American Journal of Life Sciences
2024, Vol. 12, No. 4, pp. 73-85
https://doi.org/10.11648/j.ajls.20241204.12

Review Article

Effect of Irrigation Water Quality on Selected Soil Physico-Chemical Properties in Ethiopia: Review

Firaol Gemeda[1,*], Belay Yadeta[2,*]

[1]Nekemte Soil Research Center, Oromia Agricultural Research Institute, Addis Ababa, Ethiopia
[2]Department of Water Resource and Irrigation Management, Ambo University, Addis Ababa, Ethiopia

Abstract

Saline and sodic water qualities used for irrigation could deteriorate soil physico-chemical properties based on type and amount of salts present in irrigation water and soil type being irrigated. Irrigation water with marginal quality could lead to the buildup of new soil characteristics that affect its fertility and productivity. In line with these issues, this review paper focused on reviewing the effect of irrigation water quality on selected soil physico-chemical properties in Ethiopia. Consequently, irrigation water quality of Errer River of Babile District, Ground water of Babile District, Tumuga and Gerjale irrigation sources, Adamitulu surface and ground water, Abaya Lake water, mixed water (Awash River to Beseka Lake River) and effect of these water sources qualities on selected soil physico-chemical properties were reviewed. The Errer River of Babile District, Tumuga and Gerjale irrigation water quality extent were within and below permissible value based on degree of restriction on use for irrigation and some selected soil physicochemical properties weren't affected in observable extent due to quality of irrigation water. Certain irrigation water quality extent implied that Ground water of Babile District, Adamitulu Surface and Ground water, Abaya Lake water, mixed water (Awash River to Beseka Lake River) problem of suitability for irrigation and some selected soil physicochemical properties were affected due to extent of irrigation water quality were above threshold limit of irrigation water quality. The reviewed papers indicated that the soil quality was affected due to quality of irrigation water like its quality extent of salinity (EC), sodium adsorption ratio (SAR), residual sodium carbonate (RSC) and soluble sodium percentage (SSP) as it increased sodium, salt level and salinity in soil due to these parameters of irrigation water quality were above threshold limit, but calcium, magnesium and organic matter particulate content of irrigation water could improve soil fertility. Therefore, monitoring of irrigation water quality and checking of pre-planting and after harvesting soil physicochemical properties is very crucial to reveal and monitor the effect of irrigation water quality on soil physico-chemical properties.

Keywords

Effect, Irrigation, Physico-Chemical, Quality, Review, Salinity, Sodicity, Soil and Water

1. Introduction

The net and gross irrigation potentials of Ethiopia were about 2.6 and 3.7 million hectares respectively [3, 12]. Even if the potential and actual irrigated area isn't precisely investigated [5] estimates of irrigable land in Ethiopia vary between

*Corresponding authors: firaolgemeda1994@gmail.com (Firaol Gemeda), belayad@gmail.com (Belay Yadeta), belay.yadeta@ambou.edu.et (Belay Yadeta)

Received: 8 June 2024; **Accepted:** 9 July 2024; **Published:** 20 August 2024

1.5 and 4.3 million ha, averaged about 3.5 million hectare [14, 10]. Small scale irrigation agriculture is vital to enhance crops production and attain food self-sufficiency in Ethiopia, but monitoring the impacts of irrigation on soil chemical properties is crucial for the sustainable crop production and productivity [9].

Soil salinization and sodicity a major problem in irrigated agriculture and agricultural productivity remains meager due to lack of quality irrigation water resulted in declining of soil fertility and increasing soil salinity [18]. Salinity being one of the common problems in irrigation which can be built up with time though the rates varies on the salt content of the water used and can cause serious problems to soil quality and productivity [4]. Water quality-related problems in irrigated agriculture are salinity, reduced water infiltration rate, specific ion toxicity, and miscellaneous [17]. Highly saline and sodic water qualities can cause problems for irrigation depending on the type and amount of salts present, the soil type being irrigated, the specific plant species and growth stage and the amount of water that is able to pass through the root zone [16]. Soil electrical conductivity increased as a result of increment of salinity levels of irrigation water and saline water can affect soil physical properties by causing fine soil particles to bind together into aggregates [16]. Irrigation with water of marginal quality could lead to the buildup of new soil characteristics that affect soil fertility and lead to lower productivity [6, 15]. Irrigation water quality problems can be caused by total mineral salts accumulation so that crops can't be produced well due to the development of sodic soils and accumulation of toxic levels of elements such as chloride, sodium and boron, these elements could make the land unproductive that incurs additional cost soil and water for leaching [4]. Excess amounts of chloride, boron, and sodium ions in irrigation water can be harmful to normal plant growth [7]. The criteria for the quality of irrigation water are classified as water salinity (EC), sodium adsorption ratio or sodium hazard (SAR), residual sodium carbonate (RSC), sodium percentage (%Na), soluble sodium percentage (SSP) and Kelley's ratio (KR) [11, 2]. The water quality and suitability for irrigation are indicated by water quality parameters such as pH, electrical conductivity, sodium adsorption ratio, residual sodium carbonate, exchangeable bases, carbonate, bicarbonate and chloride [2]. For salinity problem: electrical conductivity (EC) or total dissolved solids (TDS); for infiltration: calcium, sodium, magnesium, and sulphate as well as electrical conductivity; for specific ion toxicity: sodium, chloride boron, and chromium; and for miscellaneous: nutrients (nitrate-nitrogen, ammonium-nitrogen, orthophosphate, and potassium), bicarbonate, carbonate, and pH should be determined [17]. Permeability affects infiltration rate of water into the soil and it is determined by the relative concentrations of salinity and sodicity [13]. The order of bases in quality water or soils is calcium>magnesium>potassium>sodium and deviations from this order create ion-imbalance problems for plants [8]. The widely considered chemical properties of soil include pH, electrical conductivity (EC_w or EC_e), exchangeable basic cations, available phosphorus, available sulfur, organic carbon, total nitrogen, and micronutrients while, widely used soil physical properties include soil texture, bulk density, soil moisture content at field capacity (FC) and permanent wilting point (PWP), and infiltration rate [8].

Different scholars have studied that irrigation Agriculture is one of main crucial way to achieve the food security; however, it is quality of irrigation water which determines the level of soil productivity because the extent of quality irrigation water affects the suitability of soil physico-chemical properties to produce crops. Especially, use of quality irrigation water is the key determinant of soil productivity to produce crops on saline, saline-sodic and sodic soil of arid and semiarid regions. Information about soil salinity/sodicity and irrigation water quality status plays a vital role for proper management of agricultural fields [10]. The main objective of review article is to review previously conducted investigations concerning the effect of irrigation water quality on soil physico-chemical properties in Ethiopia and to discuss results of the investigations and limitation of conducted investigations.

2. Methodology of Review

This review article was reviewed using different secondary sources from published Research Journals and Articles. Journals and articles concerned on both the irrigation water quality of irrigated field and soil physico-chemical properties were used to prepare this review paper. The review paper was reviewed from journals of [1, 10, 12, 18] and from Articles of [4, 15]. The study was conducted on the impact of water quality and irrigation practices on soil salinity and crop production at Gergera Watershed, Atsbi-Wonberta, Tigray, and Northern Ethiopia [4]. The investigation was investigated to evaluate the effects of Beseka Lake on irrigation water quality, soil physico-chemical properties and Cotton yield [12]. Awash River and Beseka Lake blended water were mixed as treatment to conduct study in the middle Awash Basin Ethiopia in the ratio of 92% of Awash River to 8% of Beseka Lake water (T_1), T_2:90% of Awash River to 10% of Beseka Lake water, T_3:85% of Awash River to 15% of Beseka Lake water, T_4:80% of Awash River to 20% of Beseka Lake water, T_5:75% of Awash River to 25% of Beseka Lake water, T_6:70% of Awash River to 30% of Beseka Lake water, T_7:50% of Awash River to 50 of Beseka Lake water and T_8:100% of Awash River to 0% of Beseka Lake water (T_8) [12]. The investigation was conducted to characterize the physicochemical characteristics of soils and irrigation water qualities (Errer River and ground water irrigation) under four land use types non-cultivated (profile1), two irrigated cultivated (profile 2 & 3) and none irrigated cultivated lands (profile4) of Babile District in Eastern Ethiopia [1]. The study was studied to characterize the salinity/sodicity status of soils of irrigated lands and irrigation water quality at Raya Alamata District at Tumuga and Gerjale sites [10]. The study was conducted to evaluate the effect of on-farm water management practices and irrigation water sources on soil quality at Adamitulu District in the South Western Shewa zone of the Oromiya Regional State of Ethiopia [18]. The study was conducted to assess the impact of using water from Lake Abaya for irrigation and its impact on soil quality at Wajifo and Fura, Mirab Abaya, Ethiopia [15].

Accordingly, pH, salinity (EC), sodium adsorption ratio (SAR), residual sodium carbonate (RSC), soluble sodium percentage (SSP) and Kelley's ratio (KR) of irrigation water quality used for irrigating study site were reviewed. The effect of irrigation water on soil moisture content, water holding capacity and soil infiltration rate were reviewed among soil physical properties and soil pH, electrical conductivity (EC), exchangeable bases, soluble ion, sodium absorption ratio (SAR), exchangeable sodium percentage (ESP), organic carbon, and phosphorus were reviewed among soil chemical properties from these Journal and Articles.

3. Discussion of Review

3.1. Effect of Irrigation Water Quality on Selected Physical Properties of Soil

Soil texture (particle size distribution), bulk density, and water holding capacity at field capacity and permanent wilting point are some of the physical properties [12]. The soil moisture content, water holding capacity and infiltration rate of soil were reviewed among the physical properties.

3.1.1. Effect of Irrigation Water Quality on Soil Moisture Content and Water Holding Capacity

Soil physical properties water-holding capacity showed no change after application of the blended water and it indicated that the effect of blended water on the soil will need further experiment and assessment [12]. Even though further experiment is very necessary to reveal it, but this could be due to applied mixed water per planting season couldn't increase sodicity and salinity of soil to extent of affecting the soil structure and varying soil porosity to alter water holding capacity of soil.

The lowest and the highest soil water content at field capacity (FC) were 32.45v/v and 42.88v/v in the surface (0-30cm) in profile 4 and bottom layer (90-150+cm) of profile 2, while the lowest and the highest soil water contents recorded at PWP were 17.82v/v and 23.56v/v in the surface (0-30cm) layers of profile 1 and the sub surface (90-150+cm) layer of profile two respectively [1]. The available water holding capacity varied from 13.04 to 21.57 within profile and the values of AWHC of profile 1, 2 and 3 were slightly higher than the other profile4; this could be due to the increased retention of moisture with increasing clay contents at FC and PWP [1]. The moisture content of irrigated cultivated soil surface (profile 2 and 3) at field capacity (FC) was sufficient for clay soil, but there was only small range variation between irrigated soil surface and non-irrigated soil surface and the values of available water holding capacity of irrigated soil surface (profile 2 and 3) were higher than the none irrigated cultivated soil surface but there could be small clay clogging which may enhance holding capacity in irrigated land soil surface (profile 2 and 3) due to sodium content of irrigation water used.

3.1.2. Effect of Irrigation Water Quality on Soil Infiltration Rate

Soil physical properties infiltration rate after application of the blended water indicated that the effect of blended water on the soil of Werer, middle Awash Basin site will need further experiment and assessment [12]. Even though, SAR content of mixed water was medium to high to cause the sodicity hazard, soil clay dispersion extent wasn't high enough to affect soil moisture content.

Soils of Bisidimo steady state infiltration ranged from 2.2 to 3.0cm/hr and cumulative infiltration rates ranged from 22.6 to 29.7cm, but the soil in non-irrigated cultivated land (profile 4) showed the highest infiltration rate at the beginning and decreased steadily at different rates which could be due to relatively higher sand and lower clay content relative to profiles 1, 2 and 3 [1]. The relatively lower infiltration rates of soils in irrigated cultivated land (profile 2 and 3) could be due to higher soil exchangeable Na (ESP>15%), clay content and the higher soil SAR values of irrigated cultivated land (profile 2 and 3) which could induce soil dispersion and structural deterioration leading to lower infiltration rates [1]. The steady infiltration rate of soils of the Bisidimo, Babile District was optimally suitable, but relatively lower infiltration rates of soils in irrigated cultivated lands (profile 2 and 3) could be because of sodium adsorption impact from repeated use of irrigation water without proper management since RSC content of groundwater was 3.11meq/L>2.50meq/L which was high enough to rise sodium content of soil due to precipitation of calcium and magnesium in bicarbonate and carbonate forms which could reduce soil infiltration and permeability because of dispersion of clay soil.

3.2. Effect of Irrigation Water Quality on Selected Chemical Properties of Soil

The soil chemical properties are soil pH, electrical conductivity (EC), cation exchange capacity (CEC), exchangeable bases (Ca, Mg, K and Na), soluble bases (Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}), anions (Cl^{-}, HCO_3^{-}, CO_3^{2-}) [12]. Soil chemical parameters are pH, electrical conductivity (EC), total nitrogen, organic carbon, phosphorus, cation exchange capacity (CEC), exchangeable bases (Ca^{2+}, Mg^{2+}, K^{+}, and Na^{+}) [18]. The soil chemical properties like soil pH, electrical conductivity (EC), exchangeable bases (Ca, Mg, K and Na), soluble bases (Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}), anions (Cl^{-}, HCO_3^{-}, CO_3^{2-}), sodium absorption ratio (SAR) and exchangeable sodium percentage were reviewed.

3.2.1. Effect of Irrigation Water Quality on Soil pH

The soil pH related to HDW was slightly acidic (6.5 to 8.0) compared to pond related soil which was slightly basic (7.50 to 8.20) at Gergera watershed [4]. This indicate that pH of irrigated subsurface soil (20-60cm) was alkaline and at normal condition but, decreasing of pH with depth could be because of upward movement of ground water over leaching.

Mixed Beseka and Awash water irrigation treatments applied to the field increased soil pH in the experiment site and soil pH increased after cotton harvest involving Awash water as the first pre irrigation, and fluctuated around (8.5 to 8.9) values attained during the experimentation [12]. Lower proportion 8, 10 and 15% blended water application and intervening higher rainfall might have helped to reduce the soil pH after harvesting in treatments T_1(8.50), T_2(8.70) and T_3(8.60) while, maximum soil pH was found in T_5(8.9) treatments involving a blended water with mixed ratio except T_8(8.7) which has nearly the same pH before planting and this could mainly be attributed to the fact that the maximum ratio of Beseka water will affect fresh water quality of Awash River and results clearly indicated that if Beseka water is diluted to Awash River at a rate higher than currently in use, which is 2% it will affect the cotton yield and soil quality [12]. Increasing of irrigated soil pH at T_5 (25% of Beseka Lake water to 75% of Awash water) could be due to impact of sodium salt from Beseka Lake water, but fluctuation of soil pH with increment of Beseka Lake water proportion require further investigation.

The pH of the surface soil of non-irrigated cultivated land (profile 4) of Bisidimo, Babile district was slightly alkaline (pH:7.76) and increased almost consistently but slightly with depth to moderately alkaline (pH:8.23) at the lower layer while soils of irrigated cultivated land (profile 2 and 3) of Bisidimo, Babile district were alkaline (pH>8.35) throughout the entire depths of their respective layers and increased almost consistently with depth; this could be due to the dominance of Na^+ among the cations and the presence of sufficient amounts of HCO_3^- ions among the anions [1]. Accordingly, the pH of irrigated cultivated soil surface (profile 2 & 3) of Bisidimo, Babile district were higher than pH of both none irrigated cultivated soil surface (profile 4) and non-cultivated soil (profile1) soil numerically and this could be because of gradual effect of basic salts of irrigation water of Errer River and Ground water which were used for irrigating the cultivated soils surface (profile 2 & 3).

The pH of irrigated field of Adamitulu ranged from 8.13 (Tr-2) to 8.69 (Tr-4) and the data indicate that lower and higher values for both parameters were observed in FP fields but, both fields were irrigated with different water sources during the experimentation period and its value in WFD field conditions gets low (8.39) as compared to its value (8.41) in FP fields and its initial value (pH=8.20) [18]. In addition, the spatial variability pH for the surface, subsurface, and subsoil showed significant difference at P<0.05 across the depth and source of water used and the values of pH across the depth ranged between 7.5 (subsoil) and 8.3 (surface soil) and the highest value observed in groundwater irrigated fields [18]. Higher values soil pH was observed in groundwater Adamitulu irrigated fields and the ground water irrigation could affect for soil pH relative to surface water irrigated soil.

The analytical results of soil reaction (pHe) from saturated paste extract of the surface soil ranged from 8.01 to 8.47 with an average value of 8.29 and from 7.96 to 8.41 with an average value of 8.21 at Tumuga and Gerjale irrigation sites, respectively [10]. Reason for the higher soil pHe values of the study area could be due to relative abundance of alkaline forming cations from both groundwater and surface water used for irrigation.

Soil pH at Wajifo, Algae and Fura pre- and post-harvest was varied numerically, but the differences were statistically insignificant at the 95% confidence interval (p¼ 0.06, 0.88, 0.98, respectively) [15]. Furthermore, the soil pH was similar for irrigated and rain-fed areas but the variation in pH of the irrigated soils is less than that of the rain-fed soils, and statistically insignificant at 95%, however, Lake Abaya water did not affect soil pH [15]. The values of soil pH for both pre-harvest and post-harvest irrigated soil and rain fed soil pH of both Wajifo and Fura were slightly alkaline to alkaline, but variation in pH between pre-and post- harvest of irrigated soil and rain fed weren't observed.

3.2.2. The Effect of Irrigation Water Quality on Electrical Conductivity of Soil

The electrical conductivity values at 25 ℃ for soil samples from HDW irrigated land of Gergera watershed varied from 17 and 1445 µS/cm and EC of the soil from pond water irrigated land ranges from 51 to 1734 µS/cm and EC values for soils from hand dug-well water irrigated land of Gergera watershed in general are lower compared to soil from pond water irrigated land and EC values decrease downwards with depth [4]. This implied that EC of irrigated subsoil with hand dug well water and pond water were none-saline.

Electrical conductivity of soil at experiment site before planting was 0.81, 0.83 and 1.92 dS/m at 0 to 30, 30 to 60 and 60 to 90 cm depth, respectively and the EC of the soil increased at harvesting time as compared to before planting [10]. Accordingly, electrical conductivity of the soil obtained in irrigation treatments T_7 (1.60 dS/m), T_6 (1.30 dS/m) and T_5 (1.34 dS/m) were higher than other treatments [10]. Electrical conductivity (EC) of after harvesting soil was increased per treatments relative to EC of pre-planting soil with increment of Beseka Lake water proportion, but inconsistent with Beseka Lake water percentage volume.

The ECe of non-cultivated land (profile1) of Bisidimo, Babile district decreased inconsistently with depth from 5.22 to 3.62dS/m and non-irrigated cultivated land (profile4) decreased inconsistently with from 5.12dS/ m to 3.86dS/m and the inconsistent distribution of soluble salts within the profile could be due to the upward (capillary) movement of salts in saline ground water was more dominant than downward (leaching) movement of salts with rain waters [1]. In contrary to ECe of non-cultivated land (profile1) of Bisidimo, Babile district and ECe of irrigated cultivated land (profile4) of Bisidimo, Babile district, the ECe of irrigated cultivated land (profiles2) of Bisidimo, Babile district was increased from 4.46 to 5.88dS/m consistently and ECe of irrigated cultivated land (profiles3) of Babile district was increased from 4.68 to 5.48dS/m consistently, but gradually with profile depth and this could be attributed to the dominance of downward leaching/ removal of soluble salts over surface accumulation of salts [1]. The values of soil electrical conductivity indicate that upward movement of saline ground water was observed in both non-irrigated cultivated land (profile1) and irrigated cultivated soil (profile4) of in the profile depth while downward leaching of soluble salts was observed in both of irrigated cultivated soil (profiles 2 &3) of in profile depth. The electrical conductivity of non-cultivated soil surface of Bisidimo, Babile district were ranged in moderately saline.

The EC of irrigated soil of Adamitulu ranged from 0.61 dS/m (Tr_{-2}) to 1.03 dS/m (Tr_{-4}) and the data indicate that lower and higher values for both parameters were observed in FP fields but the EC values did not show any significant variation among treatments [18]. The higher value for EC was observed in groundwater irrigated fields and irrigation water source has pronounced effects on soil quality aside from management practices, however, the average value of both parameters (EC=0.84) remains below the limit [18]. All irrigated fields soil across the depth are non-saline and electrical conductivity of surface water irrigated fields ranged 0.27 to 0.63dS/m in profile depth and electrical conductivity of groundwater irrigated fields 0.50 to 0.78 dS/m in profile depth [18]. The results of soil EC implied that water sources used and on-farm irrigation management practices showed variation numerically on soil quality parameters and higher value of EC was observed in groundwater irrigated fields. The ground water irrigation had higher effects for soil salinity development.

The irrigated surface soil exhibited high variation with respect to ECe values for both sites and accordingly, ECe values varied from 0.03 dS/m to 4.15dS/m at Tumuga site and from 0.05 dS/m to 7.45 dS/m in Gerjale site [10]. In addition, the ECe value of the soil profile also increased slightly with depth for both sites and this implied that the down ward movement of the salt (leaching) was dominant over that of the upward (capillary) movement of salts [10]. Electrical conductivity of soil ranged from non-saline to saline, but spatial variations in EC of irrigated soil surface were high at both Tumuga and Gerjale sites, but variation in EC was higher at Gerjale site from 0.05 dS/m to 7.45 dS/m and this could be due to irrigation water sources and management implemented in addition to dynamic property of soil in its content even per spot.

The soil EC at Wajifo and Fura decrease between the pre- and post-harvest seasons, but the changes were insignificant at 95%, however, the soil EC at Algae rose and the increase was statistically significant [15]. The values of pre-harvest soil EC for both irrigated soil and rain fed soil of both Wajifo and Fura were none-saline. The soil EC of post-harvest slight decreased numerically relative to its pre-harvest soil EC for both irrigated soil and rain fed soil at both Wajifo and Fura. This could be because of moderate leaching of salts below root zone and absorbance of salts by crops. The soil EC of prost-harvest increased numerically relative to its pre-harvest soil EC for irrigated soil at Algae.

3.2.3. The Effect of Irrigation Water Quality on Total Dissolved Salt

The average value of soil TDS in WFD installed Adamitulu fields is 528 mg/l compared with 547.23mg/L in FP fields and indicated that aside from management practices, irrigation water sources would also play a role in salinity build-up around the root zone, however total dissolved solutes (TDS) during the study periods did not show any variation among treatments statistically [18]. Total dissolved salt (TDS) of soil values in the study Adamitulu field ranged from 306.40 to 1742.90 mg/L and relatively its higher value was observed at surface soils in groundwater irrigated fields but TDS values across the depth under both water sources irrigated fields did not show such variation statistically [18]. Soil surface was affected due to salt from irrigation water because high total dissolved salt content of soil surface relative other soil profile depth numerically. The results of soil TDS implied that water sources used and on-farm irrigation management practices showed differences in numeric on soil total dissolved salt content. The ground water could cause salinity in irrigated soil relative surface water.

3.2.4. Effect of Irrigation Water Quality on Sodium Adsorption Ratio (SAR) and Exchangeable Sodium Percentage (ESP) of Soil

The SAR values of hand-dug wells and ponds water irrigated soil of Gergera watershed range from 0.19 to 1.27 while the exchangeable sodium percentage (ESP) results were below 1% and both values were categorized under normal range [4]. Both SAR and ESP of irrigated soil content were low to affect soil physical and chemical properties and this imply that both sources of water couldn't affect soil quality due to SAR of water sources were within recommended limit.

Exchangeable sodium percentage of experiment soil values of Werer, middle Awash Basin site were obtained in a range (11.10 to 15.13 %) at a depth of (0 to 0.3 m) and a soil in T_8 (Awash River without mixed Beseka water) and irrigation treatments involving the use of mixed Beseka with Awash water increased ESP with increasing mixing ratio T_7 (15.13%) and T_5 (13.86%) [12]. The same results were obtained in T_2 (12.61%), T_3 (12.61%), T_4 (12.61%) and T_6 (12.61%) with that of T_8 (11.61%) having 100% Awash and this could be mainly due to rainfall, and leaching downward might be the case [12]. The exchangeable sodium percentage of after harvesting soil surface values were increased relative to pre-planting soil surface with increment of Beseka Lake water proportion at T_5 (25% of Beseka Lake water to 75% of Awash water) and T_7 (50% of Beseka Lake water to 50% of Awash water) and this could be because of sodium salt content of Beseka Lake water but increment remain constant (12.61%) at other proportion of Beseka Lake water proportion.

The sodium adsorption ratio (SAR) of the soil solutions ranged from 5.89 to 6.69 in non-cultivated land (profile 1), 13.41 to 13.92 in irrigated cultivated land (profile 2), 14.41 to 16.64 in irrigated cultivated land (profile3) and 6.85 to 7.68 in non-irrigated cultivated land (profile 4) of Bisidimo, Babile district and the SAR of the saturated paste extracts of the soils in profile 1 and 4 of Bisidimo, Babile district were medium but SAR values were higher for irrigated cultivated land (profile 2 and 3) throughout the horizons which may induce soil dispersion and structural deterioration leading to infiltration problems [1]. The mean ESP of soils varied from 11.19 to 21.34% and showed a declining trend with increasing soil depth following the same trend as distribution of exchangeable Na; thus, soils near irrigated cultivated land (profile 2 and 3) of Bisidimo, Babile district had very high ESP (>15%) classified as sodic/saline sodic, while soils under profile 1 and 4 of Bisidimo, Babile district had lower ESP (<15%) values to qualify for saline soil [1]. The ESP was high at the surface horizons might be due to the capillary rise of the ground water during the dry season and evapotranspiration leaving the salts on the surface horizon continually. The SAR and ESP of the irrigated cultivated land soil surface (profile 2 and 3) were higher than that of non-cultivated land soil surface (profile1) and non-irrigated cultivated land soil surface (profile 4) and this could be because of irrigation water sources in the study area contained low to medium concentration of sufficient dissolved salts that could gradually increase salt in the soils profile under continuous irrigation.

The sodium adsorption ratio (SAR) and exchangeable sodium percentage (ESP) content of Adamitulu irrigated field during the study period showed significant variations at P<0.05 across the season and among treatments [18]. In addition, the average value of exchangeable sodium percentage (ESP) in WFD fields (9.8%) is lower than the value of exchangeable sodium percentage (ESP) in FP fields (14.3%) and this highlighted the importance of irrigation management to reduce the adverse effects of irrigation practices on soil quality in the area [18]. The values of ESP across the depth ranged from 3.74 to 11.27% and its higher value were observed in subsurface (30-60 cm) soil in groundwater irrigated fields and its values showed significant variation across the depth and source of water used, but the analysis revealed that the sodicity problem was more pronounced under the groundwater user's fields [18]. The sodium adsorption ratio (SAR) and exchangeable sodium percentage (ESP) values before planting soil surface showed increment from after harvesting irrigated soil surface values of SAR and ESP. This could be because of the value of SAR for the surface water irrigation was 7.56$(meq/L)^{0.5}$ and it was slight to moderate based on the degree of restriction on use for irrigation purpose whereas average SAR value groundwater of was 10.52$(meq/L)^{0.5}$ above permissible value and had a limitation on use for irrigation purpose. The SAR and ESP of after harvesting irrigated soil showed increment relative to its pre-planting irrigated soil and sodium level can deteriorate the soil physical properties. The average value of soil ESP under wetting front management was lower than the value of ESP in farmer's soil field management due to management options. The values of ESP were decreased in trend with increasing depth in the soil profile. This could be because of sodium salt leaching from soil surface in the bottom layer.

The sodium adsorption ratio (SAR) of the soil solution ranged from 0.39 to 4.05$(meq/L)^{0.5}$ for surface soils of Tumuga site and it was ranged from 0.57 to 6.72$(meq/L)^{0.5}$ at Gerjale site but, SAR of the soil profiles did not reveal any consistent trend in both sites [10]. The values of sodium adsorption ratio (SAR) and exchangeable sodium percentage (ESP) of irrigated soil implied that the soil was affected by sodicity hazard in some extent at some sampling spot of both irrigation sites and this could be due repeated use of irrigation water without proper management but irrigation water of the sites was within critical limit.

The change in soil ESP (p¼0.047) was statistically significant (at 95%) in the Wajifo irrigated soil, but were all insignificant in the rain-fed soil while the average soil SAR values at Algae, Wajifo, and Fura were within the FAO recommended range of 0 to nine [15]. The exchangeable sodium percentage (ESP) of Wajifo, Fura and Algae pre-and post-harvest irrigated soil and rain fed soil were low to cause soil structure deterioration, even though residual sodium carbonate (RSC) and sodium adsorption ratio (SAR) contents of irrigation water were high enough to increase sodium level to extent of soil sodicity hazard.

3.2.5. Effect of Irrigation Water Quality on Kelley's Ratio, Permeability Index (PI) and Soluble Sodium Percentage (SSP) of Soil

The average KRs for the soils at Algae and Fura both exceeded one, indicating soil sodium hazards but if a soil's KR is below one, it can be irrigated [15]. The value differences of SSP weren't statistically significant between pre- and post-harvest at Wajifo, Algae and Fura but, soil PI differences at Fura were statistically significant (95%) according to [15]. Variation between Kelly's ratio (KR) and soluble sodium percentage (SSP) content of pre-and post-harvest irrigated soil weren't observed but soluble sodium percentage (SSP) value was increased in post-harvest soil numerically at Algae and Fura relative its pre-harvest soil but Kelly's ratio (KR) and soluble sodium percentage (SSP) content Abaya Lake water were high enough to increase Kelly's ratio (KR) and soluble sodium percentage (SSP) content of post-harvest soil. Permeability Index (PI) content of post-harvest soil was increased relative its pre-harvest and this might be because of permeability index (90.91%) of Abaya Lake water.

3.2.6. Effect of Irrigation Water Quality on Soil Exchangeable Cations

The abundance of the basic exchangeable cations content of soil of Bisidimo, Babile district showed consistent trends with increasing depths and were in the order of Ca>Mg>Na>K in profile 1 and 4, while the order reversed to Ca>Na>Mg>K in profile 2 and 3 [1]. Accordingly, soils exchangeable Na content in irrigated cultivated land (profile 2 and 3) were higher than soils in profile 1 and 4 compared to the critical level that brings deterioration of soil structure and Na toxicity [1]. Toxic level concentration of exchangeable sodium (Na) could be due to continuous use of the irrigation water for crop production. The value of calcium (Ca^{2+}) to magnesium (Mg^{2+}) ratio of non-cultivated soil surface (soil profile1), irrigated cultivated soil surface (profile2), irrigated cultivated soil surface (profile3) and none irrigated cultivated soil surface (profile 4) were 4.04:1, 4.17:1, 4.077:1 and 3.77:1, respectively. The values of Ca^{2+} to Mg^{2+} ratio of irrigated cultivated soil surface (profile2) and irrigated cultivated soil surface (profile 3) and non-cultivated soil surface (profile1) were categorized under optimum or balanced ratio whereas that none irrigated cultivated soil surface (profile4) was categorized under below balanced Ca^{2+} to Mg^{2+} ratio. Placement of magnesium instead of sodium in Ca>Na>Mg>K in irrigated cultivated Land (profile 2&3) relative to normal order of exchangeable cation Ca>Mg>Na>K content of soil could be due to repeated use of groundwater with RSC (3.11>2.50meq/L) which could rise sodium extent of the soil by precipitating calcium and magnesium in carbonates form in the soil.

The values of Adamitulu irrigated field exchangeable bases (Ca^{2+}, Mg^{2+}, K^{+} and Na^{+}) were showed variations among treatments and exchangeable bases showed an increasing trend except Ca^{2+} compared to their initial values at the end of the growing season and this increment might be attributed due to differences in irrigation management implemented and water sources used and higher values for these parameters were observed in FP fields during the study periods [18]. Furthermore, the total exchangeable bases showed slightly increasing trend under groundwater irrigated fields, however, Mg^{2+} concentration gets high under surface water irrigated fields and paying attention to the implementation of certain irrigation water management practices is critical to maintaining soil fertility in the area in addition to consideration of groundwater quality to sustain agriculture in the area [18]. The Adamitulu before planting soil exchangeable calcium (Ca^{2+}) to magnesium (Mg^{2+}) ratio was 1.46:1 under farmer's practice with surface water and 2.23:1 under wetting front detector management with surface water irrigation whereas after Adamitulu harvesting soil surface values of exchangeable calcium (Ca^{2+}) to magnesium (Mg^{2+}) ratio of soil irrigated farmer's field with surface water was 1.48:1 under farmer's practice management and 2.95:1 under wetting front detector management and before planting values exchangeable calcium (Ca^{2+}) to magnesium (Mg^{2+}) ratio was 1.86:1 under farmer's practice with ground water and 1.62:1 under wetting front detector management with ground water irrigation whereas after harvesting values soil surface of Adamitulu exchangeable calcium (Ca^{2+}) to magnesium (Mg^{2+}) ratio of soil irrigated farmer's field with ground water irrigation was 2.69:1 under farmer's practice management and 3.13:1 under wetting front detector management with ground water. The Adamitulu soil surface exchangeable calcium (Ca^{2+}) to magnesium (Mg^{2+}) ratio of irrigation site was varied 1.46:1 to 3.13:1 and content of soil calcium was low relative magnesium and calcium availability to crops can be affected due to high level of magnesium. The Adamitulu soil surface exchangeable calcium (Ca^{2+}) to magnesium (Mg^{2+}) ratio was improved after irrigation under Adamitulu surface water and groundwater.

The exchangeable calcium (Ca) followed by exchangeable magnesium (Mg) were the dominant basic cations in the exchange complex of the surface and soil profiles for both sites of the Tumuga and Gerjale sites [10]. The magnitude of the soil exchangeable cations for both sites were in the order of Ca>Mg>Na>K at Tumuga site and Gerjale site but, both of the exchangeable bases in all sites of the soil profiles did not show consistent trend with increasing soil depth [10]. The exchangeable sodium (Na^{+}) was varied from moderate to very high and exchangeable potassium (K^{+}) was varied from very low to high at Tumuga irrigated soil surface and Gerjale irrigated soil surface content of exchangeable sodium (Na^{+}) was varied from low to very high and potassium (K^{+}) was varied from moderate to high. Exchangeable calcium (Ca^{2+}) and exchangeable magnesium (Mg^{2+}) were ranged from high to very high at both Tumuga and Gerjale irrigated soil surface.

3.2.7. Effect of Irrigation Water Quality on Organic Matter and Available Phosphorous

The highest OM content (4.9%) was observed at managed fields compared to unmanaged fields (3.1%) and the high value of (AP=30 ppm) was observed under WFD installed fields as compared to FP fields (AP=17 ppm) [18]. The OM and available phosphorous values in the Adamitulu field were significantly varied at $P<0.05$ among studied treatments and implied that treatment effects were noticeable and confirmed that irrigation management and water sources could influence soil quality [18]. In addition, the soil OM and AP showed a clearly observable increase in the case of groundwater user fields compared to surface water user fields [18]. The value of before planting soil organic matter (OM) was varied from 1.95% to 1.98% with surface water and it was under moderate range having average soil structural stability whereas after harvesting values of surface water irrigated soil organic matter (OM) was varied from 2.25% to 5.01% and categorized under moderate to high range having average to high soil structural stability. Before planting values of ground water irrigated soil of Adamitulu field content of organic matter (OM) was 1.52% to 1.88% which was in low to moderate range having average to high soil structural stability while after harvesting values of ground water irrigated soil organic matter (OM) was varied from 3.86% to 4.81% was in high range having high soil structural stability. The values of soil organic matter (OM) irrigated with both water sources were within acceptable range but, Adamitulu irrigated soil with ground water contained higher soil organic matter (OM) and available phosphorus relative to soil irrigated with surface water. This might be due to increment of organic matter in irrigated field could be due to micro-flora, micro-fauna and other particulates (biological oxygen demand) in groundwater that can be decomposed in soil after irrigation in addition to water sources and its management which can highly influence soil quality. The ground water irrigation improved soil fertility of soil organic matter (OM) and available phosphorus relative to surface water irrigation water.

The change in OC (p¼0.031) was statistically significant (at 95%) in the Wajifo irrigated soil, but insignificant in the rain-fed soil [15]. The change in soil OC between pre-and post-harvest weren't observed due to Abaya Lake irrigation water at Algae and Fura statistically, but variation in OC content between pre-and post-harvest irrigated soil and rain fed soil was observed statistically at Wajifo site only, but post-harvest OC (0.96% ±0.14%) content of irrigated soil was decreased relative its pre-harvest OC (1.50% ±0.09%) content of soil. This might be because of low content of other organic particulate (biological oxygen demand) that can be decomposed in the soil after irrigation.

3.2.8. Effect of Irrigation Water Quality on Soil Soluble Ions

Sulphate values were higher compared to others in both types of soil followed by chloride and bicarbonate and sulphate values are lower in HDW soil of Gergera watershed (12 to 23 mg/L) compared to pond-related soil of Gergera watershed (7.2 to 52.3 mg/L) and in both the cases no clear trend is observed with depth while, chloride also showed similar trend like sulphate indicating higher values for pond- associated soil (7 to 35 mg/L) compared to HDW associated soil (7 to 28 mg/L) and do not show any clear trend with depth; bicarbonate on the other hand showed downward decrease in soil profile in both HDW (nil to 0.9 mg/L) and pond-related soil (nil to 36.6 mg/L) [4]. This implies that sulphate and chloride salts were dominant in both HDW and pond water irrigated soil but salinity level of HDW water (0.57 to 1.358dS/m) more than pond water (0.15 to 0.695dS/m).

Soluble Na^+ and Ca^{2+} content of soil of Bisidimo, Babile district were the dominant cations, whereas Cl^- and $SO4^{2-}$ were the dominant anions in all profiles and anions gradually decreased with depth almost linearly in profiles one and four [1]. In addition, soluble Na^+ was the dominant cation followed by soluble Ca^{2+}, whereas soluble Mg^{2+} and K^+ were present in relatively lower concentrations in profiles 2 and 3, but Cl^- and $SO4^{2-}$ were dominant anions throughout the soil layers of these profiles [1]. Higher extent of soluble salts at the underlying horizons than the surface layers revealed that the leaching of the salts were dominant over that of the upward movement of salt groundwater. This indicates that sodium chloride, sodium sulphate, calcium sulphate and calcium chloride were dominant salt in irrigated cultivated land (profiles 2 and 3) and this could be because of repeated use of irrigation groundwater without management.

Ca^{2+} followed by Na^+> Mg^2 > K^+ in this order were dominant soluble cations and Cl^- = SO_4^{2-} followed by HCO_3^- were dominant among the anions in Tumuga surface soils while Na^+ followed by Ca^{2+}, Mg^{2+} and K^+ in this order were the dominant soluble cations and SO_4^{2-} = Cl^- or followed by Cl^- and HCO_3^- were dominant among the anions at Gerjale site [10]. This imply that calcium salts of bicarbonate, carbonate, chloride and sulphate were dominant followed salts of sodium chloride and sulphate in irrigated soil surface of Tumuga site whereas sodium salts of chloride and sulphate were dominant in irrigated soil surface of Gerjale site and sodium salts of chloride and sulphate were dominant in the soil profile depth due to leaching of water containing sodium salts of chloride and sulphate.

3.3. Quality of Applied Irrigation Water to Soil of Agriculture

The analysis determined the concentration of pH, EC, OC, CO_3^{2-}, HCO_3^-, Cl^-, K^+, Ca^{2+}, Mg^{2+}, Na^+, and B for irrigation water quality [18]. The pH, salinity (EC), sodium adsorption ratio (SAR), residual sodium carbonate (RSC), soluble sodium percentage (SSP) and Kelley's ratio (KR) of irrigation water quality were reviewed.

3.3.1. pH and Salinity (EC) of Irrigation Water

The electrical conductivity values for water (EC_w) from HDW ranged from 570 to 1358 with a mean value of 887 μS/cm and for pond at Gergera watershed EC ranged from 150 to 695 with a mean value of 441 μS/cm while, pH values vary from 7.7 to 7.9 for water from HDW at Gergera watershed and 6.7 to 8.3 from ponds [4]. No restriction to use HDW and pond water for irrigation for almost all crops and for almost all kinds of soils as no soil or cropping problems will rise [4]. The EC values indicate that HDW water was none-saline to moderate and pond water was none-saline whereas pH of both water sources was slightly alkaline to alkaline.

A six month result showed high values of pH occurred in May (9.88) and low value was obtained at March (8.80) while, the result found in June (9.12), July (9.23) and August (9.13) were decreasing, in fact this might be due to high flood during rainy season and results indicate that the value of pH increased after Beseka water blending point [12]. The EC value of blended (Awash and Beseka) irrigation water of the study area ranged from 1.606 to 2.97 dS/m while, maximum EC of Blended irrigation water obtained from treatment (T7,50%) was 2.97 dS/m and all Blended irrigation treatments were increased with increasing mixed ratio [12]. Furthermore, high values of EC occurred in August (2.16 dS/m) and low was obtained in April (1.90 dS/m) whereas the result found in March (2.60), May (1.92), June (1.98) and July (2.03) were decreasing; in terms of the degree of restriction on use, EC values of all treatments are categorized under slight to moderate in terms of salinity hazard [12]. Beseka lake water was responsible for increment of both pH and EC could be due its sodium salt content and alkalinity of calcium and magnesium salts content of lake water from its proportion.

The EC values of the ground water ranged from 0.57 to 0.61dS/m with mean value of 0.53 dS/m which was higher than the EC (0.35dS/m) values of Errer River and values were lower than permissible value and none saline [1].

The pH of the irrigation water varied from 7.59 to 8.82 and 7.60 to 8.48 at Tumuga and Gerjale sites, respectively while, electrical conductivity of irrigation water (EC_w) ranged from 0.13 to 0.34 dS/m at Tumuga and from 0.07 to 0.37 dS/m at Gerjale [10]. The irrigation water quality of the study area classified as slight to moderate and classified from low salinity hazard to medium salinity hazard with respect to EC. The EC of the water at both sites were categorized under none saline.

The values of pH and EC in the Adamitulu water sources ranged from 7.98 to 8.23 with 8.06 mean value and 0.48 to 2.73dS/m with 1.29dS/m mean value and the highest values in both cases were observed in groundwater samples and the use of groundwater for irrigation purposes is the most likely factor to influence soil quality compared to surface water [18]. The higher value of EC was observed in groundwater of Adamitulu relative to surface water irrigation and irrigation water the surface water was categorized under none saline water and whereas the ground water was categorized under slight to moderate.

The minimum and maximum values of EC for Lake Abaya water were within permissible range and it is classified as slight to moderate saline water (0.7 to 3.0 dS/m), which can be used for salt-tolerant crops [15]. Salinity level of Abaya lake water with respect to electrical conductivity was within permissible limit under proper management of irrigation water.

3.3.2. Residual Sodium Carbonate (RSC) and Sodium Adsorption Ratio (SAR) of Irrigation Water

SAR values for water from shallow hand dug well of Gergera watershed was from 0.09 to 0.55(meq/L) $^{0.5}$ and Gergera watershed pond water was ranged from 0.02 to 0.13(meq/L) $^{0.5}$ according to [4]. This indicates that the both water sources were suitable for irrigation Agriculture concerning degree of restriction on use.

Low value of SAR in T_1 was found to be 3.45 meq/L and maximum were obtained in T_7 (7.24) and the result indicated that rating of sodicity hazards based on SAR values for all Blended water treatments were medium hazards except treatment T_7 (50% ratio) water which was high sodium hazards [12]. In all irrigation treatments RSC values were above 2.5meq/L and very high at month of March during study season and the classification of different water samples for irrigation in the studied area indicate that all of the studied samples are above 2.5meq/L and classified as hazards [12]. Increasing concentration of SAR because of sodium salt content of Beseka lake water and increment of mixed water RSC was due to high concentration of calcium and magnesium content of lake water from its proportion.

The SAR values, both water sources (the ground water and Errer River water) classified under the low Na hazard and the RSC contents of the Errer River was range of 1.25 to 2.50meq/L with mean of 1.78meq/L which is considered to be marginal to be used for irrigation purpose while, the ground waters in profile 1, 2 and 3 contained 2.88, 3.31 and 3.13meq/L RSC contents, respectively [1]. RSC contents of the ground water sources were greater than 2.50meq/ L which was classified as unsafe for irrigation purposes. The mean residual sodium carbonate (RSC) content of the ground water irrigation was 3.11meq/L>2.50meq/L and Ground water irrigation was unsuitable for irrigation while average SAR value of Errer River water and Ground water irrigation were below critical limit based on the degree of restriction to use water sources for irrigation because of SAR the Errer River water and Ground water for irrigation were 2.96 and 3.29 (meq/L) $^{0.5}$.

The SAR value of irrigation water in the present study area ranged from 7.43 to 13.45 and surface water average SAR value=7.56(meq/L) $^{0.5}$. v is found within the limit and suitable for irrigation while, groundwater samples average SAR value =10.52(meq/L) $^{0.5}$ remains beyond this limit and have a limitation on use for irrigation purpose [18]. The value of RSC in the area was ranged from 0.99 to 10.82meq/L and the highest value for this parameter was observed in groundwater samples compared to surface water [18]. Residual sodium carbonate (RSC) value in groundwater samples was above limit and the use of it for an irrigation purpose could rise sodium level because the water contained a high carbonates that favors the precipitation of calcium and magnesium.

The sodium adsorption ration (SAR) of the irrigation water ranged from 0.19 to 4.95 at Tumuga and from 0.25 to 3.28 at Gerjale while, residual sodium carbonate (RSC) values of irrigation water ranged from trace to 3.09meq/L and 2.98 meq/L at Tumuga and Gerjale sites, respectively [10]. The concentration of Ca^{+2} and Mg^{+2} were higher in the irrigation water at both sites relative to Na^+ and trace values of RSC were due to non-presence of CO_3^{2-} in some irrigation water samples, but enough to encounter the effect of Na^+ hazard [10]. This indicates repeated use of irrigation water without proper management can deteriorate soil quality.

RSC of Lake Abaya water is unsafe as its RSC exceeds 2.5meq/L and the average SAR value of Lake Abaya irrigation water was 16.8$\pm$3.30 (meq/L)$^{0.5}$ [15]. The average SAR value was marginally above permissible value and had slight limitation suitability for irrigation purpose.

3.3.3. Kelly's Ratio, Permeability Index (PI) and Soluble Sodium Percentage (SSP) of Irrigation Water

The SSP and KR are widely used parameters for evaluating the suitability of water quality for irrigation because of excess sodium concentration in irrigation water produces undesirable effects on soil and crops, however, both surface and groundwater samples' values in the area were above the limit [18]. The permeability index (PI) is used to evaluate the effect of long term use of irrigation water on soil quality and PI content of water in the Adamitulu was varied from 87.47 to 97.16%. The Kelly's ratio (KR), permeability index (PI) and soluble sodium percentage (SSP) content of both water sources imply that use of both water sources for irrigation agriculture can affect soil structure and soil infiltration rate of water due to sodium increment [18].

Lake Abaya water's mean KR value was 6.3 ±1.2, implying that it wasn't suitable for irrigation because of excess sodium content and SSP value of Lake Abaya water exceeded the FAO recommended level for irrigation [15]. The soluble sodium percentage (SSP) >60% and it can increase sodium in soil to which can cause soil clay dispersion. The values of Kelly's ratio (KR), permeability index (PI) and soluble sodium percentage (SSP) content of the Lake Abaya irrigation water were above the limit. Irrigation water content with SSP> 60% and KR>1 can deteriorate soil physical properties by increasing sodium concentration in soil. The KR, PI and SSP content of lake water imply that use of lake water for irrigation agriculture can cause clogging of clay soil due to sodium.

4. Conclusion

The effects of irrigation water quality of on selected soil physicochemical properties were reviewed from research journals and articles papers. The irrigation water with above permissible values of salinity (EC), sodium adsorption ratio, residual sodium carbonate (RSC), soluble sodium percentage (SSP) and Kelley's ratio (KR), specific ion toxicity (CO_3^{2-}, HCO_3^- and Cl^-) affect soil physico-chemical properties. The soil salinity hazard is caused from above critical limit electrical conductivity (EC) or total dissolved solids (TDS) content of irrigation water. Soil sodicity hazard were caused when sodium adsorption ratio and residual sodium carbonate (RSC) content of irrigation water is marginal to above permissible value because of adsorption of sodium onto soil exchange complex sites from irrigation water used. Soil infiltration reduced due to sodium adsorption on soil exchange complex and interlayer space of soil from irrigation water containing high sodium adsorption ratio (SAR), residual sodium carbonate (RSC), soluble sodium percentage (SSP) and Kelley's ratio (KR). High sodium level results in dispersion of soil clay but SAR and RSC of irrigation water were mostly responsible to soil sodicity hazard based on reviewed papers. But, extent of infiltration rate of irrigation water into irrigable soil based on both sodium adsorption and salinity (EC) content of irrigation water quality. Even, repeated use of irrigation water containing medium to moderate sodium adsorption ratio (SAR), residual sodium carbonate (RSC) and salinity (EC) caused soil salinity and soil sodicity respectively if used without proper management.

The strength of reviewed papers is that irrigation water quality levels were assessed pre-planting crops to check its quality for irrigation, contained clear methods and obtained results were described with clear interpretations and sufficient discussions. The limitation of reviewed papers is that some of reviewed papers hadn't contained clear result of pre-planting soil physico-chemical properties.

Consequently, it can be concluded that excess concentration of salinity; sodium adsorption ratio (SAR) and residual sodium carbonate (RSC) from irrigation water deteriorate soil physico-chemical properties and reduce soil productivity extent whereas high calcium, magnesium and other organic particulate in irrigation water can improve soil fertility level in salt free soil. It is crucial to suggest that irrigation water quality should be monitored before planting crops intended to be planted to check and manage its extent of quality to minimize the impact it can cause on the soil physico-chemical properties and crops intended to be planted.

Abbreviations

FC	Filed Capacity
AWHC	Available Water Holding Capacity
PWP	Permanent Wilting Point
pHe	pH from Saturate Paste Extract
EC_e	Electrical Conductivity of Soil from Saturate Paste Extract
ECw	Electrical Conductivity of Irrigation Water
AP	Available Phosphorus
OM	Organic Matter
ESP	Exchangeable Sodium Percentage
SAR	Sodium Adsorption Ratio
RSC	Residual Sodium Carbonate
SSP	Soluble Sodium Percentage
PI	Permeability Index
KR	Kelley's Ratio
HDW	Hand Dug Well
FP	Farmer's Practices
WFD	Wetting Front Detector

Acknowledgments

This review article was prepared for the purpose of fulfilling requirement of academic course for Master of Science in soil science at Ambo University, Ethiopia and it was graded A- according to University's evaluation criteria. Primarily, thanks to almighty God because I am alive. I give deepest thanks to Nekemte Soil Research Center, Oromia Agricultural Research

Institute which gave me opportunity to study MSc in Soil Science at Ambo University and Ambo University which granted me scholarship opportunity through agreement and collaboration with Oromia Agricultural Research Institute. I give the deepest thanks to my Review Article Advisor Dr. Belay Yadeta Negara who advised me to prepare this Review Article. Thanks to scholars of department of Natural Resource Management, Guder Mamo Mezemir Campus, Ambo University for their counseling and guidance to prepare this review in the process of upgrading my education level in degree of Master of Science in Soil Science (MSc). Finally, thanks to families and friends who supported me when I prepared this Review directly and indirectly.

Author Contributions

Firaol Gemeda: Conceptualization, Formal Analysis, Visualization, Writing – original draft, Writing – review & editing

Belay Yadeta: Project administration, Supervision, Validation

Conflicts of Interest

The authors declare no conflicts of interest.

Appendix

Table 1. *Summary of above reviewed pH, EC, exchangeable cations, SAR and ESP of soils surface.*

Sites name specification		pHe	EC (dS/m)	Na^+ $cmol_{(+)}Kg$	Ca^{2+}	Mg^{2+}	SAR $(meq/L)^{0.5}$	ESP (%)
1	Profile1 (0-30cm)	7.7	5.52	5.56	24.9	6.16	6.69	14.55
	Profile2 (0-20cm)	8.47	4.46	8.67	26.2	6.28	13.41	20.39
	Profile3 (0-15cm)	8.35	4.68	8.97	25.4	6.23	16.64	21.49
	Profile4 (0-35cm)	7.76	5.12	5.23	24.4	6.48	7.68	13.85
2	Tumuga	8.29	0.34	0.98	25.33	9.1	2.35	1.75
	Gerjale	8.21	0.43	0.87	26.87	6.95	1.6	0.4
3	Tr-1:BP	8.05	0.56	3.85	26.55	11.86	2.53	11.29
	Tr-2:BP	7.99	0.47	2.63	22.64	15.56	1.82	8.31
	Tr-3:BP	8.07	0.48	2.79	22.65	13.96	2.63	7.92
	Tr-4:BP	8.71	0.63	5.54	19.75	10.62	5.31	13.19
	Ave. of:BP	8.2	0.54	3.7	22.9	13.09	3.1	10.18
4	Tr-1:AH	8.23	1.04	1.55	23.22	7.98	2.68	9.24
	Tr-2:AH	8.13	0.61	3.91	22.87	15.5	3.04	15.43
	Tr-3:AH	8.55	0.65	3.33	43.76	8.13	3.46	10.39
	Tr-4:AH	8.69	1.06	5.27	23.58	8.76	4.53	13.1
	Ave.:AH	8.4	0.84	3.51	28.36	10.09	2.93	11.04
	5: 0-30cm	7.86	0.63	2.98	29.92	9.89	2.75	7.92

Sources: [1, 10, 18]

1: Bisidimo Babile district soil surface, 2: Tumuga and Gerjale soil surface 3: Tumuga and Gerjale soil surface, 4: Adamitulu after planting soil surface and 5: Adamitulu irrigated farmer's field, Treatments (T1 to T8) represents mixing ratio of Awash river to Beseka Lake water, Adamitulu Pre-planting irrigated soil with surface water under farmer's practice (Tr-1:BP), Adamitulu after harvesting irrigated soil with surface water under farmer's practice (Tr-2:BP), Adamitulu pre-planting irrigated soil with groundwater under wetting front detector (Tr-3:BP), Adamitulu pre-planting irrigated soil with groundwater under farmer's practice (Tr-4:BP), Adamitulu after harvesting irrigated soil with surface water under wetting front detector (Tr-1:AH), Adamitulu after harvesting irrigated soil with surface water under farmer's practice (Tr-2:AH), Adamitulu after harvesting irrigated soil with groundwater under wetting front detector (Tr-3:AH) and Adamitulu after harvesting irrigated soil with groundwater under farmer's practice (Tr-4:AH).

Table 2. *Summary of above reviewed organic matter (OM) and available phosphorus (AP) content of irrigated soil surface.*

Irrigated soil code	OM (%)	AP (ppm)
Tr-1:BP	1.95	35.01
Tr-2:BP	1.98	17.35
Tr-3:BP	1.52	22.33
Tr-4:BP	1.88	30.96
Ave. of:BP	1.83	26.41
Tr-1:AH	5.01	30.99
Tr-2:AH	2.25	19.24
Tr-3:AH	4.81	29.65
Tr-4:AH	3.86	28.82
Ave.:AH	3.98	23.68

Sources: [18]

Table 3. *Summary of above reviewed soluble cations and soluble anions of soils surfaces.*

Sites specification		Na	K	Ca	Mg	HCO_3^-	CO_3^{2-}	Cl^-	SO_4^{2-}
		meq/L				meq/L			
1	Profile1 (0-30cm)	13.88	2.67	5.96	2.64	0.29	nil	11.2	9.8
	Profile2 (0-20cm)	25.45	1.09	5.72	1.48	0.86	nil	14.28	15.27
	Profile3 (0-15cm)	29.29	1.26	5.04	1.16	1.35	nil	17.35	17.84
	Profile4 (0-35cm)	12.96	2.31	4.37	1.32	0.4	nil	9.78	9.42
2	Tumuga	2.33	0.24	2.98	1.41	0.11	nil	0.14	0.14
	Gerjale	2.26	0.25	1.8	0.73	0.12	nil	0.13	0.17

Sources: [1, 10]
1: Bisidimo Babile district soil surface, 2: Tumuga and Gerjale soil surface.

Table 4. *Summary of reviewed Kelley's ratio, permeability index (PI) and soluble sodium percentage (SSP) of irrigation water.*

Water sources	KR	SSP (%)	PI (%)
Adamitulu Surface water	2.7	79.9	91.81
Adamitulu Groundwater	2.65	78.73	90.91
Abaya Lake water	6.3	96.70 ±1.20	85.50 ±2.10

Sources: [18, 15]

References

[1] Adane, A., Gebrekidan, H. and Kibret, K., 2019. Assessment of the pysicochemical status soils and irrigation water qualities in eastern Ethiopia. *Forest Res Eng Int J*, *3*(3), pp. 91-104.

[2] Aregahegn, Z. and Zerihun, M., 2021. Study on irrigation water quality in the rift valley areas of Awash River basin, Ethiopia. *Applied and Environmental Soil Science*, *2021*, pp. 1-20. https://doi.org/10.1155/2021/8844745

[3] Awulachew, S. B. and Ayana, M., 2011. Performance of irrigation: An assessment at different scales in Ethiopia. *Experimental agriculture*, *47*(S1), pp. 57-69. https://doi.org/10.1017/S0014479710000955

[4] Bekele, Y., Tadesse, N. and Konka, B., 2012. Preliminary study on the impact of water quality and irrigation practices on soil salinity and crop production, Gergera Watershed, Atsbi-Wonberta, Tigray, Northern Ethiopia. *Momona Ethiopian Journal of Science*, *4*(1), pp. 29-46.

[5] Belay, M. and Bewket, W., 2013. Traditional irrigation and water management practices in highland Ethiopia: Case study in Dangila woreda. *Irrigation and Drainage*, *62*(4), pp. 435-448. https://doi.org/10.1002/ird.1748

[6] Belic, S. I. M. A., Belic, A. N. D. E. L. K. A. and Vranesevic, M. I. L. I. C. A., 2013. Water quality as a limiting factor for irrigated agriculture. *Understanding Freshwater Quality Problems in a Changing World*, pp. 243-249.

[7] Borena, F. R. and Hassen, J. M., 2022. Impacts of Soil Salinity on Irrigation Potential: In the Case of Middle Awash, Ethiopian Review. *Open Access Library Journal*, *9*(4), pp. 1-18. https://doi.org/10.4236/oalib.1108123

[8] Chinasho, A., Bedadi, B., Lemma, T., Tana, T., Hordofa, T. and Elias, B., 2023. Quality assessment and evaluation of irrigation water and soil used for maize (Zea mays L.) production in Boloso Sore district, southern Ethiopia. *Heliyon*, *9*(6). https://doi.org/10.1016/j.heliyon.2023.e17299

[9] Fite, G., Abdenna, D. and Wakene, N., 2007. Influence of Small scale Irrigation on Selected Soil Chemical Properties, Tropentag 2007, October 9-11, 2007 Witzenhausen, Germany, pp: 15.

[10] Hailu, B., Wogi, L. and Tamiru, S., 2020. Salinity Status of Soils of Irrigated Lands and Irrigation Water Quality at Raya Alamata District, Northern Ethiopia. *Int. J. Res. Agric. Sci*, *7*, pp. 2348-3997.

[11] Kadyampakeni, D., Appoh, R., Barron, J. and Boakye-Acheampong, E., 2018. Analysis of water quality of selected irrigation water sources in northern Ghana. *Water Science and Technology: Water Supply*, *18*(4), pp. 1308-1317. https://doi.org/10.2166/ws.2017.195

[12] Kebede Hailu, E., Abate, B. and Hordofa, T., 2016. Effect of blended irrigation water quality on soil physico-chemical properties and cotton yield in Middle Awash Basin Ethiopia. *International Journal of Water Resources and Environmental Engineering*, *8*(1), pp. 1-10. https://doi.org/10.5897/IJWREE2015.0613

[13] Keraga, A. S., Kiflie, Z. and Engida, A. N., 2017. Evaluating water quality of Awash River using water quality index. *International Journal of Water Resources and Environmental Engineering*, *9*(11), pp. 243-253. https://doi.org/10.5897/IJWREE2017.0736

[14] Makombe, G., Namara, R., Hagos, F., Awulachew, S. B., Ayana, M. and Bossio, D., 2011. *A comparative analysis of the technical efficiency of rain-fed and smallholder irrigation in Ethiopia* (Vol. 143). *International Water Management Institute*. IWMI-Publication@cgiar.org

[15] Setegn, Y. A., Kassa, K., Dagalo, S. and Tsegaye, D., 2022. Impact of irrigation with Lake Abaya water on soil quality–southern Rift Valley, Ethiopia. *Water Practice & Technology*, *17*(7), pp. 1433-1444. https://doi.org/10.2166/wpt.2022.070

[16] Sheferia, B., Alem, M., Seid, A., 2021. Effect of Saline Water and Irrigation Interval on Soil Physicochemical Properties Adv. App sci res Vol. 12 No. 10. iMedPub Journals www.imedpub.com

[17] Tekile, A. K., 2023. Suitability assessment of surface water quality for irrigation: A case study of Modjo River, Ethiopia. *Journal of Environmental and Public Health*, *2023*. https://doi.org/10.1155/2023/1482229

[18] Wendemeneh, D., Ayana, M., Singh, P. and Haileslassie, A., 2020. Effect of on-farm water management practices and irrigation water source on soil quality in Central Ethiopia. *African Journal of Agricultural Research*, *16*(11), pp. 1481-1495. https://doi.org/10.5897/AJAR2020.14707

Biography

Firaol Gemeda has BSc degree in chemistry from Addis University, Ethiopia starting from June 6,2017. He joined Oromia Agricultural Research Institute at Nekemte soil Research Center in 2018 as Junior Soil Chemistry Researcher and worked at position of Junior Soil Chemistry Researcher until early 2021. Starting from early 2021 he worked at position of Assistant Researcher and Soil Testing Team Leader at Nekemte soil Research Center until he got master of science education in soil science in 2022 at Ambo University. Firaol Gemeda is doing his MSc Thesis research in 2024 at Ambo University.

Belay Yadeta is Assistant Professor and PhD holder in Water Resource Engineering at Ambo University, Ethiopia. Belay Yadeta is Dean of School of Natural Resource at Mamo Mezemur Campus, Ambo University.