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Irrigation water quality of middle awash river basin, Ethiopia

Abstract

The Awash River acts as a major natural drain for several tributaries and hot springs along its course, and it is the main source of irrigation water in Middle Awash Valley. Hence, evaluation of irrigation water quality through time and space could help for salinity control. Two diversion weirs: Metehara and Melka Sadi and two pump sites: Melka Werer andAmbash were sampling sites. Water quality evaluation was caried for seven years. The pH value did not changeover years. However, it slightly increased from July-September. ECw value was higher in June than the rest of sampling months. The ECw value from upstream to downstream ranged from 0.25-0.52dS/m. All samples collected from all sites showed values below FAO water quality guidelines for restriction. Thus, no salinity related or cropping problem should be expected because of using the Awash River water for irrigation. The ECw of Awash River water was lower during the rainy season than dry months. Which its water quality was inversely related to its flow. The combined effect of ECw and sodicity values on permeability or infiltration rate was in the recommendable range. However, in the draught years of June month care must be taken in down streams. Particularly, for more sensitive crops to salinity. Specific-ion toxicity hazardous was non-existent in using irrigation water from Awash River. Sodium significantly correlates with ECw and Adj.RNa rather the rest of cations. Sedimentation and siltation in the Middle Awash Valley is becoming great concern for maintenance of canal riverbank and drain to most projects in rainy seasons utilizing it for irrigation and other uses.

Keywords: irrigation water quality, river basin, salinity, soluble salts

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Introduction

The main source of irrigation water in Middle Awash Valley is the Awash River (Figure 1), which starts from central highlands of Ethiopia. It acts as a major natural drain for several tributaries and hot springs all along its course.[1] Its water quality may vary from upstream to downstream in space and time. Therefore, the quality of Awash River for irrigation should be evaluated monthly or yearly. All irrigation water contains dissolved salts, but the concentration and composition of dissolved salts varies depending on the water source and also may vary at different times in the growing season. It is therefore, important to know the concentration and composition of irrigation water at various times of the year so that sound irrigation management decisions could be made.[2] The major solute comprising dissolved salts are the cations and anions. Water quality related problem in irrigated agriculture are salinity, sodicity and specific-ion toxicity.[3,4] As the salinity of the soil water increases the water and those nutrients in the root becomes less, available to the plant.[5]

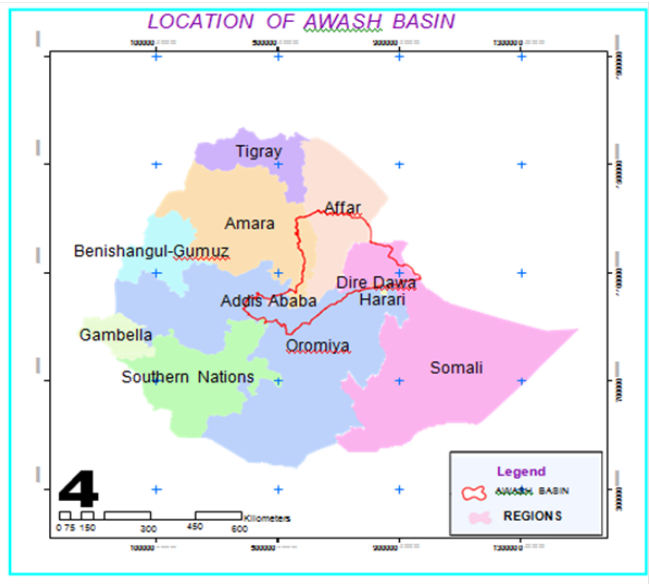

Figure 1 Awash River basin.

The two most common water quality factors that influence the normal infiltration rate are the salinity of the water and its sodium content relative to the calcium and magnesium concentration. Their relationship can be expressed in Adj.RNa. Toxicity to the normal plant development may arise from excess of chloride, boron and sodium ions concentration in the irrigation water.[6] Damage results when potential toxic element is absorbed in significant amounts with water taken up by the plant roots. Hence, the primary objective of this work was to evaluate any change of the quality of Awash River for irrigation. Secondly, to evaluate the Awash River water for irrigation within various years.

Materials and methods

There were four sampling sites along the Awash River. They were comprised of two diversion weirs (Methara and Melka Sadi) and two pumping site (Melka Werer and Ambash). The elevation of the sampling site varied from 500m to 1250m above sea level from down to upstream (Figures 2A&B). About one liter of water sample was collected in a plastic bottle from January 1989 to December 1995. The water quality analysis includes pH, electrical conductivity, soluble, cations and anions, except sulphate. Sediment load was also measured in all samplingsites.

The total salt concentration is measured by electrical conductivity (EC) Meter JENWAY model 4010 and expressed as decisiemns per meter at 25°C(dS/m). Sodium and potassium were determined by a model PFP.7 flame photomers. Magnesium and calcium were determined volumetrically titrating with ethylene diaminetetra acetic acid (EDTA). Carbonate, bicarbonate, and chloride anions were also analyzed by titration using standard solutions of sulfuric acid and silver nitrate. All analytical works followed standard procedure as outlined by USSL-Staff [7] and adjusted sodium adsorption ratio as Adj.RNa was computed by equation 1.[8]

$$SAR \equiv \frac{[Na^{+}]}{\sqrt{\frac{[Ca^{2+}]+[Mg^{2+}]}{2}}}$$

Where, Na=Sodium in the irrigation water reported in me/l Ca_x=a modified calcium value in me/l. Ca_x represents Ca in the applied irrigation water but modified due to salinity of the applied water (ECw), its HCO_3/Ca ratio (HCO_3) and Ca in me/land the estimated as partial pressure of CO_2=0.0007atmosphere). Mg=Magnesium (in the irrigation water reported in me/l).

Figure 2A Upper, middle and lower Awash River valley.

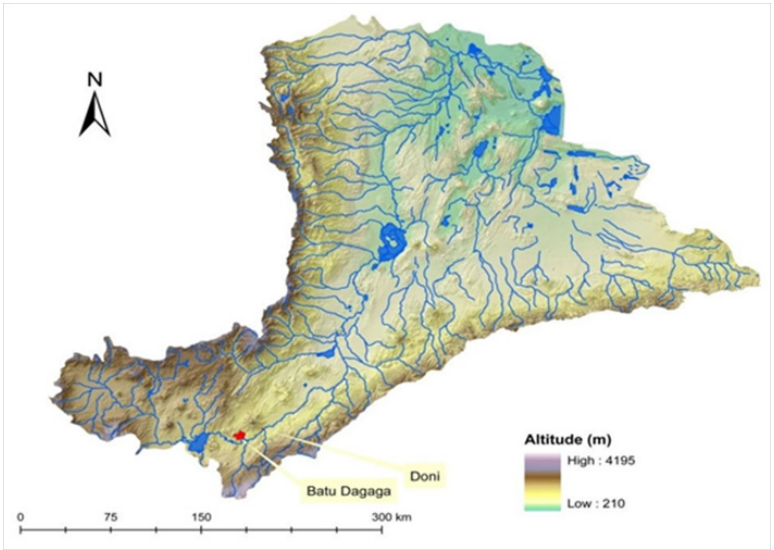

Figure 2B Elevation of Awash River basin.

Results and discussion

Total salt concentration of irrigation water is the single most important criterion of salinity evaluation. Because it is highly related to the salt concentration of the soil which is used as a measure of influence on plants.[2,4,9] In agreement with that, the total salt concentration in Awash River water was expressed in ECw(dS/m). In general, the ECw ranged from 0.20 to 0.40dS/m during the month of the year (Table 1). In addition to that, the Awash River did not show significant change in the electrical conductivity over years and sites. The highest Ecw was recorded in June. Usually, the flow of Awash River is low in June. Thus, the water quality of the Awash River was inversely related to flow of the river (Table 2). Due to run off in the rainy period's dilution effect of total salt concentration was low. In contrast, to the Awash River the salt content in WabiShebelle River waters of Ethiopia directly increases, with its flow.[10] because, during the heavy rainy period run off dissolves easily soluble salts from the surrounding Ogden plateau of Marine Origin. Nevertheless, the Ecw in the Awash River was comparatively low when big rain falls in the catchment that is July, August and September. As a result, the lowest ECw was recorded in October low.

Table 1 Mean monthly irrigation water quality

Month	pH	EC dS/m	Adj.RNa
January	8	0.31	2.73
February	7.7	0.3	1.36
March	7.5	0.3	1.15
April	7.7	0.36	1.58
May	7.6	0.33	1.96
June	8	0.4	2.55
July	8.1	0.35	1.63
August	7.7	0.24	1.25
September	7.8	0.23	0.65
October	8	0.2	1.26
November	8.2	0.3	0.29
December	7.7	0.34	0.57

Table 2 Mean monthly ground water depth and salinity* to the ground surface from different piezometer at Melka Sadi farm and Awash River water discharge

Month	Ground water	Ground water	Awash river
	Depth	Salinity	discharge
	(m)	(dS/m)	(m^3/Sec)
January	3.57Oab	9.593ab	53.90cde
February	3.83Oa	9.837ab	76.46bc
March	3.623ab	10.17a	70.62hcd
April	3.453abc	9.713ab	94.73b
May	3.533 ab	9.540abc	61.05cde
June	3.000abcd	9.623ab	58.62cde
July	2.83/bcd	10.12a	69.40cd
August	2.493d	8.200abc	233.70a
September	2.907cd	8.717abc	229.50a
October	2.540d	7.873bc	94.92b
November	2.867bcd	8.310abc	50.51de
December	3.273abcd	7.580c	39.56e
LSDO.05	0.87	1.972	47.14

NB: Data followed with the same latter is not statistically significant;

* =abandoned fields for several years.

At Melka Werer and Ambash sampling site ECw was high as compared to upstream sites (Table 3). In June, the river flow is very low and Feleweha hot spring joins the Awash River right after Melka Sedi Sampling Site with high content of electrolyte (Table 4). In effect, the ECw at this site was always higher than the other sampling sites. However, the water samples collected from all sampling sites were below the FAO water quality guidelines.[3] Provided that, no salinity related or cropping problem could be expected in using the Awash River for irrigation. Prolonged use of irrigation water from Awash River in June in drier years may cause salinity related problems only to sensitive crops.

Several authors[8,11,12] indicated that normal infiltration rate could be affected by salinity of the water and sodicity or very high sodium content over to the calcium and magnesium content. Irrigation water with very high sodium content and low salinity disperses soil aggregate and fine particles by reducing soil pore spaces, which decreases soil infiltration rate. Low salinity of irrigation water less than 0.2dS/m is corrosive and tends to leach soluble calcium and other minerals from surface soil by reducing aggregate stability and soil structure. The combined effect of salinity and sodicity (Adj.RNa) values on soil permeability was on the recommendable range (Table 5). Concentration of soluble cations and anions was low from July to September as compared to the rest

of the months. Potassium concentration was very low and did not show any significant differences over years and sampling sites. In general, concentration of soluble cations and anions in Awash River water of the Middle Awash Valley could be formulated as Na>Ca>Mg>K and $Cl>SO_4>HCO_3>CO_3$. Mass[5] showed that the most common toxic ions to plants in irrigation water are Boron (B), Na, and Cl. Accumulation of excess of these elements may cause necrosis (dead plant tissue) only to sensitive crops. Toxicity problem differs from salinity that it can easily be taken up by plant from soil-water or leached down from soil. Thus, specific-ion toxicity hazards are non-existent in using irrigation water from the Awash River at Middle Awash Valley. Table 4 showed that the Cations and anions were significantly correlated with EC and Adj.RNa.

Table 3 Mean value of soluble cations anions and Adj.RNa of different months*

Soluble cations and anions (me/l)							
Month	**HCO_3^-**	**Cl^-**	**Na^+**	**K^+**	**Ca^{++}**	**Mg^{++}**	**Adj.RNa**
Jan	3.25	1.27	2.47	0.18	1.36	0.65	3.06
Feb	3.2	1	3.06	0.18	1.53	0.58	2.83
Mar	3.23	1.69	2.83	0.22	1.66	0.65	3.04
April	3.22	1.3	2.42	0.19	1.43	0.64	2.41
May	3.38	1.02	2.89	0.26	1.34	0.55	3.25
June	4.01	1.34	3.15	0.28	1.38	0.59	3.61
Jul	4.69	1.12	2.12	0.24	1.16	0.49	2.58
Aug	2.97	0.49	1.21	0.15	1.07	0.45	1.45
Sept	2.35	0.81	1.55	0.16	1.35	0.47	1.78
Oct	2.76	0.16	1.97	0.21	1.29	0.45	2.19
Nov	2.94	1.34	1.71	0.16	1.31	0.61	2.01
Dec	2.92	1.3	2.18	0.17	1.35	0.56	2.54

*=Mean of seven years

Table 4 Mean value of soluble cations, anions and adj.RNa at different sites of awash River*

Soluble cations and anions (me/l)								
Site	**HCO_3^-**	**Cl^-**	**Na^+**	**K^+**	**Ca^{++}**	**Mg^{++}**	**Adj.RNa**	**EC^+**
Metahara	2.63	0.68	1.66	0.17	1.9	0.51	2.05	0.25
Melka Sadi	2.79	0.8	1.74	0.2	1.31	0.51	1.93	0.35
Werer	2.44	1.09	2.56	0.2	1.34	0.57	2.67	0.4
Ambash	3.53	1.1	2.58	0.19	1.33	0.54	2.93	0.5
Drainage Sink(Ambash)	3.55	2.82	2.95	0.26	1.53	0.61	3.24	0.52

*=seven years average and +=dS/m.

Table 5 Regression relationship between major irrigation water quality components in different locations

Site	Regression	r
Metahara	Na=9.1ECw-0.82	0.87
	Na=1.3adj.RNa-0.31	0.99
Melka Sadi	Na=7.7ECw-0.48	0.82
	Na=1.2 adj.RNa+0.2	0.98
Melka Werer	Na=9.9ECw=1.2	0.9
	Na=1.17adj.RNa-0.23	0.96
	Ca=0.84ECw-1.01	0.98
Ambash	Na=9.3ECw-0.71	0.83
	Na=1.2adj.RNa-0.2	0.69

Conclusion

Salinity and sodicity increases from upstream to downstream. Values of salinity and combined effect salinity and sodicity levels were below the FAO guidelines for water quality restriction limit. Thus, no salinity problem could be expected in using Awash River water for irrigation in Middle Awash area. However, in June care must be taken for sensitive crops. Specific-ion toxicity hazardous was non-existent in utilizing Awash River water for irrigation.

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None.

Conflicts of interest

The authors declare that there are no conflicts of interest.

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