonly used to express EC are Deci siemens/meter (dS/m). Soils are classified on the basis of salinity according to Kryzanowski *et al*., (1988), the EC ranges specified (the soil depth 0-60cm) as; soil salinity rating <2dS/m is referred as non-saline,2-4 as Weakly saline,4-8 as Moderately saline,8-16 as strongly saline, and soil salinity > 16 dS/m as very strongly saline.

Additional, according to FAO (1985), it classified as excellent (0-0.25 ds/m), Good (0.250-0.750 dS/m), high, (0.750-2.250 dS/m) and unsuitable (very high) (> 2.250 dS/m).

Excess soil salinity causes poor and spotty crop stands, uneven and stunted growth and poor yields. Salinity restricts plant water uptake, interferes with nutrient availability and can impair germination and root growth because of caustic salt effects. Saline areas also tend to have poor soil structure and are subject to water logging, both of which are harmful to crop growth. However, tomato crop without yield reduction is the threshold value of soil salinity 2.5 dS/m (FAO,1985).

2.6.2. Total dissolved solid, TDS

Total dissolved solids (TDS), a measure of the bulk salinity often determined indirectly by measuring electrical conductivity of the water. In terms of 'Degree of restrictions on use' the TDS values <450, 450-2000 and >2000 mg/l represent the irrigation water as 'none'; 'slight to moderate' and 'severe', respectively (FAO, 1985; USSLS, 1954; Bauder *et al.*, 2014).

2.6.3. Sodium adsorption ratio, SAR

SAR is an important parameter for the determination of suitability of irrigation water because it is responsible for the sodium hazard. The waters were classified in relation to irrigation based in the ranges of SAR values. Water with SAR ranging from 0 to 3 meq/l is considered good and with greater than 9meq/l is considered unsuitable for irrigation purpose.

It is the estimation of the degree at which Sodium will be absorbed by the soil. It also influences infiltration rate of water. According to USSLS, (1954) and Zaman *et al*., (2018), a Sod-city classes of irrigation water can have different sodicity level based on the sodium adsorption ration. Irrigation water with SAR less than10 $(\text{mmols/l})^{0.5}$ low sodicity hazard, can be referred as class S1. Irrigation water sodicity (SAR) within 10-18 medium sodicity hazard, its represented S2. Irrigation water sodicity (SAR) within 18-26 high sodicity hazard, its represented S3 and greater than 26 as very high sodium hazard(S4). According to Horneck *et al*., (2007), irrigation water class value with SAR below 13 can be referred as non-saline and above 13 can be referred as saline sodic.

2.6.4. Residual sodium carbonate, RSC

Concentration levels of bicarbonate and carbonate affect the water suitability for irrigation. Water with high RSBC has a high pH. Soil irrigated with such water becomes infertile leading to deposition of sodium carbonate (Eaton, 1950). According to Eaton (1950), RSC value less than 1.25 $meql^{-1}$ are safe for irrigation. A value between 1.25 and 2.5$meql^{-1}$ are marginal quality and value more than 2.5meq^{-1} is unsuitable for irrigation.

2.6.5. Sodium exchangeable percentage, ESP

Exchangeable Sodium Percentage (ESP) Another index that characterizes soil sodicity. As noted above, excess sodium causes poor water movement and poor aeration. By definition, sodic soil has an ESP greater than 15 (US Salinity Lab Staff, 1954). Sodium reacts with soil to reduce its permeability. Sodium percent in water is a parameter computed to evaluate the suitability for irrigation. Usually little or only minor problems occur when ESP values are less than 15%. When ESP> 15%, reduced permeability will occur. Sodium percentage (ESP) determined by (USSL Staff, 1954; Horneck et al., 2007).

2.6.6. The pH

The pH of water is a measure of the acidity or basicity. The pH is the concentration of hydrogen ions (H+) and hydroxyl ions (OH-) in the water. It is used to determine the acidic, basic or neutral behaviors of water. The pH values range from 1 to 14, which means, if pH of water is less than 7 then it is called acidic water whereas, pH equal to 7 as neutral and more than 7 is called the basic nature water (USSL Staff, 1954). pH standard is (6–8.5) for irrigation purpose (FAO, 1985). The high pH value (>8.5) is often caused by high bicarbonate (HCO_3^-) and carbonate (CO_3^{2-}) concentrations, known as alkalinity (Bauder *et al*., 2014).

2.7.Salt Tolerant Plant

Salt Tolerant plant is commonly described by the decline in yield as related to increasing salinity or the salinity level at which yield starts to decline (Maas and Hoffman,1977; Ayers and Westcot,1985; Mass and Grattan,1999; Grieve *et al*.,2012). Relative salt tolerance is defined as yield under saline conditions divided by yield under non-saline conditions. Plant that has increased yield at specific salinity level may thus be either more salt tolerant, more vigorous and less salt tolerant. Determination of salt tolerance thus requires that plants be grown under a range of salinity condition. Tomato is one of the most important horticultural crops in the world. Tomato production is very concentrated in semiarid regions, where saline water is most severed. For more than 30% of the world tomato production comes from countries around the Mediterranean Sea and about 20% from California (FAO,1995).

2.8.Crop Water Requirement Relation to Salt Tolerant

Water is the most limiting natural resources for agricultural production in arid and semiarid regions. Therefore, by using more irrigation efficient methods, decreasing plant water consumption is best method to safe water. The total crop water requirement is the maximum amount of water that a crop can use productively when the soil water content is not limiting. Crops mainly need water for cooling purposes; most of the root's water uptake is released back to the atmosphere through transpiration, and only a negligible fraction is retained for crop growth. In field experiments, partitioning transpiration from soil water evaporation is difficult (Abebe *et al*., 2013).

The hydrological cycle describes the constant movement of water above, on and below the Earth's surface. The cycle operates across all scales, from the global to the smallest stream catchment and involves the movement of water along evapotranspiration, precipitation, surface runoff, subsurface flow, and groundwater path ways (Hagos *et al*.,2019). Evapotranspiration (ET) is usually the largest component of the hydrologic cycle, given that most precipitation that falls on land is returned to the atmosphere. Globally, about 60% of the annual precipitation falling over the land surface is consumed by ET. Quantification of ET is used for many purposes, including crop production, water resources management, and environmental assessment. Irrigation requirement (IR) can be computed when ET is known using the following formula (Irmak, 2009).

The evapotranspiration from a reference surface not short of water is called the reference crop evapotranspiration and is denoted by ETo. The only factors affecting ETo are climatic parameters. As a result, ETo is a climatic parameter and can be computed from weather data. Experimentally determined ratios of ETc / ETo, called crop coefficients (Kc) (FAO, 1998).

2.9.Irrigated Agronomy of Tomato Crop to Salt Tolerant

One method of conserving water would be to mine the plant-available soil water gradually during the irrigation season, in anticipation of recharge from precipitation during the off season. Yields were related linearly to irrigation and water use with a reduction in irrigation or water use reflected by a reduction in yield (Nelson *et al.,* 1993). Proper irrigation scheduling is simply applying the appropriate amount of water at the correct time. Scheduling considers such physical factors as the water holding capacity of the soil, crop water use rate, and plant characteristics (e.g., root depth and sensitivity to water stress). Two reasons are often given for irrigation scheduling it saves water and it protects the environment (USDA, 2004).

Plant response to irrigation is influenced by the physical condition, fertility and biological status of the soil. Soil condition, texture, structure, depth, organic matter, bulk density, salinity, sodicity, acidity, drainage, topography, fertility and chemical characteristics all affect the extent to which a plant root system penetrates into and uses available moisture and nutrients in the soil (FAO, 2002). Crop ET is generally computed using the reference crop ET (ETo or ETc) and a crop coefficient to relate actual crop water use to the reference crop. For many crops' irrigation should start when soil water content drops below 50 % of the total available soil moisture. The RAW is the amount of water that crops can extract from the root zone without experiencing any water stress (FAO, 1998; Jensen *et al*., 1990). Tomato is Modera sensitive crops to salinity, for high yield, soil water depletion is 40% (FAO, 1998).

2.10. Review of Related Study

The sustainability of water resources is a critical issue as water demand for agricultural, industrial, and domestic purposes is rising (Provenzano *et al.,* 2013). (FAO, 2013) Indicated that about 60% more food will be needed to feed the 9.5 billion people in 2050. To supply water for agriculture, it is vital to achieving food security for the rapidly increasing global population (Singh, 2012). The sustainability of water resources largely depends on the proper management and efficient utilization of agricultural water (Fasakhodi *et al.,* 2010).

Utilization of saline water for irrigation, as an alternative, is in some way challenging. If used appropriately, it can pose serious threats to agricultural sustainability and food security by creating salt buildup in the root zone (Tyagi, 2003). Conjunctive use of saline and freshwater for irrigation allows the utilization of poor-quality surface water and/or groundwater resources with freshwater (Crescimanno *et al.***,** 2002; Datta & Jong, 2002; Yadav *et al.*, 2004; Kaur *et al.*, 2007). Blending and cyclic use are two options adopted when coordinating the use of water with different qualities (Wichelns *et al*., 2002; Hamilton et al., 2007; Dudley et al., 2008; Kulkarni, 2011). In the blending or mixing mode, the non-saline water can be mixed with saline water to be applied to the field, while the two water sources can be used alternately in the cyclic mode (Aslam & Prathapar, 2006; Singh, 2014).

Hamady *et al.*, (2005) investigated the possibility of saline supplemental irrigation for rain fed wheat and barley during their sensitive stages of flowering and seed formation in a Mediterranean climate. In both cases, their results showed that crop yield increased under limited irrigation of brackish water. The limited amounts of added salts could be easily leached out even by modest off-season precipitations. Huang *et al.* (2012) studied the impact of saline water irrigation on soils in northwest China. Soil salinity increased with saline irrigation water (7.03 dS/m) and slightly increased with brackish irrigation water (2.66 dS/m). No significant increase in soil salinity was observed under the freshwater application. Li *et al.*, (2015) investigated the effects of saline irrigation water on soil salinity and plant growth in the Taklimakan Desert in the northwest of China. Saline water irrigation did not interfere with the normal growth of adaptive plants (*Tamari*, *Hemoxylin*, and *Collegium*), which may be attributed to the plant's adaptability to salinity stress through root morphology adjustment.

Talebnejad & Sepaskhah (2015) investigated the influence of irrigation water salinity on the growth and yield of quinoa (*Chenopodium quinoa Willed*) in lysimeters under greenhouse conditions. Results indicated that increased water salinity caused a significant decrease in seed yield and dry matter. Arslan *et al.*, (2015) reported the 50% yield reduction in chickpea, lentil, and faba bean occurred at salinity levels of 4.2, 4.4, and 5.2 dS/m, respectively. Faba bean was a more tolerant crop to irrigation water salinity as compared to lentil and chickpea.

Salinity reduces yield and affects the physiology and biochemistry of plants. Seed germination, water deficit, ion balance of the cellular ions (cause ion imbalance of the cellular ions resulting in ion toxicity), and osmotic stress is affected by salinity (Khan *et al*., 2002; Panda, 2008) and also the salinity reduces the ability of plants to utilize water and causes a reduction in growth rate, as well as changes in plant metabolic processes (Munns, 2002). Salinity causes a decrease of K^+ and Ca^{2+} content while an increased amount of NaCl and SO4 (Mansour *et al*., 2005). The NaCl caused in a reduction root length, fresh and dry weight of roots, number of leaves, and leaf area in pepper (Zhan *et al*., 2012). Excess of salt in many plants causes the decreasing amount of Ca^{2+}, K^+, and Mg^{2+} while increases the amount of Na^+ and Cl^- (M.H and S.K, 2008). Similarly, Erdal *et al*., (2000), reported that the salt stress increases Na^+, Ca^{2+}, Mn^{2+}, Cu^{2+}, and Fe^{2+} but it causes to decrease K^+ and P_3^-.

3. MATERIALS AND METHODS

3.1. Description of the Study Area

The study was conducted at Melkassa Agricultural Research Center experimental site during 2019/20 dry season. The center is located in the Central Rift Valley of Ethiopia, Oromia Regional State (8°24′36” N - 8°26′24” N latitude and 39°19′12” E - 39°21′48” E longitude at an altitude of 1,550 ma.s.l).

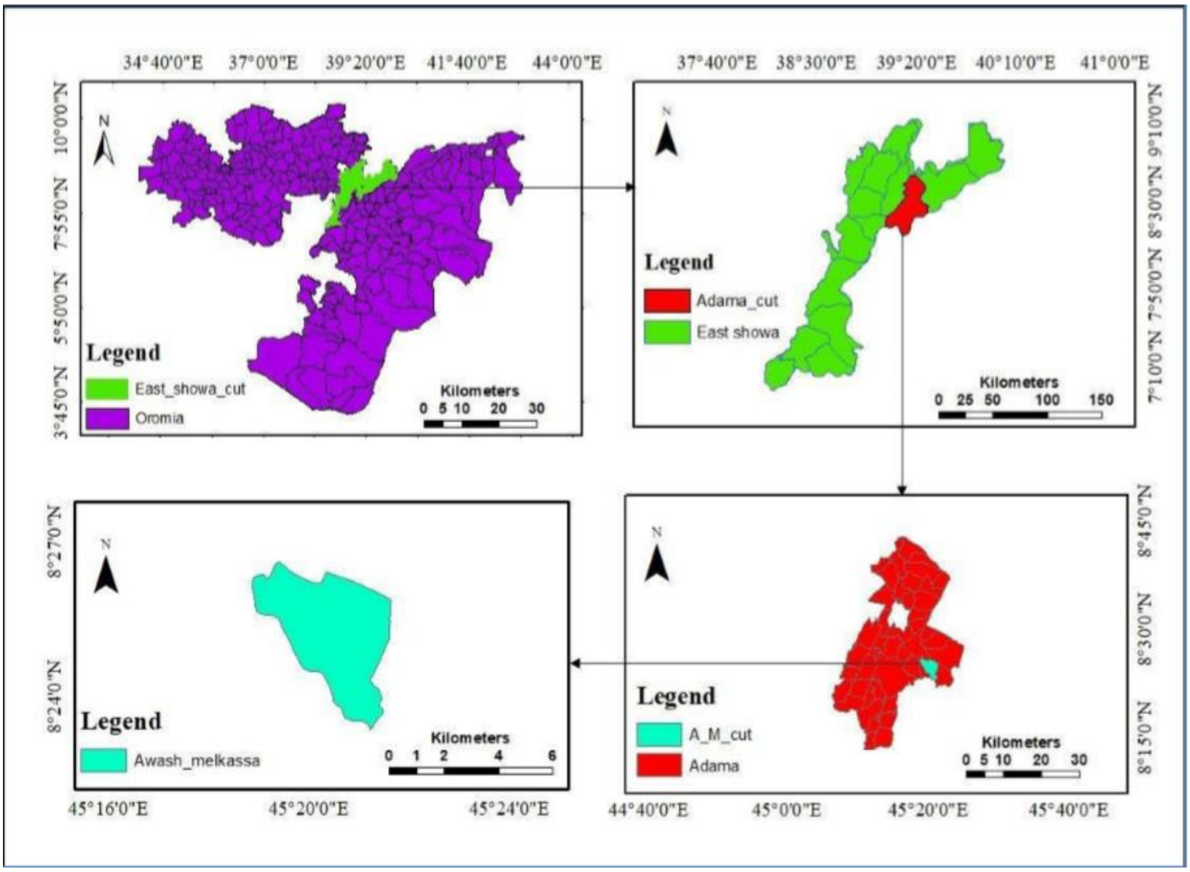

Figure 3. 1:Location map of the study area

The climate of the study area is characterized as semi-arid with uni-modal low and erratic rainfall. Kiremt season has more rainfall and contribute about 67.4% of the total rainfall of the year occurring during June to September with peak on the months of July and August. From long-term (1977–2017) climatic record of Melkassa agro-meteorological observatory station indicted the average annual rainfall in the area was 824.9 mm and the mean maximum and minimum monthly rainfall were 204.2 mm and 9.6 mm occurs in the month of August and November, respectively. The mean maximum temperature varies from 26.3 ^{0}C to 31.0 ^{0}C while the mean minimum temperature varies from 10.4 ^{0}C to 16.4 ^{0}C, with the average of 21.3 ^{0}C. The source of irrigation water in the study area is Awash River that serves 27% of the total irrigated agriculture of the country (Zemede Abebe, 2011). The textural class of the experimental site dominantly classified as loam to clay loam.

3.2.Experimental Material

The materials used on-site were summarized below the table 3.1.

Table 3. 1:-Material used on site

Water tank	Used to store water and mixing
Water track	Used to transported Beseka water
Water can	Used to supply water over the seedbed in the nursery site
Hoe	used in agricultural and horticultural, for soil shaped (piling soil around the base of plants)
Shovel	used for digging, lifting, and moving the bulk material from the entering of irrigation canal
Bottle (plastic vessel)	used for taken water sample from irrigation canal and lake beseka
Can	Used to kept sample soil
Sensitive balance	Used to measured sample soil
Auger	Used to trench and captured sample soil
Double ring	Used to measured infiltration

3.3.Soil Physical and Chemical Properties of Experimental Site

3.3.1. Soil physical characteristics

The representative composite soils were collected from experimental filed for soil physical and chemical analysis, from five depths of 0-20 cm, 20-40 cm, 40-60 cm, 60-80 cm and 80-100 cm by considering the effective root zone of tomato from five points along the diagonal of experimental plot for physical and chemical analysis before commencing the experiment. The soil samples were bagged, and properly labeled. Then, soil samples were air-dried, grounded, sieved with 2 mm sieve in laboratory characterization and analyzed. The soil analysis was carried out following the standard procedure for soil physical and chemical analysis.

The soil samples collected were analyzed for soil physical soil properties at Werer Research soil laboratory following standard test procedures. Soil texture (particle size distribution) and water holding capacity at field capacity and permanent wilting point are some of the physical properties analyzed.

Soil bulk density was determined from undisturbed soil sample taken using core sampler of known volume at desired soil depth. The soil was oven dried and weighed (Michael, 2008). Then bulk density was calculated as the ratio of dry weight of the soil to known cylindrical core sampler volume.

$$\mathrm{BD} = \mathrm{Ms}/\mathrm{Vt} \tag{3.1}$$

where BD is bulk density (g/cm^3), Ms. is dry weight of the soil (gm) and Vt is total volume of the soil (cm^3). The FC and PWP of the soil computed from in terms of volumetric soil water content as:

$$\mathrm{FC, PWP} = \frac{\mathrm{Ww-Wd}}{\mathrm{Wd}} * BD * 100 \tag{3.2}$$

where, FC and PWP is in %v, W_w is weight of wet soil, (gm), Wd is weight of dry soil, (gm). The FC and PWP were used to compute the total available water of the experimental field using Eq. 3.2.

$$\mathrm{TAW} = 100\sum(\theta\,\mathrm{FC} - \theta\mathrm{PWP})\mathrm{BD} * \mathrm{Zr} \tag{3.3}$$

where, TAW is total available water in the root zone, (mm/root depth), Zr depth of soil layer with in root zone (mm).

The soil textures were determined using the USDA textural triangle. Soil infiltration measurements were made for the identified fields/plots/ using double ring infiltrometer.

Infiltration characteristic of the soil was determined with double ring infiltrometer. The test was conducted by pouring water into the rings (inner and outer) at the same time to approximately up to the same depth. Data was record from the water level in the inner cylinder with point rod. A stop watch was used to record the time against corresponding depth of infiltration recorded by point rod. The measurements were continued at least for three hours and terminated when two consecutive reading show same infiltration depths as outlined by (Walker, 2003).

3.3.2. Soil chemical characteristics

The soil chemical analyzed included soil pH, electrical conductivity (EC), CEC, exchangeable bases (Ca, Mg, K and Na), soluble bases (Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}) and anions (Cl^{-}, HCO_3^{-}, CO32-). The analyses for soil chemical were undertaken using standard procedure in soil laboratory. Finally, ESP was determined as the percentage of the sum of exchangeable bases and exchangeable Na to the CEC of the soil as follows:

$$\mathrm{ESP} = \frac{\text{Sodium exchangeable(Na+)}}{\text{CEC}} * 10 \qquad (3.4)$$

where, ESP is exchangeable sodium percentage (%), Na^{+} is concentration of sodium in of soil (cmol/kg)

ESP value < 15% is non-saline soil; ESP > 15% is saline soil.

Basic cations (Ca, Mg, Na, and K) and anions (Cl^{-}, HCO_3^{-} and CO_3^{2-}) were measured on a 1:5 soil water ratio extract following the methods described by the US Salinity Laboratory Staff, (1954). Sodium adsorption ratios (SAR), of the soil solution were determined from the concentrations of soluble Na, Ca and Mg as following Formula:

$$\mathrm{SAR} = \frac{(\mathrm{Na+})}{\sqrt{(\mathrm{Ca+Mg/2})}} * 100 \qquad (3.5)$$

where, the concentrations of sodium, calcium, and magnesium ([Na^{+}], [Ca^{2+}], and [Mg^{2+}]) are in Exchangeable cation.

SAR value < 13 is non-saline; SAR >13 is saline soil.

The soils were classified to the different salinity soil classes based on the criteria established by the US Salinity Laboratory Staff (1954).

3.3.3. Water quality

Water samples collected from Beseka and Awash River were analyzed for pH, EC, dissolved cat ions (Ca, Mg, Na and K), alkalinity (HCO_3^{-} and CO_3^{2-}), and Cl^{-}, contents in the laboratory every time before irrigation application at Werer Agricultural Research Center. The following parameter were determined from the laboratory analysis:

3.3.3.1 Total dissolved Salt or solid, TDS

Both water sources had mixed based on Crop water requirements to measure current volume by electrical conductivity (dS/m) of water in laboratory. FAO (1985) had reported TDS are depend on water salinity (ECw), the water salinity less or greater than

5ds/m. Total dissolved solid (TDS), of water solution were determined from the concentration of water electrical conductivity (ECw ds/m) as the following condition and formula.

$$TDS\ (mg/L) = EC\ (dS/m) \times 640 \qquad (3.6)$$

where, K is 640 in most cases (EC: 0.5 -5 dS/m) or K = 800 (EC > 5 dS/m) and TDS is total dissolved solid (mg/L), EC_w is electrical conductivity of water

3.3.3.2 Sodium adsorption ratio (SAR)

Chemical parameter of irrigation water is measured the concentration of soluble Sodium, calcium (Ca) and magnesium (Mg) in water by titration method. According to Richard (1954) SAR was determined using Eq. (3.5).

3.3.3.3 Residual sodium carbonate (RSC)

Chemical parameter of irrigation water is measured the concentration of soluble of Ca^{2+}, Mg^{2+}, CO_3^{2-} and HCO_3^- in in me/l (USSL Staff, 1954; Horneck et al., 2007). According to Eaton (1950) residual sodium carbonate, RSC was determined using from the concentrations of HCO_3^-, CO_3^{2-}, Ca^{2+} and Mg^{2+} ions using Eq. (3.7).

$$RSC = (HCO_3^- + CO_3^{2-}) - (Ca^{2+} + Mg^{2+}) \qquad (3.7)$$

where, concentrations of cations and anions are in meq/L

RSC value < 1.25 is Safe; 1.25 – 2.50 is marginal and > 2.5 is unsuitable

3.3.3.4 Sodium percentage (SP %)

Water Exchangeable cations (Na^+, Ca^{2+}, $Mg^{2+,}$ K^+) are measured in the laboratory by titration method. SP% was determined using from the sum of exchangeable- cation (CEC) and exchangeable sodium ion as the follows:

$$SP = \frac{(Na+)}{CEC} * 100 \qquad (3.8)$$

Generally, the collection and handling of irrigation water samples were done in accordance with the procedure outlined by the US Salinity Laboratory Staff, (1954). Each of the water sampling points was also registered using GPS.

Table 3. 2:-Water sampling location

No	Water sample	Symbol	GPS		Elevation	Site
			Easting	Northing	(masl)	
1	Awash River water	Aw	39^0 52''20'	08051''52'	957	Melkassa
2	Lake Beseka water	LB	39^0 54''22'	08053''55'	946	Beseka

3.4.Experimental Treatments and Design

The treatments include five mixed irrigation water (2:98, 3:97, 5:95, 8:92 and 10:90% of Lake Beseka and Awash River, respectively by volume) and control (0% Lake Beseka and 100% Awash River) because the mix ratios fixed the maximium10% Beseka Lake water by financial scarcity. The experimental treatments were arranged in RCBD with three replications.

The Ministry of water and energy, MoWE used a minimum mix ratio of 2:98% Lake Beseka water to Awash River (MoWE, 2014). The mix ratios of Beseka Lake water and Awash River was fixed the gross depth and plot area.

Table 3. 3:-Mixing ratio of Awash River and Lake Beseka water used in the treatment

Treatment	Beseka Water (%)	Awash Water (%)	Designation
T1	0	100	B_0A_{100}
T2	2	98	B_2A_{98}
T3	3	97	B_3A_{97}
T4	5	95	B_5A_{95}
T5	8	92	B_8A_{92}
T6	10	90	$B_{10}A_{90}$

The experimental field contained 18 plots in an area of (40.5 m x 18.95 m) 767.475 m^2. The experimental plot size was about 18.25 m^2 with 5.0 m x 3.65 m. The recommended plant and row spacing for tomato was 30 cm by 75 cm, respectively.

The distance between adjacent plots was 1.5m whereas the distance between replication was 2 m to eliminate influence of lateral sub-surface water movement.

The experimental plots were having 3.65 m by 5 m (18 m^2) with six plots in each replication. Each plot was having five furrows with 60 cm between ridges and middle three furrows were considered for data collection. The spacing between plants and between rows will be 30 cm and 75 cm, respectively. The treatment description and layout are shown in Table 3.3 and Fig. 3.2.

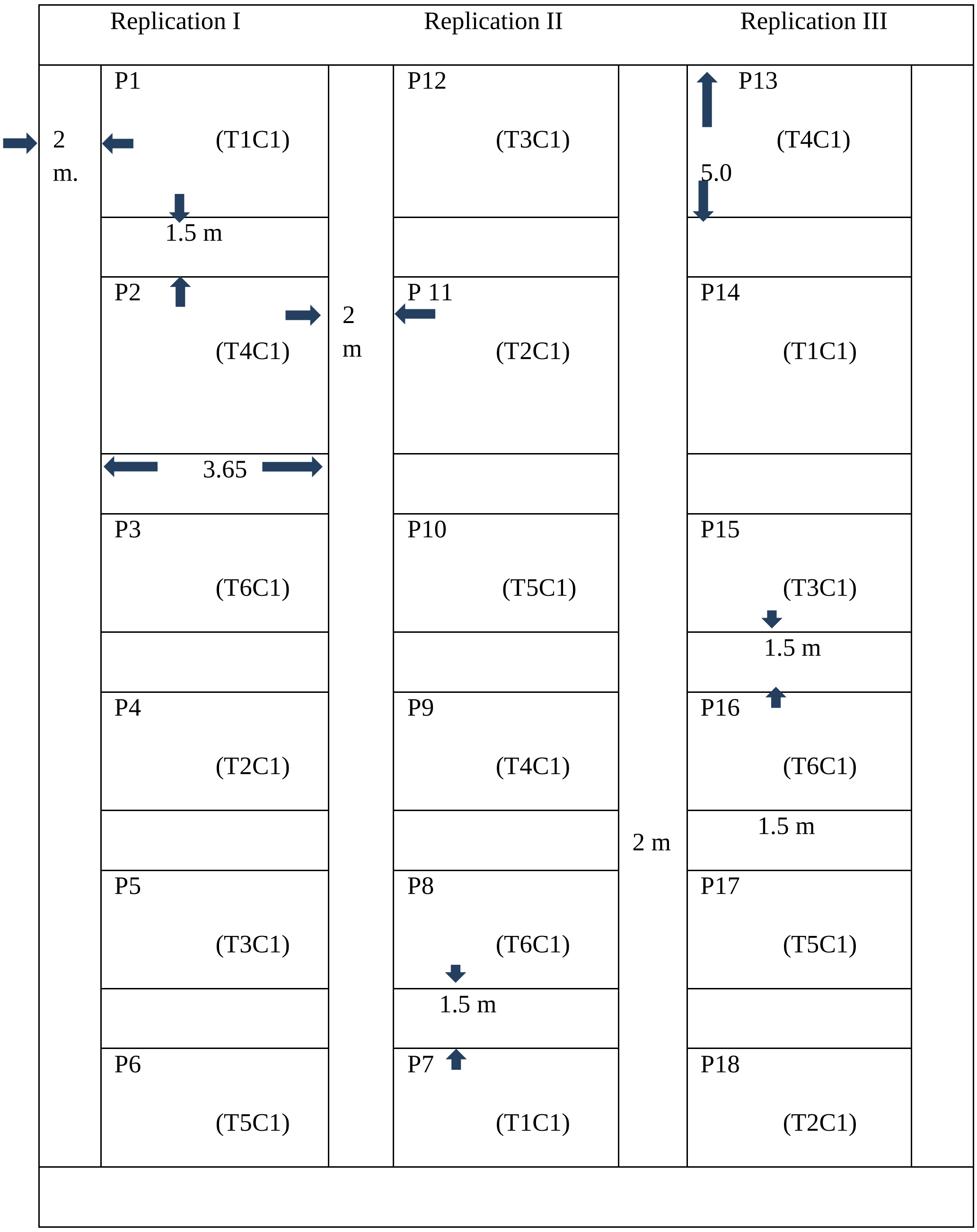

Figure 3. 2:-Experimental field layout

3.5. Agronomy Practices

The selected variety seed (Melk shola) was sown on 15 February 2019 on nursery field. Prior to transplanting the seedling, pre-irrigation was applied to all experimental plots. The tomatoes were then transplanted two days after pre-irrigation (21 March 2019) at a population rate of 44,444 plants ha^{-1}. The plots received three common light irrigations in four days interval to ensure better plant establishment.

Irrigation water was applied when 40 percent of the total available water was depleted. The p for tomato was assumed as 40% (Allen *et al*., 1998). In every water application, depth of irrigation water was determined from the control treatment (100%, 0%) and the rest treatments received the respective percentage of the control as Beseka and Awash water.

Five plants were selected and tagged from the middle two rows for plant and growth parameters collection and yield and yield parameters were collected from net area. The chemicals selecron and ridomil gold were used to safeguard the crop against harmful insects and fungal diseases. All other cultural practices other than treatment variables were done in accordance with the prevailing local condition and the recommendations made for the area. Three water tank and pond were used as reservoir for Beseka and Awash water. The irrigation water amount was measured by a water can and graduated cylinder was used for mixing Beseka and Awash water.

3.6. Crop water requirement

The daily crop water requirement was estimated based on Eq. (3.9) and with help of Cropwat 8.0 for windows, daily reference evapotranspiration, ETo was determined using FAO Penman-Month method. The daily climatic data, viz., maximum and minimum temperature, humidity and sunshine hours were used to compute ETo.

$$\mathrm{ETc} = \mathrm{ETo} * \mathrm{Kc} \tag{3.9}$$

where, ETc is crop evapotranspiration (mm/day); Kc is crop coefficient (fraction) and ETo is reference evapotranspiration (mm/day).

Table 3. 4:-Date of Tomato growth stage and crop coefficient (Kc)

Growth stage	Day	Root depth	Kc
Initial	20	0.25-0.54	0.47
Develop	30	0.54-0.99	0.47-1.18
Mid	45	1	1.8
Late	15	1	1.8-0.63

Source: (FAO, 1998)

Excel sheet was used to compute daily crop water requirement using appropriate crop coefficient, Kc values. Crop data were utilized as input in determination of crop water requirement.

3.7. Irrigation Water Management

The depth of water to be applied was based on allowable soil moisture depletion fraction (p) and irrigation water was applied at regular soil moisture observation when 40% (p) of the total available water, TAW depleted with in the root depth during the growing season.

The irrigation schedule was fixed based on readily available soil water, RAW, the fraction of TAW that a crop can extract from the root zone without suffering water stress. The RAW was obtained from the following expression.

$$\mathrm{RAW} = \mathrm{p} * \mathrm{TAW} \qquad (3.10)$$

where, RAW is the readily available water (mm), p is depletion fraction (fraction) and TAW is the total available water in the root depth (mm/ depth).

The total available water, TAW stored water in a soil was computed using Eq. (3.11).

$$\mathrm{TWA} = (\mathrm{FC} - \mathrm{PWP}) * \mathrm{BD} * \mathrm{Drz} \qquad (3.11)$$

where, FC and PWP (% wt base); Dzr is effective root zone depth (mm) and BD is the bulk density (gm/ cm^3).

The soil moisture depleted between irrigation at any time was computed using Eq. (3.12)

$$\mathrm{SMD} = FC - SMC \qquad (3.12)$$

where, SMD is the soil moisture depleted before the next irrigation (mm), FC is the soil water content at field capacity (mm/ root depth) and SMC is the soil moisture content before the next irrigation (mm).

The net irrigation depth required for the control plot was also obtained from simplified water balance Eq. (3.13).

$$\mathrm{IRn} = \mathrm{ETc} - \mathrm{Peff} \qquad (3.13)$$

where, IRn is the net irrigation depth (mm), ETC is the crop water requirement (mm) and P_{eff} is the effective rainfall (mm).

The effective rainfall estimated using dependable rain (FAO/AGLW formula) as given by FAO (1998).

$$\mathrm{Peff} = 0.6 * \mathrm{P} - \frac{10}{\frac{30}{31}} \quad for\ month\ \leq \frac{70}{30/31} \qquad (3.14)$$

$$\mathrm{Peff} = 0.8 * \mathrm{P} - \frac{24}{\frac{30}{31}} \quad for\ month\ > \frac{70}{30/31} \qquad (3.15)$$

Where, P_{eff} is the effective rainfall (mm) amd P is daily rainfall (mm)

Irrigation water was applied as per the treatment to refill the crop root zone depth close to field capacity. The gross irrigation requirement was obtained from the Eq. (3.16).

$$\mathrm{IRg} = \frac{\mathrm{IRn}}{\mathrm{Ea}} * 100 \qquad (3.16)$$

where; Ig is the gross irrigation depth (mm), In as obtained from Eq. (12) and Ea is the field application efficiency (%).

Field application efficiency was taken as 90% for can irrigation application. The irrigation frequency, f was determined by dividing calculated RAW by mean daily ETc.

$$\mathrm{f} = \mathrm{RAW/ETc} \qquad (3.17)$$

where, f is irrigation frequency (day), RAW is readily available water (mm) and ETc is the mean daily crop water requirement (mm/day).

3.8. Data Collection

3.8.1. Weather data

Data on daily weather of the site during crop growth period was collected from the Melkassa agricultural research center. The climatic data collected were maximum and minimum temperature (^oC), humidity (%), wind speed at 2 m (km/hr), sunshine hours (hr) and rainfall (mm). The data were used to compute ETo and effective rainfall.

3.8.2. Crop data

The crop data was collected and recorded from selected two rows of tomato. Five plants of each plot of the experimental unit were used for data collection of different parameters. The five plants in each plot were tagged. The net harvest area in each plot was 2.1 m^2 (middle two rows each 1.4 m long by 1.5 m width leaving five plants from the borders from each central rows or middle rows). The following data was recorded from randomly selected five plants of middle rows. The crop data were collected and recorded from selected rows of a plot. Five plants of each subplot of the experimental unit were used for data collection of different parameters for each subplot. These plots were first tagged from every eighteen subplots. The growth, yield parameter was recorded in the following situation.

Tomato height was taken by measuring the main stem height from the ground level up to the tip of the leaf. These measurements were recorded at the harvest stage of the crop. All parameter measurements were from five representative samples. The number of branches per plant is recorded in the plot base from each treatment by counting each primary branch from five selected plants. The number of fruits per plant was recorded from each randomly selected five plants from each treatment. The yield of tomato was obtained from the net area in each plot separately. All of these plants were harvested when the fruit was matured or Ripe.

3.9. Statistical Analysis

The data were subjected to analysis of variance (ANOVA) appropriate to RCBD using SAS software (Statistical Analysis Institute, Inc.2002 version 9.2) Whenever treatment effects were found significant, treatment means were compared using the least significant difference (LSD).

4. RESULT AND DISCUSSION

The findings of the study on the effect of mixed irrigation water quality on soil physico-chemical property and yield of tomato (*lycopersicon esculentum mill*) in the central rift valley of Ethiopia

4.1. Physico-Chemical Analysis of Soil and Water

4.1.1. Physico-chemical properties of soil before transplanting

The laboratory results of the average soil physico-chemical properties of the experimental site are presented in Table 4.1 and 4.2. The particle size distribution shows that the experimental field was dominantly loam texture. Bulk density varied between 1.37 to 1.54 g/ cm^3 with a mean value of 1.43 g/cm^3.

Table 4. 1:-Physio-chemical properties of experimental field

Soil Depth (cm)	Bulk Density ($g\cdot cm^{-3}$)	FC (%)	PWP (%)	TAW (mm/m)	T-N (%)	OM (%)	Sand (%)	Silt (%)	Clay (%)	Textural class
0-20	1.39	30.7	16.5	140	2.06	12.5	32	45	23	Loam
20-40	1.42	30.3	19.8	189	1.2	12.4	30	40	30	Clay loam
40-60	1.37	31.2	17.5	130	0.85	12.4	32	43	25	Loam
60-80	1.54	29.8	15.9	154	0.81	12.3	23	45	32	Sandy loam
80-100	1.43	31.8	15.6	158	0.54	12.2	22	43	35	Loam
Average	**1.43**	**30.8**	**17.1**	**154**	**1.09**	**12.4**	**28**	**43**	**29**	**Loam**

This could be because of slight decrease of organic matter with depth and compaction due to the weight of the overlying soil layer. The top surface soil layer had slightly lower bulk density than the subsurface, and this might be due to high organic matter contents in the top soil surface and surface layers were higher in total nitrogen than that of subsurface layers in the soil profiles. This showed that more nutrients are concentrated in the surface soil than in the subsurface soil, implying that, the agricultural crops grown on this soil can access nutrients in their rooting depth (Abay and Sheleme, 2012).

The average value of TAW was 154 mm/m and this value is within the range of 100 – 175 mm/m for loam soil (Goffman, 1985). The analytical results indicated that the textural class of the experimental site was mainly of loam soil with a proportion of 28% sand, 43% silt and 29% clay, respectively.

Table 4. 2:-Soil chemical properties of experimental site

		Water soluble Cation and Anion(meq/l)						Exchangeable Cation(cmol/kg)			CEC	ESP
Soil depth(cm)	pH	EC (dS/m)	Ca^{2+}+ M^{2+}	Na^+	K^+	Cl^-	HCO^-_3	Ca^{2+}+ M^{2+}	Na^+	K^+	cmol /kg	(%)
0-20	7.6	0.46	2.4	5	6.4	2.5	2.5	18.4	2.4	7.2	28.0	8.6
20-40	7.5	0.37	2.25	4.1	4.5	2.3	1.5	17.0	2.5	8.5	28.0	8.8
40-60	7.5	0.32	1.20	4.7	4.7	1.7	1.0	18.2	2.6	9.7	30.5	8.5
60-80	7.6	0.40	1.55	4.8	4.1	1.6	1.3	23.8	2.6	10.1	36.5	7.1
80-100	7.9	0.50	1.50	5.2	4.8	1.7	2.6	26.2	2.7	10.8	39.7	6.8
Average	**7.6**	**0.41**	**1.78**	**4.8**	**4.9**	**2**	**1.8**	**20.7**	**2.6**	**11.0**	**34.3**	**7.6**

As indicated in Table 4.2, the soil pH of the experimental site varied from 7.5 to 7.9 with an average pH-value of 7.6 that indicates the soil is slightly alkaline and suitable for most crops. Best yields are obtained in well-drained sandy loam to clay loam soils with a pH range of 6.7-7.3 as neutral (Kryzanowski *et al*.,1988). The soil had an average electrical conductivity of soil 0.41 dS/m (Table 4.2) which is below the threshold value as indicated in FAO, (1985). The OM and TN of the soil had average values of 12.4% and 1.09% respectively (Table 4.1). Tomato is considered moderately sensitive to salinity. The maximum soil ECe level for Tomato without a significant yield loss has been indicated as 2.5 dS m-1 (FAO, 1985).

4.1.2. Quality of lake beseka and awash river water

4.1.2.1 Total dissolved solid, TDS

The present study result of the Lake Beseka water for Total dissolved salt value was 2,812 mg/l (Table 4.4). These showed that the irrigation water quality of Lake Beseka is salty water. The allowable total dissolved salt concentration of FAO is ranged from 0 to 2000 mg/l. Thus, the obtained value of the study area is above the acceptable limit as per FAO standards. The result of this study is similar to the findings of Olumana and Loiskandl (2015), who reported that north parts of Lake Beseka adjoining Abadir farms had maximum TDS (12,000 ppm) and hence classified as salty water, almost similar to seawater which means the Beseka Lake is the higher ionic concentration.

In addition, the study agrees with the finding of Faud and Gelanew, (2019), analysis of physicochemical properties of Lake Beseka was carried out for Beseka Lake located in the Oromia region, Ethiopia by the effect of water quality parameter with respect to TDS. The total dissolved chemical species was 2569.7 mg/l. This Beseka Lake water of

TDS values between 1500 mg/l and 5000 mg/l are classified as brackish water. The total dissolved salt values of the Awash River water in the present study were 1,930 mg/l, according to the guideline of FAO, (1985) is suitable for irrigation.

According to the guideline of USSLS (1954) and Mass *et al*., (1987), Beseka Lake and Awash River water was classified as the severe and slightly moderate category correspondently.

4.1.2.2 pH of water

The chemical characteristics of Lake Beseka and Awash River water are given in Table 4.4 and Fig. 4.1. Results have shown that the pH of Beseka water was within the range of 9.2 to 9.5. The Beseka water samples were taken from three locations viz., Beseka main (Bm) with a pH of 9.5, Beseka outlet (B0), and Beseka one (B1) with pH values of 9.2. The pH value of Beseka Lake indicates that the chemical quality was not good as a source for irrigation. Thus, Beseka water quality is under strongly sodic water which is not suitable for crop production as per FAO (1985). According to FAO, (1985), pH values of water ranging between 6 to 8.5 are most suitable for irrigation water. Table 4.4 shows that the pH value of Beseka Lake is greater than 8.5 which is highly alkaline water that affects water quality (Olumana, 2015).

Table 4. 3:-FAO standard and quality of water at the sampling sites

Parameters	Symbol	Unit	FAO (1985)	Awash River	Bm	Bo	B1
pH	pH		6-8.5	7.64	9.50	9.20	9.22
Electrical conductivity	EC	ds/m	0-3	0.30	5.27	3.26	3.33
Total dissolved solid	TDS	Mg/l	0-2000	1930	4216	2086.4	2131
Magnesium and Calcium	Mg^{2+} + Ca^{2+}	Mel^{-1}		2.06	0.40	0.50	0.49
Sodium	Na^{+}	Mel^{-1}	0-40	7.39	46.09	36.10	37.82
Potassium	k+	Mel^{-1}	0-2	3.08	10.13	7.31	7.56
Carbonate	CO_3^{2-}	Mel^{-1}	0-0.1	1.00	16.40	7.00	6.60
Bicarbonate	HCO_3^{-}	Mel^{-1}	0-10	1.30	5.40	7.50	7.60
Chloride	Cl-	Mel^{-1}	0-30	0.79	13.11	7.13	6.80
Sodium adsorption ratio	SAR	$(Mel)^{0.5}$	0-15	7.28	103.06	72.17	76.41
Residual sodium carbonate	RSC	Mel^{-1}	1.25-2.5	0.24	21.40	14.00	13.71

Note: Bm =Beseka main, Bo=Beseka Outlet, B1=Beseka one

Long data of Beseka Lake shown in Appendix table 1, the pH values are increased from 2008 to 2011 and decreased from 2012 to 2013. But the pH value of Beseka main is the same pH values from 2010 and 2011 years. According to Fito *et al*. (2019), who reported that the pH value of Lake Beseka is greater than 10, it is not suitable for irrigation. The pH value of the Awash River water at the sampling site is 7.64. it is the accepted value of the guideline of the FAO standard limit (Table 4.4).

4.1.2.3 Electrical conductivity of water, ECw

The result of Lake Beseka and Awash River water; the physical characteristics of water quality parameter for electrical conductivity was 0.302-4.4 dS/m respectively (Table 4.4). According to Wilcox (1955), the irrigation water quality standard classified, in terms of the degree of restriction on use; electrical conductivity is less than 0.7 dS/m, refers the water to 'non',0.7 up to 3 dS/m Slight to moderate, and it was greater than three dS/m 'sever'. From this point of view, referring value to the electrical conductivity values of Awash River water is under non-category, suitable for irrigation, whereas irrigation water quality of Lake Beseka is fall under of severe category, which is not suitable for irrigation.

similarly, to finding out the guideline of FAO standard (1985), Based on limits indices parameter of irrigation water quality by the electrically conductive indicated that 0-0.25 dS/m low limited,0.25-0.75 good limit indices,0.75-2.25 high limit indices, and >2.5 very high limit indices for irrigation purpose. Hence, the irrigation water quality of Lake Beseka water is highly limit induce (4.4 dS/m), and the Awash River water is low limited indices (0.302 dS/m).

The higher value of ECw (10.27dS/m) of Lake Beseka was the indicator for higher ionic concentrations, probably due to high anthropogenic in the region and geological weathering condition acquiring high concentration of dissolved minerals (Olumana and Loiskandl, 2015).

4.1.2.4 Sodium adsorption ratio, SAR

The value of SAR in the present study was 103.06 mel^{-1} for Lake Beseka. According to FAO (1985), it is not suitable for irrigation purposes. The Lake Beseka electrical conductivity is low which increases the value of SAR and the value of sodium is very high relative to Ca and Mg this might increase the value of SAR in Lake. According to the findings of Tadesse (2019), SAR is significantly correlated with sodium and electrical conductivity. The present study indicated SAR (7.28 meq/l) value of Awash River is suitable for irrigation purposes and is within the limit of FAO standard. Classified data indicate that the rating of sodicity hazards based on SAR values for all Beseka lake water were High sodium hazards (S3). Therefore, Beseka Lake water no for any use because of very high sodium hazard.

4.1.2.5 Residual sodium bicarbonate, RSC

The value of water quality indices (RSC) of Beseka water and Awash river water were 0.24 and 21.4 meq/l, respectively. The present study indicated only Awash River is safe for irrigation since the RSC value are less than 3 meq/l, whereas the RSC value of Lake Beseka is beyond the upper limit of FAO (1985) standard and Eaton (1950). According to FAO (1985) and Eaton (1950), the allowable value of RSC for irrigation is in the range between 1.25 – 2.5meq/l. The RSC values have shown in Appendix Table 1 that RSC is very high due to high concentrations of carbonate and bicarbonate with low concentrations of magnesium and calcium (Table 4.4). This on lined with the findings of Yimar and Jin (2020) and Olumana and Loiskandl (2015).

4.1.3. Quality of Mixed irrigation water

4.1.3.1 pH values

The pH values in the different treatments ranged between 7.9 -8.9. The maximum pH of 8.9 was obtained by mixing 10% Beseka lake water with 90% Awash irrigation water. The minimum pH of 7.9 was obtained from Awash River water containing no Beseka lake water. Mixing Beseka lake water with Awash River water increased the pH by increasing the mixed ratio in reference to fresh Awash River water/ control treatment (Table 4.5). According to FAO (1985), the desirable pH level of water is within the range between 6 to 8.5. Hence, Beseka water, 2%, 3% with Awash River water was within the acceptable limit of FAO standard, and Beseka water mixed 5%,8%,10% with Awash River water was out of the acceptable limit value of the pH. This indicates the water is a high concentration of carbonate and bicarbonate, which means highly alkaline water that affects water quality and also reduces crop production (FAO,1985, Elias Kebede *et, al*.,2016).

4.1.3.2 Electrical conductivity, EC

As shown in Table 4.5, the ECw values of irrigation water used as treatment ranged from 0.5 to 1 dS/m. Maximum ECw of 1 dS/m was obtained from mixing 8% and 10% of Beseka lake water with 92 and 90% Awash River water (Table 4.4).

Table 4. 4:-Quality of mixed water over months

Parameter	Unit	T1	T2	T3	T4	T5	T6
pH		7.9	8.3	8.5	8.6	8.7	8.8
EC	dS/m	0.3	0.5	0.6	0.7	1.0	1.0
TDS	mg/l	192	320	384	448	628.2	640
$(Ca^{2+}+Mg^{2+})$	mel^{-1}	2.4	2.2	2.3	2.2	2.0	1.9
Na^{+}	mel^{-1}	5.0	4.3	4.8	5.6	6.6	7.0
K^{+}	mel^{-1}	3.4	1.6	1.6	1.8	2.1	2.1
Cl^{-}	mel^{-1}	0.9	1.7	1.4	2.0	3.7	5.0
CO_3^{2-}	mel^{-1}	1.0	1.0	1.2	1.6	2.4	2.4
HCO_3^{-}	mel^{-1}	1.5	3.3	4.0	4.2	5.2	5.2
SAR	mel^{-1}	4.6	4.2	4.6	5.3	6.7	7.1
RSC	mel^{-1}	0.1	2.1	2.90	3.6	5.7	5.7

Yimer and Jin (2020) and Elias Kebede *et al.* (2016) have also reported increasing the mix ratio of Lake Beseka to Awash River water rapidly increased electrical conductivity in irrigation water under different irrigation treatments.

4.1.3.3 Total dissolved solid, TDS

TDS values in irrigation water are presented in Table 4.5 and ranged between 192 and 640 mg/l. The lowest and highest TDS values were recorded from the control treatment and from blended water of 10% Beseka lake water and 90% Awash River water, respectively.

All TDS values of the blended water were within the range of FAO irrigation water quality standard range for none and slight to moderate. According to USSLS (1954) and Bauder *et al., (2014*), findings, in terms of 'degree of restrictions on use' of TDS values <450, 450-2000 and >2000 mg/l represent the irrigation water as 'none'; 'slight to moderate' and 'severe', respectively. Accordingly, treatments 1 to 4 are classified as "none'' and treatments 5 and 6 are classified as slight to moderately suitable.

4.1.3.4 Sodium absorption ratio, SAR

The SAR values of mixed water samples in the treatment ranged between 4.2 - 7.1 and then presented in Table 4.5. Maximum SAR value was obtained from mixed irrigation water of 10% Beseka water and 90% Awash water whereas, the minimum SAR value was obtained from mixed water of 2% Beseka water and 98% Awash water (Table 4.5).

The result SAR values have shown that the mixed ratios of 2%, 3%, 5%, 8%, and 10% are in the normal sod-city hazard category which is an indication of the suitability of these mixed ratios for agricultural irrigation purpose (Horneck et al., 2007). The mix of Lake Beseka with Awash River water increases the value of SAR also increased. Yimer and Jin. (2020), Tadesse (2019) and Elias Kebede *et al*. (2016), who is stated that increasing mixed ratios of Lake Beseka with Awash River water increases the value of SAR. The SAR increased from 4.2 to 5.7 within increasing the salinity of irrigation water from 0.5 to 1 dS/m. Similarly, Mahdy ,(2011), reported that SAR increased from 5.29 to 8.27 with increasing salinity of irrigation water from 0.5 to 8.7 dS/m.

4.1.3.5 Residual sodium carbonate, RSC

The RSC values of water samples ranged from 0.1–5.7 $me1^{-1}$. According to Eaton's (1950) classification, 2%, 3%, and Freshwater (0%) are considered safe for irrigation since the RSC values are lower than 3 mel^{-1} whereas 5%, 8%, and 10% Beseka water mixed with Awash River water for irrigation water are beyond the acceptance limit.

4.1.4. Quality of Awash River water over months

The analysis for Awash River water quality over five months is shown in Table 4.6. The analysis indicated that Awash River quality in most cases increasing during dry season and decreasing during rainy. The seasonal water quality variation affects monitoring and mixing activities of lake Beseka water. The parameters considered for Awash River water quality analysis fell within FAO standard range. Therefore, Awash River can be considered for irrigation purpose (Table 4.6).

This present result was similar with those reported by other authors that observed reduction of pH and ECe during rainy season and increasing during dry season in May, June and July even including September (Elias Kebede *et al*., 2016; Tadesse, 2019 and

Yimer and Jin, 2020). Seasonal variation flow of Awash River water (only fresh water of control treatment) per irrigation is given in Table 4.6.

Table 4. 5:Average of Awash water quality over months

Parameter	Unit	FAO standard	March	April	May	June	July
pH		6-8.5	7.73	7.64	7.63	7.32	7.14
ECw	dS/m	0-3	0.41	0.43	0.42	0.38	0.34
TDS	mg/l	0-2000	263	280	273	247	221
$Ca^{2+}+Mg^{2+}$	meq/l		2.10	2.20	2.11	2.06	2.03
Na+	meq/l	0-40	5.30	4.90	6.23	4.43	4.41
K+	meq/l	0-2	0.34	0.17	0.23	0.13	0.15
CO_3^{2-}	meq/l	0-0.1	1.34	1.59	1.59	2.25	2.17
HCO_3^-	meq/l	0-10	1.45	2.75	1.81	1.62	1.54
Cl^-	meq/l	0-30	0.76	0.77	1.78	1.34	3.05
SAR	$(meq/l)^{0.5}$	0-15	5.17	4.67	6.07	4.37	4.38
RSC	meq/l	*	0.69	2.14	1.29	1.81	1.68

- RSC<1.25=,1.25-2.5 is marginal and RSC>2.5 is unsuitable for irrigation

4.2.Effect of Mixed Irrigation Water Quality on Tomato Growth and Yield

The mixed irrigation water had a highly significant ($p< 0.01$) effect on plant height, yield and yield parameters of tomato. The outcome of the study is presented in Table 4.6.

4.2.1. Plant height

The plant height ranged from 66.23 –89.63 cm and decreased with the increasing doses of Beseka water. The highest plant height was obtained from T1 (0% Beseka lake water and 100% Awash River water) and there was no significant difference with T2, T3 and T4 with a blending ratio of 2%, 3% and 5% of Beseka water. While the lowest plant height was observed from T6 with a blending ratio of 10% Beseka water and significantly inferior to all other treatment. This finding is in agreement with previous studies as indicated salinity reduced plant height (Achilea,2002; Agong *et al*., 2004 and Hajer *et al*., 2006).

4.2.2. Number of branches per plant

Number of branches per plant was greatly reduced as compared to the control treatment. The number of branches per plant ranged from 5.6-3.3 (Table 4.6).

It was observed that the number of branches per plant decreased significantly ($p < 0.01$) with the mix ratio of Beseka water. The control treatment (Fresh water) gave the highest in number of branches per plant and had no significant difference with T2, T3 and T4. While T6 gave the lowest branches per plant and had no significant difference with T5. The present finding agrees with the findings of (Ahmed, 2017) who reported that the numbers of branches per plant were affected by increasing salinity level in fresh water.

4.2.3. Number of fruits per plant

Analysis of variance indicated that mixed Beseka water with Awash River water had a highly significant ($p < 0.01$) effect on number of fruits per plant. The highest number of fruits per plant (28.67) was recorded from the control treatment and there was no significant different with treatments T2 to T4 and the lowest fruit per plant were obtained from treatment T6 and there was no significant difference with treatment (mix ratio 8% of Beseka water with 92% Awash River water).

4.2.4. Yield of tomato

Tomato yield ranged from 39.23 – 30.34 t ha^{-1}. The maximum total yield (39.23 t ha^{-1}) was recorded from the control treatment T1 and had no significant difference with treatment T2 to T4. Whereas the lowest total yield (30.34 t ha^{-1}) was registered from treatment T6 and had no significant difference with treatment T5. However, Compared with T1 (100% Awash water) irrigation treatment, about 20% yield reduction recorded under the mix ratio of 10% and 8% Beseka Lake water. This indicates that increasing Beseka mixing ratio beyond 5% significantly decreasing yield. However, tomato yield was not significantly affected with mixed ratio of 2%, 3% and 5% Beseka water with Awash River. Similarly, according to Fahandi *et al*. (2013), the yield of tomato was increased for fresh water and then with increasing salinity yield was decreased.

Wan, (2017) reported that salinity of 1.1-4.9 dS/m had little effect on tomato yield. Therefore, compared to fresh water with mixed irrigation water reduced tomato yield by 2-10%. This indicate that tomato moderate sensitive and in fact requires a certain level of salinity for optimal (less than 2.5 dS/m). Conversely, Fernande *et al*. (2013), the total yield of tomato under unitary increase of saline water above 1 dS/m was reduced by 11%

Results indicated that tomato can be grown successfully when irrigated with mixed water up to 5% Beseka Lake water with 95% Awash water as it can be observed from the yield data, a non-significant yield were obtained in treatments T1, T2, T3 and T4. Yield decrease was related with continuous use of high salinity water (Hanson *et al*., 1991).

Table 4. 6:-Tomato yield and growth parameters analysis

Treatment	PH (cm)	NBPP	NFPP	Yield (t/ha)
T1	89.63^{a}	5.6^{a}	28.67^{a}	39.23^{a}
T2	88.43^{a}	5.5^{a}	28.7^{a}	38.37^{a}
T3	88.2^{a}	5.13^{ab}	28.56^{a}	38.23^{a}
T4	87.7^{a}	4.393^{ab}	27.47^{ab}	37.78^{a}
T5	76.2^{b}	3.5^{b}	21.22b^{c}	32.23^{b}
T6	66.23^{c}	3.3^{b}	19.54^{c}	30.34^{b}
Mean	**82.73**	**4.7**	**25.68**	**36.0**
LSD (5%)	**8.631**	**8.63**	**6.42**	**3.10**
CV	**5.73**	**16.87**	**13.73**	**8.87**

Means followed by the same letter in a column are not significantly different from each other at 5% probability level. Means followed by the same letter are not significantly different at 5% probability level .PH- Plant height (cm), NBPP- numbers of branches per plant, NFPP- numbers of fruits per plant.

4.3.Effect of Mixed Irrigation Water on Soil Chemical properties

The results showed that pH, ECe, SAR, ECE, and ESP of soil increased under different mixed irrigation relative to control treatment. This could be due to an increase in sodium concentration from Beseka Lake water in to Awash River water under different irrigation treatments. Due to increasing salinity, soil in different mixed ratio was classified as non-saline to saline (FAO, 1985). In the following subsection were discussed.

4.3.1. Soil pH

Mixed irrigation water from Lake Beseka and Awash River water used as irrigation treatment increased soil pH (Table 4.8). As a result, the Soil pH values increased from 7.7 to 8.6 after harvest by the application of mixed irrigation water. The proportion of

Beseka water (0%, 2% 3% and 5%) do not significantly affect the soil pH and remain within safe limit of FAO (1976) standard. However, the increase of Beseka water above 8% increased the pH of mixed irrigation water to the extent not safe for irrigation purpose and negatively affects the soil and yields of tomatoes. A similar result was obtained by different authors who have observed that increasing in soil pH due to blended irrigation water (Jingang, 2019 and Elias Kebede *et al*,2016).

According to FAO (1985), the pH of soil higher than 8.5 is classified as sodic soil. The soil pH values for T5 and T6 were 8.5 and 8.6, respectively, and categorized under sodic soil that hinders yield. Thus, the pH of the experimental site for T1 to T4 were within the range productive soils but mixed irrigation water if used for long term, it is important to use amendment that could decrease soil pH.

Analysis of variance indicated that mixed Beseka water with Awash River water had a highly significant ($p < 0.01$) effect on soil quality parameter. The highest soil pH value (8.6) was recorded from T6 and there was no significant different with treatments T4 to T5 and the smallest pH value of soil were obtained from treatment T1 and there was no significant difference with T2 and T3.

4.3.2. Electrical conductivity, ECe

The blended irrigation water used as treatment have shown a slight increase in ECe throughout the soil surface at 20 cm depth interval after end of irrigation. The increase in ECe remained higher after harvest than before planting. The ECe of the soil obtained after the application of blended irrigation in the treatments T6 (2.1dS/m), T5 (1.7 dS/m), and T4 (1.5 dS/m) were relatively higher than other treatments (Table 4.8).

Table 4. 7:-Soil chemical properties of experimental field after Harvesting

Parameter	Unit	T1	T2	T3	T4	T5	T6
pH		7.7	7.8	7.8	8.4	8.5	8.6
EC	dS/m	0.7	0.8	1.2	1.5	1.7	2.1
(Ca^{2+}+Mg^{2+})	mel^{-1}	3.60	3.20	2.65	2.45	2.30	2.25
Na^{+}	mel^{-1}	3.91	4.35	6.20	6.50	7.20	7.60
K^{+}	mel^{-1}	3.2	2.8	2.4	2.7	2.6	2.5
Cl^{-}	mel^{-1}	2.6	2.8	4.2	5.6	6.7	7.1
HCO_3^{-}	mel^{-1}	2.5	2.5	3.5	3.6	3.8	3.9
(Ca^{2+}+Mg^{2+})	cmolc/kg	18.7	18.5	17.8	17.5	17.3	16.8

Na^+	cmolc/kg	2.64	3.10	3.05	3.50	4.11	4.25
K^+	cmolc/kg	4.5	4.7	5.3	5.7	7.3	8.9
CEC	cmolc/kg	25.84	26.30	26.15	26.70	28.26	29.95
ESP	%	10.2	11.8	11.7	13.1	14.5	14.2

The ECe of soil before planting were 0.455 dS/m at the depth of (0-20cm) experiment site. The ECe of the soil increased at harvesting time as compared to the before planting. In general, Soil EC_e values remained much lower than threshold level of salinity for Tomato crop which is 2.5 dS/m (FAO,1985). Therefore, according to FAO classification the values of ECe of the soil are grouped to be suitable for tomato production with no reduction in yield. Different authors also reported that an ECe increases with the increasing salinity of irrigation water especially in the top surface soil (Chauhan *et*, *al*,.2007, (Tedeschi, 2005), Elias and Brook, 2016).

Analysis of variance indicated that mixed Beseka water with Awash River water had a highly significant ($p < 0.01$) effect on soil quality parameter. The maximum soil electrical conductivity (2.1) was recorded from the T6 and there was significant different from other treatments and the minimum soil electrical conductivity (0.68) were obtained from treatment T1 and there was no significant difference with treatment T2. Therefore, the electrical conductivity of soil was increased the effect with increased mix ratio of Beseka Lake water.

4.3.3. Exchangeable sodium percentage, ESP

The ESP of soil after harvest was found in a range between 10.2–14.5 %. A soil in treatments T1 to T4 have shown safe pH condition and low saline content. According to FAO, (1985), the soil quality can be classified based on ECe, ESP and pH and, based on the classification mix ratios of 2%, 3% and 5% Beseka lake with Awash River water has not negative effect on the soil chemical properties. A soil in T5 (8%) and T6 (10%) have shown a value for ESP of 14.5% and 14.2%, respectively. Irrigation Treatments involving the use of 8% and 10% mixed Beseka with Awash water increased ESP values. The exchangeable sodium affects the movement of water in soil particle and the concentration salt solution is percolated. This indicated containing sodium salts capable of alkaline hydrolysis, mainly exhibiting degraded soil behavior such as dispersion when wet and crusting when dry and the soils containing sufficient neutral soluble salts to adversely affect the growth of most crop plants (Plessis and Shainberg,2013).

Analysis of variance indicated that mixed Beseka water with Awash River water had a highly significant ($p < 0.01$) effect on soil quality. The highest ESP (14.5) was recorded from the treatment T5and there was no significant different with treatments T6 and T4 and the lowest ESP were obtained from treatment T1 and there was no significant difference with treatment T2 and T3.

Table 4. 8:-Selected soil quality parameter analysis

TRMT	pH	ECe (dS/m)	CEC (cmol/kg)	ESP (%)
T1	7.7^{b}	0.68^{d}	27.43^{a}	10.2^{c}
T2	7.8^{b}	0.78^{cd}	26.31^{ab}	11.7^{bc}
T3	7.8^{b}	1.12^{c}	26.25^{b}	11.67^{bc}
T4	8.4^{a}	1.5^{b}	26.72^{b}	13.09^{ab}
T5	8.5^{a}	1.7^{ab}	28.26^{ab}	14.5^{a}
T6	8.6^{a}	2.1^{a}	29.95^{a}	14.23^{a}
Mean	**8.3^{a}**	**1.31**	**27.49**	**12.57**
LSD (5%)	**0.18**	**0.39**	**2.84**	**1.81**
CV	**1.30**	**15.23**	**1.70**	**9.45**

Means followed by the same letter in a column are not significantly different from each other at 5% probability level. Means followed by the same letter are not significantly different at 5% probability level. pH- hydropower, ECe- electric conductivity of soil, CEC- cation Exchangeable capacities’-exchangeable sodium percent.

4.3.4. Exchangeable bases

In all use of treatment, the exchangeable complex was dominated by $Ca2^{+}$ $+Mg^{2+}$ on soil depth at 0-20cm (Table 4.6). The absence of CO_3^{2-} in the soil seemed to have favored the adsorption of the divalent cations by the soil exchange to a significant extent. Similar findings were also reported by Eylachew (2004) on soils of the Rift Valley System of Ethiopia. Heluf, (1985) also reported the dominance of exchangeable Ca^{2+}+Mg^{2+} throughout the soil’s depths in the Rift Valley of Ethiopia. The highest exchangeable Ca^{2+} + Mg^{2+} were found from the control treatment T1 with minor difference with T2 and the least Ca^{2+} + Mg^{2+} were obtained in treatment T6 (16.80 cmolc/kg).

The result of the basic exchangeable cations in soil were in the order of Ca^{2+} + Mg^{2+} > Na^{+} > K^{+}. This order of abundance was varied into Ca^{2+}+ Mg^{2+} > K^{+} > Na^{+} which may be due to the effects of rain. However, the exchangeable Na^{+} and K^{+} were seen to decrease with the increasing mix ratio of Lake Beseka and the exchangeable Ca^{2+}+ Mg^{2+} decreased when increasing the mix ratio of Lake Beseka. The sum of the bases of the soil was ranged from 25.84 cmolc/kg in control treatment to 29.95cmolc/kg in treatment T6. The highest value of the sum of exchangeable cation was recorded from treatment T6 (29.95 cmol/kg). The lowest value of CEC was recorded from treatment T1 (25.84 cmol/kg). According to Haussen, (1985), the mineral component of soil ranging from 15 to 30 cmol/kg was classified under clay loam soil texture. However, the soil texture class before commencing the experiment was dominantly Loam texture. But, within this short period of time one cannot expect change in texture. However, the long-term effect Beseka mixed with awash river water for irrigation at 8%,10% could influenced the soil particle distribution.

5. CONCLUSIONS AND RECOMMENDATION

5.1. Conclusion

From laboratory result, mixing of Lake Beseka to Awash Fresh water, the quality of fresh water has shown change in chemical parameters. In spite of increasing mixed ratio, irrigation water quality under different treatments changed the quality of Awash River water. Additional, soil salinity increased with increasing the amount of irrigation water with saline water i.e., increasing Lake Beseka in mixed ratio. This might decrease nutrients assimilation with increasing soil solution which decreases the growth of crop, soil structure degraded sod-city effect. All physico-chemicals of Lake Beseka water before any treatments are beyond upper limit of FAO standard that used for irrigation purpose.

Increasing Beseka water mix ratio decreased yield gradually; however, low saline water ratios T2, 2%, T3, 3%, and T4, 5% mixed with Awash River produced the highest yield relative to control treatment. Thus, mixed ratio of Lake Beseka to Awash River is safe, if it is 2-5 % based on the quality of Awash River. The water quality of Awash River will get out of the allowable maximum limit as mixing more than 10% of Lake Beseka to Awash River water. Generally, mixing Lake Beseka water into Awash River will affect Awash River's water quality and reduce tomato yield. Moreover, the result revealed that Lake Beseka is a great source of pollution for down streams agricultural farm and it is a great environmental concern that needs immediate attention.

5.2.Recommendations

This study recommends adoption and application of effective experimental field practices. Due to the complex nature of water and soil chemistry, the study recommends that the effect of mixed irrigation water quality acquire a mix ratios of Beseka Lake water with Awash river water like 2%: 98%, 3%: 97%,5%: 95%, 8%: 92% ,10%: 90% and tomato crop while problem solving the expansion of Beseka Lake and using water resource during water scarce season and reduce downstream pollution.

- The researcher suggested that Irrigation water could use under the mixing ratios of 2-5% of Lake Beseka with Awash River water, thus it does not affect the growth, yield of tomato and soil chemical properties to ensuring controlling the expansion of Lake Beseka.

- Further research is needed to undertake for more than one cropping season and during dry season to get sounding experimental output.
- The study suggests emphasis be given to the experiment will done under green house to identify the effect of growth, yield of tomato and soil physico-chemical properties are more effectively executed in order to fully meet set objectives.
- The future researcher needs a minimum year of experience under water resources and irrigation engineering in order to be better understanding to water quality course that incorporate a mix ratios saline with fresh water who are more capable of effectively determine the physico-chemical properties of water and soil, thus for ensuring performance of further research.

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7.`APPENDICES

Appendix Table 1:-Laboratory result Lake Beseka water sample point (2008-2013)

Parameters	Unit	2008	2009	2010	2011	2012	2013
Total dissolved Solid 105oc	mg/l TDS	3877	3883	3526	3444	3387	3158
Electrical Conductivity	µs/cm	6057	6068	5510	5382	5292	4934
pH	0-14	9.4	9.4	9.5	9.5	9.3	9.2
Sodium	mg/l Na+	1565	1595	1613	1218	1286	1196
potassium	mg/lKa+	65	59	49	47	47	44
calium	mg/l Ca+	7.1	4.5	5.6	4.6	5.3	6.9
Magnesium	mg/l Mg+	1.9	1.3	0.9	1.6	2	4.3
chloride	mg/l Cl-	506	554	422	438	437	412
carbonate	mg/l CO^{2-}_3	636	539	365	460	547	504
Bicarbonate	mg/l HCO3	1471	1595	1557	1306	1028	892

Source: Awash Authority Basin

Appendix Table 2:-Laboratory result Awash River water sample point (2010-2012)

Awash River Chemical composite

parameter	2010 E.C	2011 E.C	2012 EC
PH	7.28-8.07	7.29-7.77	7.56-7.84
EC (µs/cm)	101-428	245-327	340-410
Na(mg/l)	3.4-5.6	3.6-6	4.1-6.23
Ca (mg/l)	7-57	46-81	6,67
Mg(mg/l)	6.5-70	09,12	5,15
CO32-(mg/l)	45-120	59-105	134-217
HCO3-(mg/l)	60-210	115-210	145-275
CL-(mg/g)	3.195-31.95	22-35	0.76- 3.05
TDS (mg/l)	68.7-285	199-164	221-279.5

Appendix Table 3:-Irrigation water quality on March month

			water soluble Cation and Anion(meq/l)								
TRMT (%)	P^H	EC (dS/m)	$Ca^{2+}+Mg^{2+}$	Na^+	K^+	Cl^-	CO_3^{2-}	HCO_3^-	RSC	SAR	TDS (mg/l)
100,00	7.9	0.3	2.1	4.3	3.1	0.8	1.0	1.3	0.2	4.22	195.2
98,2	8.2	0.5	2.2	4.4	1.3	1.7	1.0	2.6	1.4	4.18	345.6
97,3	8.5	0.7	2.1	4.8	2.8	1.3	1.1	2.8	1.8	4.68	416
95,5	8.6	0.8	2.2	5.7	2.8	2.0	1.6	3.7	3.1	5.39	537.6
92,8	8.7	1.1	2.0	6.8	3.5	5.2	2.3	5.9	6.2	6.87	678.4
90,10	8.8	1.0	2.0	7.0	3.6	5.4	2.3	6.0	6.4	7.06	659.2

Appendix Table 4:-Irrigation water quality on April month

			water soluble Cation and Anion(meq/l)								
TRMT (%)	P^H	EC (dS/m)	$Ca^{2+}+Mg^{2+}$	Na^+	K^+	Cl^-	CO_3^{2-}	HCO_3^-	RSC	SAR	TDS (mg/l)
100,00	7.9	0.3	2.2	3.6	3.6	0.9	1.2	1.5	0.5	3.41	195.2
98,2	8.2	0.4	2.0	4.5	1.3	1.7	1.2	2.8	2.0	4.48	268.8
97,3	8.5	0.7	2.3	4.8	1.2	1.6	1.0	3.3	2.0	4.5	416
95,5	8.8	0.8	2.0	5.5	1.3	2.2	1.5	3.4	2.9	5.46	499.2
92,8	8.8	1.1	1.9	6.6	1.9	3.5	2.8	5.1	6.1	6.87	691.2
90,10	8.9	1.1	1.8	6.7	1.5	5.0	2.9	5.2	6.3	7.08	672

Appendix Table 5:-Irrigation water quality on May month

			water soluble Cation and Anion(meq/l)								
TRMT (%)	P^H	EC (dS/m)	$Ca^{2+}+Mg^{2+}$	Na^+	K^+	Cl^-	CO_3^{2-}	HCO_3^-	RSC	SAR	TDS (mg/l)
100,00	7.9	0.4	2.9	3.3	3.5	1.0	0.8	1.2	-0.9	2.73	257.28
98,2	8.5	0.5	2.5	3.9	1.3	1.6	1.0	2.9	1.4	3.47	320
97,3	8.6	0.6	2.4	4.9	1.2	1.5	1.4	3.8	2.8	4.45	384
95,5	8.7	0.7	2.5	5.2	1.3	1.4	1.7	4.4	3.7	4.7	460.8
92,8	8.8	0.9	2.3	6.4	2.0	3.0	2.7	5.1	5.6	6.02	576
90,10	8.8	1.0	2.0	6.5	1.0	5.4	2.8	5.1	6.0	6.52	665.6

Appendix Table 6:-Irrigation water quality on June month

			water soluble Cation and Anion(meq/l)								
TRMT (%)	P^H	EC (dS/m)	$Ca^{2+}+Mg^{2+}$	Na^+	K^+	Cl^-	CO_3^{2-}	HCO_3^-	RSC	SAR	TDS (mg/l)
100,00	7.9	0.5	2.1	4.2	2.8	0.6	0.9	2.0	0.8	4.1	288
98,2	8.3	0.5	2.3	4.4	1.3	1.7	1.0	4.8	3.5	4.1	314
97,3	8.4	0.6	2.2	4.6	1.2	1.5	1.3	5.4	4.4	4.3	352
95,5	8.5	0.6	2.3	6.2	1.4	2.1	1.4	5.4	4.5	5.8	403
92,8	8.6	1.0	1.8	8.2	1.2	3.0	2.0	4.9	5.1	8.7	640
90,10	8.8	1.0	1.7	8.4	2.3	4.3	2.1	4.9	5.3	9.1	653

Appendix Table 7:-Yield and Agronomic parameters result

Plot	Rep	TRMT	Ph(cm)	NBPP	NFPP	YIELD
1	1	T1	89.7	6.2	32	40.2
2	1	T4	89.2	4.3	28.52	37.62
3	1	T6	64	3	15.4	30.5
4	1	T2	89.9	5.6	35	36.7
5	1	T3	89.9	6.3	35	39.2
6	1	T5	69.9	3.32	15.7	29.89
7	2	T3	79.9	4.5	22.67	38.1
8	2	T2	80.5	5.5	23.2	39.63
9	2	T5	78.8	3.7	17.3	31.3
10	2	T4	88	5.5	27	36.3
11	2	T6	66.7	2.3	16.4	31.8
12	2	T1	90.2	5	31	39.9
13	3	T4	86	3.39	26.9	39.42
14	3	T1	89	5.6	23	37.6
15	3	T3	94.8	4.6	28	37.4
16	3	T6	68	2	16.2	32.3
17	3	T5	79.79	4.7	17	33.2
18	3	T2	94.9	5.4	28	38.79

Appendix Table 8:-Analysis of variance of plant height

Source	DF	SS	MS	F	P
Rep	2	70.77	35.385		
TRMT	5	1351.2	270.24	12.01	0.0006
Error	10	225.09	22.509		
Total	17	1647.06			
LSD (5%)	8.63				
G.mean	82.73				
CV %	5.73				

Appendix Table 9:-Irrigation water applied over five months (Liter)

Irrigation (	Irrigation	Growth	ETc mm	Peff (mm)	Net irrigat	Igros(mm)	Area(n	Lake Be	Awash wat	Total V L
First	21-Mar	PI	17.1	0	17.1	19	8	0	2,736.0	2,736.00
second	28-Mar	intial	22	0	22	24	8	164	3,348.0	3511.84
Third	3-Apr	intial	23.87	0	23.87	26.5	8	178.2	3,641.0	3819.2
Fourth	9-Apr	dev't	19.88	0	19.88	22.1	8	148.44	3,032.4	3180.80
Fifth	16-Apr	dev't	18.5	0	18.5	20.6	8	138.13	2,821.9	2960.00
Sixth	25-Apr	dev't	28.878	0	28.878	32.1	8	215.62	4,404.9	4620.48
Seventh	2-May	dev't	29.9	0.62	29.28	32.5	8	218.62	4,466.2	4684.80
Eighth	9-May	Mid	36.12	0	36.12	40.1	8	269.70	5,509.5	5779.20
Ninth	16-May	Mid	52.9	0	52.9	58.8	8	394.99	8,069.0	8464.00
Tenth	23-May	Mid	45.1	0	45.1	50.1	8	336.75	6,879.3	7216.00
Eleventh	29-May	Mid	36.84	0	36.84	40.9	8	275.07	5,619.3	5894.40
Twelfth	5-Jun	Mid	25.97	0	25.97	28.9	8	193.91	3,961.3	4155.20
Thirteen	12-Jun	Mid	34.94	0	34.94	38.8	8	260.89	5,329.5	5590.40
Forteenth	19-Jun	Mid	36.2	0	36.2	40.2	8	270.29	5,521.7	5792.00
Fifth	26-Jun	Late	30.5	0	30.5	33.9	8	227.73	4,652.3	4880.00
Sixth	1-Jul	late	24.8	1.5	23.3	25.9	8	173.97	3,554.0	3728.00
								3466.2	73,546.1	77,012.32

Appendix Table 10:-Analysis of variance of number of branches per plant

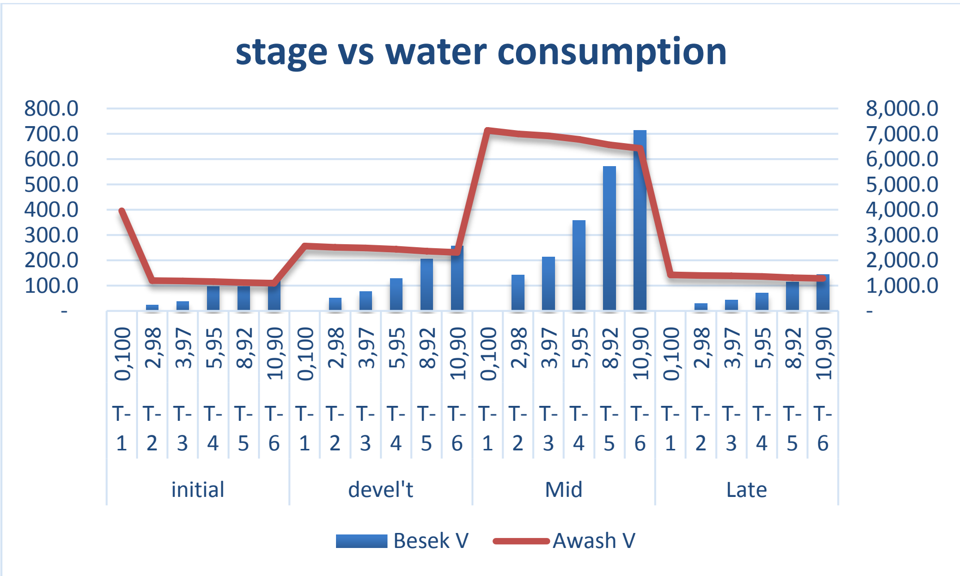
Source	DF	SS	MS	F	P
Rep	2	0.8203	0.41015		
TRMT	5	21.7344	4.34688	7.56	0.0035
Error	10	5.7494	0.57494		
Total	17	28.3041			
LSD (%)	8.63				
Grand Mean	4.495				
CV	16.87				

Appendix Table 11:-Analysis of variance of Number of fruits per plant

Source	DF	SS	MS	F	P
Rep	2	60.439	30.219		
TRMT	5	582.164	116.433	8.39	0.0024
Error	10	138.789	13.879		
Total	17	781.391			
LSD (5%)	6.7776				
Grand Mean	24.349				
CV	15.3				

Appendix Table 12:-Analysis of variance of Yield

Source	DF	SS	MS	F	P
Rep	2	3.648	1.8242		
TRMT	5	174.185	34.837	12.73	0.0005
Error	10	27.357	2.7357		
Total	17	205.19			
LSD(5%)	3				
Grand Mean	36.231				
CV	4.57				



Appendix Figure 1:-Water consumption with in plant growth

Seed sown on bed and covering sacke

Land preparation for tomato

Watering on bed

Appendix Figure 2:-Land preparation and water supply for seedling on bed

B

Beseka water sample taken

Awash water sample taken

Appendix Figure 3:-Lake Beseka and Awash water sample site

SOIL SAMPLE BEFORE STARTED

SOIL SAMPLE AFTER HARVEST

SOIL WEIGHTBY SENSE METER

Appendix Figure 4:-Soil sample taken before and after harvesting

Evaluation of plant parameter

Site

Appendix Figure 5:-Top view of site and supervision

Measured plant height

HARVESTED (YIELD)

Counte

Appendix Figure 6:-Taking agronomy data and Harvesting