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The Possibility of Groundwater in the Wells of Southern Najaf for Multiple Uses

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ABSTRACT

Najaf is a biggest city an agricultural the result of this study carried to evaluate the quality of groundwater for drinking and agricultural purposes. To evaluate the quality of well water in the southern and western Najaf region, 27 water wells located in the area were selected and some chemical and physical parameters (pH, electrical conductivity, total dissolved solids, total hardness, calcium, magnesium, sodium, potassium, chloride, bicarbonate, and sulfate) were tested to calculate the water quality index for drinking water. The obtained values for water quality parameters were compared with the World Health Organization (WHO) guidelines. Seven irrigation test parameters were also selected to calculate the water quality index such as: EC, SSP, SAR, MAR, PI, KR, and PS, which were used in the traditional way. The results showed that the groundwater of most samples was suitable for drinking according to the WHO guidelines (2011). Whatever, the calculated DWQI for drinking use showed that 10% of the water samples were founded good, 40% were very poor, and 50% were unfit for drinking. For irrigation purposes, most of the samples were fit table for irrigation. The calculated IWQI showed that 15% of the water samples were excellent, and 45% were good. Most of the groundwater samples in this area are suitable for irrigation according to WHO guidelines (22).

KEY WORDS: physical and chemical parameters, Groundwater wells, Water quality indexes for Drinking DWQI , irrigation IWQI.

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1-INTRUDCTION

The backup resources for industrial development and human survival it was the groundwater which is one of waters shapes . It is essential for its use on the earth's surface for drinking, industrial, irrigation, and domestic purposes, and it plays a influence role in the life of all creatures worldwide. Consequently, estimating the quality of groundwater for irrigation and drinking has become a critical dilemma for next groundwater quality management. Assessing water quality for irrigation and livestock relies on several criteria, the most important of which is the total salt content and ionic composition. The resulting variation in quality relies on the type and quantity of dissolved salts, Meanwhile the dissolved or weathered rocks, such as dissolved gypsum. Researchers have discovered six types of saline water. For drinking water, it must have characteristics and features that should be accepted by the World Health Organization (WHO) as a guide for drinking water standards and guidelines followed by countries worldwide. Any country has special guide based on the quality of its water. The natural groundwater purification process begins with the soil, which is a porous medium that adapts to natural water filtration (8,10).

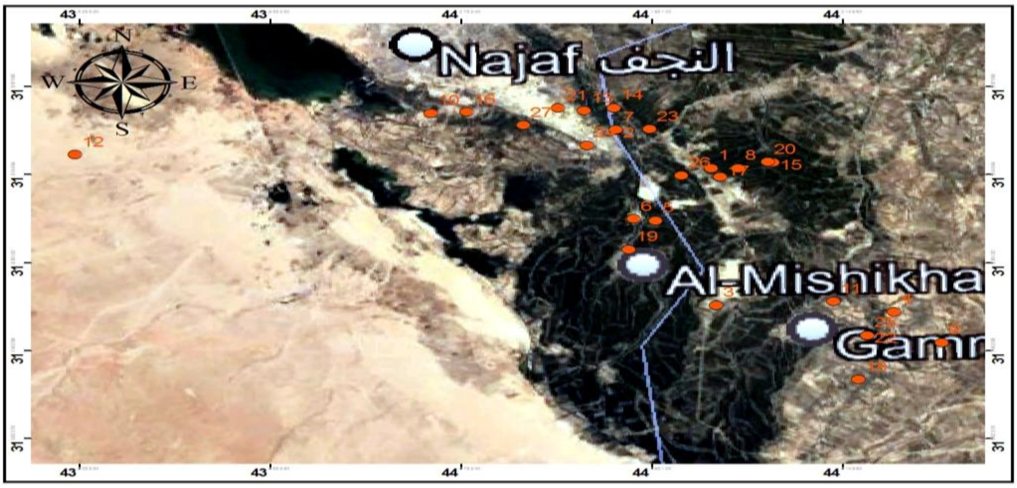


Fig (1) the Study area.

2- SITE OF THE STUDY AREA

The area of study is located in the southern of Najaf, specifically in the (Najaf Sea) region. It lies Among latitudes 44° 10′ 56″ and 31° 55′ 12″ east, and longitudes 44° 06′ 50″ and 31° 57′ 9″ east.(Fig 1) Najaf's climate is semi-arid & arid, differentiated with hot, driest summers and cold, Semi rainy winters. The average annual temperature is 20.1°C. The average maximum temperature is 40.5°C in summer, and the average minimum temperature is 17.3°C in winter. Average winter rainfall is less to 5.0 mm per year, while the relative humidity is 25.3%.The region is characterized by its rural environment, and its population relies primarily on agriculture. Water in this area is typically obtained from wells for the various uses.

3- WATER QUALITY INDEX OF DRINKING (DWQI)

Groundwater samples had been taken through the period 2021-2023 from 27 wells in the study area. Analyses had been conducted in the survey laboratory of the ministry of water Resources. Each sample was analyzed for 11 parameters: Ca^{+2}, K^{+}, Na^{+}, Mg^{+2}, $SO4^{-2}$, Cl^{-}, $HCO3^{-}$, $NO3^{-}$, TDS, EC, and pH, using the standard procedure (21). The results of the laboratory tests of the taken samples showed in (Table 1). To test the suitability of human drinking use according to WHO guidelines, the Water Quality Index (WQI) is calculated for each well as follows:

$WQI = \Sigma(Ci/Si)/n$ where:

Ci = concentration of each parameter in the sample in ppm.

Si = Iraqi drinking specifications to the every parameter.

n = Number of parameters in the sample.

4-IRRIGATION WATER QUALITY INDEX (IWQI)

The water quality index (IWQI) gets a completely picture of groundwater quality for Irrigation use. To calculate the IWQI in this study, seven parameters were considered: salinity (EC), soluble sodium percentage (SSP), sodium adsorption ratio (SAR), magnesium adsorption ratio (MAR), permeability index (PI), Kelly ratio (KR), and potential salinity (PS). There are three steps to calculate the IWQI. In the first step, a weight (wi) was limited to each parameter according to the importance. Like the maximum weight of 5 was limited to SAR and SSP for their significant importance in assessing water quality and their direct correlation with salinity effects. EC was the second important parameter for irrigation it got 4 because it indicates salinity hazards. PI, KR, and PS are the third important parameters were limited as 3 weight because they predict the accumulation of salts and sodium in the soil which came from calcium and magnesium carbonates. Finally, MAR was fourth important parameter it took 2 weight that indicated to magnesium effects. then relative weight (Wi) was calculated in this formula:

$Wi = Wi / \sum n \; wi$

Where Wi is the relative weight, Wi is the weight constant of each parameter table(3), and n is The number of parameters. The relative weight (Wi) is determined for individual parameters. WSAR = 0.2, WSSP = 0.2, WEC = 0.16, WPI,KR,PS = 0.12 and WMAR = 0.08.

The third step is the quality rating (Qi) for each parameter and is determined by the next formula

$Qi = (Ci/Si)*100$ whereas:

Qi = Individual parameter quality rating.

Ci = concentration of the individual parameter obtained from laboratory analysis.

Si = Standard concentration value for irrigation quality for the individual parameter

In this study, the standard values for individual parameters were derived from the averages of the classification categories of questionable irrigation water (Table 8). To calculate the internal water quality index (IWQI), the sub-index (SI) for each parameter was determined separately for each water sample, which was calculated from the following equation:

$SIi = Wi * Qi$

Qi = Quality Rating , Wi = Relative Weight

In this study, the sub-indices of the parameters were SISAR, SISSP, SIEC, SIPI, SIKR, SIPS, and SIMAR. the Irrigation Water Quality Index (IWQI) is determined for each water sample as follows:

$IWQI = \sum (SI\ SAR)i + (SI\ SSP)i + (SI\ EC)i + (SI\ PI)i + (SI\ KR)i + (SI\ PS)i + (SI\ MAR)i$

Electrical conductivity (EC), dissolved sodium ratio (SSP), sodium adsorption ratio (SAR), magnesium adsorption ratio (MAR), permeability index (PI), Kelly ratio (KR), and potential salinity (PS) were used to evaluate the suitability of groundwater quality for irrigation as follows.

Sodium percentage (SSP) $Na\% = \{(Na+)/(Ca^2+Mg^2+Na+\}x100$

Sodium absorption ratio (SAR): $SAR = Na/\sqrt{(Ca^2+Mg^2)/2}$

Permeability Index (PI) $PI = \{(Na+ \sqrt{HCO3-})/(Ca2 + Mg2 + Na)\}x100$

Kelly ratio (KR) $KR = Na/(Ca^2+Mg^2)$

Magnesium Absorption Ratio (MAR) $MAR = \{Mg^{2+}/(Ca^{2+}+Mg^{2+})\}x100$

Potential salinity (PS) $= CL^- + 0.5\ SO4^{-2}$

Table (1) Some hydraulic features and coordinates of the wells of the study area.

name	Nourth	East	depth	static WT	dynamic WT	Q (l/sec)	drilling year
MASHAB MADHLOUM	44 13 56.9	31 55 12.3	60	11	25	9	2023
ezzias	44 10 19.6	31 57 22.2	65	9.5	23	8	2023
uyoon al ruhba	44 14 06.55	31 47 22.56	80	18	42	8	2022
uyoon al ruhba	44 20 49.44	31 46 59.77	70	13	37	10	2022
wadi al milh	44 11 49.88	31 52 12.07	80	18	42	8	2022
wadi al milh	44 11 01.1	31 52 18.1	80	12	31	9	2021
ezzias	44 10 20.3	31 57 22.8	65	12	25	8.5	2023
MASHAB MADHLOUM	44 14 57.1	31 55 11.7	60	8	24	9	2023
wadi waer	44 22 38.18	31 45 14.41	70	14	38	9	2022
rehema	44 03 22.38	31 58 20.32	60	17	36	6	2021
ruhba	44 18 33.49	31 47 33.88	70	12	37	8	2022
rehema	43 49 56.83	31 55 57.89	70	16	40	6	2022
ezzia	44 09 08.1	31 58 28.6	70	15	46	6	2023
ezzia	44 10 15.6	31 58 38.5	70	15	48	6	2022
gazia road	44 16 14.8	31 55 32.28	120	43	62	3	2022
rehema	44 04 44.1	31 58 23.86	80	13	42	8	2022
mASHAB MADHLOUM	44 14 15.8	31 54 42	60	13	37	6	2022
ruhba	44 19 28.39	31 43 07	80	13	37	6	2021
wadi al milh	44 10 50.17	31 50 32.78	80	13	44	8	2022
bahr al najaf	44 16 03.02	31 55 32.61	120	68	81	6	2022
ezzia	44 08 10.9	31 58 37.7	70	11	36	9	2022
ruhba	44 19 48.54	31 45 38.57	70	12	39	6	2021
ezzia	44 11 35.95	31 57 25.95	80	14	38	6	2021
ezzia	44 09 14.8	31 56 29.9	70	11	29	9	2022
ruhba	44 19 48.54	31 45 38.57	70	12	39	6	2021
MASHAB MADHLOUM	44 12 48	31 54 46.9	120	26	49	6	2021
rehema	44 06 50.8	31 57 39.01	70	13	35	6	2021

Table (2) Physical and chemical properties and Drinking Water Quality Index (DWQI) of groundwater samples.

wells	NO3	SO4	HCO3	CL	K	Na	Mg	Ca	TDS	EC	PH	DWQI
1	**1.1**	**1724**	**602**	**1054**	**54**	**815**	**277**	**462**	**5061**	**7800**	**7.14**	**222**
2	**0.9**	**1733**	**584**	**1035**	**44**	**788**	**259**	**444**	**4952**	**7640**	**7.18**	**225**
3	**1.6**	**550**	**200**	**588**	**12**	**258**	**115**	**174**	**1922**	**2970**	**7.26**	**90**
4	**0.5**	**670**	**364**	**389**	**12**	**349**	**89**	**178**	**2080**	**3210**	**7.2**	**101**
5	**0.9**	**1490**	**460**	**659**	**87**	**565**	**156**	**330**	**3800**	**5860**	**7.14**	**201**
6	**1.7**	**802**	**230**	**563**	**10**	**235**	**164**	**277**	**2314**	**3570**	**7.2**	**105**
7	**1.4**	**1017**	**326**	**716**	**20**	**447**	**225**	**593**	**3392**	**5230**	**7.2**	**153**
8	**1.5**	**1918**	**732**	**1240**	**68**	**895**	**336**	**503**	**5772**	**8900**	**7.12**	**269**
9	**1.1**	**744**	**215**	**526**	**13**	**285**	**212**	**222**	**2248**	**3470**	**7.25**	**104**
10	**1.1**	**1635**	**613**	**812**	**100**	**695**	**279**	**458**	**4660**	**7180**	**7.12**	**243**
11	**0.2**	**683**	**374**	**397**	**10**	**357**	**97**	**186**	**2130**	**3290**	**7.25**	**102**
12	**1.4**	**532**	**237**	**416**	**7**	**264**	**119**	**188**	**1789**	**2760**	**7.15**	**85**
13	**1.4**	**1278**	**652**	**789**	**15**	**710**	**307**	**412**	**4230**	**6510**	**7**	**189**
14	**0.5**	**676**	**367**	**390**	**12**	**350**	**90**	**179**	**2096**	**3230**	**7.22**	**101**
15	**1.2**	**1210**	**593**	**717**	**62**	**643**	**241**	**315**	**3860**	**5960**	**7.2**	**195**
16	**0.9**	**694**	**384**	**407**	**10**	**367**	**107**	**196**	**2193**	**3390**	**7.24**	**105**

17	0.9	743	215	527	12	286	211	222	2250	3470	7.2	104
18	1.2	579	151	292	5	240	59	175	1519	2350	7.13	72
19	1.1	819	494	638	18	459	135	294	2890	4460	7.28	136
20	1.1	533	237	417	9	265	120	189	1795	2770	7.22	86
21	0.4	688	378	401	10	361	104	190	2160	3330	7.2	103
22	0.6	525	193	577	12	247	104	163	1843	2850	7.14	86
23	1.4	527	234	413	7	261	116	185	1767	2730	7.16	84
24	1.5	565	215	601	14	271	128	187	2010	3100	7.16	94
25	0.6	525	193	577	12	247	104	163	1843	2850	7.14	86
26	1.2	604	480	568	4	356	135	236	2410	3730	7.14	111
27	1.4	554	213	599	12	269	126	194	1990	3080	7.15	93
Standard deviation	0.5	442	172	227	26	203	76	125	1215	1871	0.06	222

Table (3) The weight (wi) and relative weight (wi) of each chemical parameter were calculated based on the standard values reported by the World Health Organization.

Parameter	**WHO guideline (mg/L)**	**Weight (w_i)**	**Relative weights (W_i)**
[K]	**12**	**2**	**0.056**
[Na]	**200**	**4**	**0.111**
[Mg^{2}]	**50**	**3**	**0.083**
[Ca^{2}]	**75**	**3**	**0.083**
[HCO$_3$]	**120**	**1**	**0.028**
[Cl]	**250**	**5**	**0.139**
[SO$_4$]	**250**	**5**	**0.139**
[pH]	**8.5**	**3**	**0.083**
[TDS]	**500**	**5**	**0.139**

Table (4) Water quality classification based on water quality index limits for proposed drinking water.

Water Quality Index Value	**water quality**	**Number of water samples**		**% of water samples**
0-25	**Excellent water quality**	**0**		**0**
25-50	**Good water quality**	**0**		**0**
50-75	**Poor water quality**	**1**		**3**
75-100	**Water quality is very poor**	**10**		**37**
> 100	**Not suitable for drinking**	**16**		**16**

Table (5) Correlation coefficient matrix for water quality standards and water quality index for study samples.

	EC	**SSP**	**SAR**	**MAR**	**KR**	**PI**	**PS**	**IWQI**
EC	**1**							
SSP	**0.97****	**1**						
SAR	**0.97****	**0.78****	**1**					
MAR	**0.96****	**-0.16**	**0.06**	**1**				
KR	**0. 97****	**0.34**	**0.64***	**0.78***	**1**			
PI	**0.91***	**0.98****	**0.87****	**0.98****	**0.87***	**1**		
PS	**0.98****	**0.17**	**0.79***	**0.92****	**0.83***	**0.94****	**1**	
IWQI	**0.99****	**0.96****	**0.82****	**0.95****	**0.93****	**0.98****	**0.95****	**1**

Table (6) Water quality classification ranges and water types based on the internal water quality index values.

Range	Type of groundwater
o 50	Excellent water
50–99.99	Good water
100–199.99	Poor Water
200–299.99	Very poor water
Z 300	Unsuitable for drinking/Irrigation purpose

Table (7) Water quality classification limits for irrigation purposes and internal water quality index values.

Quality of parameters	Range	Type of water	No. of samples	% of samples	wells	IWQI
	100 - 250	Excellent	9		1	117
ECW (μS/cm)	250 - 750	Good	5	25	2	114
	750 - 2250	Doubtful	4	20	3	46
	> 2250	Unsuitable	2	10	4	49
	0 - 20	Excellent	4	20	5	87
	20 - 40	Good	2	10	6	57
Soluble sodium percentage (%)	40 - 60	Permissible	10	50	7	92
	60 - 80	Doubtful	4	20	8	132
	> 80	Unsuitable	--	--	9	54
	0 -10	Excellent	20	100	10	108
SAR (meq.l^{-1})	10 - 18	Good	--	--	11	51
	18 - 26	Doubtful	--	--	12	44
	> 26	Unsuitable	--	--	13	99
	< 25	Safe	5	25	14	50
Permeability index (%)	25 - 75	Moderate	11	55	15	88
	> 75	Unsafe	4	20	16	52
Kelly's Ratio (ppm)	< 1	Safe	12	60	17	54
	> 1	Unsuitable	8	40	18	39
Magnesium Adsorption Ratio (%)	< 50	Suitable	11	55	19	70
	> 50	Unsuitable	9	45	20	44
	< 5	Excellent to good	14	70	21	51
Potential Salinity (ppm)	5 - 10	Good to Injurious	2	10	22	45
	> 10	Injurious to Unsatisfactory	4	20	23	44

5. RESULTS AND DISCUSSION

5.1 Reaction potential function (pH):

pH is a measure of water acidity and one of the most important tools of water quality. the pH of Groundwater samples ranges from 7 to 7.3, with an average value of 7.15 and a standard deviation of 0.06. The desired pH is 6.5, and the maximum permissible value is 8.5. so as pH in water affects the carbonate-bicarbonate balance, leading to the release of carbon dioxide and increased water solubility, which increases the concentration of dissolved salts (1).

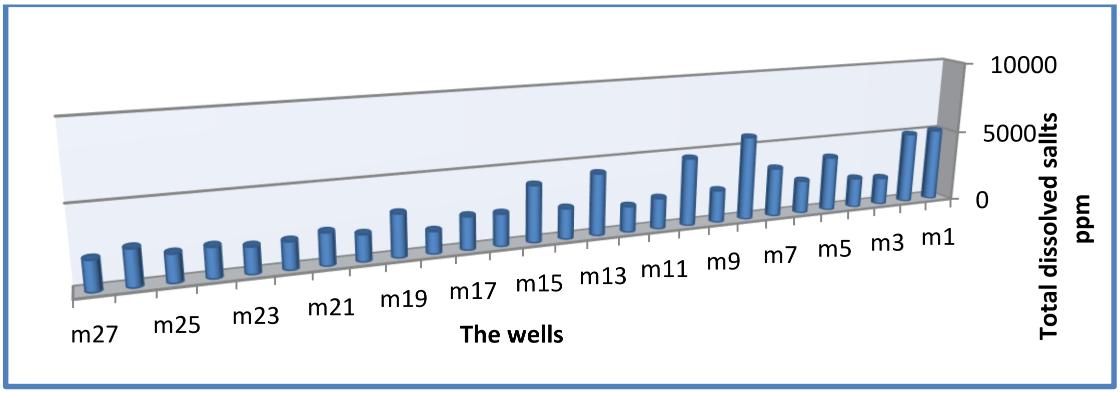


Fig (2) Total dissolved salts values from the study area.

5.2 .Total Dissolved Solids (TDS):

Water concentrations ranged from 1519 to 5772 ppm, with a mean value of 3040 ppm and a standard deviation of 1215 ppm. Total dissolved solids (TDS) are considered good, with maximums of 500 and 1500 ppm. According to the world health organization (2011), All samples exceeded the permissible limit, there were not good for drinking.

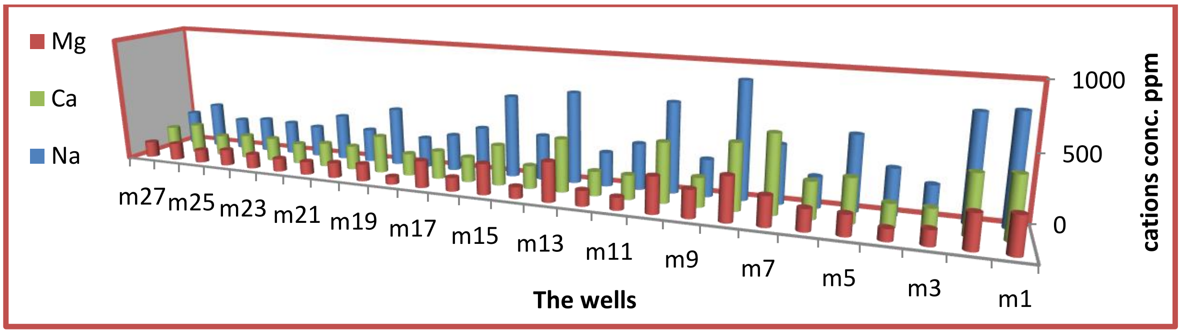


Fig (3) Concentration of dissolved cations of the study area.

5.3 .Soluble cations:

Calcium and magnesium (Ca^{+2} and Mg^{+2}):

calcium concentrations in the study area ranged from 190 to 593 ppm, with a mean value of 391 ppm and a standard deviation of 124. Thirteen groundwater wells were considered suitable, with a calcium concentration of 75-200 ppm as the permissible limit. Magnesium concentrations ranged from 98 to 336 ppm, with a mean value of 76.7 ppm with standard deviation of 76 ppm. The permissible limit for magnesium concentration is 50-150 ppm (WHO). Only nine samples exceeded these limits. Magnesium concentrations were lower than calcium, with a calcium-to-magnesium ratio of 1:0.6. However, 14.18% of the samples (calcium, magnesium) were considered unsuitable, with a percentage of 51.66%. The increased calcium concentration in the well water samples studied can be linked to the geological nature of the area, where limestone rocks are formed. the source of magnesium in groundwater is minerals containing it, which are washed out of the rocks and subsequently settle in the water in various ways (10), (12).

5.4. Sodium and potassium (Na^+ and K^+):

The concentration of sodium (Na^+) in the groundwater in the study area tended between 240 and 898 ppm, with an average value of 569 ppm and a standard deviation of 203 ppm. The results showed that sodium was the dominant cation in the groundwater, with the sodium concentration being 1.5-2 times that of calcium. The sodium concentration was also higher than that of magnesium. 24 samples showed sodium concentrations higher than the permissible limit of 200 ppm. Every groundwater sample contained some sodium, as most rocks and soils contain soluble sodium ions (6).

Potassium (K^+) concentrations ranged from 4 to 100 ppm with a mean of 52 ppm and a standard deviation of 26.4. The maximum permissible potassium concentration in drinking water is 12 ppm, and 10 samples were found to be over the WHO limit. high potassium concentrations have been associated with high sodium levels.

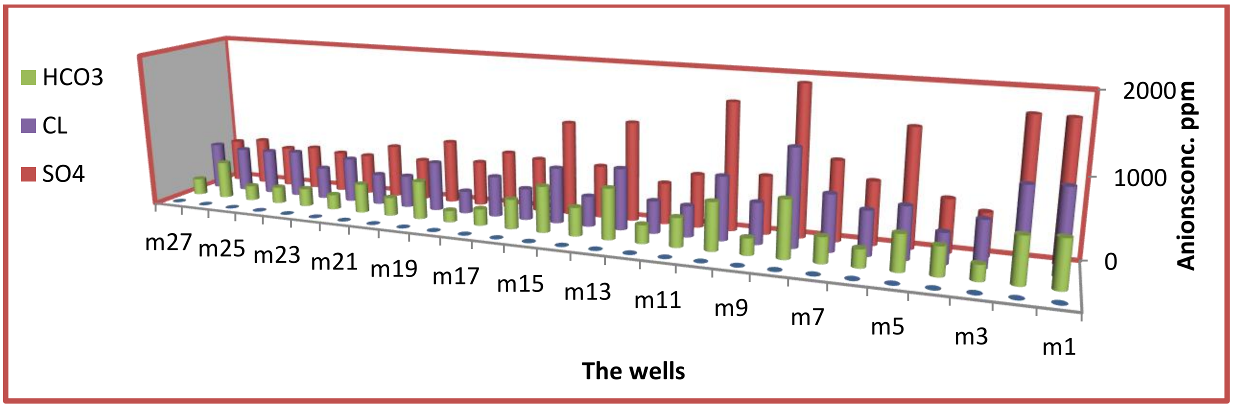


Fig (4) Concentration of dissolved anions in the of the study area.

5.5 .Soluble anions:

Sulfate ($SO4^{-2}$) Chloride (Cl^{-1}): The soluble anions were characterized by the predominance of $SO4^{-2}$, followed by chloride and then bicarbonate in most cases. Sulfate ranged from 525 to 1918 ppm, with a mean of 1221 ppm and a standard deviation of 442. The SO4 concentration in the study area was within the permissible limit of 200-400 ppm source of sulfate is the dissolution of gypsum deposits and human activities. The chloride present in the groundwater samples ranged from 292 to 1240 ppm with a mean of 766 ppm and a standard deviation of 227. Soluble chloride in the groundwater was found within the permissible limit of 600 mg/L according to WHO standards. Chloride (Cl^{-1}) is a common element in all rock types in various forms. it found greatly in groundwater, where rainfall is low and temperatures are high (12).

The $HCO3^{-1}$ concentration ranged from 193 to 732 ppm with a mean of 461 ppm and a standard deviation of 172 ppm. Bicarbonate ($HCO3^{-1}$) and carbonate ($CO3^{-2} = 0$) which responsible for alkalinity. The highest desirable limit for total bicarbonate according to the World Health Organization (2011) is 240 ppm. all groundwater samples were within the permissible limit.

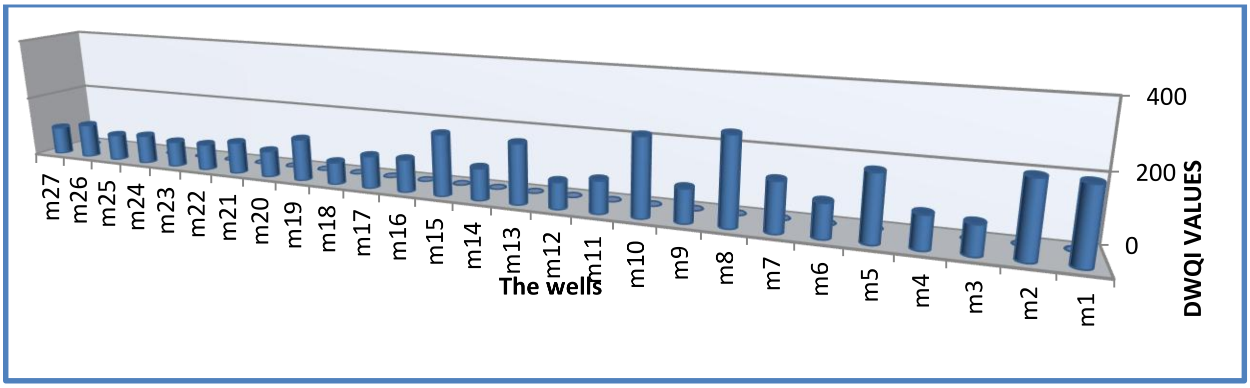


Fig (5) the water quality index values for groundwater samples in the study area.

5.6. Drinking Water Quality Index (DWQI):

In this study, the Water Quality Index (WQI) was taken for 27 groundwater samples from across the research area. Thus, the WQI for most of the groundwater samples ranged between 72 and 269, with a mean of 171 and a standard deviation of 94.3, which are unfit for human drinking, as shown in Figure 5, with the exception of wells M3, M12, M18, M20, M21, M22, M25, and M27, which had very poor water quality that could be used for drinking by animals or livestock (13). The Water Quality Index (WQI) can provide clear information about the subsurface geological conditions in which the water is found. It is a digital device used to convert a huge amount of water quality information into a single number that addresses the degree of water quality (7). In this study, the physicochemical parameters Ca^{2+}, K^{+}, Na^{+}, $Mg^{2+,}$ $SO4^{2-,}$ $Cl^{-,}$ $HCO3^{-}$, $NO3^{-}$, TDS, EC and pH were used to evaluate the suitability of groundwater for human consumption, according to the WHO 2011 standard (5), (14).

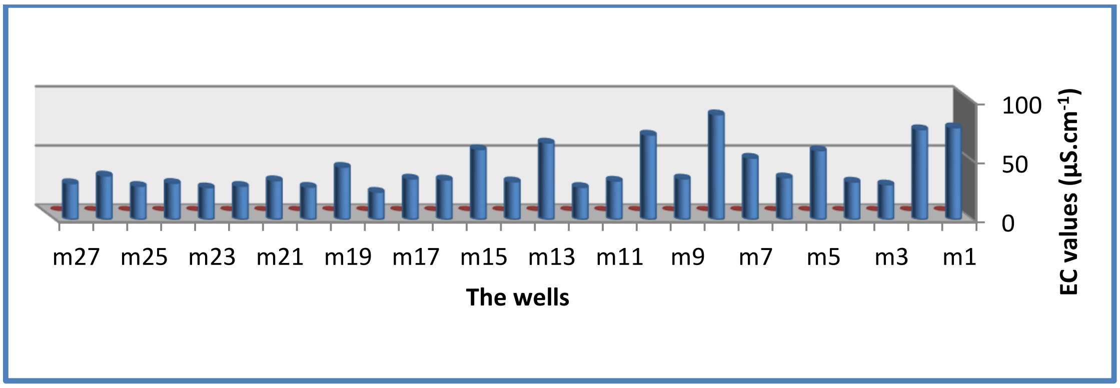


Fig (6) EC values of groundwater samples in the study area.

5.7. Salinity hazard:

Electrical conductivity (EC) is a good measure of the salinity effect in soils (8). EC data showed that samples with EC values ranged from 2350 to 7800 ($\mu S.cm^{-1}$) at 25°C, with an average value of 5750 ppm showed (Fig 6). then only 10% of groundwater samples were used for irrigation. Duo to the leaching and dissolution of salts into the surface aquifer in the studied area (13).

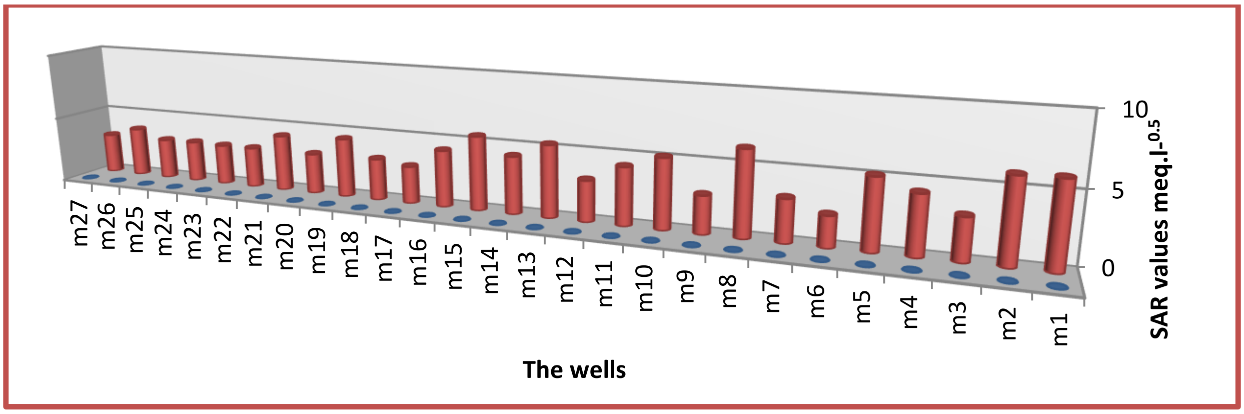


Fig (7) Sodium absorption rate values of groundwater samples in the study area.

5.8. Sodium absorption ratio (SAR):

The sodium absorption ratio (SAR) values ranged from 2.25 to 6.22 with a mean of 4.23 and a standard deviation of 0.06. This ratio is a measure of the alkalinity via sodium content of the water and its potential impact on crops. As a result, all groundwater samples recorded excellent SAR values. Most well samples fell into the very high salinity with low sodium (C4-S1) category (Fig 7). This type of water can be used for irrigating sodium-tolerant crops under special drainage conditions without any risk of exchangeable sodium (20).

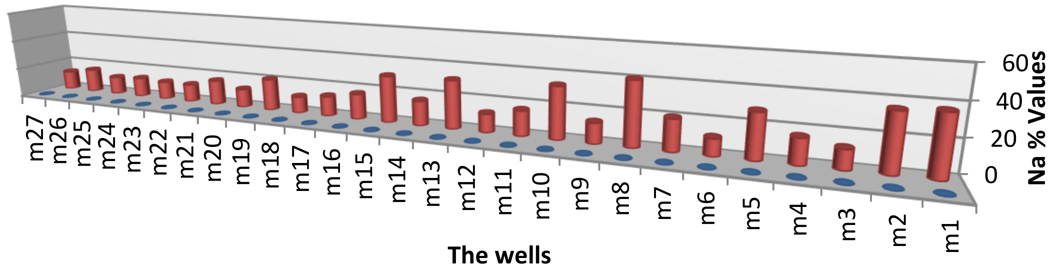


Figure (8) Sodium % values for groundwater samples in the study area.

5.9. Dissolved sodium content:

The dissolved sodium content (SSP) values ranged from 10.7% to 40.8%, with an average value of 47.4% and a standard deviation of 0.47%. Sodium hazards were an important factor in irrigation water quality. The results showed that 70% of the dissolved sodium content in the groundwater samples followed the good category, but 30% with the permissible category (Figure 8). Meanwhile, all groundwater contains some amount of sodium, as most rocks and soils contain sodium ions that dissolve (16).

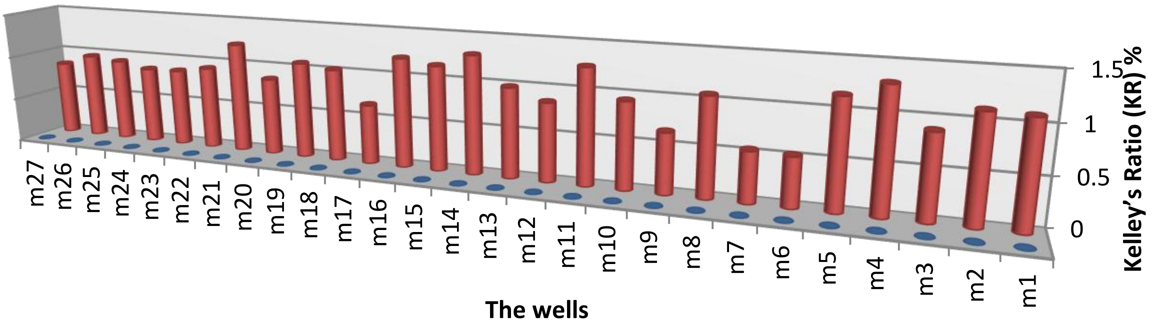


Fig (9) KR values for groundwater samples in the study area

5.10. Kelly ratio (KR):

The Kelly ratio (KR) values ranged from 0.66 to 1.30%, with an average value of 0.88 % and a standard deviation of 0.93 %. According to the Kelly ratio (Fig 9) water with a KR of less than one is considered good for irrigation, then KR more than one are considered unsuitable for irrigation. Data showed that 56% of the groundwater KR values in the study area were less than one, indicating good irrigation water quality, while the remaining 44% were above one, indicating unsuitable water quality for irrigation (20).

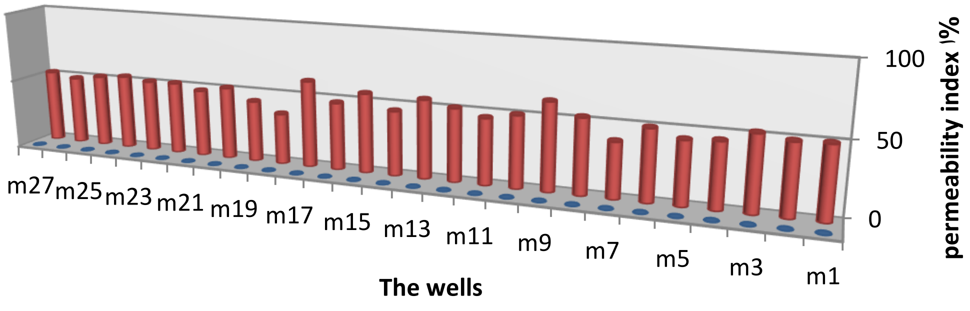


Fig (10) permeability index values for groundwater samples in the study area

5.11.Permeability Index (PI):

The permeability index (PI) values in the study area ranged from 26.8% to 59.8%, with an average value of 6.17% and a standard deviation of 1.5%. The PI results of groundwater showed that all groundwater samples (Figure 10) fall within the moderate water category for irrigation purposes. (17).

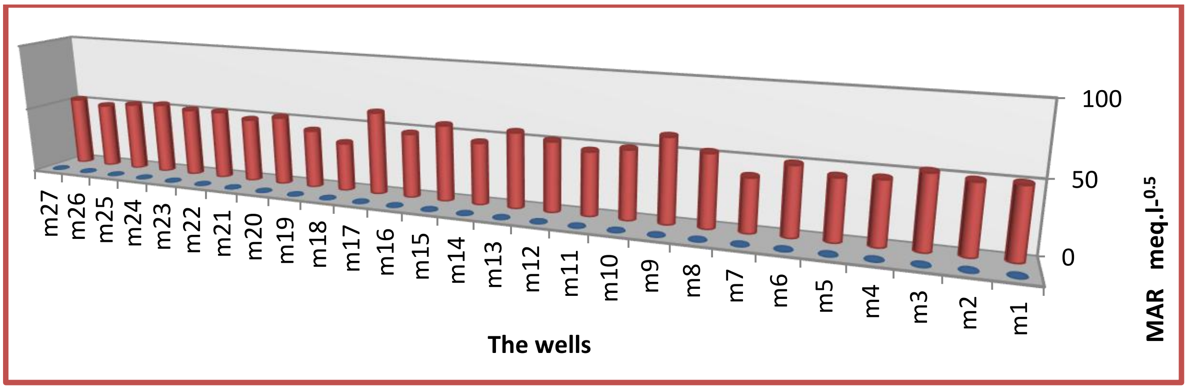


Fig (11) MH values for groundwater samples in the study area

5.12. Magnesium risky

The magnesium adsorption ratio (MAR) ranged from 25.21 to 49%, with a mean value of 37.1% and a standard deviation of 0.12% (Figure 11). MAR is expected to be an indicator of the risk of using high levels of magnesium in water and soil, which leads to poor crop production. The study showed that 12 wells were suitable for irrigation. while 15 were considered unsuitable, which may affect cultivated soil and crop production (18).

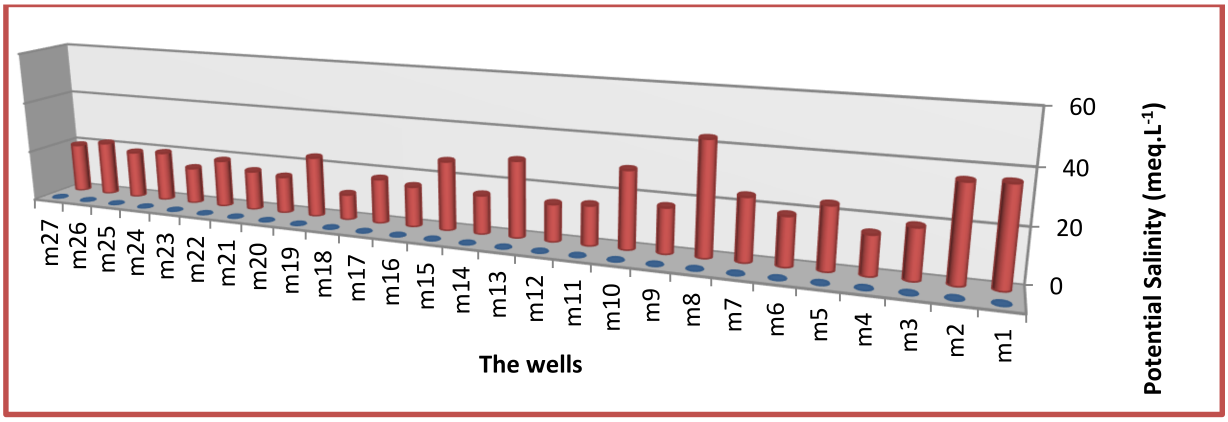
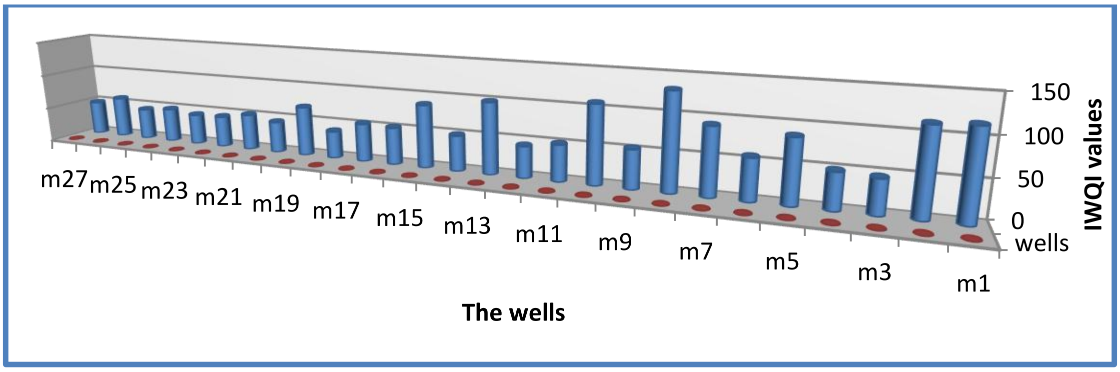


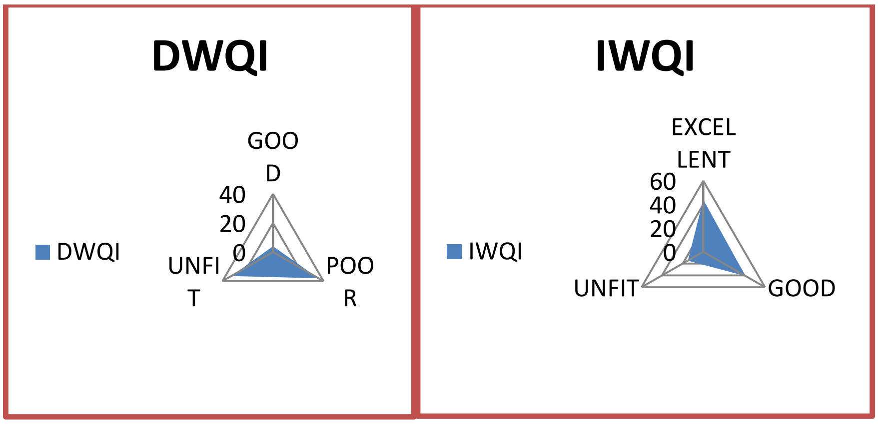
Fig (12) Potential salinity (PS) of groundwater samples in the study area.

5.13. Potential Salinity (PS):

Potential salinity (PS) values in the study area ranged from 9.9 to 43.5 meq.L-1, with a mean value of 26.5 meq.L-1 and a standard deviation of 10.74 meq.L-1. High PS values above the critical level of 5 meq.L-1. due to the high concentrations of chloride and sulfate ions into groundwater had bad effect on plants and soil. So the water of wells could be used to the irrigation under reclamations condition (19).



(Fig 13) the water quality index values for groundwater samples in the study area.



(Fig 14) Comparison between two indicators.

5.14. Irrigation Water Quality Index (IWQI): The results of the Irrigation Water Quality Index (IWQI) are presented in table 7. Various parameters such as EC, SAR, SSP, PI, MAR, KR, and PS were taken into account to evaluate the groundwater quality for irrigation. The values of the indices were summed and then classified into excellent to unsuitable groundwater quality. The results in Table 7 and Figure 13 showed that 15% of the samples with the Irrigation Water Quality Index (IWQI) belong excellent water quality and thus could be used for irrigation purposes. But most of the samples (41%) had good water quality and could be used for irrigation purposes (2) and (3). Fig (14) shows the comparison between the Drinking Water Quality Index (DWQI) and Irrigation Water Quality Index (IWQI).

6. THE RECOMMENDATION

- Comparison of the two indicators showed that the studied area contains less than 5-10% of the fresh water that is considered a safe reserve and should be used for drinking during times of shortage.
- Emphasis should be placed on reclamation and treatment of the remaining 40% of the water, converting poor quality water into good quality water to cover the water deficit in the supply share.
- The high percentage (15% excellent + 44% good) of the estimated irrigation water opened the door for its use in modern irrigation methods instead of surface irrigation.
- Controlling and monitoring the water quantities and quality of the supplied wells (weekly, monthly) helps in water testing because the properties of the aquifer can change over time according to hydrogeological and environmental factors.

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