Investigation on Salinity Problem of Efratana Gidim and Kewet Weredas

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Abstract

Among the methods of agricultural production intensification, irrigation is considered prominent. However, in order to harvest the virtues of irrigation sustainabley, the production system must be enhanced towards the potential use of resources maintaining it without causing waterlogging and salinization. Often times, irrigation is associated with salinization in many parts of the world. In North Shawa, Salinity problem has manifested itself to the extent that farmers are experiencing tremendous yield losses, especially on vegetable crops, and some farms had to be abandoned or farmers had to switch to producing more salt tolerant crops. Methodical approaches towards reclamation of these salt-affected soils and/or prevention of development of non-saline soils to saline or alkaline soils is very essential in transforming rainfall dependant traditional agriculture to sustainable irrigated agriculture. Soil and water qualities of Yellen and Jeweha areas were investigated to support the decision making process and to benchmark the problem of salinity. Soil profile and surface samples and temporal water samples were analyzed. Soil types in the study area were mainly black and brown. The samples from the black Vertisols of Garda were found to fall in the saline range while the samples from the brown soils were non saline. The lower layers of the excavated profile were saline showing the potential alkaline soil development. A wide area of salt affected soil as well as shallow ground water was found in Wacho. Most of irrigation sources fall in the high salinity class but were low sodicity and safe to marginal residual sodium carbonate content.

Key words: Cation exchange capacity, Electrical conductivity, exchangeable sodium percentage, soil profile

Introduction

Land is one of the basic resource bases of production in agriculture. While demand is increasing as a result of growing human and livestock population, the vital land resource is finite and there is a limit to its expansion. With growing claim for land from non-agricultural sectors, such as residence, industry and infrastructures, bringing new land under cultivation might not be feasible in the future. Accordingly, appropriate means to intensify agricultural production will spin around upon our efforts to manage the existing soil and water resources for maximum production.

It is known that, one method of intensification of agricultural production is through irrigation. However, irrigation should be managed well to derive the merits out. In order to harvest the virtues of irrigation sustainabley, the production system must be enhanced towards the potential use of resources maintaining it without causing waterlogging and salinization. Incorporation of water of any quality adds salts to the soil. In the long run this results in the accumulation of soluble salts which will cause salinity problems mainly in arid and semi arid regions.

Large amount of salt-affected areas are found worldwide in places where precipitation to evaporation ratios are 0.75 or less (Brady and Weil, 1999). In Australia, Africa, Latin America, and in the Near and the Middle East countries these soils are widely present. About 951 million hectares of land is affected world wide and 80.4 million hectare of it is shared by Africa (Abrol et al., 1988). Ethiopia is not an exception to the problem although irrigation is not widely developed compared to the potentially irrigable area. In fact it stands first in acreage of saline soil in Africa (Abrol et al., 1988). According to FAO (2005), Ethiopia has 10.61 million ha saline and 425,000 ha sodic land. The semi-arid and arid lowlands and valleys have major problems of salinity and alkalinity. Tamirie (no date) reported that 44 million ha is potentially susceptible to be salt affected. Out of the 44 million ha, 75 % have dominantly salinity problems, 18 % have combined salinity and alkalinity problems and 7 % have dominantly alkalinity problems.

According to Tamirie, out of the 170,000 ha under irrigation by state farms in Awash Valley and in Central Rift-Valley lake area, almost 10 % (11,000 ha) are feared to have been salinized and have already gone out of production. Likewise, in North Shawa, Salinity problem has manifested itself to the extent that farmers are experiencing tremendous yield losses, especially on vegetable crops, and some farms had to be abandoned or farmers had to switch to producing more salt tolerant crops. For example, in Efratana Gidim Wereda at Negesso Kebele, about twenty farmers lost their fields to salinity (Yonas, 2002).

Methodical approaches towards reclamation of these salt-affected soils and/or prevention of development of non-saline soils to saline or alkaline soils is very essential in transforming rainfall dependant traditional agriculture of the locality to sustainable irrigated agriculture. Assessing soil and water qualities for salinity and suggesting remedies are fundamental in management decision options. Therefore, this experiment was initiated to assess salinity status of water and soils of Yellen and Jeweha for future management or economic reclamation options.

Materials and methods

The study area is found at 10°5'32" N Latitude and 39°54'51" E Longitude at about 1197 meter above sea level average elevation within the Awash river basin in the East African Rift Plateau. This area is administered by two weredas, to be precise Kewet and Efratana Gidim. Yellen kebele belongs to Kewet while Jeweha is to Efratana Gidim. It is located at a distance of about 235 km to the north east of Addis Ababa. The annual average rainfall from 18 years record at Shewa Robit town was 1007.8 mm and the temperature ranges from 16.5 °C to 32 °C (Kewet Wereda Bureau of Agriculture, unpublished data). Koch *et al.*, (1990) reported that the annual evapotranspiration is 1517 mm.

The study area is one of the widely irrigated areas of North Shewa Zone having various springs, the river Jeweha and its tributary Sewer as sources of irrigation water. The area is mainly cropped with tef, sorghum, onion, maize and tobacco.

Soil and water samples were gathered to appraise the importance of salinity. Point surface soil samples were collected by auger sampling to the depth of 30 cm at 15 cm intervals from localities; Wacho, Negesso1, Negesso2, Goleguadisa, Garda, Godguadit, Abunu and Negesso Chaka within the study area. Water samples were taken from springs and rivers. Rivers were also monitored for temporal fluctuation in salt contents. A soil profile was opened at Wacho to a depth of 1.7 m to see the vertical distribution of salts. Samples were collected at 30 cm interval.

The soil samples were first air dried, ground and passed through 2 mm sieve to undergo the physical and chemical properties analyses. Texture was analyzed by the hydrometrical method. Soil bulk density was evaluated by taking core samples. Soil reaction (pH) was by pH meter. Electric conductivities were measured by compensating EC meter. Soil quality was assessed in terms of its electrical conductivity or the total dissolved solids

(TDS) of the saturated extract while water quality was assessed based on the salt content of the water sources. Irrigation water quality is primarily related to salinity and sodicity in terms of the total dissolved salts, the sodium adsorption ratio and residual sodium carbonate content. These criteria were used to assess the quality of the soil and irrigation water in the area. In this study the detailed profile soil and water investigation data were obtained from a similar thesis work [Yonas, 2006].

TDS content or the amount of soluble salts in the water is generally estimated by determining its electrical conductivity (ECw). Water salinity has four classes: C1, C2, C3 and C4 accounting for the low (0.1-0.25 dS m^{-1}), medium (0.25-0.75 dS m^{-1}), high (0.75-2.25 dS m^{-1}) and very high (> 2.25 dS m^{-1}) salinity levels (US salinity laboratory, 1954).
The sodium hazard of irrigation water is estimated by the sodium adsorption ratio, SAR. This is the proportion of sodium to the sum of calcium and magnesium in the water used for agriculture ($SAR = Na^{+}((Ca^{2+}+Mg^{2+})/2)^{-1/2}$). Water with SAR in the range 0 to 6 can generally be used on all soils with little problem of a sodium buildup. When SAR range from 6 to 9, chances for soil permeability problems are increased. Soils should be sampled and tested every 1 or 2 years to determine whether the water is causing a sodium increase (Hergert and Knudsen, 1997). The USSLS (1954) classify irrigation water into four sodium hazard classes as S1, S2, S3 and S4 to signify low, medium, high and very high hazard levels based on the amount of SAR content. The ranges in this system are <10, 10-18, 18-26 and > 26 for the low, medium, high and very high hazard levels respectively. High CO_3^{2-} and HCO_3^- tend to precipitate as calcium carbonate ($CaCO_3$) and magnesium carbonate ($MgCO_3$) thereby essentially increasing the sodium hazard of the water to a level greater than that indicated by the SAR (Gupta and Stewart, 1990).

The carbonate and bicarbonate hazard criterion is appraised by the residual sodium carbonate content ($RSC = ((HC_3O^- + CO_3^{=}) - (Ca^{2+} + Mg^{2+})))$. RSC of less than 1.25 meq lt^{-1} guaranty a safe irrigation water while amount exceeding 2.5 results in an unsafe situations. Amounts ranging in between the two extremes are marginal (USSLS, 1954).

Result and discussions

Soil type in the study area was mainly black and brown soil known by the local names Tikure Mererie and Boda Afer respectively. All the samples from the black Vertisols of Garda were found to fall in the saline range while the samples from the brown soils were non saline. In Goleguadisa though the soil was tikur mererie the soil was none saline except two of the samples collected. The soil in Negesso 1 was partly saline. A wide area of salt affected soil as well as shallow ground water was found in Wacho. As a result, it felt important to look in to the profiles and detailed physical and chemical composition assessment.

Table 1. Saturated extract chemical composition

Depth (cm)	pH	EC_e dS m^{-1}	Cations (meq/ 100 gm Soil)				Anions (meq/ 100 gm Soil)				BSP
			Na^+	K^+	Ca^{2+}	Mg^{2+}	Cl^-	SO_4^{2-}	CO_3^{2-}	HCO_3^-	
0-30	9.2	0.51	0.33	0.01	0.09	0.04	0.21	nil	nil	0.25	101
30-60	9.3	0.77	0.65	0.01	0.06	0.04	0.24	0.18	nil	0.33	100
60-90	9.2	1.49	2.45	0.01	0.06	0.04	0.75	0.97	nil	0.80	102
90-120	8.9	6.99	3.86	0.02	0.84	0.04	3.83	nil	nil	0.72	104

120

Table 2. Selected physical and chemical properties of the soil profile

Depth cm	Bulk Density gm cm^{-1}	Textural Class	pH 1:2.5 H_2O	EC 1:2.5 dS m^{-1}	Exchangeable Cations meq/ 100 gm Soil				CEC meq/ 100g Soil	ESP	BSP
					Na	K	Ca	Mg			
0-30	1.46	Clay	9.80	0.43	5.53	2.95	33.14	8.77	60.00	9.22	84
30-60	1.48	Clay	9.60	0.69	11.45	1.93	33.62	6.80	64.36	17.79	84
60-90	1.62	Clay	9.50	0.94	14.38	1.68	36.17	7.20	66.36	21.67	90
90-120	1.54	Clay	8.30	5.02	16.56	1.52	34.55	8.85	64.86	25.53	95
120-150	-	-	8.30	5.81	20.00	1.47	34.83	9.66	67.36	29.69	98

In the profile, the ECe buildup with depth increment dictated by the washing down of the ions by irrigation. ECe value abruptly increased beyond layer three (60 - 90 cm). Sodium was still the dominant soluble cation followed by Ca^{2+}, Mg^{2+} and potassium. Soluble SO_4^{2+} dominated the top three layers while the last two layers were Cl^- conquered, from the anion point of view.

Calcium was the leading ion in the exchange complex in this profile. Sodium followed Ca, except in the first layer. Soil pH of the extract was also high. The ESP increased down the layers. Looking the salt distribution in the layers it could be said that salt mobilization may have resulted from irrigation. However, the fact that this profile had black, highly clayey and deep soil which indicates failure of soil structure, there is high probability that salinization was from below and reoriented by irrigation water.

Irrigation Water Quality Characterization

Irrigation water sources were also analyzed to asses their contribution in the salinization process. Irrigation water quality is primarily related to salinity and sodicity in terms of the total dissolved salts, the sodium adsorption ratio and residual sodium carbonate content. These criteria were used to assess the quality of irrigation water in the area.

It was observed that the pH in the investigated water samples was high. This is because of the presence of alkali ions mainly bicarbonates (Table 3). An increase in alkalinity is accompanied by an increase in pH (Gupta and

Abrol, 1990). Majority of electrical conductivities of the samples were also high. Therefore, most of these samples contained appreciably high concentration of dissolved salts sufficient enough to change salt free soils into saline and sodic conditions up on the continued uses of these water sources for irrigation. The dominant soluble cation in the irrigation waters was Na^{+} while the dominant anions were HCO_3^{-} and SO_4^{2-}.

Table 3. Soluble chemical characteristics of irrigation water

Site location	pH	E.C dS m^{-1}	Cations (meq/lt)				Anions (meq/lt)			
			Ca^{2+}	Mg^{2+}	K^{+}	Na^{+}	Cl^{-}	SO_4^{2-}	CO_3^{2-}	HCO_3^{-}
Ambo Spring	8.8	1.06	1.17	1.83	0.15	7.78	1.44	2.00	1.40	5.40

Table 4. Salinity hazard classes of investigated irrigation water

Site location	SAR	RSC	Salinity Class	Sodicity Class	RSC Class
Ambo Spring	6.35	3.79	High (C3)	Low (S1)	Marginal
Bira Boy Minch	3.73	2.83	High (C3)	Low (S1)	Marginal
Tkure Diversion	3.13	-0.76	High (C3)	Low (S1)	Safe
Tkure Water Well	2.02	-10.9	High (C3)	Low (S1)	Safe
Kuribri at Monopol	1.05	0.78	Low (C1)	Low (S1)	Safe
Ground water Dug	15.16	-4.54	Very High (C4)	Medium (S2)	Safe
Eddo Chekecheq	1.66	1.45	Medium (C2)	Low (S1)	Marginal
Sewer Wenz	5.15	0.56	High (C3)	Low (S1)	Safe

All irrigation water sources investigated were found to be non-sodic (table 4). Nonetheless, with regard to residual sodium carbonates criteria of the USSLS (1954) classification, 61 percent (RSC < 1.25 meq lt^{-1}) were safe for irrigating crops while 39 percent (RSC between 1.25 and 2.5 meq lt^{-1}) were marginally acceptable. It has been mentioned that the majority of irrigation water in this area were derived from springs. Besides, these springs were concentrated in and near Wacho village. Therefore, application of these saline spring waters without caution for irrigation in the traditional and modern irrigation schemes installed with poor drainage facilities must have contributed to the development of saline soils in the study area.

River water was monitored at four locations in the main Jeweha and tributary Sewer rivers namely Asmak, Balchi, Jeweha and Sewer. Observed seasonal fluctuation trends show, electrical conductivities of river waters in the wet regime were lower than the dry regime. The main rainy season, *Meher* (*Hamle and Nehase*), and the minor rainy season, *Belg* (*Tir*) had the smallest electrical conductivities while the rest had relatively higher salt contents in terms of electrical conductivity (Figure 1). The reason for this could be due to the dilution effect of non-saline surface run off during the wet seasons.

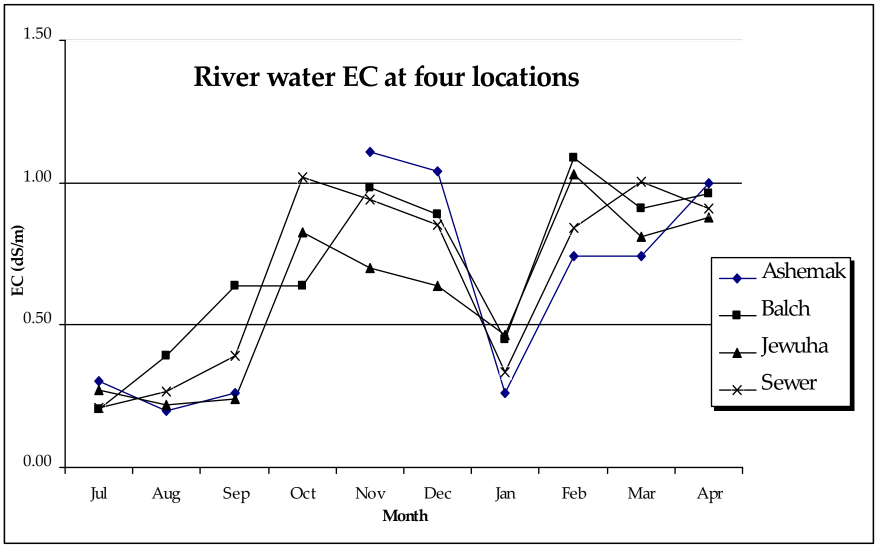

Figure 1. Electrical conductivity fluctuations with time

Conclusion and Recommendation

This study confirmed the importance of salinity and sodicity hazards of the district. Point soil sample tests indicated that there was salinity problem in a substantial coverage. As a result, salinity in overall has emerged as a threat for irrigation development. It was possible to investigate that majority of irrigation source springs were saline.

However, the salinity problem in the area can easily be avoided by leaching reclamation. Education and demonstrations can increase farmers' awareness and adoption of preventive measures than seeking cure after serious problem (sodicity) emanates. Moreover, further investigations and researches in the area of leaching requirement for the locality should be done.

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