International Journal of Scientific Engineering and Research (IJSER)
ISSN (Online): 2347-3878
Index Copernicus Value (2015): 56.67 | Impact Factor (2017): 5.156

Application of the Water Quality Index (WQI) to Evaluate the Groundwater Quality for Drinking Purposes in the (Fakka, Heweta) Areas, East Maysan Governorate, South Iraq

Sarteel Hamid Al-Shammary

College of Science, Wasit University, Iraq
drsarteelalshamary[at]gmail.com

Abstract: ***The objectives of this study is to analyze groundwater quality in the (Fakka, Heweta) area in Maysan Governorate in eastern Iraq according to water quality index (WQI). Ten Chemical, physical parameters such as, total hardness(TH), pH, total dissolved solids (TDS), calcium(Ca), magnesium(Mg), sodium(Na), potassium(K), chloride(Cl), sulfate(SO_4) and nitrate(NO_3)collected from 12 different locations (wells) since 2017. In this study, 25% of the water samples were found to be of good quality, 33.3% poor quality, 33.3% very poor and 8.3% unsuitable for drinking purpose. The water quality index ranges from 51.6 to 375.9.Therefore, some treatment is needed before use, as is necessary to protect that area from contamination.***

Keywords: water quality index, ground water, Fakka, relative weight

1. Introduction

The arid and semi-arid regions of the world rely heavily on groundwater as one of the major water resources. The study area is located in the East part of Iraq, called Al-Fakka and Hewetaareas in Maysan Province. Groundwater is one of the most important sources of water for drinking, agricultural and industrial activities.

The water quality index is defined as a classification that reflects the combined effect of different water quality parameters. It shall be calculated according to the validity of the use of groundwater for the purpose of human consumption [1]

Groundwater samples are analyzed for a number of parameters to assess their suitability for drinking purposes. The Water Quality Index digitally summarizes easy information from water quality parameters to a single value that can be used to evaluatethe spatial and temporal changes in water quality[2].

The water quality indicator method for evaluating the quality of water worldwide is widely used for its ability to fully express water quality and It is a highly effective tool [3].

The Water Quality Index (WQI) is a very effective tool for communicating water quality information to citizens and decision-makers [4].

Groundwater is a major source of water supply in the world due to the lack of surface water[5].

Water quality refers to the physical, chemical and biological characters of water [6], [7].

Water quality is controlled by several factors, including climate, soil characteristics, rock type, human activities and topography of the region[8].

Groundwater is a major and a good source of freshwater resources, and it is an important issue for policymakers to plan for optimal user. Natural filtration of soils and sediments makes ground water free from impurities [9].

The main factors influencing groundwater chemistry are regional geological factors, geochemical treatment and land-use patterns [10].

Twelve samples from the water wells of the study area (sample per well) were analyzed for pH, total hardness (TH), total dissolves solids TDS), cations (Ca, Mg, Na, K) and anions (Cl, HCO_3, SO_4, NO_3). The water quality of these wells was explained according to water quality index (WQI).

2. Aim of Study

The objective of this study is to apply the method of water quality index to the groundwater of the Al-Fakka and Heweta areas in the Maysan Governorate, south Iraq and its validity for drinking purposes.

3. Study Area

The study areaoccupies an area of (70 km^2) in the east of Maysan Governorate, in Iraq between latitudes (32^0 $01^/$ $00^{//}$ - 32^0 $05^/$ $00^{//}$) N and longitudes (47^0 $24^/$ $00^{//}$ -47^0 $40^/$ $00^{//}$) E, which is bordered by Iraq – Iran border (Hemrine structure), (Figure1), Table 1.

4. Geology of Study Area

The geology of the study area indicates various litho units dating from Miocene to Recent. The studied area is mostly dominated by, sandstone, silt, conglomerate, red and gray marls and recent alluvial [11].

The formations cropping out in the study area are, Injana formation, the rocks composing of the Injana formation is: Siltstone, Sandstone, and Conglomerate. Mukdadiya formation, the rocks composing of the formation.

Siltstone, Marl and Conglomarate and Bai Hassan formation, its rock composition from Conglomerate [12].

5. Materials and Methods

5-1 Sample Collection and Analysis

Groundwater samples were collected in the summer of 2017, groundwater samples were collected from wells in glass containers (table 1). Pumping was done in the well for 5-10 minutes before sampling until the temperature was stabilized. According to standard procedures, samples were transferred to the laboratory for chemical analysis.

The results were compared withWorld Health Organization [13]and Iraqi drinking water standards[14]. (PH) and Total dissolved solids (TDS) measurements were taken in the field and the geographical location of each well as determined by GPS. All the chemical concentrations are expressed in mg/l.The sampling locations are mentioned in the (Figure 1), table (1).

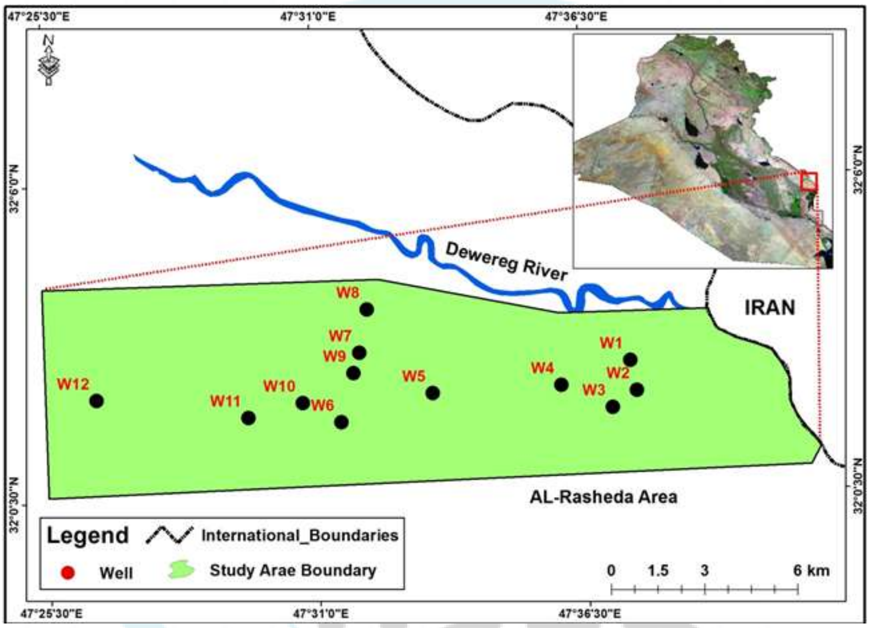

Figure 1: Location map of the study area showing water sampling stations

Table (1): Geographic coordinates about wells in (Fakka, Heweta) area, Maysan

Well No.	Well Name	Longitude	Latitude
1	Fakka / 1	47° 37′ 26″	32° 02′ 47″
2	Fakka / 2	47° 37′ 31″	32° 02′ 34″
3	Fakka / 4	47° 37′ 27″	32° 02′ 35″
4	Fakka / 5	47° 36 ′01″	32° 02′ 23″
5	Hewetate	47° 33′′ 23″	32° 02′ 17″
6	Heweta	47° 31′ 30″	32° 01′ 49″
7	Heweta / 4	47° 31′ 54″	32° 03′ 01″
8	Ebresam	47° 32′ 04″	32° 03′ 46″
9	Heweta / 3	47° 31′ 40″	32° 02′ 40″
10	Heweta / 1	47° 30′ 34//	32° 02′ 10″
11	Al- Salmman / 1	47° 29′ 36″	32° 01′ 56″
12	Wayed	47° 26′ 30″	32° 02′ 17′

Table (2) : Physica;-chemical parameters of well samples in study area (2017)

Param. / W. No.	PH	TH	TDS mg/l	Ca^{+2} mg/l	Mg^{+2} mg/l	Na^{+} mg/l	K^{+} mg/l	HCO_3 mg/l	Cl^{-} mg/l	SO_4^{-2} mg/l	NO_3^{-} mg/l
1	7	1234.1	3388	349.7	87.7	615.8	3.56	67	828.9	1280	0.09
2	7	1319.7	3420	383.5	88	585.6	3.57	67.2	801.7	1317.2	0.09
3	7.1	1246.2	3470	353.1	88.6	622	3.6	67.7	839.4	1292.6	0.1
4	7.2	1105.2	3150	313.1	78.6	551	3.2	60.3	742.4	1145.5	0.08
5	7.1	607.3	1650	140.6	62.3	255.2	0.58	78.3	361	549.5	0.14
6	7.1	599.3	1640	138.7	61.5	251.6	0.57	77.2	356	541.9	0.14
7	7.3	2171	6320	521.6	211.1	1266.8	24.8	471.9	1639.4	2068	0.62
8	7.1	1367.9	4730	361.6	113	1039.6	16.27	117.5	1283.6	1586.5	0.36
9	7	300	930	66.3	32.7	143.5	0.31	53	174.7	306.5	0.23
10	7.1	779	2130	174.2	83.6	340.1	2.28	62.7	363	874	0.19
11	7	733.3	1980	164	78.7	320.4	2.14	59	341.8	823.4	0.18
12	7.1	791.7	2230	177	85	345.4	2.31	63.7	368.6	887.8	0.2

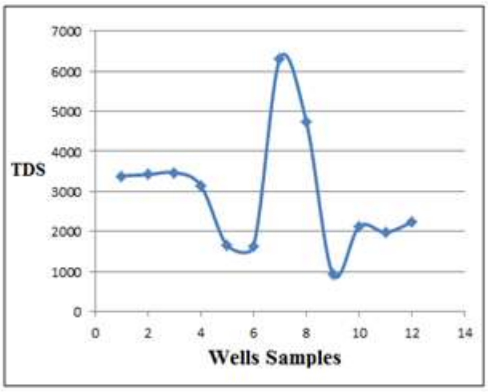

Figure 2: Concentration of Total Dissolved Solids

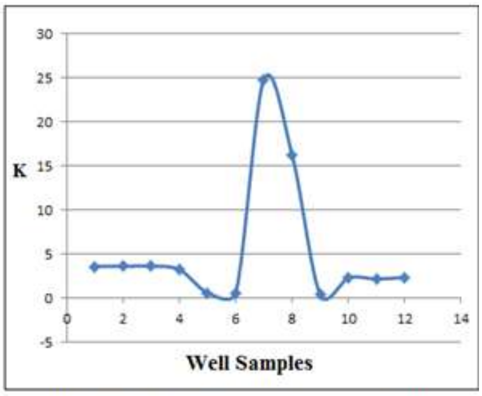

Figure 6: Concentration of potassium

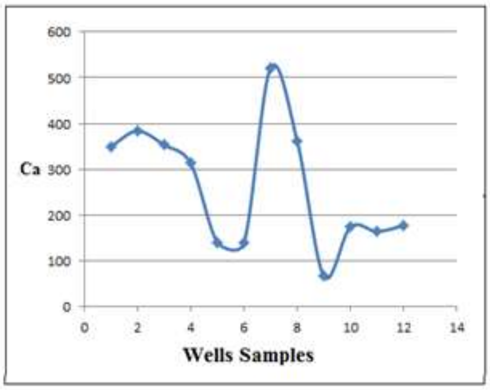

Figure 3: Concentration of calcium

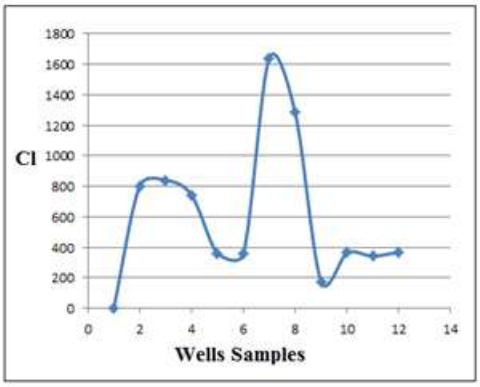

Figure 7: Concentration of Chloride

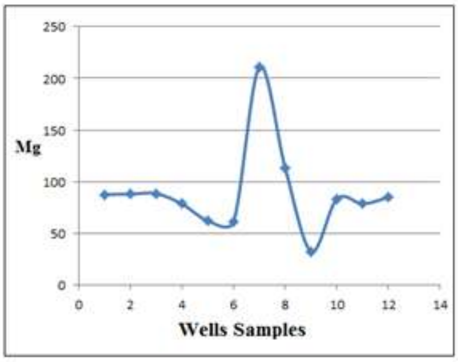

Figure 4: Concentration of Magnesium

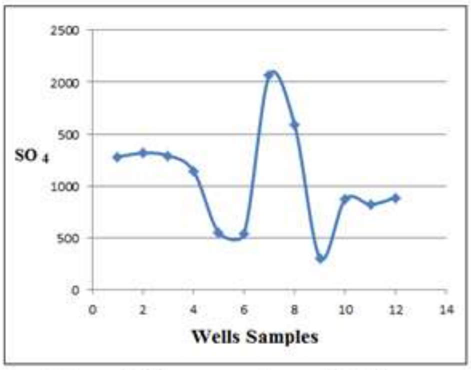

Figure 8: Concentration of Sulphate

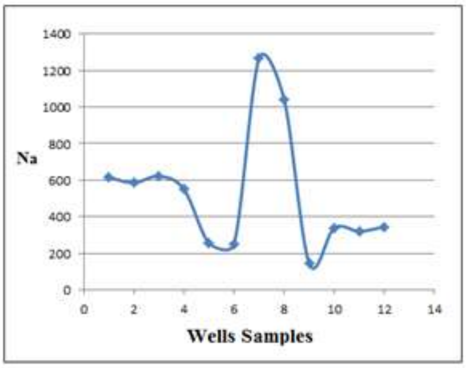

Figure 5: Concentration of Sodium

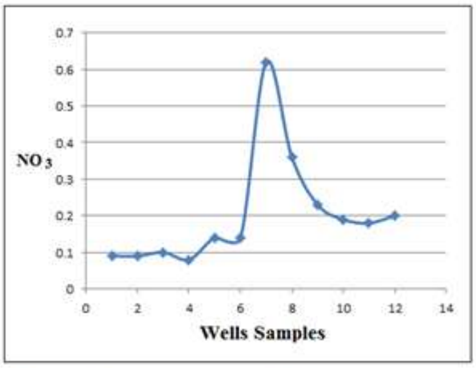

Figure 9: Concentration of Nitrate

5-2- Water quality index assessment

The water quality index (WQI) is an effective tool in water pollution control which can be applied efficiently to improve the quality of groundwater. The Water Quality Index provides information to measure the assessment by relying on a single number of zero to hundred [15]. In this study, ten parameters were used to design the water quality index.

The importance of parameters (weight) depends on the intended use of water and therefore the quality of the water quality is formulated, here, water quality criteria have been studied in terms of their suitability for human use [16].In this study, standards (values allowed for differentparameters) are those recommended by Iraqi drinking water standards [14].

The water quality index was used in this study to assess the suitability of groundwater for drinking purposes in the Fakka and Heweta areas in Maysan Governorate, Iraq. WQI requires several parameters for accurate calculation. These parameters include physical and chemical characteristics of groundwater sampling, each sample was analyzed for ten parameters, which are: pH, Total hardness, Total Dissolved Solids, Calcium, Magnesium, Sodium, Potassium, Chloride, Sulfate and Nitrate. The results of these physic-chemical parameters were mathematically used to calculate the WQI. The Physical and chemical parameters are shown in (Table 2).

The calculation of WQI is including three steps: First step, "specific weights (wi) is assigned to the chemical parameters according to itsrelative importance in the overall quality of water for drinking purposes which range from 1 to 5. For example, Nitrate parameter playing a prominent role in groundwater quality for drinking purposes", (Table 3) than the other parameters hence higher wattage is given in nitrate parameter. Whereas magnesium is assigned less weighting because it is not harmful to groundwater quality for drinking purposes[1]. In the second step, "the relative weight (Wr) is computed from the following equation"[17]:

$$\mathbf{Wr = w_i \ / \sum^{n}_{i=1} w_i} \qquad (1)$$

Where, "Wr is the relative weight, w_i is the weight of each parameter and n is the number of parameters. Calculated relative weight (Wr) values ofeach parameter are given in (Table3)".

In the third step, "a quality rating scale (q_i) for each parameter is assigned by dividing its concentration in each water sample (Table4) by its respective standard according to the guidelines laid down in the Iraqi standards which is illustrated in (Table, 4-34) and the result multiplied by 100"[18].

$$\mathbf{q_i = (C_i - C_o / S_i - C_o) \times 100} \qquad (2)$$

Where q_i is the quality rating scale, C_i is thevalue of the water quality parameter obtained from the laboratory analysis in(mg/l), C_o is the ideal value of this parameter in pure water (C_o=0 except for pH =7) and S_i is the (Iraqi Standard parameters[14], for each chemical parameter. For the purpose of the WQI calculation, Sli is identified (for each chemical parameter) of the ten parameters used, which are then used to determine WQI as the following equations:

$$SI_i = Wr \times q_i \quad (3)$$

$$WQI = \sum^{n}_{i=1} SI_i \quad (4)$$

SI_i is the index of the parameter, shown in (Table, 4).

6. Results

6-1 Water quality index analysis

The computed WQI values could be classified as <50 = Excellent, 50-100 = Good, 100-200 = Poor, 200-300 =Very poor, >300 = Unsuitable for drinking purpose[19], [1], as showing in (Table5).

The results of the application of the water quality index for the wells of Al-Fakka-Heweta area showed that it varies between good and unsuitablefor drinking purpose. Wells 5, 6, 9 good well water, wells, 4, 10, 11, 12poor water, wells1, 2, 3very poor water and well7 are unsuitable for drinking purpose. (Figure 10) shows the distribution of WQI in the study area.

7. Conclusion

In this study, 25% of groundwater samples of good quality, 33.3% poor quality, 33.3% very poor and 8.3% unsuitable for drinking purpose. The water quality index ranges from 51.6 to 375.9. Therefore, some treatment is needed before use and is required to protect that area from contamination.The rainwater must be well managed to recharge groundwater and improve groundwater resources. In order to preserve the quality and quantity of aquifers and thus reduce the high concentration of chemical components and soluble salts. The Public Awareness Program should be launched to promote knowledge and awareness of the provision of drinking water to humans around their areas of residence.

Table (3): Relative weight for each parameter [1]

Parameters	Iraqi standard (2004)	Standard value WHO (2008)	Weight (wi)	Relative weight (Wr)
PH	6.5 – 8.5	7-8	4	0.1333
TH	500	100-500	2	0.0666
TDS (mg/ l)	1000	1000	4	0.1333
Ca^{+2} (mg/ l)	150	75-200	2	0.0666
Mg^{+2} (mg/ l)	50	30-150	2	0.0666
Na^{+} (mg/ l)	200	200	2	0.0666
K^{+} (mg/ l)	-	12	2	0.0666
Cl^{-} (mg/ l)	250	250	3	0.1
SO_4^{-2} (mg/ l)	250	250	4	0.1333
NO_3^{-} (mg/ l)	50	50	5	0.1666
Total			**Σwi=30**	

Table (4): The values of qi , Sli, WQI for each parameter in water samples

Par. W.No		PH	TH	TDS	Ca^{+2}	Mg^{+2}	Na^{+}	K^{+}	Cl-	SO_4^{-2}	NO_3^{-}	WQI
W 1	**pi**	0	246.8	338.8	233.1	175.4	307.9	29.6	331.5	512	0.18	
	Sli	0	16.4	45.1	15.5	11.7	20.5	1.9	33.15	68.2	0.03	**212.5**
W 2	**pi**	0	263.9	342	255.6	176	292.8	29.7	320.6	526.8	0.18	
	Sli	0	17.5	45.6	17.02	11.7	19.5	2.97	32	70.2	0.03	**216.5**
W 3	**pi**	20	249.2	347	235.4	177.2	311	30	335.7	517	0.2	
	Sli	2.7	16.6	46.2	15.6	11.8	20.7	2	33.5	68.9	0.03	**218**
W 4	**pi**	40	221	315	208.7	157.2	275.5	26.6	297	458.2	0.16	
	Sli	5.3	14.7	41.9	13.9	10.4	18.3	1.7	29.7	61	0.02	**196.9**
W 5	**pi**	20	121.4	165	93.7	124.6	127.6	4.8	144.4	219.8	0.28	
	Sli	2.6	8.1	21.9	6.2	8.3	8.5	0.32	14.4	29.3	0.04	**99.6**
W 6	**pi**	20	119.8	164	92.4	123	125.8	4.75	142.4	216.7	0.28	
	Sli	2.6	7.9	21.8	6.1	8.2	8.3	0.3	14.2	28.8	0.04	**98.2**
W 7	**pi**	60	434.2	632	347.7	422.2	633.4	206.6	655.7	827.2	1.24	
	Sli	7.9	28.9	84.2	23.1	28.1	42.2	13.7	65.5	110.2	0.2	**375.9**
W 8	**pi**	20	273.5	473	241	226	519.8	135.5	513.4	634.6	0.72	
	Sli	2.6	18.2	63	16	15	34.6	9	51.3	84.6	0.11	**294.4**
W 9	**pi**	0	60	93	44.2	65.4	71.7	2.5	69.8	122.6	0.46	
	Sli	0	3.9	12.4	2.9	4.3	4.7	0.17	6.9	16.3	0.07	**51.6**
W10	**pi**	20	155.8	210	116.1	167.2	170	1.9	145.2	349.6	0.38	
	Sli	2.6	10.3	27.9	7.7	11.1	11.3	1.2	14.5	46.6	0.06	**133.2**
W11	**pi**	0	146.6	198	109.3	157.4	160.2	17.8	136.7	329.3	0.36	
	Sli	0	9.7	26.4	7.2	10.5	10.6	1.18	13.6	43.9	0.05	**123.1**
W12	**pi**	20	158.3	223	118	170	172.7	19.2	147.4	355.1	0.4	
	Sli	2.6	10.5	29.7	7.8	11.3	11.5	1.2	14.7	47.3	0.06	**136.6**

Table (5) : Water quality classification based on WQI value [20]

WQI value	Quality of water	Well Sample No.
< 50	Excellent	
50-100	Good	W 5, W 6, W7
100-200	Poor	W 4, W 10, W 11, W 12
200-300	Very Poor	W 1, W 2, W 3, W 8,
> 300	Unsuitable For drinking purpose	W 7

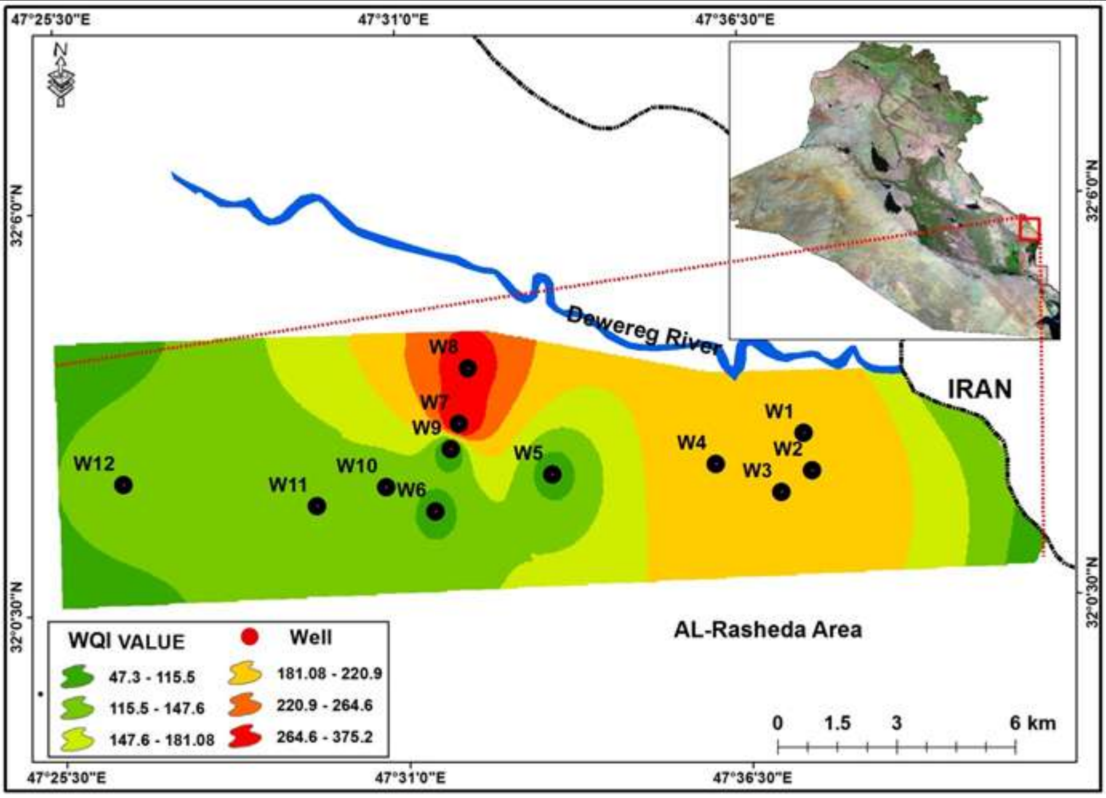

Figure 10: The distribution of WQI in the study area

References

[1] **Ramakrishnaiah CR, Sadashivaiah C, Ranganna G (2009).** Assessment of WaterQuality Index for Groundwater in Tumkur Taluk, Karnataka State, India. E-Journal of Chemistry, 6 (2): 523-530.

[2] **Krishan, G., Singh, S. Kumar CP, Garg PK, Suman, G., Ghosh, NC and AnjuC., 2016,** Assessment of Groundwater Quality for Drinking Purpose by Using Water Quality Index(WQI) in Muzaffarnagar and Shamli Districts, Uttar Pradesh, India. Hydrol Current Res., Vo.7, Issue 1.

[3] **Al- Mohammed, F., M., Mutasher, A., A., 2013,** Application of Water Quality Index forEvaluation of Groundwater Quality for Drinking Purpose in Dibdiba Aquifer, KerbalaCity, Iraq, Journal of Babylon University/Engineering Sciences, Vo.21, No. 5 (1647-1660).

[4] **Sukumaran., D., Saha, R., Saxena., R., C., 2015,** Ground Water Quality Index of Patna, the Capital City of Bihar, India, American Journal of Water Resources, Vol. 3, No. 1, (17-21).

[5] **Pichiah S., Senthil Kumar G.F., Srinivasamoorthy K., Sarma V. S., 2013,** Hydrochemical characterization and quality assessment of groundwater in TirupurTaluk, Tamil Nadu, India: Emphasis on irrigation quality journal of academic and industrial research, Vol.1 (12), 805-812.

[6] **Santhosh P., Revathi D., 2014,** Geochemical Studies on the Quality of Ground Water inTirupur District, Tamilnadu, India. Journal of Chemical, Biological and Physical Sciences, 4 (2), 1780-1786.

[7] **Zayed1, M. A., Elhdad, A.M.A., 2015,** Assessment of Groundwater Pollution with Heavy Metals based on Pollution Index and Investigation of Groundwater Quality UsingWater Quality Index in Western Nile Delta, Egypt**,** International Journal of Scientific Engineering and Research**,** Value: 62.86 **(**2347-3878**).**

[8] **Prasanna M.V., Chidambaram S., Srinivasamoorthy K., 2010,** Statistical analysis of the hydrogeochemical evolution of groundwater in hard and sedimentary aquifers systemof Gadilam river basin, South India. Journal of King Saud University (Science), 22 (3), **(** 133-145).

[9] **Karanth, K. R., 1989,** Hydrogeology. New Delhi: Tata McGraw-Hill.

[10] **Kumar, M., Ramanathan, A. L., Rao, M. S., & Kumar, B. (2006),** Identification andevaluation of hydrogeochemical processes in the groundwater environment of Delhi, India. Environmental Geology, 50, (1025–1039).

[11] **Pirasteh S., Safari H. O., Pradhan B., Attarzadeh I., 2010,** Litho – morphotectonics Analysis using Landsat ETM data and GIS techniques: Zagros Fold Belt (ZFB), S W Iran.

[12] **Budy, T. and Jassim, S., 1980,** The regional geology of Iraq. Vol. 1, stratigraphy and paleogeography. I.I.M., Kassab and S.Z. Jassim (ed) SOM. Baghdad. 445p.

[13] **World Health Organization, 2011,** Guidelines for drinking water quality, Recommendations, 4 th Ed. WHO, Geneva, Switzerland, v. 1, 541
[14] **Drinking-Water Standard IQS, 2004:** 417, Central Organization for Quality Control and Standardization, Council of Ministers, Republic of Iraq.
[15] **Saleem, M., Hussain, A., and Mahmood, G., 2016,** Analysis of groundwater quality using water quality index: A case study of greater Noida (Region), Uttar Pradesh (U.P), IndiaCIVIL & ENVIRONMENTAL ENGINEERING | RESEARCH ARTICLE**.**
[16] **Abdul Hameed M., Alobaidy, J., Abid, H., S., Maulood. B., K., 2010,** Application of Water Quality Index for Assessment of Dokan Lake Ecosystem, Kurdistan Region, Iraq, Journal of Water Resource and Protection, 2, (792-798).
[17] **Iman Al-Ali, Sattar Obaid, Wiam Hassan, 2017,** Estimate Groundwater Suitability for Drinking Purposes by using WQI Technique in Al-Teeb area-Maysan Governorate –South Iraq**,** ADVANCES in NATURAL and APPLIED SCIENCES**,** 11(14): pages(39-44
[18] **Gebrehiwot AB, Tadesse N, Jigar E., 2011,** Application of water quality index to assess suitability of groundwater quality for drinking purposes in References - 130 – Hantebet watershed, Tigray, Northern Ethiopia. ISABB J. Food and Agric. SCI. J (1): (22-30).
[19] **Ramakrishnaiah, C., R., Sadashivaiah, C. and Ranganna, G., 2009,** "Assessment of Water Quality Index for the Ground Water in Tumkur Taluk, " E-Journal of Chemistry, Vol. 6, No. 2, pp. (523-530).
[20] **Kavita, P. and Vineeta, P., 2010,** "Evaluation Water quality Index for drinking purpose of river Subenarekha in Singhbhum District", International Journal of Environmental Sciences, 1(1), (77-81)