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Irrigation Water Quality Index and GIS Approach based Groundwater Quality Assessment and Evaluation for Irrigation Purpose in Ganta Afshum Selected Kebeles, Northern Ethiopia

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Abstract
The research has conducted over a total areal coverage of about 38.94km^2 which covers all the well fields which are serving the irrigating land and supporting the food security at house hold level. The area is located in the Ganfa Afishum Wereda which includes two kebeles in the Eastern Tigrai, Northern Ethiopia. This paper assesses the groundwater quality and evaluates its quality for irrigation purpose with GIS technology and Irrigation Water Quality Index approach and compare with irrigation water quality standards. The status of the groundwater in the area varies widely depending up on the human activities. A total of 22 (13, 4, 4 and 1 from Bore hole, shallow wells, 4 handug well and reservoirs respectively), Depth integrated groundwater samples were collected by purpose sampling technique. These samples were analyzed for their Physico- chemical components. The groundwater was evaluated by nine chemical parameters (EC, SAR, Na^+, Ci^-, $NO3^{-2}$, pH,TDS, SSP, HCO_3^- and IWQI) and five water quality parameters (EC, SAR, Na^+, Ci^-, and HCO_3^-) were utilized to calculate the irrigation water quality index. The groundwater is suitable for irrigation purpose with respect to pH, EC, Na^+, Ci^- , $NO3^{-2}$, SSP and SAR but, with TDS and HCO_3^-, the groundwater needs slight water treatment for quality adjustment. The ionic concentration and the chemical parameters, generally is high near the town in all side of the area but, it is also significant in highly cultivated agricultural fields where point and non sources. The groundwater in the area is classified as moderate restriction (90.1%) and high restriction (8.9%). The groundwater is suitable generally with some moderate restrictions. The objectionable groundwater is restricted around the town with main of contaminants domestic and factories wastes.

Keywords: *Groundwater; Irrigation; GIS; suitability; Irrigation water quality index.*

Introduction

As compared to surface water resources, Ethiopia has lower groundwater potential but, the total exploitable groundwater potential is high. Based on the scantly knowledge available on groundwater resources, the potential is estimated to be about 2.6 Billion Meter Cube annually rechargeable resources (MoWR, 1999).

The main economic means of Tigrai region, located in the northern part of the country, is rain fed agriculture. The rainfall is erratic and unreliable. The topography of the area is undulating. Thus with the traditional agricultural practices, natural resources are severely degraded due human as well as natural devastation ;the level of land productivity is declined at alarming rate. As a result, because of moisture limitation and the above reasons, the region is not in a position to cover the annual food requirement of the people.

To alleviate the challenges of food insecurity in the country, promotion of irrigated agriculture was given priority in the strategy of the Nations (Mekuria, 2003). According to Abraham et al. (2005), irrigation is one of the methods used to increase food production in arid and semi-arid regions.

Groundwater utilization was considered a potential option next to surface water harvesting operations. Groundwater as one positive feature, utilization for irrigation, has its own contribution in attaining food security at the household level. As a result hand dug and shallow well construction and utilization is practiced in the region by association as well as by individuals in the processes of food security attaining at the households in sustainable basis. Implementation of this technology does not need high investment and skill work force to commence and a household can easily practice. However, the issue of sustainability regarding quality and quantity wise required addressing in the premature commencement.

Availability of water by itself is not a guaranteed for sustainable development, but it fits specific purposes like irrigation uses in respect of both quantity and quality. Knowledge of irrigation water is critical to understanding what management changes are necessary for long-term productivity (Bohn et al., 1985; Fassil, 1999; Brady et al., 2000). Besides these, irrigated agricultural crops need very good quality water (FAO, 1985). Determination of water quality is the most important aspect to determine its suitability to grow crop. But, in the area, the people do not know which crop should be chosen per of the groundwater quality. Due to this reason, they do not produce as what is required per a year. Beside to its dynamism nature, groundwater resources can also by some factors including expansion of irrigation activities, industrialization and urbanization. As a result it should be managing and mentoring. Evaluation water quality implies the determination of its physical, chemical and biological parameters with respect to particular purpose. According to Sargonkar and Deshpande, 2003; and Khan et al., 2003, assuring the water quality is mandatory prior to its application for different uses including drinking; agricultural recreational and industrial.

Water quality index provides a single number that expresses overall water quality assessment at certain location and time based on several water quality parameters. The objective of an index is to turn complex water quality data into information that is understandable and useable by the public, a single number cannot tell the whole story of water quality; there are many other water quality parameters that are not included in the index. However, a water quality index based on some very important parameters can provide a simple indicator of water quality (Yogendra and Puttaiah, 2008).

In very recent, mapping of groundwater quality become one of the best approach which provide the information about the suitability of the water for irrigation purpose. Water Quality Index (WQI) is a very useful and efficient method for evaluate the suitability of water quality and for communicating the information on overall quality of water (Hu, K., Y. Huang, etal 2005). Although Water Quality Index (WQI) is usually orientated to qualify urban water supply, it has been widely used by environmental planning decision makers. The quality of the irrigation water has to be evaluated to avoid or, at least, to minimize impacts on agriculture (Mohammed, 2011). The integration of the geographic information system (GIS) platform to the assessment procedure not only allows the decision maker to create parameter maps for easy visual interpretation but also makes the overall analysis more sound, objective and simple (Waqed Hameed, 2014) .

Location

The study area is part of the Ganta Afshum Wereda surrounding the Adigrat town which is located in Tigray Regional State. It is located towards Northern part of Ethiopia (Figure 1).

Geographically it bounded between 547165 to 553246m latitude and 1574517 to 1583969m longitude. It covers all the well fields which are serving both the community of the town as well as University with a total areal coverage about 38.94km^2.

Material and equipments used

The following material and equipments were used during the research work:

- GPS, Plastic bottle, Ice box, Plaster(scotch), Permanent marker
- EC, pH and TDS meter
- ASS, UV and Titrometric materials and chemicals

Methodology

Sample Collection

For chemical and ionic constituents, purpose sampling technique was applied to collect 22 samples with one litter amount from different water points (Figure 2) and transported to the laboratory (Mekelle university) and conducting the analysis with a week from the date of data collection to avoid possible contamination. For this purpose five, four, twelve, and one sample from handug, shallow, deep well and collecting chamber respectively were taken by applying depth integrated groundwater sampling.

Sample Analysis

Analysis of 22 groundwater samples for the major and minor ions (Na^+, K^+, Ca^{2+} and Mg^{2+},) and anions (Cl, NO3, HCO3, SO_4^{2-} and $PO4^{2-}$ and other chemical parameters (total hardness, hardness, Alkalinity, SAR and SSP have also determined using standard empirical formulas. Beside this, measurements of pH, EC, TDS were done. The accuracy of the analysis results were checked by two option methods which are duplicated method and The Electro Neutrality analysis methods. The duplicated run method was applied during the analysis period at a random check points and the difference between the two run was with insignificant value.

The Electro Neutrality analysis methods was done using the equation (Matthess, 1982), which is the balance between cations and anions. It has observed that most of the samples revealed ion balance error value less than 5 %.

The Sodium absorption ratio (SAR) of individual sample was determined using:

$$SAR = \frac{[Na^+]}{\sqrt{\frac{1}{2}([Ca^{2+}]+[Mg^{2+}])}} \text{ -------------- (3)}$$

Where the soluble sodium percent (SSP) was calculated using Doneen LD (1964:

$(K^+ + Na^+)$ X 100[/ $(Ca^{2+} + Mg^{2+} + Na^{1+} + K^{1+}]$… (4) Where all the cations are in meq/l.

The descriptive Statistics of the chemical parameters are organized (Table 8)

Irrigation Water Quality Index (IWQI) Determination

Calculating of water quality index is to turn complex water quality data into information that is understandable and useable by the public. Therefore, water Quality Index (WQI) is a very useful and efficient method which can provide a simple indicator of water quality and it is based on some very important parameters. In the current research, the IWQI model which was developed by Meireles et al, 2010, has used based on the laboratory analysis result of the twenty two samples taken from the study area. The IWQI model was applied through the following two consecutive procedures.

First step: identifying the parameters which can play a great role in the irrigation water quality variation which are also important to produce the model were adopted (EC, Na^+, Ci^-, and $HCO_3^-$and SAR) and Water quality is defined in a better way based on the motioned fractional load parameters. In the second step, the water quality measurement parameter value (Q_i) and the accumulation witness (W_i). The water quality measurement parameter value (Q_i), was determined depending on individual parameter values taking in to account the criteria which were proposed by Ayers and Wescot,1999 (Table 3), representing non dimensional number where the lower value indicates the poor quality water and vice verse. The value of Q_i was calculated using the following equations:

Q_i=Q_{ima}x-[(X_{ij}-X_{inf})*Q_{iamp})/X_{amp}------(1)

Where: Q_i is the maximum value of Q_i for the category (Table3); X_{ij} is the observed value of each parameter X_{inf} is the corresponding value to the lower limit of the class to which the parameter belongs; Q_{iamp} is class amplitude; X_{amp} is class amplitude to which the parameter belongs where the upper most border was take as a maximal value obtained in the physico-chemical and chemical examination of water samples to determine this value for the final category of individual parameters. The accumulation weight of individual parameters used to in the IWQI determination was adopted from Meireles et al., 2010 (Table5) where its value is normalized and the summation is equals to one. Finally, the irrigation water quality index (IWQI) was determined as:

IWQI= $\sum_{i=1}^{n}$ QiWi------------ (2)

Where IWQI is none dimensional Irrigation water quality index from 0to 100); Qi is quality the of ith parameter form (0 to 100) and is a function of its measurement or concentration; *wi* is the normalized weight of the ith parameter, function of importance in explaining the global variability in water quality. Division in classes based on the proposed water quality index was based on existing water quality indexes, and classes were defined considering the risk of salinity problems, soil water infiltration reduction, as well as toxicity to plants as observed in the classification presented by Bernardo (1995) and Holanda and Amorim (1997). Restriction to water use classes were characterized based on Meireles et al., 2010 (Table 5).

Further, the analytical results were taken in to GIS environment to generate the numerical spatial distribution of the parameter and IDW (Inverse Distance weight) technique adopted to create the spatial distribution maps of water quality parameters and WQI.

RESULTS AND DISCUSSIONS

EC

The electrical conductivity is ranging from 142µS/cm in DW_7 to 836 µS/cm in HDW_6 (Table 1). It is below the maximum tolerance as compared to the water quality standards (Bauder et. al., (2003) and Wilcox (1980) and the groundwater is suitable for agricultural purpose. The higher is indicated recorded in the western, north western as well as eastern but, it is lower in the southern and central part of the area in generally (Figure3A). This is due to wastes materials due non point source dumped by the track and the chemicals leaching elements from the waste disposal site, but, in the eastern part it could be due to the liquid and solid wastes discharge from the town and the factories beside the Carbone containing sandstone.

TDS

The TDS values of the groundwater of the basin range from 144 mg/l in DW_7 to 596.17 mg/l in HDW_6 (Table1). The TDS value is high at some spot places western and eastern but, low in some spot in generally in the southern (Figure5B) which is could be due to waste materials and chemicals that discharge from these town and the industries around in addition to the effect of the aquifer materials. The groundwater quality is evaluated to be good with some restrictions. Hence, the groundwater is recommended for irrigation use with some management and the groundwater is characterized by medium salinity hazards (figure 6).

pH

The pH of the groundwater in the area is within the recommended tolerance interval (pH= 6.5 – 8.5) and is ranging from 6.8 in DW3 to 7.76 in WD_7 (Table1). Hence, the groundwater is suitable for drinking purpose. The higher value recorded in the southern and south eastern where as lower generally in the western and north western part of the area (Figure 5A). This is due to the liquid waste discharged from the surrounding factories

Sodium concentration

Sodium is an abundant element having a value ranges from 1mg/l in RV_1 to 29 mg/l in DW_6 (Table1). The maximum concentration observed in the western, south and northwestern part of the area (Figure 3 C). This is due to clay material disintegrated from the volcanic rocks. Additional anthropogenic source for the sodium concentration beside the natural sources, effect of the wastes and chemicals discharged from the town and the industries in the town itself and in the nearby area also contributed to the increase mental of sodium concentration. The water analysis result indicates that, the groundwater is suitable for irrigation use as the sodium concentration is far below the maximum limit Based on the guidelines proposed by Bauder et. al., (2003) and Wilcox (1980) and the groundwater is characterized by low sodium hazards (Figure 6).

Nitrate Concentration ($NO3^{-2}$)

The concentration of nitrate ion ranges between 1.59 mg/l in WD_{10} to 9. 68 mg/l in WD_6 (Table1). The concentration of this constituent is high both in eastern, southern as well as northern part of the area (Figure 5C) round the concentrated rural areas. Having relative concentration in the recharge area could be due to natural nitrogen mixed with rain water in the air and from human and animal wastes with some contribution from fertilizers (mainly urea). Beside this contribution from the solid wastes and chemicals from the sewerage and the industries might be other source for the nitrate concentration in the area. The groundwater is suitable for irrigation purpose since the higher concentration is below the permissible limit of the standards (FAO, 1989).

Chloride

Chloride is also abundant anion where the concentration varies from 2.13 mg/l in SW_3 to 26.12 mg/l in SW_5 (Table1). The Chloride concentration is high concentration in the western as well as at some spot in the south and northwestern part of the area (Figure 3B) specially, in the town and its surrounding including the pharmaceutical factory. This could be also due to the pollution effect caused by leaching of the constituents from sewerages and chemicals as well as the industries around and the leached components introduced to the groundwater thereby change the chloride concentration in the groundwater quality. The chloride concentration in the area is far below the permissible limit (FAO, 1989) and the groundwater is suitable for drinking purpose taking Chloride as parameters.

Bicarbonate

Bicarbonate is the most dominant anion in the area which ranges from 0.8985meq/l in SW_3 to 6.89meq/l in DW_{10} (Table 1). The maximum concentration is observed in the central and in some spot in the northern part of the area (Figure 3D). It particularly, shows high variation near the Adigrat town. This may be due to the effect of the constituents that are leached from the sewerage and from the old waste disposal sites and the small factories that introduced in the groundwater. Except two samples, the concentration lies in the range from 1.5 to 8.5meq/l which indicates that the groundwater can use for irrigation with slight to moderate restrictions (FAO, 1989).

Sodium Absorption Ratio (SAR)

The value of sodium absorption ratio in as high as 0.802965 (DW_{14}) with lower value 0.026658 (HDW_1) (Table1). Based on the spatial distribution map of SAR, there is high anomalous in northern part of the are especially around the old and terminated factories (Figure 3E). These causes the wastes from the factories. The groundwater samples from the area show a SAR value below the permissible limit (FAO 1989). Therefore, the groundwater is classified under excellent quality for irrigation that can be used without any restriction (Todd, 1980).

Soluble Sodium Percent (SSP)

The value of soluble sodium percentage in the groundwater in the area is varies between 1.00895 in HDW_1 and 20.4931 in DW_{14}.The spatial distribution of SSP indicates that there is high value in the eastern and western as well as some spot in the northern part of the area (Figure 5D).This is due to the wastes from the terminated and old factors as well as from the old waste disposal sites.

Groundwater for irrigation purposes is classified based on per cent sodium as follows, groundwater with %Na of less than 20 is considered as excellent, if the %Na ranges 20-40, 40-60, 60-80 the groundwater is classified under good, permissible and doubtful, respectively where as a water with %Na value greater than 80 is a kind of unsuitable water for irrigation (Wilcox, 1955) from this concept point of view, the groundwater in the area is classified under excellent where the sodium percent (%Na) is as high as 22.363% as the concentration is in milliequivqlents per liter (Table1).

Irrigation Water Quality Index

As mentioned in the above the IWQI concept was done by adopting the model developed by Meireles etal, 2010 to determine the suitability of groundwater for irrigation purposes. Accordingly, the five parameters which are dominantly influence the water quality for irrigation were considered for computing IWQI. Based this, the groundwater is classified in to two classes; Moderately Restriction ($55 \leq$ IWQI ≤ 70) and high restriction ($40 \leq$ IWQI ≤ 55) (Table2). More than 90.1% of the sample indicates a water quality index classified under moderately restriction where as the remaining indicated the water quality index is categorizing under highly restriction class. From this, it is conclude that the groundwater in the area is suitable generally for short term with some restrictions. The objectionable (highly restriction class) groundwater is restricted generally near the terminated and old factories in southern part of the area (figure 4F) which indicates the main sources of the contaminants are from the domestic and factories wastes.

More than 90% of the samples indicate that the groundwater in the area can be used for irrigation purpose with moderately restriction (Meireles etal, 2010). This indicates the groundwater needs a water quality management to improve the quality status. The objectionable (poor and unsuitable class) groundwater is restricted generally around the town which indicates the main sources of the contaminants are from the domestic and factories wastes.

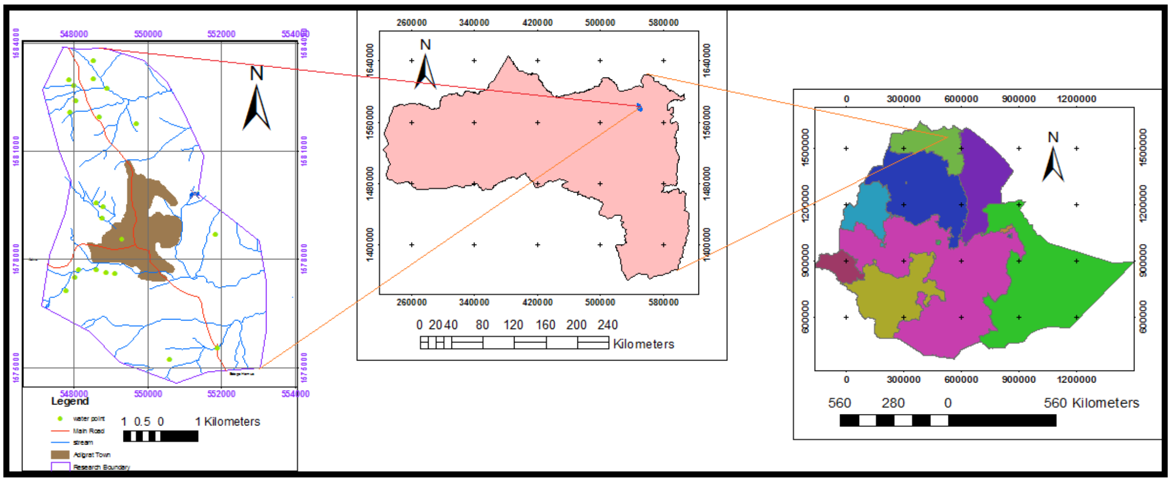

Figure 1 Location of the Area

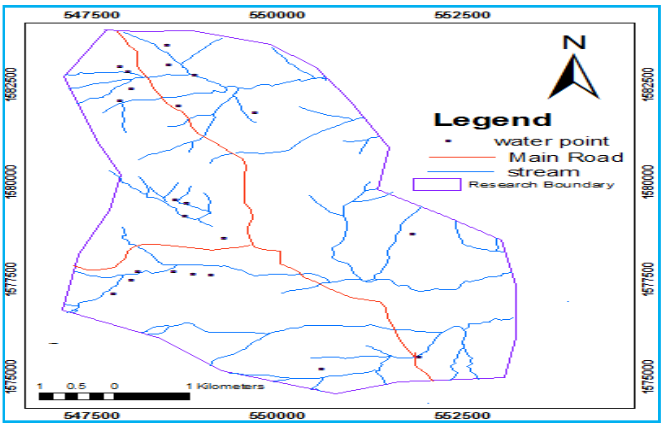

Figure 2 Location of Groundwater point

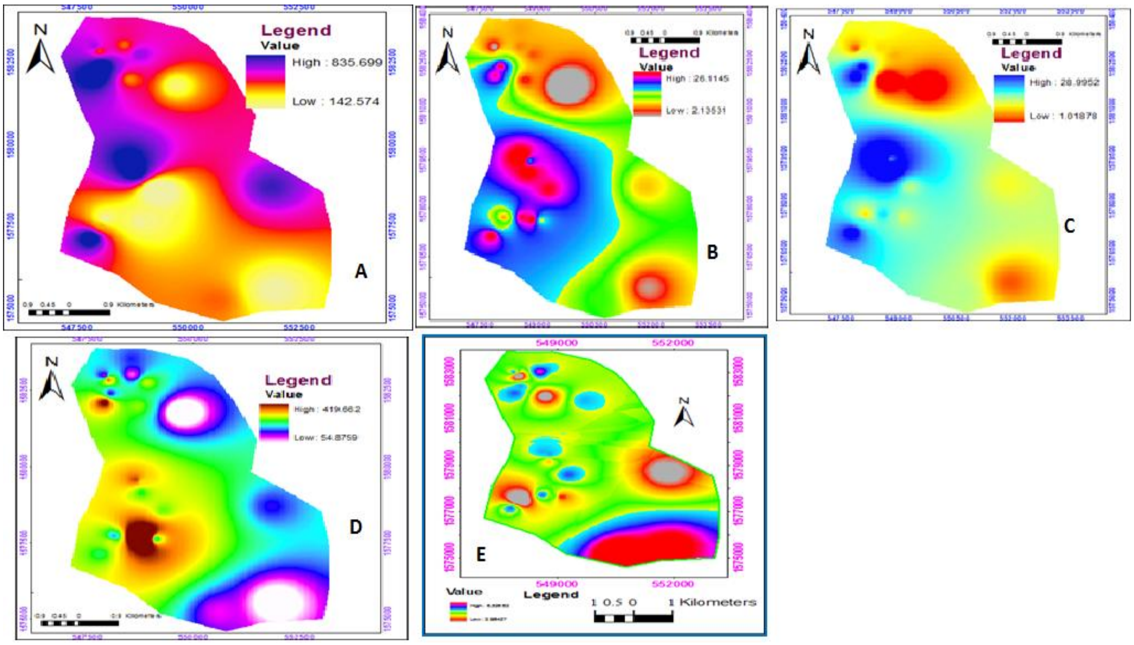

Figure 3 Spatial distribution map A) EC, B) Ci^- C) Na^+ D) HCO_3^- E) SAR

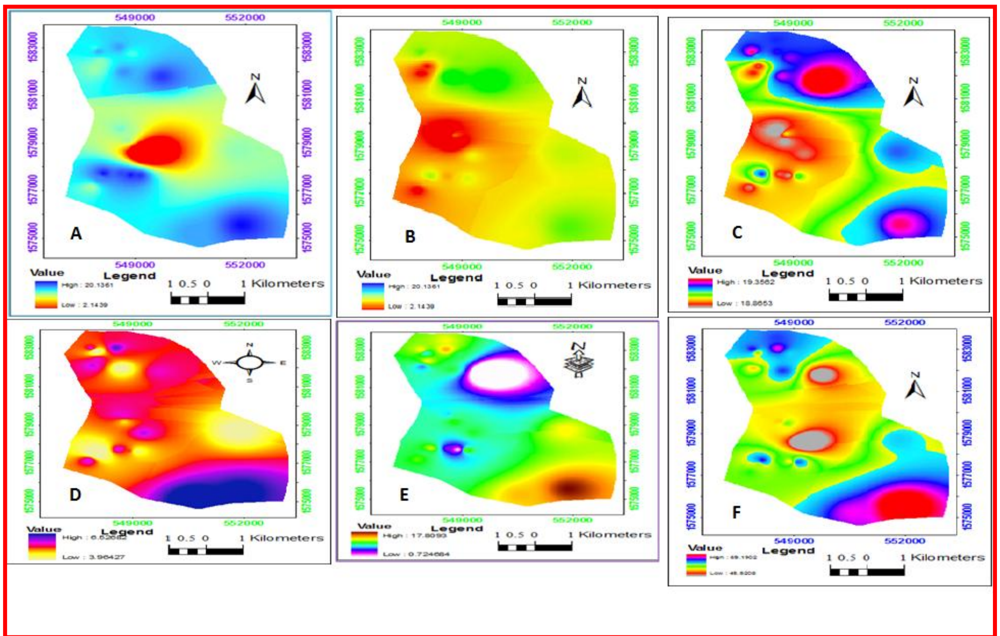

Figure 4 Spatial distribution map A) Qi*Wi of EC, B) Qi*Wi of Na^+ C) Qi*Wi of Ci^- D) Qi*Wi of SAR E) Qi*Wi of HCO_3^- F) IWQI

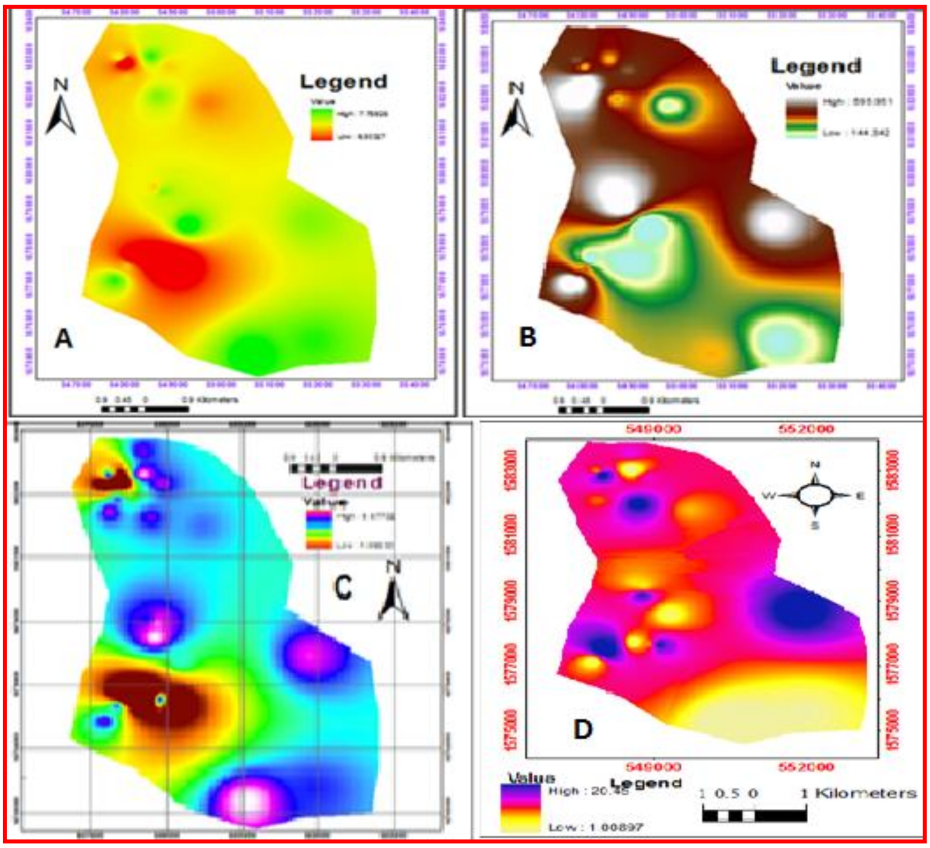

Figure 5 Spatial distribution map A) pH B) TDS C) NO_3^{-2}D) SSP

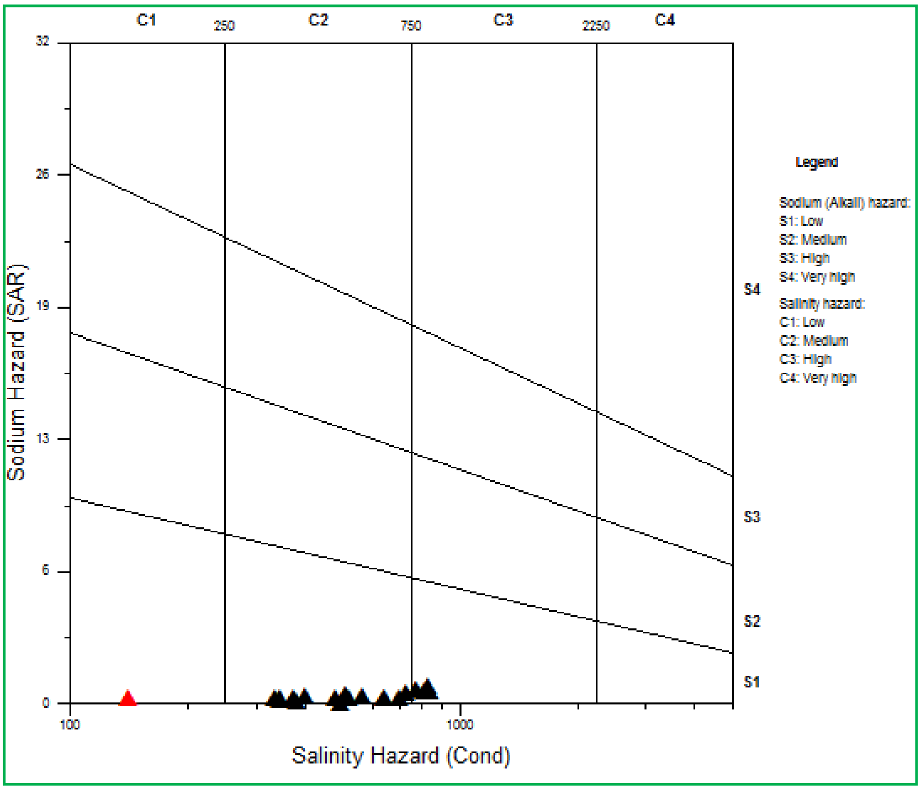

Figure 6 Wilcox Diagram indicating Sodium and salinity hazards

Table 1. Chemical analysis

No	Sample code	EC	Na	Ci	HCO3	SAR	TDS	pH	No3-2	SSP
1	HDW1	511	15	14.56	137.9	0.026658	364.4	7.7	2.56	1.008948
2	HDW4	337	9	8.71	85.06	0.101144	240.32	7.6	4.13	4.311758
3	DW3	816	23	22.15	159.89	0.299609	581.89	7.3	4.13	10.36821
4	HDW5	833	24	21.52	277.4	0.269485	594.02	7.3	6.13	8.855828
5	SW2	637	9	8.12	148.39	0.286744	454.25	7.4	3.58	8.016802
6	DW4	560	13	11.52	161.21	0.367341	399.34	7.4	8.76	11.51551
7	DW5	507	12	11.13	131.8	0.194485	361.5	7.6	3.12	3.54933
8	DW2	639	11	10.53	219.6	0.371177	455.68	7.3	6.12	10.92488
9	SW3	382	3	2.13	54.81	0.307473	272.41	7.2	5.12	7.891437
10	SW4	732	20	18.26	229.39	0.298523	521.99	7.5	4.15	6.962299
11	SW5	772	28	26.12	259.18	0.304505	550.52	7.3	7.56	7.24577
12	DW6	828	29	23.53	202.59	0.464793	590.45	7.4	9.68	14.28078
13	DW7	142	15	22.4	210.3	0.266707	144	7.76	4.24	5.219526
14	HDW6	836	24	22.53	197.7	0.275122	596.16	7.6	6.52	5.314181
15	DW9	402	18	22.2	320.4	0.275836	250	6.85	2	4.943339
16	DW10	347	16	23	420.3	0.373199	220	6.83	1.59	8.342552
17	DW11	374	14	15.8	190.7	0.541169	240	6.88	1.7	14.64788
18	DW12	701	13	12.15	158.09	0.621281	528.58	7.5	7.61	16.49529
19	DW8	345	12	11.5	172.5	0.591303	220	6.91	2.48	14.58988
20	RV1	494	1	9.88	213.49	0.626621	352.28	7.5	7.51	15.90386
21	DW13	520	14	13.5	252.2	0.703948	350	6.8	1.95	17.01407
22	DW14	480	17	15	221.4	0.802965	380	7.3	1.9	20.49311

Note: SSP is Soluble Sodium Percent

Table 2. Q_i X W_i of individual parameters and Irrigation water Quality Index (IWQI)

No	Sample code	X Coordinate	Y Coordinate	Wi*QI of EC	Wi*QI of Na	Wi*QI of Cl	Wi*QI of HCO3	Wi*QI of SAR	IWQI
1	HDW1	550619	1575214	18.9126	4.811739	19.1016225	15.88956284	6.526828	65.24239
2	HDW4	551923	1575538	20.1364	5.743043	19.2215063	17.80977705	6.280467	69.19123
3	DW3	548056	1582405	17.5552	3.57	18.946081	15.28273497	5.624042	60.97806
4	HDW5	547910	1582106	17.4574	3.414783	18.9589916	12.12	5.723679	57.67483
5	SW2	547896	1582989	18.0264	5.743043	19.2335972	15.6000847	5.666594	64.26975
6	DW4	548547	1583533	18.568	5.122174	19.1639211	15.24630874	5.40002	63.50042
7	DW5	548559	1583023	18.9408	5.277391	19.1719134	16.05789617	5.97174	65.41971
8	DW2	548910	1582758	18.0124	5.432609	19.1842092	13.635	5.387331	61.65152
9	SW3	549725	1581790	19.8199	6.674348	19.35635	0.717431148	5.598032	52.16609
10	SW4	548810	1579476	17.3583	4.035652	19.0257986	13.3648388	5.627634	59.41219
11	SW5	548639	1579569	17.8084	2.793913	18.8647239	12.54276503	5.607851	57.61765
12	DW6	548788	1579149	17.4861	2.638696	18.9178007	14.10440164	5.077697	58.22474
13	DW7	549303	1578579	2.14165	4.811739	18.9409578	13.89163934	5.732868	45.51885
14	HDW6	547809	1577141	17.4401	3.414783	18.9382937	14.23934426	5.705033	59.73756
15	DW9	548628	1577714	19.6793	4.346087	18.9450563	10.85336066	5.702671	59.52644
16	DW10	548883	1577652	20.0661	4.656522	18.928662	9.102418033	5.380645	58.13435
17	DW11	549125	1577624	19.8762	4.966957	19.0762113	14.43251366	4.825083	63.17696
18	DW12	551850	1578689	17.5763	5.122174	19.1510106	15.3324071	4.560113	61.742

19	DW8	548143	1577714	20.0802	5.277391	19.164331	14.9347541	4.659264	64.11591
20	RV1	548696	1581978	19.0322	6.984783	19.1975296	13.80360929	4.542451	63.56057
21	DW13	548004	1582850	18.8493	4.966957	19.1233451	12.73538251	4.286691	59.96171
22	DW14	548048	1577501	19.1307	4.501304	19.0926056	13.58532787	3.959194	60.2691

Table 3: Parameter limiting values for quality measurement (Qi) calculation (Meireles et al., 2010)

Qi	EC(μs/cm)	SAR(mmol/L)^1/2	Na+	Cl-	HCO3-
			mmol/L		
85-100	200≤EC<750	2 ≤SAR< 3	2 ≤ Na < 3	1 ≤ Cl < 4	1≤ HCO3<1.5
60-85	750≤EC<1500	3 ≤SAR< 6	3 ≤ Na < 6	4 ≤ Cl < 7	1.5≤ HCO3<4.5
35-60	1500≤EC<3000	6≤SAR<12	6 ≤ Na < 9	7 ≤ Cl < 10	4.5≤ HCO3<8.5
0-35	EC<200 or EC≥3000	SAR<2 or SAR≥12	Na < 2 or Na ≥ 9	Cl< 1 or Cl≥ 10	HCO3<1 or HCO3≥ 8.5

Table 4: weights for the IWQI parameters (Meireles et al., 2010)

Parameters	Wi
Electrical conductivity (EC)	0.211
Sodium (Na+)	0.204
Chloride (Cl-)	0.194
Bicarbonate (HCO3-)	0.202
Sodium Absorption ratio(SAR)	0.189
Total	1.00

Table 5: Irrigation Water Quality Index Characteristics (Meireles et al., 2010)

IWQI	Water use restriction	Recommendation	
		Soil	Plant
85 ≤ 100	No restriction	May be used for the majority of soils with low probability of causing salinity and sodicity problems, being recommended leaching within irrigation practices, except for in soils with extremely low permeability	No toxicity risk for most plants
70 ≤ 85	Low restriction	Recommended for use in irrigated soils with light texture or moderate permeability, being recommended salt leaching. Soil sodicity in heavy texture soils may occur, being recommended to avoid its use in soils with high clay levels 2:1.	Avoid salt sensitive plants
55 ≤ 70	Moderate restriction	May be used in soils with moderate to high permeability values, being suggested moderate leaching of salts.	Plants with moderate Tolerance to salts may be grown
40 ≤ 55	High restriction	May be used in soils with high permeability without compact layers. High frequency irrigation schedule should be adopted for water with EC above 2.000 dS m-1 and SAR above 7.0.	Should be used for irrigation of plants with moderate to high tolerance to salts with special salinity control practices, except water with low Na, Cl and HCO3 values
0 ≤ 40	Severe restriction	Should be avoided its use for irrigation under normal conditions. In special cases, may be used occasionally. Water with low salt levels and high SAR require gypsum application. In high saline content water soils must have high permeability, and excess water should be applied to avoid salt accumulation.	Only plants with high salt tolerance, except for waters with extremely low values of Na, Cl and HCO3.

Table 6. Guidelines for interpretations of water quality for irrigation (FAO, 1989).

Potential Irrigation Problem	Degree of Restriction on Use		
	None	Slight to Moderate	Severe
Salinity EC_w at 25 ºC (dS/m) (or) TDS (mg/l)	 < 0.7 < 450	 0.7 - 3.0 450 - 2000	 > 3.0 > 2000
Infiltration (sodicity) SAR = 0 - 3 and EC_w = = 3 - 6 = = 6 - 12 = = 12 - 20 = = 20 - 40 =	 > 0.7 > 1.2 > 1.9 > 2.9 > 5.0	 0.7 - 0.2 1.2 - 0.3 1.9 - 0.5 2.9 - 1.3 5.0 - 2.9	 < 0.2 < 0.3 < 0.5 < 1.3 < 2.9
Specific Ion Toxicity Sodium (Na) Surface irrigation (SAR)	<3	3-9	>9
Sprinkler irrigation (meq/l)	<3	>3	
Chloride (Cl) Surface irrigation	(meq/l) < 4	4 - 10	> 10
Sprinkler irrigation	(meq/l) < 3	> 3	
Boron (B)	(mg/l) < 0.7	0.7 - 3.0	> 3.0
Miscellaneous Effects Nitrogen (NO_3 - N)	(mg/l) < 5	5 - 30	> 30
Bicarbonate (HCO_3)	(meq/l) < 1.5	1.5 - 8.5	> 8.5
pH	Normal Range 6.5 - 8.4		

Table 7. Suggested limits for irrigation water use based upon conductivity (Bauder et. al., 2003 and Wilcox (1980)).

Classes of water	Electrical conductivity (µS/cm at 25 ºC)*	Electrical conductivity (dS/m at 25 ºC)*
Class 1, Excellent	≤ 250	≤ 0.25
Class 2, Good	250-750	0.25 – 0.75
Class 3, Permissible[1]	760-2000	0.76 – 2.00
Class 4, Doubtful[2]	2000-3000	2.01 – 3.00
Class 5, Unsuitable[2]	≥ 3000	≥ 3.00

Table 8. Descriptive Statistics

	N	Minimum	Maximum	Mean		Std. Deviation	Variance	Skewness	
	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Statistic	Statistic	Std. Error
EC	22	142	836	554.32	42.098	197.459	3.899E4	-.076	.491
Na	22	1	29	15.45	1.530	7.176	51.498	.079	.491
Ci	22	2	26	15.74	1.369	6.419	41.203	-.125	.491
HCO3	22	55	420	201.10	16.671	78.194	6.114E3	.809	.491
SAR	22	0	1	.38	.042	.195	.038	.509	.491
TDS	22	144	596	393.99	30.612	143.583	2.062E4	.015	.491
pH	22	7	8	7.32	.062	.293	.086	-.556	.491
NO3	22	2	10	4.66	.529	2.480	6.149	.486	.491
SSP	22	1	20	9.90	1.096	5.140	26.422	.319	.491
IWQI	22	46	69	60.50	1.043	4.890	23.912	-1.326	.491
Valid N (listwise)	22								

Conclusion

The research has been conducting in two select Kebeles under the Ganta Afshum wereda Easter zone of Tigray, northern Ethiopia which is about 38.94km^2. Groundwater is the only resource for irrigation purpose in the area. In the area, groundwater drawn from 21 bore wells and one resrviorros were analyzed for their Physico-chemical components. Individual Nine chemical parameters were assessed to evaluate the groundwater quality for agricultural use in the area. The analytical results of chemical parameters of groundwater were compared with different irrigation water quality standard and guideline values (Bauder et. al., 2003, Wilcox 1980, Atekwana, et al 2004, FAO, 1989, Todd 1980) for individual parameters and (Meireles etal, 2010) for the irrigation water quality index.

The best groundwater quality zone in the area was assessing from spatial distribution map of certain parameters prepared from the hydro chemical data in GIS environment.

The groundwater is suitable for irrigation purpose with respect to pH, EC, Na^+, Ci^- , $NO3^{-2}$, SSP and SAR but, with TDS and HCO_3^-, the groundwater needs slight water treatment for quality adjustment. The ionic concentration and the chemical parameters, generally is high near the town in all side of the area but, it is also significant in highly cultivated agricultural fields with point and non sources from domestic, factories as well as feltrizer are the main contaminant sources beside the geogenic sources. From spatial distribution of the ionic concentration and the chemical parameters, generally it is high surrounding the town and the old waste disposal sites as well as in the highly cultivated agricultural fields.

The ionic and chemical parameter of the groundwater in the area includes point and non sources of domestic, factories as well as feltrizer beside the nature sources.

The best groundwater quality zone in the area was assessing from spatial distribution map of certain parameters prepared from the hydro chemical data in GIS environment.

More than 90.1% of the sample indicates a water quality index classified under moderately restriction where as the remaining indicated the water quality index is categorizing under highly restriction class. From this, it is conclude that the groundwater in the area is suitable generally for short term with some restrictions. The objectionable (highly restriction class) groundwater is restricted generally near the terminated and old factories which indicates the main sources of the contaminants are from the domestic and factories wastes.

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