Suitability of Groundwater in Basrah Province for Industrial, Construction and Agricultural Purposes

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***Abstract*- This study aims to evaluate quality of groundwater samples in south of Basrah Province for industrial, construction and agricultural purposes. Groundwater samples were collected in summer season of the year 2015 from (29) wells located in different districts in Basrah province (Safwan, Zubair and Um-Qasir). The groundwater samples were analyzed for pH, electrical conductivity (EC), total dissolved solids (TDS) and other major ions. The chemical results indicate that the groundwater in the study area was unsuitable for industrial uses according to standard classification. Some other standard classification recommended that, the unsuitable groundwater could be used after treatment of some of its element while groundwater in study area may be used for construction purposes with suitable treatment of high ions concentration. After studying the factors that determine the suitability of groundwater for irrigation purpose such as pH, electrical conductivity, total dissolved solids, Sodium ratio(Na%) and sodium adsorption ratio (SAR). The groundwater in study area can be classify based on (EC) values, as unacceptable for irrigation except for very salt-tolerant plants and excellent drainage. According to other parameters like Na% and SAR , groundwater of the study area are classify as poor to very poor water and need for suitable treatment before using it.**

Key word: groundwater, evaluation, SAR, Na%

I. INTRODUCTION

Groundwater is the second main source of water in all over the world. Ground water reaches the surface through springs or by drilling wells where the human takes advantage of this water for drinking, agricultural and industrial production, where surface water is scarce or non-existent. Groundwater chemistry is the function of the minerals composition of the aquifer through which it flows. The groundwater quality is not less important than its quantity (Todd and Mays 2005). Therefore, it is necessary to determine chemical, physical characteristics of groundwater and find out their suitability for domestic, agricultural, industrial uses. Iraq has suffered from long is not close to the problem of lack of water levels across tributaries of the Tigris and Euphrates rivers and increase the high concentrations that led to the reduction of large tracts of fertile agricultural land and turned it into a non-arable areas. Causing severe water shortages to the deterioration of water quality and increase the negative impact on public health, livestock, industrial and agricultural activities. Human realized the importance of water as essential component in the building of human civilizations. The study of the regions that have been exploited agricultural correctly to provide groundwater where many shallow wells and deep wells that are used in agriculture spread. Water quality might be differ depending on the variation in geological formation and human activities like extreme agricultural and urbanization. It was noted that the groundwater is an important water resource for agriculture uses in study area, therefore, the current research attempt to evaluate the suitability of groundwater in Basrah province for agricultural, industrial and construction. The spatial distribution of chemical parameters were drawing by using deterministic interpolation technique namely inverse distance weight (IDW) in Arc GIS (10.2) software.

II. METHODOLOGY:

A. Study area

Study area is located in the southeastern part of Iraq/Basrah governorate. It is located between the longitudes of 47° 40' and 48° 30' of east and latitudes of 29° 50' and 31° 20' in the north as shown in Fig. 1. The governorate is located in the desert climate, which is warm and dry. It was accompanying by those few in the amount of rain and lack of regularity in the fall rise in annual average temperatures. The average annual temperature in the range of (33.6 ° C) with a more pronounced rise in the summer months to up to (46.6° C) in August. Study area located within earth formation named "Dibdibba formation ", which has a large extension over a large area in the southern part of Iraq plus some area in the middle west of Iraq. Dibdibba formation age is upper Miocene- Pliocene, and it is consisting of sand, gravel with pebbles of igneous rocks and white quarts somewhere cemented into a hard grit (Jassim and Goff. 2006). It is (30-260) m thick (Krasny 1982). Dibdibba formation characterized by unconfined to semi-confined condition, the average of its saturated thickness is about (14m) (Al-Basrawi, 2006). It was exposing at the southeastern part of the southern desert. The formation contains two water layers, in some places, lower and upper layers. The lower layer is characterized by salinity more than (10000 mg/l) in most areas, while the salinity in the upper layer dose not exceeds 10000 mg/l (Al-Kubaisy, 1996). Dibdibba formation is also characterized by sand dunes, especially in the southwest part of the region. These sand dunes are either stable or movable. Direct rainfall recharge is considered as the source of recharge in the study area. The aquifers have high values of permeability's (0.3-25.1) m/day , well discharge (86-1037) m3/day and static water level ranges from (18) to (103) m below groundwater surface (Al-Basrawi, 2006) . Total dissolved solids range from (4790) to (35710) mg/l with chloride water type (Al-Jiburi and Al-Basrawi, 2008). The average infiltration is more than (2) m/day in Safwan area. Dibdibba formation has a simple slope in the south of Iraq toward the north-eastern side of Dibdibba plain (Macfadyen, 1939).The sediments of this formation changed gradually from marine origin into river sediments which are increased in it quantity and sizes of granules from oldest into recent (Buday, 1980).

B. Groundwater Samples Collection

The water samples were collected from (29) wells sites from different district in Basrah governorate (Safwan, Zubair and Um-Qasir) in two periods during summer season of 2015; the first period during the end of August (2015) from the wells that its ownership belong to the General Authority for groundwater - Basrah branch, which is encoded by (W) while the second period was during the beginning of September (2015) from the wells that its ownership belong to Basrah environment directorate, which is encoded by as shown above in Fig. 1. The analyses of samples were done in the laboratories of Basrah environment directorate - division of environmental analysis. The groundwater samples are collected after (10) minutes of pumping to avoid unpredictable change in characteristics of groundwater according to standard procedures (APHA, 1995), the time of sampling was in the morning by using polyethylene bottles of one litter volume (Rainwater, 1960) and samples transported to the laboratory within the same day of collection. pH ,electrical conductivity (EC), total dissolved solid (TDS) and temperature(T°) were measured immediately by using portable electronic instrument model SD300. Sodium and potassium were measured by flame photometer; Calcium, Magnesium and total hardness measured by Titration with EDTA (Ethylene Diamine Tetrscitic Acid); chloride measured by titration with $AgNO_3$ as well as sulphate measured by turbidity metric method. Bicarbonate measured by technician in volumetric. While the phosphate measured by Ascorbic acid method. Results of chemical analyses of the samples, their electrical conductivity, total dissolved solids and major ions are shown in Table 1. Quality data is checking by ionic balance, which is very important assessment for data quality. The sum of all cations and anions must balance because of all groundwater is electrically neutral (Dawood et. al., 2008) The test is basing on the difference percentage (% Difference) within ± 10 which is defined as :

$$\%Difference = \frac{\sum cations - \sum anions}{\sum cations + \sum anions} * 100\% \qquad (1)$$

III. Result and Discussion

A. Groundwater Suitability for Industrial Purposes

The use of groundwater for industrial purposes requires different specification of qualities and specification for each industry. The quality of salts in the water had a role to influence in factory production. The study of the uses of water was important for industrial purposes because they reduce the cost of maintenance and equipment services (Hem,1985). There are several individual industries that need water such as food industry, chemical industry, cement industry, petroleum industry and paper industry. A classification proposed by Salvato (1982) (Table 2) and Hem (1985) (Table 3) are used to evaluation suitability of groundwater in the study area for industrials purposes. According to Salvato (1982) classification, groundwater of the study area is not suitable for industries purposes except for chemical industry in condition of treating the high concentration of calcium (Ca) ion. According to Hem (1985) classification, groundwater of the study area is unsuitable for any type of industries purposes due to high concentration of ions from standard limitation.

B. Groundwater Suitability for Construction Purposes

To evaluate the suitability of groundwater in the study area for building and construction purposes, Altoviski (1962) classification has been used as shown in Table 4. The comparison of the samples of study area groundwater with the standards suggested by Altoviski (1962). The classification showed, the best wells are (W4 and W5) with proper treatment of high concentration of (HCO_3). Other wells may be used for construction purposes with suitable treatment of high ions concentration.

C. Groundwater Suitability for Irrigation Purposes

Quality standards for irrigation water are based on the total salt effects, the concentration of specific ions that may be toxic to plant and the concentration of cations that can cause deflocculating of the clay in soil resulting damage to soil structure and declines infiltration rate (Bouwer,1978). The suitability of irrigation water was determined by its mineral constituents and the type of the plant and soil to be irrigated.

1. Sodium Adsorption Ratio (SAR)

While EC is an assessment of all soluble salts in a sample, sodium hazard is defined separately because of sodium's specific detrimental effects on soil physical properties. The (SAR) index quantifies the proportion of sodium (Na^+) to calcium (Ca^{+2}) and magnesium (Mg^{+2}) ions in a sample. High values of SAR imply a hazard of sodium to soil structure (Hem, 1985). SAR values were calculated according to the following equation (Todd and Mays, 2005):

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

Where:

SAR: sodium adsorption ratio

Na^+, Ca^{+2} and Mg^{+2} : concentration of ions in (meq/L) units.

The spatial distribution of SAR value in the study area are shown in Fig. 2. The high sodium adsorption ratio (SAR) indicates high enrichment of Na^+ in the coastal zones which was attributed to influence salt water from seawater intrusion. Turgeon (2000) classify irrigation water based on SAR value in four classes as shown in Table 5. Based on the classification of Turgeon (2000), 13.79% of sample lies in class S1, 51.7% lies in class S2, 20.68% lies in class S3 and 13.79% lies in class S4 as shown in Fig. 3.

2. Soluble Sodium Percentage (Na%)

Sodium ion is important in classifying irrigation water because sodium reacts to soil to reduce its permeability. The sodium in irrigation waters is usually denote as percent Sodium and can be determined using the following formula, (Todd and Mays, 2005):

$$Na\% = \frac{Na + K}{Ca + Mg + Na + K} * 100\% \qquad (3)$$

Where:

Na^+, Ca^{+2}, Mg^{+2} and K^+ : concentrations of ions in (meq/L) units.

Wilcox (1955) and Don (1995) suggested a classification based on Na% in to excellent, good, permissible, doubtful and unsuitable as shown in Table 5 and Fig. 4. Most of study area samples lie in doubtful class while the other samples distributed between good to permissible to unsuitable.

3. Magnesium Hazard (MH)

It is a useful indicator to specify the magnesium hazard which is proposed by Szaboles and Darab (1964) for irrigation water as follows:

$$MH = \frac{Mg}{Mg + Ca} * 100\% \qquad (4)$$

Where :

Ca^{+2}, Mg^{+2} ions are measured in (meq/L) units.

It is reported that if the value of MH is less than 50%, then the water is safe and suitable for irrigation. All groundwater samples are less than 50% that is safe and suitable for irrigation as shown in Fig. 5.

4. US Salinity Laboratory's diagram (Richard diagram, 1954)

The US Salinity Laboratory's diagram (Richard, 1954) was using widely for rating irrigation water by plotting SAR against EC. SAR is an index of sodium hazard and EC is an index of salinity hazard (Fig. 6). The diagram was divided into (16), (Table 6) areas that were used to rate the degree to which a particular water may give rise to salinity problems and undesirable ion exchange effects in soil (Hem, 1989). Based on this division, the cases of the use of water for irrigation purposes, salinity and sodium hazard has showed as the following:

1. Low-salinity water (C1) can be used for irrigation of most crops in most soils with little likelihood that soil salinity will develop.
2. Medium-salinity water (C2) can be used if a moderate amount of leaching occurs.
3. High-salinity water (C3) cannot be used on soils with restricted drainage.
4. Very high-salinity water (C4) is not suitable for irrigation under ordinary conditions, but it may be used occasionally under very special circumstances.
5. Low-sodium water (S1) can be used for irrigation on almost all soils with little danger of developing harmful levels of sodium.
6. Medium-sodium water (S2) may be cause an alkalinity problem in fine textured soils under low leaching conditions. It can be used on coarse textured soils with good permeability.
7. High-sodium water (S3) probability of producing an alkalinity problem. This water requires special soil management such as good drainage, heavy leaching, and possibly the use of chemical amendments such as gypsum.
8. Very high sodium water (S4) is usually unsatisfactory for irrigation purposes.

V. CONCLUSION

The groundwater samples of study area were found to be unsuitable for industrial uses according to standard classification. Some other standard classification recommended that, the unsuitable groundwater can be used after treatment of some elements. For construction purposes, the result showed that, the most of groundwater in study area may be used for construction purposes with suitable treatment of high ions concentration. Groundwater of the study area classify as poor to very poor water which show an appreciable sodium hazard in fine- textured soils but could be used on sandy soils with good permeability.

IV. ACKNOWLEDGMENT

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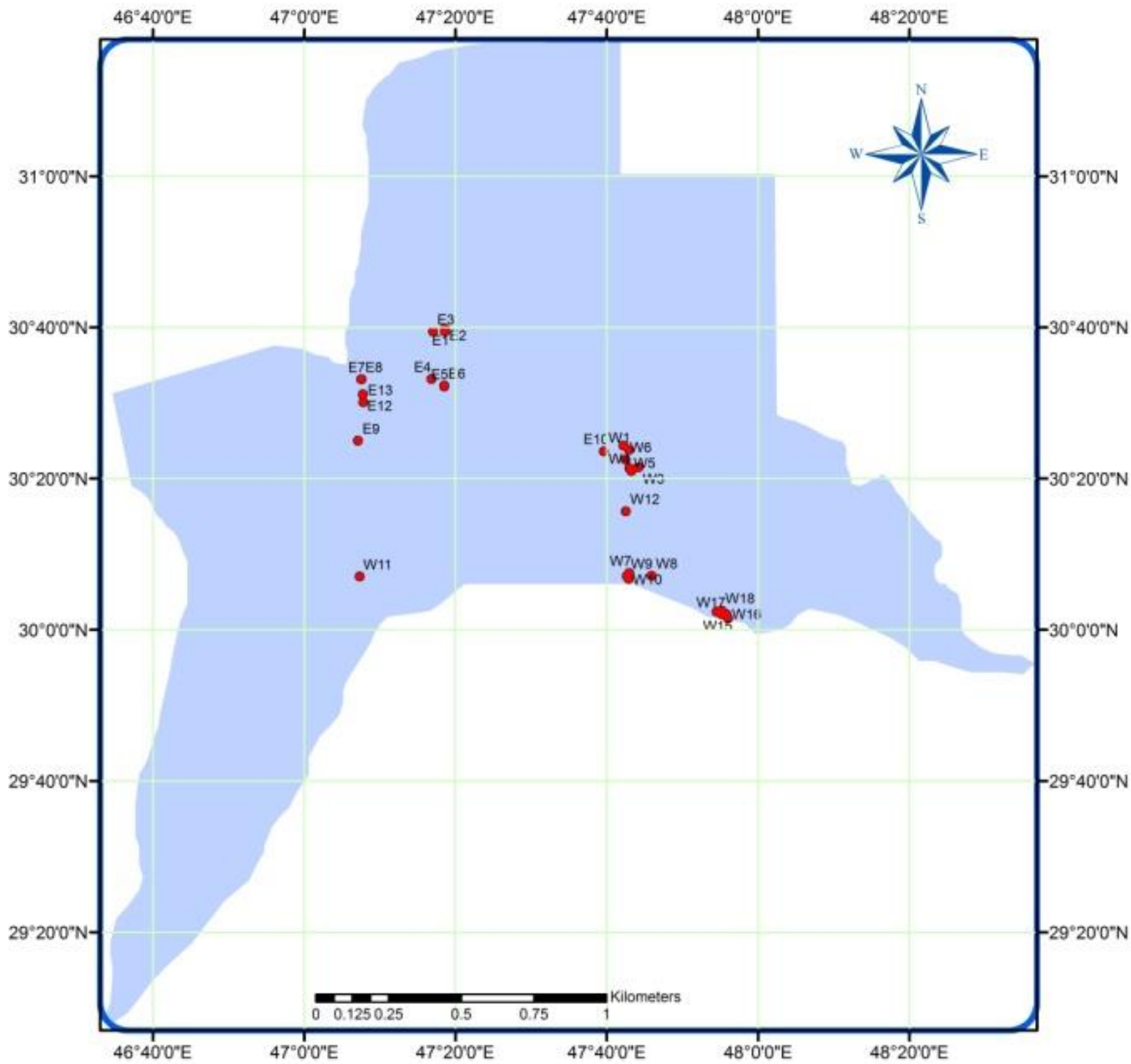

Fig.1 Location groundwater wells in the study area

Table 1 Chemical analyses of groundwater samples in the study area

Well No.	pH	TDS mg/L	EC (µS/cm)	Cations (mg/L)				Anions (mg/L)				
				Ca^{+2}	Mg^{+2}	Na^{+}	K^{+}	Cl^{-}	SO_4^{-2}	HCO_3^{-}	NO_3^{-}	PO_4^{-3}
W1	7.1	3837	7665	468	150	1220	24	1853	1200	1303	25.45	0.18
W2	7.4	3859	7718	484	197	2000	34	2280	1300	2038	12.06	0.18
W3	7.4	3772	7502	452	141	1260	25	2090	1400	1215	12.04	0.2
W4	7.5	3031	6063	406	103	860	24	950	1200	1251	26.14	0.18
W5	6.6	2182	4364	484	75	320	28	380	700	1431	14.05	0.18
W6	7.3	4382	8765	593	169	3000	60	3705	900	2194	26.13	0.18
W7	6.7	3600	7260	655	150	1170	36	2470	1000	2275	25.88	0.5
W8	7.1	4558	9115	764	179	3800	63	3943	800	3100	25.9	0.22
W9	6.8	4044	8136	452	160	2200	36	2518	800	1803	25.9	0.20
W10	7.1	3396	8040	671	150	2800	39	2993	900	2614	25.92	0.20
W11	7.2	4953	9906	468	188	4000	66	4655	900	1959	15.05	0.21
W12	7.3	3710	7421	499	122	1420	30	1805	1200	1764	25.83	0.08
W13	7.3	4300	8880	515	113	1290	26	1900	1100	1764	25.62	0.09
W14	7.1	4499	9057	359	113	1800	39	2233	1400	1371	26.07	0.09
W15	7.3	4093	8136	608	132	1600	22	2138	1300	2078	25.83	0.08
W16	6.7	3571	7143	593	141	1000	25	1663	1000	2079	25.83	0.10
E1	7.7	6100	8250	560	336	1200	0	1805	1300	1797	25.68	0.26
E2	7.5	8916	12090	800	384	2500	0	2898	1800	2587	25.92	0.25
E3	7.0	5610	7940	546	207	1500	0	1710	1150	2231	51.08	2.68
E4	7.3	6628	9420	499	160	1800	0	2090	1450	1917	29.95	0.37
E5	7.3	6688	8510	562	235	1700	0	1853	1400	2386	53.79	0.38
E6	7.3	7226	9210	608	221	2130	0	2233	1500	2444	29.3	0.35
E7	7.1	5926	7580	800	528	1500	0	1710	1100	3731	22.2	0.48
E8	7.1	13000	15750	1280	579	4500	0	4750	4500	4792	51.49	0.56
E9	7.1	4420	6010	484	132	1100	0	1140	1200	1764	8.75	0.156
E10	7.6	5000	6900	432	144	1360	0	1407	900	2140	51.5	0.35
E11	7.3	6706	8700	585	1934	1100	0	1197	1400	2274	52.7	0.32
E12	7.5	5948	8779	530	197	1400	0	1552	1800	2156	16.63	0.81
E13	7.6	5902	7190	562	207	1200	0	1455	1600	2274	13.48	0.73

Table 2 Groundwater classification for industrial purposes by Salvato(1982)

Type of industry	pH	Cl^{-1} meq/L	SO_4^{-2} meq/L	Ca^{+2} meq/L	Mg^{+2} meq/L
Food industry	6.5-8.5	8.462	5.205	5.988	8.226
Chemical industry	6-9	14.103	17.697	9.98	---
Cement industry	6.5-8.5	7.052	5.205	---	---
Petroleum	6-9	45.13	11.867	10.978	6.992
Paper industry	6-9	5.641	-	0.998	0.987

Table 3 Groundwater classification for industrial purposes by Hem(1985)

Industry type		Ca mg/L	Mg mg/L	Cl mg/L	HCO_3 mg/L	SO_4 mg/L	NO_3 mg/L	TH mg/L	TDS mg/L	PH
Petroleum products		75	30	300	..	..	..	300	1000	6-9
Cement industry		..	..	250	..	250	..	..	600	6.5-8.5
Wood industry		100	50	500	250	100	5	900	1000	6.5-8
Leathers industry			..	250		250		Soft		6-8
Soft drinking bottling		100	..	500	..	500	..	..	..	..
Fruit icing				250		250	10	250	500	6.5-8.5
Chemical Pulp & paper	unbleached	20	12	200	..	..	..	100	..	6-10
	bleached	20	12	200	..	..	..	100	..	6-10

Table 4 Groundwater classification for building purposes by (Altoviski, 1962)

Ions	Permissible limits (ppm)
Na^{+}	1160
Ca^{+2}	437
Mg^{+2}	271
Cl^{-}	2187
SO_4^{-2}	1460
HCO_3^{-}	350

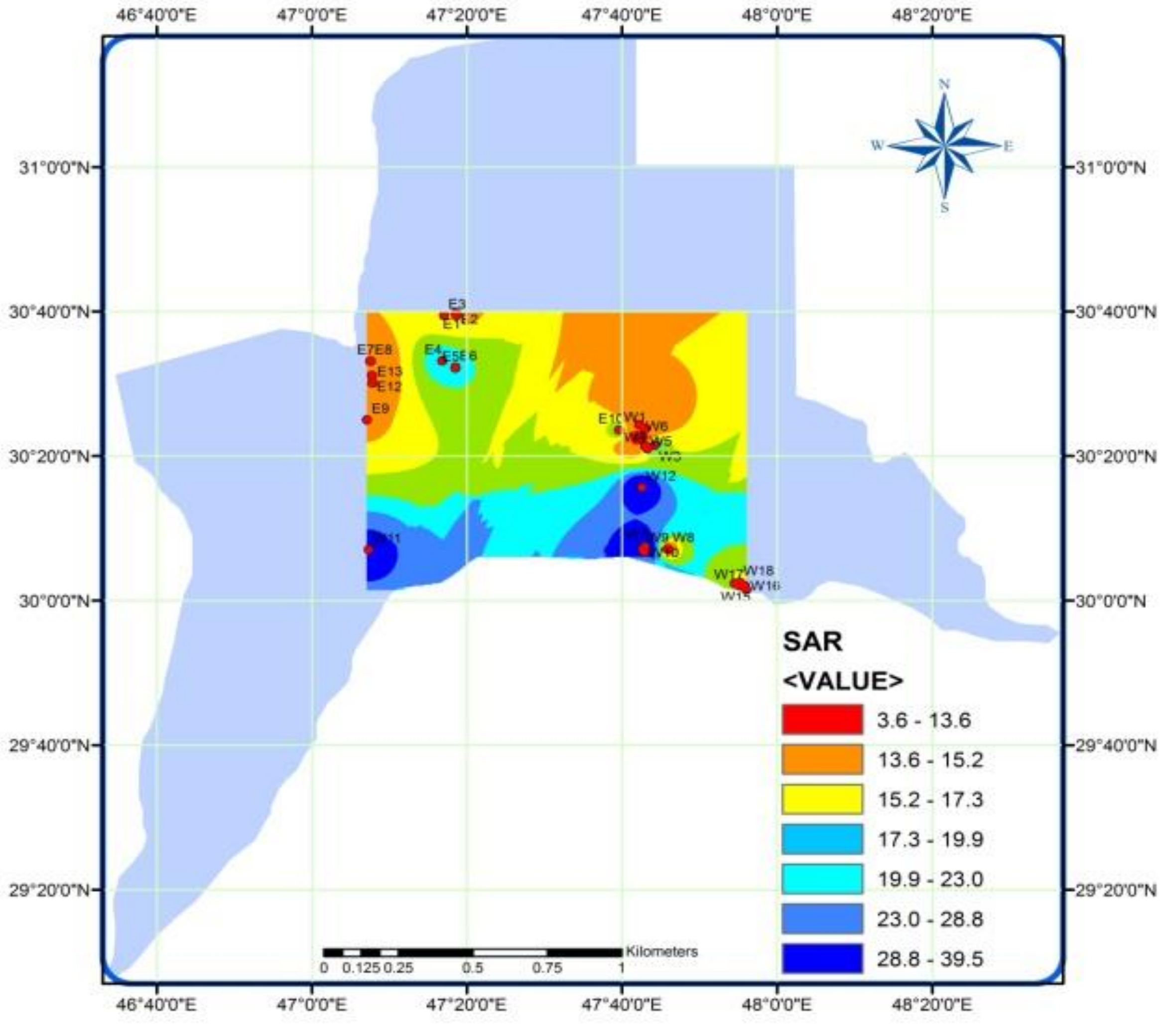

Fig.2 GIS Spatial distribution of SAR values for groundwater of the study area

Table 5 Classification of Irrigation water based on SAR values (Turgeon,2000)

Class	SAR	Hazard and limitation
S1	< 10	No Harmful effect of sodium
S2	10-18	An appreciable sodium hazard in fine- textured soils of high CEC but could be used on sandy soils with good permeability
S3	18-26	Harmful effects could be anticipated in most soils and amendments such as gypsum would be necessary to exchange sodium ions
S4	> 26	Generally unsatisfactory for irrigation

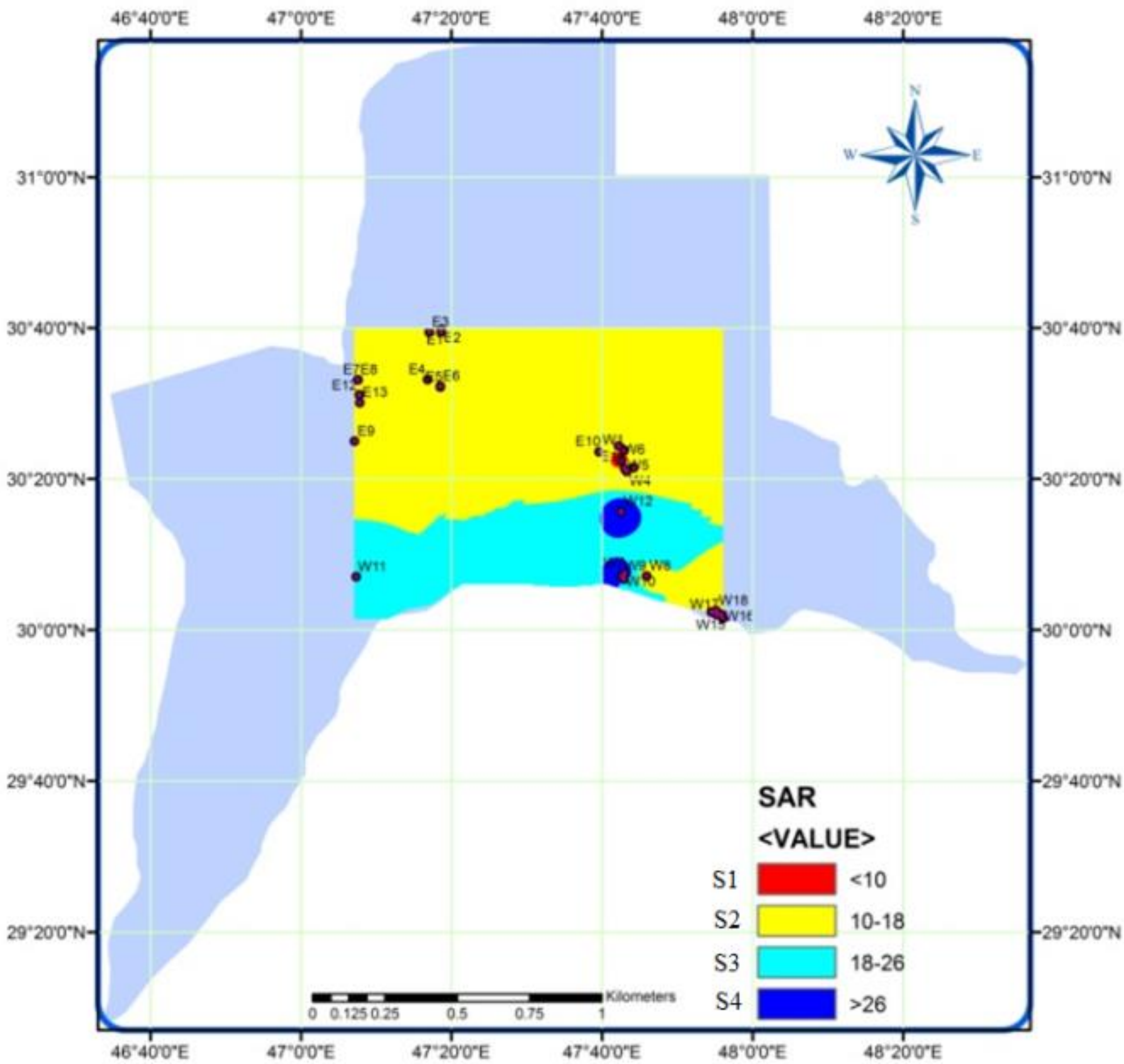

Fig. 3 GIS spatial distribution of SAR for groundwater of the study area (after Turgeon, 2000)

Table 5 Classification of Irrigation water based on Na% values according to Wilcox (1955) and Don (1995)

Na%	Water quality
<20	Excellent
20-40	Good
40-60	Permissible
60-80	Doubtful
>80	Unsuitable

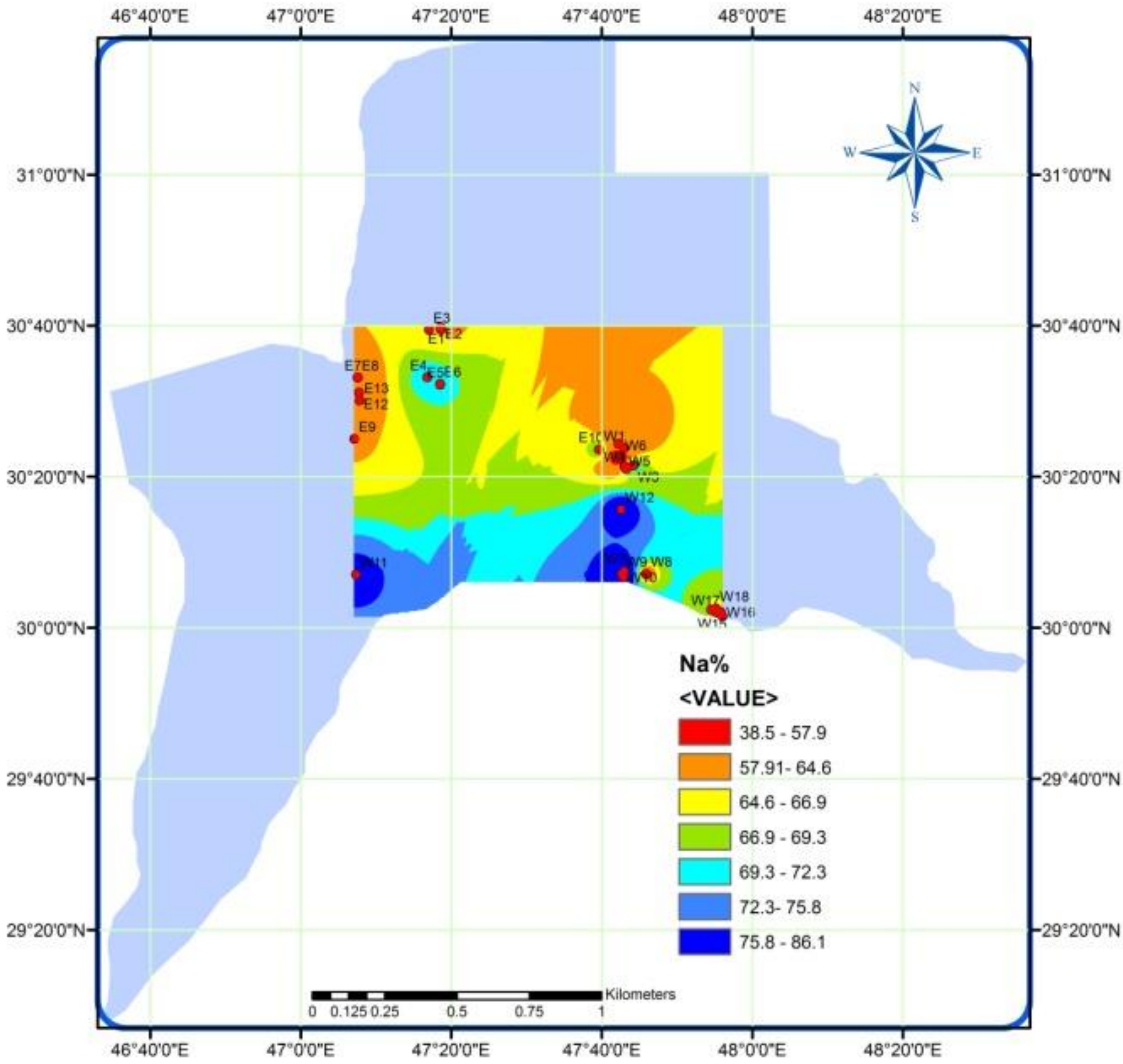

Fig. 4 GIS spatial distribution of Na% for groundwater of the Study area according Wilcox (1955) and Don (1995)

Table 6 Classification of groundwater and surface water according to Richard Diagram,(Richard, 1954)

Index	Water class	Index	Water class
C1 S1	Excellent	C3 S1	Admissible
C1 S2	Good	C3 S2	Marginal
C1 S3	Admissible	C3 S3	Marginal
C1 S4	Poor	C3 S4	poor
C2 S1	Good	C4 S1	Poor
C2 S2	Good	C4 S2	Poor
C2 S3	Marginal	C4 S3	Very poor
C2 S4	Admissible	C4 S4	Very poor

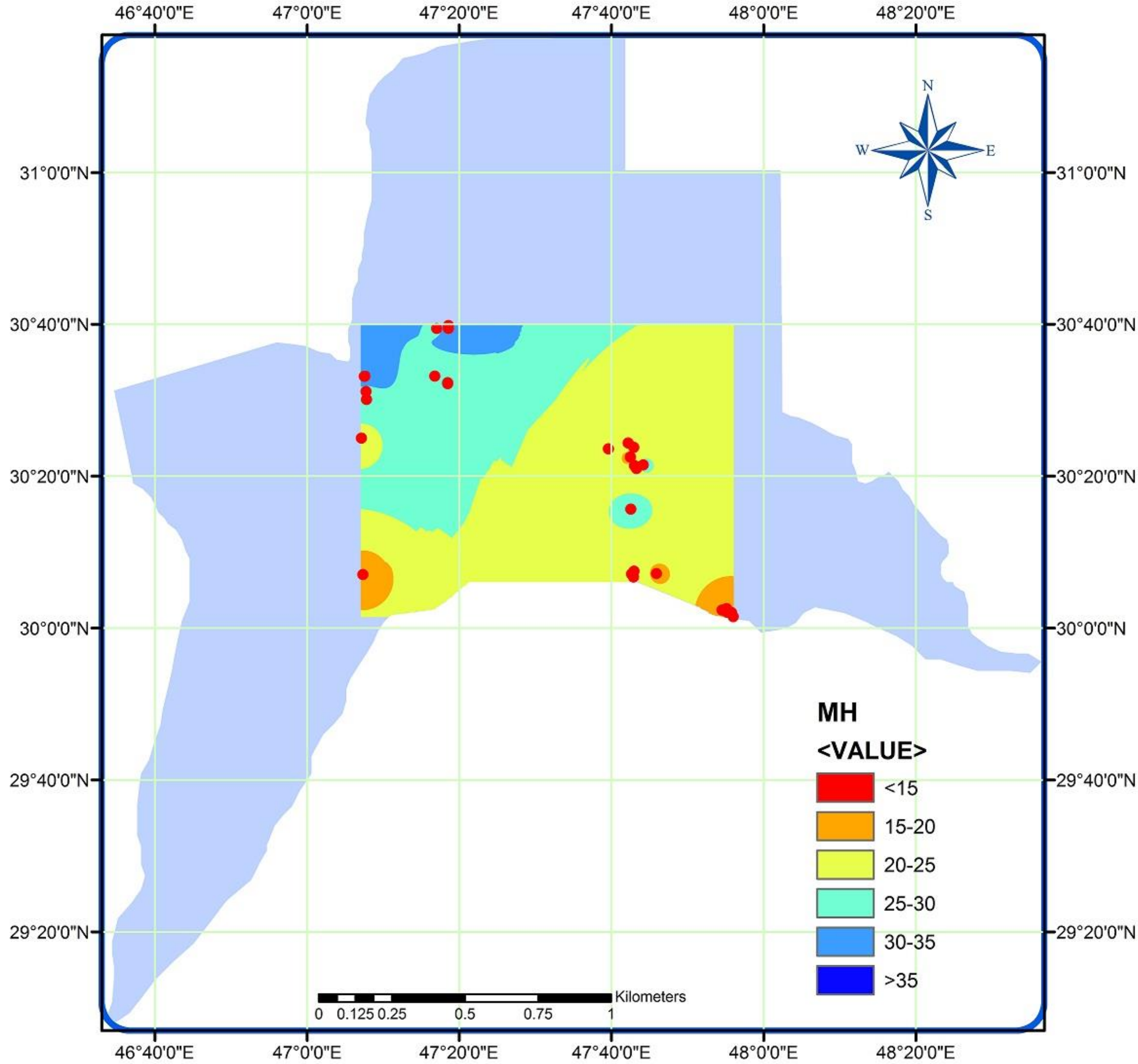

Fig. 5 GIS spatial distribution of MH for groundwater of the Study area

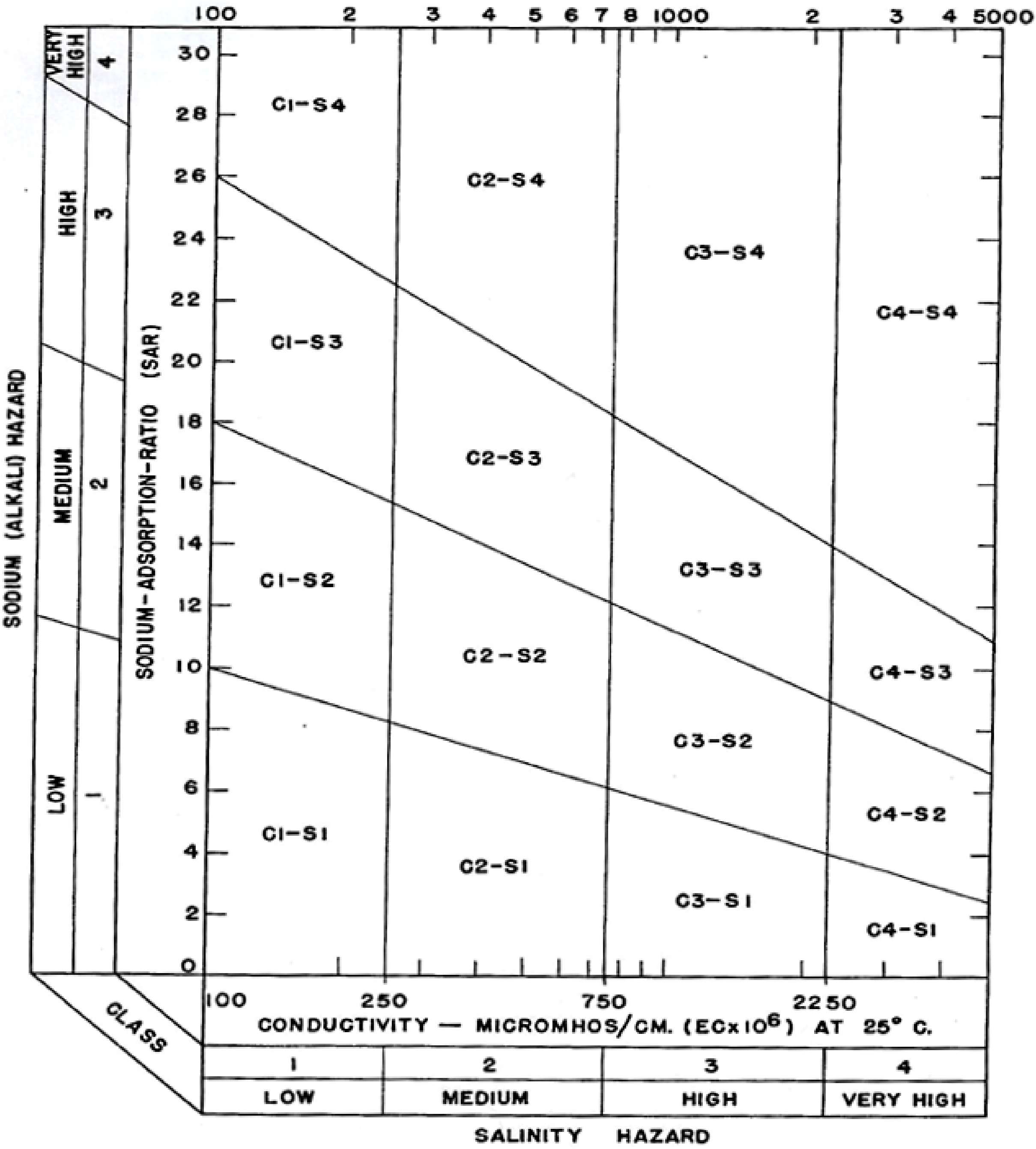

Fig. 6 US Salinity Laboratory's diagram (Richard,1954)