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Groundwater Quality Assessment for Irrigation purposes in Kirkuk Governorate.

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ABSTRACT
The study of groundwater quality is important as one of the main freshwater resources that are used for various purposes, including the irrigation of agricultural crops. The study aims to identify the chemical composition of groundwater in Kirkuk Governorate, and evaluate its quality for irrigation purposes. The irrigation water quality index (IWQI) method [1] is one of the most important indicators of irrigation water quality. It is mainly used to evaluate water for agricultural purposes, using the technique of analysing multiple variables. The study area is located between two latitudes (35̊ 23′51″-35̊ 29′ 50″) N and longitudes (44̊ 12′47″-44̊ 27′81″) E and has a total area of about (305158.41) hectares. Samples were collected during September (2023), where sixty wells randomly distributed in the study area were selected, chemical and physical analyzes were conducted, GIS technology was used to perform spatial analysis using (Arc GIS v,10.4.1), IWQI irrigation water quality index was determined with five parameters including, electrical conductivity EC, sodium Na, chlorides Cl , bicarbonate HCO_3 ions and Sodium absorption ratio SAR. The values of the irrigation water quality index IWQI ranged between 46.37 and 86.59.The spatial distribution map of the irrigation water quality index showed that 0.02% of the study area was classified as excellent restrictions and determinants for irrigation purposes, and that 88.97% of them were classified as having low restrictions and determinants. In comparison, 10.98% of them were classified as having moderate restrictions and 0.02% occupied a small area west of the study area within high use restrictions.

***Keywords*:** groundwater, IWQI, SAR, GIS, Kirkuk, Iraq.

INTRODUCTION

The world, including Iraq, is deficient in water sources, one of which is groundwater, which is necessary for daily, agricultural and industrial use, and it faces many environmental pollution problems due to the increased demand for it as a result of population growth [2]. Water is a pressing factor for all living things on Earth[3].The limited natural resources in dry areas are accompanied by a decrease of agricultural from these resources are unable to find alternative sources to meet the growing needs of food[4].Groundwater is one of the most important water resources because it accounts for 71.7% of potable water in the world and includes groundwater and springs,which are mainly arising from rainwater and irrigation water that exudes into the ground and stores under its surface in in non-porous layers for the formation of groundwater aquifer [5] .

which method [1]is one of the most important indicators of irrigation water quality, which is mainly used in the evaluation of water for agricultural purposes and is based on the multivariate analysis technique.

The IWQI index [1] is one of the most widely is applied in irrigation water classification systems, with the limited number of parameters, the availability of data, and the ease of obtaining their estimates, in addition to its relative modernity, all that made it the subject of study by many researchers and those interested in irrigation water quality issues.

The IWQI Index has been used to assess irrigation water quality for the Halabja - Sayed Sadiq Basin in Iraq during wet and dry seasons by [6], also for several underground reservoirs in Halayeb and Shalateen south eastern desert of Egypt [7], in northwestern Minya Governorate in Egypt by [8]. Also in the regions of Chabahar, Sistan and Baluchestan southeastern Iran by [9]. [10] showed during their study of groundwater in some areas of Mosul city in terms of its suitability for irrigation using IWQI, that the quality of the studied water was suitable for irrigation, the water class (excellent and good).

Materials and Methods

2.1. Description of the study are The study included a group of groundwater wells within (Daquq, Taza, Laylan, Qara Hanjir) area in the province of Kirkuk / northern Iraq, which is located between longitudes (44̊ 12′ 47″ - 44̊ 27′ 81″) E and latitudes (35̊ 23′ 51″ - 35̊ 29′ 50″) N, total area of about (305158.41) hectares (Figure 1). These waters are mostly used in agriculture, livestock and animal husbandry.

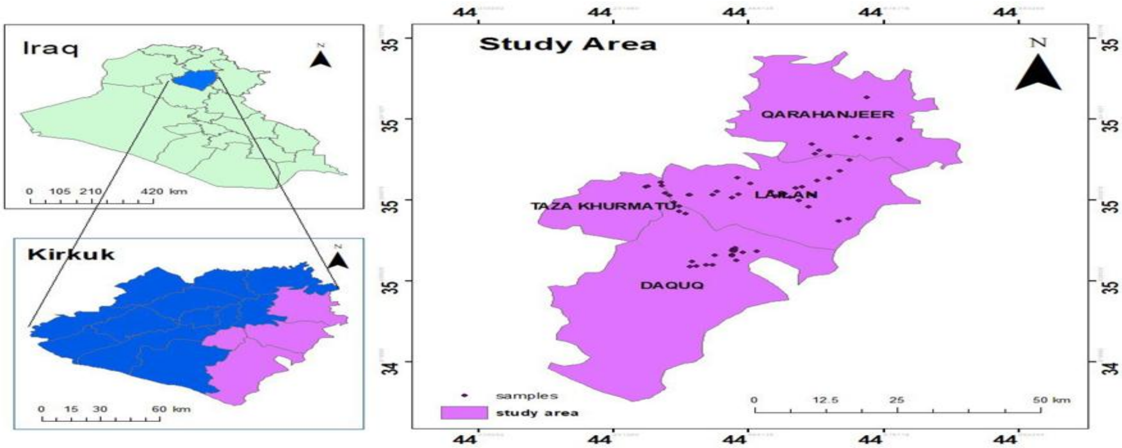

Figure 1: The study area location showing the groundwater wells.

2.2. Water sampling and field tests:

The samples were collected during the September (2023), where sixty wells distributed randomly in the study area were selected, the water samples from the well were collected in plastic bottles with a capacity of 1.5 liters after operating the well for 15 minutes to get rid of the stagnant water in the pipes. The bottles were washed with well water first and then filled to the edge to avoid exposure to ventilation, the samples were transferred to the laboratory and placed in the refrigerator at a temperature of (4) ° C to prevent the growth of fungi until laboratory analysis [11].

2.3. Water Analysis

Some chemical analysis for soil samples were done as shown in table 1

Table 1: Laboratory Analysis for Some Chemical Characteristics

Parameter	Methods
EC ($dS.m^{-1}$)	EC meter
Na^{+1}($Meq.L^{-1}$)	Flame Photometer
Cl^{-1}($Meq.L^{-1}$)	EDTA with AgNO3 0.005N
$HCO3^{-1}$($Meq.L^{-1}$)	EDTA with HCl
Ca^{+2}, Mg^{+2}($Meq.L^{-1}$)	EDTA Method

-Sodium Adsorption Ratio (SAR) represents the relative effectiveness of sodium ion to the ratio of calcium and magnesium ions, calculated according to the following equation [12]

$$SAR = \frac{Na}{\sqrt{\frac{Ca + Mg}{2}}} \dots \dots \dots (1)$$

− The irrigation water quality index (IWQI) was calculated through the following equation referred by [1], which is used to assess water quality for agricultural purposes, this is calculated in three steps:

First Step: Five indicators were used to calculate IWQI includes (EC, Na, Cl, HCO3, and SAR). To calculate each of these indicators, the calculation of the relative weight and the value of the qi water quality measurement were used.

Second step: - Measuring the quality of irrigation water qi based on the different parameters recommended by [13]. The qi value is estimated as shown in Table 2 and calculated using equation (2)

$$\mathrm{qi} = \mathrm{qmax} - \left(\frac{(\mathrm{Xij} - \mathrm{Xinf}) \times \mathrm{qimap}}{Xamp}\right) \dots \dots \dots (2)$$

Whereas: -

qi: - *Water Quality Measurement*

qmax:-Maximum value per item

XIJ:-Measured value per parameter

Xinf:-Represents the minimum value of the item that the parameter follows

qimap:-represents the capacity of the item

Xamp:-Represents the value corresponding to the item capacity that the parameter follows

Where the qi index quality ranged (0-100) corresponding to the concentration.

Table2:Irrigation water quality parameters and their proposed limiting.

qi	SA	EC ($dS.m^{-1}$)	Na ($Meq.L^{-1}$)	Cl ($Meq.L^{-1}$)	HCO3 ($Meq.L^{-1}$)
85-100	<3	200-750	2-3	<4	1-1.5
60-85	3-6	750-1500	3-6	4-7	1.5-4.5
35-60	6-12	1500-3000	6-9	7-10	4.5-8.5
less than35	>12	<200 or>3000	<2 or>9	>10	<1or>8.5

To calculate the relative weight values Wi, the equation proposed by [1] was used, which was formulated based on its relative importance to the quality of irrigation water. As shown in Table (3).

Table (3) The weights of the IWQI parameters (3)

1. parameters	2. Wwi
3. EC	4. ***0.211***
5. SAR	6. ***0.204***
7. Na	8. ***0.202***
9. Cl	10. ***0.194***
11. HCO_3	12. $\mathbf{0}.189$

Calculate the irrigation water quality index IWQI from the following equation [1]:

$$IWQI = \sum_{i=1}^{n} qiwi \dots\dots\dots (3)$$

the IWQI value ranges between (0-100) and is classified into five categories (Table 4), where these categories were determined based on soil permeability and problems of salinity risk and ion toxicity for plants

Table4: Classification of groundwater quality for the investigated sites based on IWQI

IWQI	Values and type of restriction	Recommendations for plants	Crops and soil Soil
85-100	No restriction	No toxicity	Groundwater can be used for all types of soil as low risk of soil salinity and sodicity is prevailed
70-85	Low restriction	Avoid the use of salt sensitive	Groundwater can be used for light soil texture with high sand content ,moderate to high permeability
55-70	Moderate restriction	Moderate sait tolerance plants	Groundwater can beused for moderate to high permeable soil taking in consideration moderate soil leaching processes
40-55	High restriction	Moderate to high tolerance plants	This range of water can be used in soils with high permeadility without compact layers.High frequency irrigation schedule.

0-40	Severe restriction	High salt tolerance plants only	Groundwater cant be used to irrigate soil under normal conditions,

Results and Discussion

The electrical conductivity values, sodium concentrations, chloride, bicarbonate and sodium adsorption percentage in water were used to estimate the irrigation water quality index (IWQI), as the higher the value, the better the irrigation water quality.

figure (2) showed that…. four classes of irrigation water quality index have no restrictions (85-100), low (70-85), moderate (55-70), high (40-55), for an area of 0.49 hectares, 2715.12 hectares, 335.19 hectares and 0.71 hectares respectively, with a percentage of 0.02% which occupying a small part of the center of a study area, 88.97% covering many parts of the study areas, 10.98% occupying a small area of the study area, and 0.02% occupying a small area of the west of the study area respectively.

The results in Table (5) showed that IWQI ranged between 46.37-86.59, with a general average of 72.40, the highest value was in well No. 48, and the lowest value in well No. 19, which represent the districts of (Laylan and Taza) respectively. The water of the well No. (19) falls within high use restrictions, and the values of the quality index range from 40 to 55, which can be used in high-permeable soils, which contain compressed layers requires periodic plowing, and must be done. In addition, the water of (17) wells was classified as moderate use restrictions, where the values of the irrigation water quality index were between 55 to 70.This type of water is suitable for the irrigation of medium-tolerance crops, which are grown in medium soil with high permeability. With moderate washing of salts to prevent soil degradation. The results also showed that there were (41) wells, its water with low specifications for use for irrigation purposes, where the value of the water quality index ranged between 70 to 85.This type of water is suitable for the irrigation of salt-sensitive plants, considering its use for light-strength or medium-permeable soils. The results showed that well No. (48) has good specifications and there are no restrictions for use for irrigation purposes.

12.1. Table (5) Irrigation Water Quality Index for Well groundwater Samples for the Study area

12.2. N O.	12.3. qi					12.5. qi*wi					12.6. I WQI
12.7. Sample	12.8. EC	12.9. SAR	12.10. a	12.11. l	12.12. CO3	12.13. C	12.14. AR	12.15. a	12.16. l	12.17. CO3	
12.18.	12.19. 2.67	12.20. 4.4	12.21. 1.67	12.22. 8.56	12.23. 1.25	12.24. 1.11	12.25. 7.84	12.26. 6.66	12.27. 7.18	12.28. .33	12.29. 1.13
12.30.	12.31. 9.67	12.32. 4.9	12.33. 9.50	12.34. 5.13	12.35. 7.50	12.36. 2.59	12.37. 7.94	12.38. 8.26	12.39. 8.45	12.40. 3.64	12.41. 0.87
12.42.	12.43. 4.33	12.44. 6.72	12.45. 8.50	12.46. 5.31	12.47. 0.00	12.48. 3.57	12.49. 8.28	12.50. 0.09	12.51. 8.49	12.52. 2.12	12.53. 2.56
12.54.	12.55. 1.67	12.56. 6.25	12.57. .00	12.58. 8.94	12.59. 6.88	12.60. 5.12	12.61. 8.19	12.62. .43	12.63. 7.25	12.64. 1.49	12.65. 3.48
12.66.	12.67. 2.00	12.68. 7.55	12.69. 7.50	12.70. 0.81	12.71. 0.83	12.72. 7.30	12.73. 8.44	12.74. .57	12.75. 7.62	12.76. 2.29	12.77. 9.21
12.78.	12.79. 1.33	12.80. 5.7	12.81. 8.50	12.82. 3.25	12.83. 0.63	12.84. 5.05	12.85. 8.09	12.86. 0.09	12.87. 8.09	12.88. 0.23	12.89. 1.55
12.90.	12.91. 9.00	12.92. 4.7	12.93. 8.00	12.94. 2.88	12.95. 3.75	12.96. 2.45	12.97. 7.90	12.98. 7.95	12.99. 8.02	12.100. 0.86	12.101. 7.17
12.102.	12.103. 0.00	12.104. 5.2	12.105. 2.50	12.106. 2.13	12.107. 6.25	12.108. 2.66	12.109. 7.99	12.110. 8.87	12.111. 7.87	12.112. 1.36	12.113. 8.76
12.114.	12.115. 6.83	12.116. 4.45	12.117. 9.17	12.118. 0.44	12.119. 4.38	12.120. .88	12.121. 7.85	12.122. 6.15	12.123. 7.54	12.124. 0.98	12.125. 2.41
12.126. 0	12.127. 9.67	12.128. 4.7	12.129. 1.67	12.130. 2.88	12.131. 1.67	12.132. 0.48	12.133. 7.90	12.134. 6.66	12.135. 8.02	12.136. 2.46	12.137. 5.51
12.138. 1	12.139. 0.33	12.140. 5.95	12.141. 1.00	12.142. 9.31	12.143. 9.38	12.144. 2.73	12.145. 8.13	12.146. 8.56	12.147. 7.33	12.148. 1.99	12.149. 8.75
12.150. 2	12.151. 3.67	12.152. 7.5	12.153. 7.68	12.154. 5.50	12.155. 0.50	12.156. 7.65	12.157. 8.43	12.158. .61	12.159. 8.53	12.160. .12	12.161. 0.33
12.162. 3	12.163. 0.33	12.164. 7.6	12.165. 7.50	12.166. 6.81	12.167. 1.67	12.168. 6.95	12.169. 8.45	12.170. .57	12.171. 8.78	12.172. 2.46	12.173. 0.21
12.174. 4	12.175. 3.33	12.176. 8	12.177. 1.00	12.178. 5.13	12.179. 9.17	12.180. 7.58	12.181. 8.52	12.182. .28	12.183. 8.45	12.184. 3.97	12.185. 2.82
12.186.	12.187.	12.188.	12.189.	12.190.	12.191.	12.192.	12.193.	12.194.	12.195.	12.196.	12.197.

5	9.17	5.95	5.50	2.50	9.38	2.48	8.13	9.48	7.95	1.99	0.04
12.198.	12.199.	12.200.	12.201.	12.202.	12.203.	12.204.	12.205.	12.206.	12.207.	12.208.	12.209.
6	5.17	4.2	2.50	2.69	0.00	1.64	7.80	6.83	7.98	2.12	6.38
12.210.	12.211.	12.212.	12.213.	12.214.	12.215.	12.216.	12.217.	12.218.	12.219.	12.220.	12.221.
7	2.83	0.2	2.50	0.44	7.50	.93	7.05	0.71	7.54	3.64	5.86
12.222.	12.223.	12.224.	12.225.	12.226.	12.227.	12.228.	12.229.	12.230.	12.231.	12.232.	12.233.
8	6.86	2.55	5.00	1.75	8.75	.67	7.49	1.22	7.80	1.87	4.05
12.234.	12.235.	12.236.	12.237.	12.238.	12.239.	12.240.	12.241.	12.242.	12.243.	12.244.	12.245.
9	4.59	6.16	.00	0.00	6.88	.08	6.28	.00	5.52	1.49	6.37
12.246.	12.247.	12.248.	12.249.	12.250.	12.251.	12.252.	12.253.	12.254.	12.255.	12.256.	12.257.
0	4.82	9.45	1.50	6.63	2.50	0.01	8.80	.43	8.75	6.67	0.64
12.258.	12.259.	12.260.	12.261.	12.262.	12.263.	12.264.	12.265.	12.266.	12.267.	12.268.	12.269.
1	5.27	7.75	9.25	6.63	1.88	7.99	8.47	.93	8.75	0.48	9.62
12.270.	12.271.	12.272.	12.273.	12.274.	12.275.	12.276.	12.277.	12.278.	12.279.	12.280.	12.281.
2	7.99	1.65	4.17	1.67	4.17	.91	7.32	1.05	5.84	2.96	3.08
12.282.	12.283.	12.284.	12.285.	12.286.	12.287.	12.288.	12.289.	12.290.	12.291.	12.292.	12.293.
3	3.11	2.8	4.17	8.75	8.13	.99	7.54	3.09	7.22	.72	4.55
12.294.	12.295.	12.296.	12.297.	12.298.	12.299.	12.300.	12.301.	12.302.	12.303.	12.304.	12.305.
4	4.65	1.2	0.83	6.88	1.25	.31	7.24	2.41	6.85	0.35	4.16
12.306.	12.307.	12.308.	12.309.	12.310.	12.311.	12.312.	12.313.	12.314.	12.315.	12.316.	12.317.
5	1.60	3.7	6.67	9.50	6.88	.56	7.71	1.56	7.36	1.49	2.68
12.318.	12.319.	12.320.	12.321.	12.322.	12.323.	12.324.	12.325.	12.326.	12.327.	12.328.	12.329.
6	1.67	4.15	6.67	1.94	5.63	.79	7.79	5.64	7.84	.22	9.28
12.330.	12.331.	12.332.	12.333.	12.334.	12.335.	12.336.	12.337.	12.338.	12.339.	12.340.	12.341.
7	4.02	2.55	3.33	1.25	6.88	.18	7.49	2.92	5.76	1.49	4.84
12.342.	12.343.	12.344.	12.345.	12.346.	12.347.	12.348.	12.349.	12.350.	12.351.	12.352.	12.353.
8	2.36	8.3	4.50	6.44	3.33	9.49	8.58	.00	8.71	4.81	6.59
12.354.	12.355.	12.356.	12.357.	12.358.	12.359.	12.360.	12.361.	12.362.	12.363.	12.364.	12.365.
9	4.44	3.6	8.33	6.25	7.50	.27	7.69	3.94	8.67	3.64	1.20
12.366.	12.367.	12.368.	12.369.	12.370.	12.371.	12.372.	12.373.	12.374.	12.375.	12.376.	12.377.
0	1.17	1.35	4.17	7.81	4.17	.69	7.27	3.09	7.04	2.96	9.04
12.378.	12.379.	12.380.	12.381.	12.382.	12.383.	12.384.	12.385.	12.386.	12.387.	12.388.	12.389.
1	9.00	4.55	5.50	0.25	4.17	6.67	7.87	9.48	7.51	2.96	4.49
12.390.	12.391.	12.392.	12.393.	12.394.	12.395.	12.396.	12.397.	12.398.	12.399.	12.400.	12.401.
2	2.33	2.7	1.67	4.00	4.17	3.15	7.52	6.66	8.24	2.96	8.53
12.402.	12.403.	12.404.	12.405.	12.406.	12.407.	12.408.	12.409.	12.410.	12.411.	12.412.	12.413.
3	2.00	6.2	.50	6.06	2.50	5.19	8.18	.71	8.64	2.63	5.35
12.414.	12.415.	12.416.	12.417.	12.418.	12.419.	12.420.	12.421.	12.422.	12.423.	12.424.	12.425.
4	6.33	6.8	0.50	5.31	0.00	6.11	8.30	.14	8.49	4.14	9.17
12.426.	12.427.	12.428.	12.429.	12.430.	12.431.	12.432.	12.433.	12.434.	12.435.	12.436.	12.437.
5	3.45	8.4	6.25	6.06	7.50	9.72	8.60	.36	8.64	3.64	5.94
12.438.	12.439.	12.440.	12.441.	12.442.	12.443.	12.444.	12.445.	12.446.	12.447.	12.448.	12.449.
6	9.36	8.55	6.25	3.81	5.83	8.86	8.63	.36	8.20	3.30	4.33
12.450.	12.451.	12.452.	12.453.	12.454.	12.455.	12.456.	12.457.	12.458.	12.459.	12.460.	12.461.
7	1.00	7.75	1.00	7.75	0.83	9.20	8.47	.28	8.96	2.29	3.21
12.462.	12.463.	12.464.	12.465.	12.466.	12.467.	12.468.	12.469.	12.470.	12.471.	12.472.	12.473.
8	8.55	7.75	1.00	4.56	5.83	8.68	8.47	.28	8.35	3.30	3.08
12.474.	12.475.	12.476.	12.477.	12.478.	12.479.	12.480.	12.481.	12.482.	12.483.	12.484.	12.485.
9	3.73	8.45	6.25	6.44	5.00	9.78	8.61	.36	8.71	3.13	5.58
12.486.	12.487.	12.488.	12.489.	12.490.	12.491.	12.492.	12.493.	12.494.	12.495.	12.496.	12.497.
0	3.33	8.5	4.50	4.75	1.88	7.58	8.62	.00	8.38	0.48	0.06
12.498.	12.499.	12.500.	12.501.	12.502.	12.503.	12.504.	12.505.	12.506.	12.507.	12.508.	12.509.
1	3.18	7.85	2.75	6.44	2.50	9.66	8.49	.64	8.71	2.63	4.13
12.510.	12.511.	12.512.	12.513.	12.514.	12.515.	12.516.	12.517.	12.518.	12.519.	12.520.	12.521.
2	7.50	6.85	.50	4.56	1.88	2.13	8.30	.71	8.35	0.48	9.98
12.522.	12.523.	12.524.	12.525.	12.526.	12.527.	12.528.	12.529.	12.530.	12.531.	12.532.	12.533.
3	5.67	7.35	3.13	4.94	3.13	3.86	8.40	.68	8.42	0.73	4.08
12.534.	12.535.	12.536.	12.537.	12.538.	12.539.	12.540.	12.541.	12.542.	12.543.	12.544.	12.545.

4	4.27	7.6	2.75	7.19	4.17	9.89	8.45	.64	8.85	2.96	4.80
12.546.	12.547.	12.548.	12.549.	12.550.	12.551.	12.552.	12.553.	12.554.	12.555.	12.556.	12.557.
5	3.45	8.55	6.25	7.00	1.67	9.72	8.63	.36	8.82	4.48	7.00
12.558.	12.559.	12.560.	12.561.	12.562.	12.563.	12.564.	12.565.	12.566.	12.567.	12.568.	12.569.
6	0.33	8.15	1.00	6.06	8.33	6.95	8.55	.28	8.64	5.82	4.24
12.570.	12.571.	12.572.	12.573.	12.574.	12.575.	12.576.	12.577.	12.578.	12.579.	12.580.	12.581.
7	0.00	7.8	9.25	5.50	4.17	6.88	8.48	.93	8.53	2.96	0.78
12.582.	12.583.	12.584.	12.585.	12.586.	12.587.	12.588.	12.589.	12.590.	12.591.	12.592.	12.593.
8	4.67	1.4	2.50	6.81	8.33	7.86	7.27	8.87	8.78	3.80	6.59
12.594.	12.595.	12.596.	12.597.	12.598.	12.599.	12.600.	12.601.	12.602.	12.603.	12.604.	12.605.
9	6.91	7.6	9.25	6.63	7.50	8.34	8.45	.93	8.75	1.62	1.07
12.606.	12.607.	12.608.	12.609.	12.610.	12.611.	12.612.	12.613.	12.614.	12.615.	12.616.	12.617.
0	5.00	0.75	5.83	6.06	9.17	1.61	7.15	5.47	8.64	3.97	6.83
12.618.	12.619.	12.620.	12.621.	12.622.	12.623.	12.624.	12.625.	12.626.	12.627.	12.628.	12.629.
1	5.55	7.85	1.00	5.50	0.83	8.05	8.49	.28	8.53	4.31	3.66
12.630.	12.631.	12.632.	12.633.	12.634.	12.635.	12.636.	12.637.	12.638.	12.639.	12.640.	12.641.
2	5.09	9.7	3.25	7.19	3.33	0.06	8.84	.78	8.85	4.81	9.36
12.642.	12.643.	12.644.	12.645.	12.646.	12.647.	12.648.	12.649.	12.650.	12.651.	12.652.	12.653.
3	2.36	7.8	2.75	5.50	7.50	9.49	8.48	.64	8.53	3.64	4.78
12.654.	12.655.	12.656.	12.657.	12.658.	12.659.	12.660.	12.661.	12.662.	12.663.	12.664.	12.665.
4	3.18	6.85	7.50	7.56	6.25	9.66	8.30	.57	8.93	1.36	1.83
12.666.	12.667.	12.668.	12.669.	12.670.	12.671.	12.672.	12.673.	12.674.	12.675.	12.676.	12.677.
5	5.64	8.2	6.25	7.38	8.75	0.18	8.56	.36	8.89	1.87	4.85
12.678.	12.679.	12.680.	12.681.	12.682.	12.683.	12.684.	12.685.	12.686.	12.687.	12.688.	12.689.
6	4.55	9.4	1.50	6.44	8.75	9.95	8.79	.43	8.71	1.87	5.74
12.690.	12.691.	12.692.	12.693.	12.694.	12.695.	12.696.	12.697.	12.698.	12.699.	12.700.	12.701.
7	6.45	9.7	3.25	6.25	3.75	0.35	8.84	.78	8.67	0.86	5.51
12.702.	12.703.	12.704.	12.705.	12.706.	12.707.	12.708.	12.709.	12.710.	12.711.	12.712.	12.713.
8	6.73	8.95	9.75	6.81	8.13	0.41	8.70	.07	8.78	1.74	5.70
12.714.	12.715.	12.716.	12.717.	12.718.	12.719.	12.720.	12.721.	12.722.	12.723.	12.724.	12.725.
9	2.91	9.65	3.25	6.25	1.67	9.60	8.83	.78	8.67	2.46	6.35
12.726.	12.727.	12.728.	12.729.	12.730.	12.731.	12.732.	12.733.	12.734.	12.735.	12.736.	12.737.
0	1.55	8.85	8.00	4.94	7.50	9.32	8.68	.71	8.42	1.62	3.74

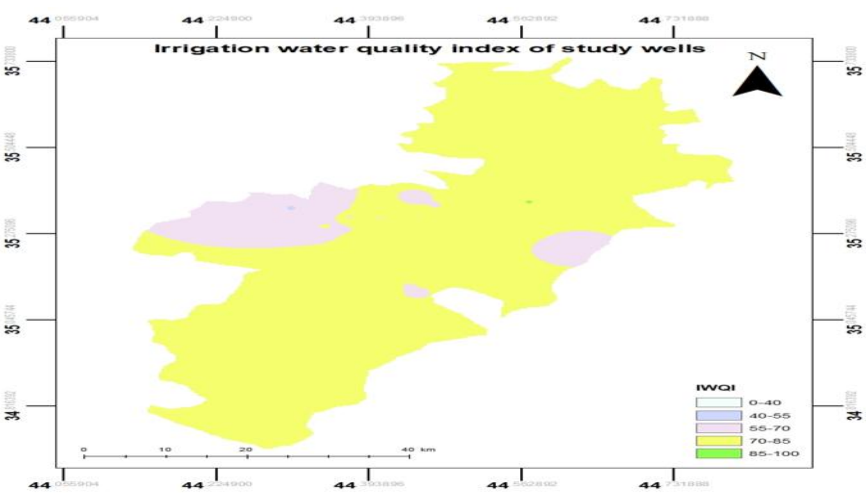

Figure 2 irrigation water quality index map of the study area

Conclusion

Through the detailed study of the variation of groundwater characteristics in different areas of Kirkuk from determining the irrigation water quality index with five parameters, it was found that most of the study area (88.97%) has low water quality restrictions for irrigation purposes and that it is suitable for irrigating salt-sensitive crops. With a percentage of 0.02%, it occupied a small part of the center of a study area with good specifications and no restrictions on use for irrigation, 10.98% occupied the west and various parts of the study area within the use of moderate restrictions, and 0.02% occupied a small area of the west of the study area within high use restrictions.

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تقييم جودة المياه الجوفية لاغراض الري في محافظة كركوك.

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الخلاصة

تعتبر دراسة جودة المياه الجوفية مهمة كأحد موارد المياه العذبة الرئيسية التي تستخدم لأغراض مختلفة ، بما في ذلك ري المحاصيل الزراعية. تهدف الدراسة إلى التعرف على التركيب الكيميائي للمياه الجوفية في محافظة كركوك، وتقييم جودتها لأغراض الري.ومؤشر جودة مياه الري (***IWQI***) تعد طريقة ***[1]*** من اهم مؤشرات جودة مياه الري التي تستخدم بدرجة رئيسة في تقييم المياه للأغراض الزراعية على تقنية تحليل المتغيرات المتعددة (***Multivariant analysis***).تقع منطقة الدراسة بين خطي عرض (35˚ 23′51″-35˚ 29′ 50″) شمالا وخط طول (44˚ 47′12"-44˚ 27′81") شرقا وعلى مساحة بلغت حوالي (305158.41) هكتارا. اذ جمعت البيانات خلال شهر سبتمبر (2023) اذ تم اختيار 60 بئرا موزعة عشوائيا في منطقة الدراسة وإجريت عدد من التحاليل الكيميائية والفيزيائية وتم رسم خريطة التوزيع المكاني بتقنية نظم المعلومات الجغرافية لإجراء التحليل المكاني باستخدام (10.4.1,Arc GIS v) وتم تحديد مؤشر جودة مياه الري IWQI باعتماد خمس معلمات تشمل التوصيل الكهربائي EC والصوديوم Na والكلوريدات Cl و بيكربونات HCO3 ونسبة امتصاص الصوديوم SAR. تراوحت قيم مؤشر جودة مياه الري IWQI بين (86.59-46.37). أظهرت خريطة التوزيع المكاني لمؤشر جودة مياه الري أن 0.02٪ من مساحة الدراسة صنفت على أنها ذات قيود ومحددات ممتازة لأغراض الري، وأن 88.97٪ منها صنفت على أنها ذات قيود ومحددات منخفضة، في حين صنفت نسبة 10.98٪ منها على أنها ذات قيود معتدلة، وبنسبة 0.02٪ شغلت مساحة صغيرة من غرب منطقة الدراسة ضمن قيود الاستخدام العالي.

الكلمات المفتاحية: مياه جوفية، دليل جودة المياه الري ،نسبة امتزاز الصوديوم ،نظم المعلومات الجغرافية، كركوك ،العراق.