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Groundwater suitability for multiple uses in Safwan district and Basya sub-district

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Abstract:
The importance of this research lies in understanding the suitability of groundwater for multiple uses in the Safwan district and the Basya sub-district. Water resources are essential to human life, as they are a primary source of drinking water, irrigation for agricultural lands, and other uses due to the scarcity of surface water. Consequently, the investment in groundwater is of great interest to researchers, especially when studying populations, their distribution, and their lifestyles. The presence of water is necessary as it is directly linked to human life. Given the great importance of groundwater in human life in the study area, studying its suitability according to a scientific and systematic plan is an important and influential driver of progress and economic development. In order to determine the suitability of groundwater in the study area, it was necessary to know the quality of the water and its content of positive and negative ions, and to know the international and Iraqi standard specifications, as these determine the various uses of groundwater. We will discuss the suitability of groundwater for multiple uses such as drinking, agriculture, and industry, based on the results of analyses, field observations, and personal interviews in the study area.

1- The problem of the study: The research problem is one of the first steps in scientific research and can be summarized in the following main question: (Is groundwater suitable for many uses?) From the main question, we derive the secondary questions.

2- Study hypothesis: The study assumes the hypothesis that it is possible to benefit from groundwater after modifying, reclaiming and desalinating it.

3- Study objective: The study aims to demonstrate the suitability of groundwater and its use in various fields in the Safwan district and Basia sub-district, based on the results of laboratory analyses, analysis of samples taken from the study area, and field observations.

4- Boundaries of the study area: The study area is astronomically bounded between latitudes (29°4'6"N- 31°0'29"N) and between the longitude brackets (44°44'33"E - 47°52'54"E) and geographically it is bordered by Basra Governorate to the east and Al-Salman District and Najaf and Anbar Governorates to the west, while the alluvial plain represents its northern borders and it is bordered to the south by the Kingdom of Saudi Arabia as shown in the map (1).

First - Groundwater suitability

1-1- Its suitability for human consumption: Water is a crucial and effective factor in the formation of most aspects of life, and life cannot continue without it. The existence of life is closely linked to water because it is the basis for the existence of living organisms on the surface of the earth.[1]Water also plays a fundamental and effective role in various aspects of life, and life cannot continue without water resources. It is divided into biological needs for the human body to perform its normal functions and nutritional needs for food production. The amount of water used by humans in hot regions differs from that in cold regions, as water use varies during the seasons. In the summer, much larger quantities of water are used than in the winter. Ensuring access to safe drinking water requires the development of programs and plans that take into account the future selection of locations for villages and residential complexes in areas where groundwater reservoirs are available. The standard specifications of the World Health Organization and Iraqi specifications, which depend on the concentrations of positive and negative ions as well as the percentage of dissolved salts, have been adopted.TDS, electrical conductivity (EC), and total hardness (TH). When comparing the chemical elements and dissolved salts in the groundwater of the study area with Iraqi and international standards, as shown in Table (1), it becomes clear that the water in the majority of wells is unsuitable for human consumption, with the exception of copper (Cu), zinc (Zn), and nitrate (NO3), which were below the permissible limits according to international and Iraqi measurements. This indicates that the groundwater is not contaminated with these elements. Similarly, the pH and HCO3 levels were within the permissible limits for potable water in some wells.

Table (1) Groundwater suitability rate for human drinking based on samples taken from the study area and compared with international standards (WHO 2007 and Iraqi 2009 in ppm units

Maximum and minimum values of the elements for the samples taken from the study area				Global Health Organization (WHO, 2007)	Iraqi specifications (IRS, 2009)	The element
Look		Safwan				
moist	dry	moist	dry			
170-570	202-632	320-721	355-881	75	50	Ca+
98-305	105-380	89-546	134-608	125	50	Mg+
345-1300	387-1778	302-847	356-986	200	200	Na+
8-124	18-178	24-142	54-189	12	-	K+
490-1243	576- 1432	499-3489	534-3623	250	350	CL-
683-2230	701-2564	408-3360	487-3654	250	400	SO4
112-803	143-923	24-207	67-257	200	200	HCO3
-	1.15-13.6	-	4-17	50	50	NO3
-	0.5-1.62	-	0.21-1.213	0.4	-	PO4
-	0.23-1.12	-	0.10-1.23	3	3	Zn
-	0.28-2.56	-	0.3-0.31	0.3	0.3	Fe
-	0.9-110	-	0.08-532	0.01	0.01	pb
-	0.21-0.432	-	0.32-0.976	1	1	CU
1087-9065	1943-12421	1786-13213	1897-14567	-	500	TH
1404-8540	1759-8822	2590-12200	2690-12408	1000	1000	TDS
7-8.5	7.12-8.10	7.1-8.7	7.20-8.30	8.5-6.5	8.5-6.5	PH
3150-8180	8587-3422	4000-17500	4320-19420	1530	1500	EC

who, international standard for drinking water, world health organization. 4 1- Edition Switzerland, 1999, p.36.
2- Thamer Mohammed Bahjat, Population Variation of Groundwater in the Al-Suleimani Plain and the Possibility of Investing in it Using Geographic Information Systems, Master's Thesis (Unpublished), Ibn Rushd College of Education, University of Baghdad, 2014, p. 134.
3- Results of laboratory analyses of the 24 samples taken from the study area

((1Saeed Al-Jazairi, Water Resources and Planning for Them, New Culture Magazine, Issue 56, 1974, p.

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1-2-Its suitability for animal drinking

The specifications for water suitable for animal consumption are generally less complex than those for human drinking water and agricultural irrigation. Despite this, animals require sufficient water to survive and function properly. However, some water in the study area is unsuitable for animal consumption due to high salt content, which contains toxic elements that can lead to the death of some animals or render their products, such as milk and meat, unfit for human consumption. Some animals have the ability to drink water with high salt concentrations, reaching (10,000) ml./liter of total salts ([2])What makes this water unsuitable in some locations is the high concentration of sulfates, especially in the dry season. Animal grazing is widely practiced in the study area because it is an economic resource for the population, whether in drought years or rainy years, and the low-quality water is often used for the drinking of animals and poultry.[3])To illustrate this, the classification of the Public Health Service in the United States of America, prepared by (CRIT & Lowery) and classification (Altoviski), which relied on positive and negative ions, and Ayers & Westcot classification, which relied on electrical conductivity (µmhos/cm Ec) to determine the specifications of drinking water for animals and poultry. It is noted from Table (2) and Table (3) TDS and Table (4) that the highest percentage (12408) was in well No. (5) in Safwan district, which is unacceptable for sheep to drink, and the lowest percentage (2376) was in well No. (19) in Basia sub-district, which was acceptable for poultry to drink. It became clear that the majority of wells fall between weak and very weak for horses to drink, and a small number of wells are suitable for poultry to drink due to the high concentrations of TDS salts. It is evident from this that the groundwater in the study area is suitable for animals to drink, except for poultry, which was limited to a small number of wells.

Classification table (2)CRIT & Lowery1972)) For the suitability of water for animal drinking according to the amount of total dissolved solids (TDS) in (ppm) units

Types of animals	Quality	TDS (PPM)
poultry to2860	Good	<1000
	Acceptable	1000-3000
horses to6435	weak	3000-5000
	Very weak	5000-7000
Dairy cows to7150 Beef cattle to10000 sheep to12900	Unacceptable	>7000

Crist MA and Lowry M.E, Ground water resources on Netrona County, A study of the availability and chemical quality of ground water, geological survey water supply paper 1897, US, Government printing offices, Washington, pp.92.

Table (3) Application of classificationLowry, & Grist) on wells in the study area for (TDS) to show the suitability of groundwater for animal drinking for the year (2024-2025)

Its suitability for drinking depends on the type of animal.	classification Lowry & Grist	TDS/PPM	Its location	Sample number
For drinking horses	weak	3789	Safwan	W1
For drinking horses	Very weak	6944		W2
For poultry drinking	Acceptable	2690		W3
For drinking milk from cows	Unacceptable	7399		W4
For sheep to drink	Unacceptable	12408		W5
For drinking horses	weak	3102		W6
For drinking horses	Very weak	5645		W7
For drinking horses	weak	3547		W8
For drinking horses	weak	4890		W9
For drinking horses	weak	3034		W10
For drinking horses	weak	3567		W11
For poultry drinking	Acceptable	2978		W12
For poultry drinking	Acceptable	2600	Basya	W13
For drinking horses	weak	3056		W14
For drinking horses	weak	3077		W15
For drinking horses	weak	4590		W16
For drinking horses	weak	4010		W17
For drinking horses	Very weak	5612		W18
For poultry drinking	Acceptable	2376		W19
For drinking horses	weak	3750		W20
For drinking beef cattle	Unacceptable	8822		W21
For poultry drinking	Acceptable	2678		W22
For poultry drinking	Acceptable	1759		W23
For poultry drinking	Acceptable	1956		W24

Source: From the researcher's work based on the results of laboratory analyses (Table 1) and Table 2

Table (4) Standard Specifications of the World Food Organization ((FAO) Water suitability for animal consumption based on positive and negative ions (Altoviski 1962) in ppm

EC	TH	TDS	CI	Mg	Ca	Na	The element / Ion concentration
3000	1500	3000	900	150	350	800	Very good water
5000	3200	5000	2000	350	700	1500	Good water
7000	4000	7000	3000	500	800	2000	Permitted water
10000	4700	10000	4000	600	900	2500	Water that can be used
15000	54000	15000	6000	700	1000	4000	maximum
19420	13245	12408	3623	608	881	1778	Upper limit in the studied samples

([2]Abbas Fadhil Ubaid Al-Qara Ghuli, Spatial Analysis of Groundwater and its Uses in Al-Qadisiyah Governorate, Unpublished Doctoral Dissertation, College of Education, Al-Mustansiriya University, 2014, p. 129

([3]Suhail Sabri Hassan Al-Dafai, Hydrogeochemistry of Groundwater in the Baiji-Samarra Area (West of the Tigris River), Master's Thesis, College of Earth Sciences, University of Baghdad, 2002, p. 100.

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Altoviski, M.E., Hand book of hydrogeology, Gosgeolitzdat Moscow, USSR (in Russian), 1962.

Regarding positive and negative ions, the following is noted from Table (4) and according to the proposed specifications.Altoviski (1962) concluded that the water in the study area was suitable for animal consumption and could be used for all types of livestock. Comparing this to the upper limits of the samples taken from wells in the study area, it was found that sodium (Na) and calcium (Ca) levels were acceptable, while magnesium (Mg) was within the upper limit. Chlorine (Cl) was also acceptable, as were total dissolved solids (TDS), total hardness (TH), and electrical conductivity (EC). Therefore, all samples in the study area, according to this classification, were suitable for animal drinking except for EC, which exceeded the permissible limit.

Table (6) Characteristics of animal drinking water according to electrical conductivity ratio(EC) According to the specifications proposed by (Ayers and Wetcot, 1989)

EC umhos/cm	Degree	Notes
<1500	excellent	Suitable for all types of livestock and poultry
5000 – 1500	Very acceptable	It is used for all types of livestock and poultry, and may cause temporary diarrhea in livestock.
8000 – 5000	Acceptable for livestock but not acceptable for poultry	It causes temporary diarrhea in livestock, death in poultry, and stunted growth.
11000 – 8000	Its use is limited to animals and unacceptable for poultry.	Do not give to pregnant or nursing animals; unacceptable for poultry.
16000 – 11000	Very limited use	Not acceptable for animals
16000 or more	Its use is not recommended.	The risks are very high and its use is not recommended.

Ayers. RS and wastcot DW Water quality for Agriculture, Irrigation and Drainage paper 29, Rev. 1. FAO, Rome, Italy, 1989, p.174.

Table (7) Results of the application of (Ayers and Wetcot, 1989) on wells in the study area to determine the suitability of groundwater for animal drinking for the year (2024-2025).

Symptoms caused by using water in animals	classification Ayers and Wetcot, 1989	µs/cm/EC	Its location	Sample number
It is used for all types of livestock and poultry, and may cause temporary diarrhea in livestock.	Very acceptable	4803	Safwan	W1
Do not give to pregnant or nursing animals; unacceptable for poultry.	Its use is limited to animals and unacceptable for poultry.	9934		W2
It causes temporary diarrhea in livestock, death in poultry, and stunted growth.	Acceptable for livestock but not acceptable for poultry	5976		W3
Do not give to pregnant or nursing animals; unacceptable for poultry.	Its use is limited to animals and unacceptable for poultry.	10300		W4
The risks are very high and its use is not recommended.	Its use is not recommended.	19420		W5
It is used for all types of livestock and poultry, and may cause temporary diarrhea in livestock.	Very acceptable	4320		W6
Do not give to pregnant or nursing animals; unacceptable for poultry.	Its use is limited to animals and unacceptable for poultry.	8102		W7
It is used for all types of livestock and poultry, and may cause temporary diarrhea in livestock.	Very acceptable	4500		W8
It causes temporary diarrhea in livestock, death in poultry, and stunted growth.	Acceptable for livestock but not acceptable for poultry	6843		W9
It causes temporary diarrhea in livestock, death in poultry, and stunted growth.	Acceptable for livestock but not acceptable for poultry	7789		W10
Do not give to pregnant or nursing animals; unacceptable for poultry.	Its use is limited to animals and unacceptable for poultry.	9018		W11
Do not give to pregnant or nursing animals; unacceptable for poultry.	Its use is limited to animals and unacceptable for poultry.	8967		W12
It is used for all types of livestock and poultry, and may cause temporary diarrhea in livestock.	Very acceptable	4650	Basya	W13
It is used for all types of livestock and poultry, and may cause temporary diarrhea in livestock.	Very acceptable	4656		W14
It causes temporary diarrhea in livestock, death in poultry, and stunted growth.	Acceptable for livestock but not acceptable for poultry	6020		W15
Do not give to pregnant or nursing animals; unacceptable for poultry.	Its use is limited to animals and unacceptable for poultry.	8587		W16
It is used for all types of livestock and poultry, and may cause temporary diarrhea in livestock.	Very acceptable	3534		W17
It is used for all types of livestock and poultry, and may cause temporary diarrhea in livestock.	Very acceptable	3422		W18
It causes temporary diarrhea in livestock, death in poultry, and stunted growth.	Acceptable for livestock but not acceptable for poultry	6022		W19
It is used for all types of livestock and poultry, and may cause temporary diarrhea in livestock.	Very acceptable	4021		W20
It causes temporary diarrhea in livestock, death in poultry, and stunted growth.	Acceptable for livestock but not acceptable for poultry	5025		W21
It causes temporary diarrhea in livestock, death in poultry, and stunted growth.	Acceptable for livestock but not acceptable for poultry	6589		W22
It is used for all types of livestock and poultry, and may cause temporary diarrhea in livestock.	Very acceptable	3933		W23
It is used for all types of livestock and poultry, and may cause temporary diarrhea in livestock.	Very acceptable	4689		W24

Source: From the researcher's work based on the table (EC) Laboratory analysis results: Table (6) and Table (7) show that some sites in the study area are in the second category, which has water acceptable for all types of animals, and these are in wells No. (1-6-8-13-14-17-18-20-23-24). As for wells (2-4-7-11-12-16), they were in the fourth category, so they were of limited use for animals and unacceptable for poultry. It is recommended to give them to pregnant and nursing animals, and they are unacceptable for poultry. As for the rest of the wells, they were in the third category, and only one well, No. (5), was in the last category, which is not recommended for use due to the presence of high risks

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in it. It is clear from this that the majority of wells in Safwan district and Basia sub-district are suitable for animals to drink, except for the limited water of some wells.

Second - The suitability of groundwater for agricultural purposes

The agricultural sector is one of the largest consumers of water. Most of the water used in this sector is lost through evaporation or transpiration into the atmosphere. The amount of water used in this sector depends on the type of crops, the nature of the prevailing climate in the region, and the nature of the soil.[4])

Currently, work is underway to exploit water resources by using groundwater, and the importance of knowing and studying the properties of the water used in irrigation cannot be overlooked due to its relationship to plant growth and the extent of improvement and degradation of soil properties.[5])

Salinity is one of the most important factors that determine the suitability of water for agricultural purposes, as the suitability of water for irrigation depends on the sodium ion concentration, electrical conductivity, total dissolved salts, positive and negative ions, and the sodium adsorption ratio.SAR) Irrigation water has been classified according to the American Salinity Laboratory system into four categories based on the combined effect of both electrical conductivity (EC) and total dissolved solids (TDS) values, as shown in Table (8).

Table (Water suitability for irrigation according to the US Salinity Laboratory classification)Lab US- Salinity) based on total dissolved solids (TDS) content and electrical conductivity (EC) value

Water suitability	Total dissolved salts (mg)/liter	electrical connection Malmouz/cm at 25m	Water classification
The water is suitable for most plants and most soils, with a very low probability of soil salinity.	160-0	0.25-0.1	C1 Low salt content
The water is suitable for plants that are tolerant of salts in the event of continuous soil leaching.	480-160	0.75-0.25	C2 Medium salinity
The water is suitable for salt-tolerant plants and well-drained soils, provided there is a good drainage and soil leaching system.	1440-480	2.5-0.75	C3 high salinity
The water is suitable for plants that are very tolerant of salinity on well-drained, permeable soils with heavy salt leaching.	3200-1440	0-2.5	C4 is very salty

Source: Nour Khalaf Khader Elias Al-Jahsani, The Impact of Civil and Industrial Wastewater from the City of Mosul on the Water Quality of the Tigris River, Master's Thesis, University of Mosul, College of Science, 2003, p. 100.

When compared with Table (8) and Table (10), it becomes clear that the groundwater in the study area is higher than the required limits, with the exception of some sites that fell within the category of (C4) Very high salinity, but suitable for plants that are very tolerant of salinity, provided that the soil has good permeability with drainage and strong leaching of salts. The suitability of water for plant irrigation purposes is related to several factors related to the type of plant, the amount of its water needs and its degree of tolerance to salinity. Todd 1980 classified plants and agricultural crops to determine salinity concentrations based on (EC) values, according to Table (10). Salts are higher in the Safwan district than in the Basia sub-district. Through the field study, it was found that some vegetable leaves are curved inwards and have a pale color due to the high percentage of salts in the groundwater. If this indicates anything, this indicates the extension of the salt tongue of the sea and the impact of wells on some old, confined water with high salinity, especially in areas near the salt flats.

Table (9) Tolerance of agricultural crops to salinity concentrations based on electrical conductivity valuesEC (microsomes) according to the classification of (Todd 1980)

The third typeHigh	The second type/ middle	Type 1/ light	Crop varieties
Crops resistant to high concentrations of dissolved salts in water	Crops resistant to moderate concentrations of dissolved salts in water	Crops resistant to low concentrations of dissolved salts in water	
(4000-10000) EC palm trees	(3000-4000) EC Olives, figs, pomegranates	(0-3000) EC Lemons, strawberries, peaches, apricots, almonds, oranges, apples, pears	Fruits
(10000-120000) EC Spinach, beets, turnips	(4000-10000) EC Cucumber, peas, onions, carrots, potatoes, lettuce, cauliflower, tomatoes	(3000-4000) EC Legumes, greens, celery, radishes	vegetables
(10000-16000) EC Cotton, sugar beets, barley	(6000-10000) EC Sunflowers, corn, rice, wheat	(4000-6000) EC agricultural legumes	Field crops

David Keith Todd, Ground Water Hydrology, John Wiley and Sons, USA, 1980, pp. 188-189.

As for positive and negative ions, the classification was adopted (Table (11) (Ayers and Westcot, 1989) was used to determine the suitability of groundwater in the region for agricultural purposes. When compared with the samples taken from the study area mentioned in Chapter Three, it was found that the groundwater was suitable to varying degrees for irrigation in some wells. It was also found that the suitability of the elements for irrigation varied. Total dissolved solids (TDS) were within the permissible limit in well (23) in the Basya district. Sodium (Na) was suitable in all wells in the Safwan district and Basya, except for two wells in Basya, which exceeded the permissible limit (wells 15 and 21). Magnesium (Mg) was unsuitable in all wells. Calcium (Ca) was suitable in wells (6, 13, 14, 16, 18, 20, 22, 23, and 24). As for chlorides (Cl), the number of permissible wells was [number missing in original text]. Wells numbered (6-9-10-11-12-13) in the Safwan district and all wells in the Basya sub-district, except for one well, which is (15), had a percentage within the limit not permitted for agricultural purposes. As for sulfates (SO), it was found that the number of permitted wells is well number (11-14) for both the dry and wet seasons, and wells 23-24 for the wet season only. As for bicarbonate (HCO3), its concentrations were within the permissible limits for all wells in the Safwan district and in the Basya sub-district, except for three wells whose concentrations were high and not permitted for agriculture, namely wells numbered (14-15-17). As for the acidity (pH) values, they were within the permissible limits for all wells in the study area, except for well number (19) in the Basya sub-district and well number (7-2) in Safwan, whose levels were high and unsuitable for agriculture.

HF, Iassim, Principles of Regional soil survey, Op, cite, P. 525. ((4

RS, A.yers and DW, west cot water quatity for Aqriculture Irrigation anddrainage ((5
paper 29, Aev.l, FAO, Rome, It ALY, 1989, P.174.

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Table (11) ClassificationAyers and Westcot (1989) to determine the suitability of groundwater in the region for agricultural purposes.

Groundwater concentrations in the study area	unit of measurement	Maximum concentration limit	variable
1404-12408	amalgam/liter	2000	Total dissolved saltsTDS
302-1778	amalgam/liter	920	sodiumNa
89-608	amalgam/liter	60	MagnesiumMg
170-881	amalgam/liter	400	CalciumCa
490-3623	amalgam/liter	1065	ChloridesCL
683-3654	amalgam/liter	960	sulfatesSO
24-923	amalgam/liter	610	BicarbonateHCO3
7-8.30	amalgam/liter	8.5	acidityPH

Ayers, R.S. and Westcot, D.W., Water quality for agricultural Irrigation and Drainage, Paper 29, Rev.1, FAO, Roma, Italy, 1989 p,174. Laboratory test results -2

sodium adsorption ratioSodium Adsorption Ratio unit (SAR)

The sodium adsorption ratio indicates the suitability of groundwater for irrigation and the damage that sodium ions cause to plants. It is one of the hydrochemical equations, and an increase in its concentration leads to an increase in the concentration ofThe pH of the soil, in addition to its contribution to soil salinity, increases in concentration when the plant consumes sodium, and the SAR ratio can be calculated from the equation (Todd, 1980)[6]The equation below determines the suitability of groundwater for irrigation on a milliequivalent basis./liter (epm) and note Table (12) as follows

$$SAR=\frac{rNa}{\frac{\sqrt{Ca+Mg}}{2}}$$

Because:
Sodium adsorption values =SAR
milliequivalentSodium/liter = rNa+1
milliequivalentCalcium/liter = rCa+2
milliequivalent/Liter of magnesium = rMg+2

Table (12) Determining the suitability of groundwater used for irrigation according to the classification of ((Todd, 1980) Sodium adsorption quantity (SAR)

SAR	Water type	Water classification
< 10	(Low risk) Excellent water	Suitable for irrigating all crops
10≤18	(Moderate risk) Good water	Suitable for irrigating grain crops
18≤26	(High risk) Medium water	Harmful to irrigate sensitive crops
>26	(Very dangerous) Poor water	Harmful to irrigate almost all types of crops

Todd, David Keith, Ground water Hydrology, John Wiley and Sons, Inc., Toppan Printing, Company(LTD). New York and London, 1980, p535.

From comparing Table (13) to the classification of ((Todd, 1980) Irrigation water according to the amount of sodium adsorption ratio (SAR) based on the results of chemical analyses of ion values in (epm) units for samples taken from well water in the study area shows that most of the groundwater samples in the study area fall within the categories of excellent and good water according to the sodium adsorption ratio equation (SAR). According to this measure, it is suitable for irrigating all crops and appropriate for irrigating cereal crops. This is attributed to the fact that the source of salinity in the region is mainly due to the dissolution of carbonate rocks and evaporites, and not to active ion exchange processes that raise sodium at the expense of calcium. This kept the water within the mixed ion pattern (Ca–Mg–Na) instead of the pure sodium pattern. Accordingly, the risk of sodium to the physical properties of the soil remains limited, despite the high total salinity in some locations, which confirms that the determining factor for the suitability of water for irrigation in the region is the total salinity more than the risk of sodium.

Table (13) Application of classification (Todd, 1980) for the amount of sodium adsorption (SAR) for the suitability of groundwater for irrigation for samples taken from wells in the study area for the year (2024-2025)

Water type	SAR	Name of the well owner	Its location	Sample number
Excellent water (low risk)	5.22	Martyr Ali Nasser School	Safwan	W1
Excellent water (low risk)	6.6	Safwan Sports Club		W2
Excellent water (low risk)	6.9	Luthan area		W3
Excellent water (low risk)	6.6	The highway cutter, Al-Lahis		W4
Excellent water (low risk)	7.9	Al-Burjasiya Research Station		W5
Good water (medium risk)	11.5	Shawqi Abdel Nabi Abdel Hussein		W6
Excellent water (low risk)	2.75	Walid Abdul Hussein Radhi		W7
Excellent water (low risk)	3.0	Aziz Saud		W8
Excellent water (low risk)	8.2	Well of Umm Anij village, farms school		W9
Excellent water (low risk)	6.9	Well of Umm Anij village, Al-Nidaa Agricultural Association		W10
Excellent water (low risk)	3.2	Abdul Jabbar Mazal Dughaim		W11
Excellent water (low risk)	4.1	Ghanem Shehaib Hawa		W12
Excellent water (low risk)	6.4	Wissam Taleb Dali	Basya	W13
Excellent water (low risk)	5.0	Zaid Malik Kamel		W14
Good water (medium risk)	12.9	Aker Jalida police station		W15
Excellent water (low risk)	6.9	Car Company		W16
Excellent water (low risk)	4.36	chastity		W17
Excellent water (low risk)	9.7	Ali Kazem Askar		W18
Excellent water (low risk)	7.4	Alaa Ali Obaid		W19
Excellent water (low risk)	3.8	Thaer Marzouk Salah		W20
Good water (medium risk)	10.2	Ismail Hashish Razzaq		W21
Excellent water (low risk)	5.0	Aqeel Jassim Karim		W22
Excellent water (low risk)	6.3	Water leakage system		W23
Excellent water (low risk)	5.3	leg		W24

Source: From the researcher's work based on the results of laboratory analyses and Table (12).

Todd, D.K., Ground Water Hydrology, John Wiley, N.Y., op cite, 1980, 535pp. ((6

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Richard's classification Richard

Richard's classification allows for the identification of groundwater quality, which is an important classification and depends on two variables: electrical conductivity (EC) and the sodium adsorption value (SAR). When the sodium adsorption concentration is less than 10 and the electrical conductivity is between (100-250) Water is used to irrigate all soils. Water with a medium concentration (SAR 10-18) and an EC between 250-750 µs/cm is used to irrigate coarse-textured, well-drained, and organic soils, but it causes damage to fine-textured soils. Water with a high salt concentration (SAR 18-26) and an EC between 750-2250 µs/cm is used if drainage is available. Water with a very high salt concentration is not used for irrigation.[7]While water with a high sodium concentration can be used if the water is slightly to moderately saline, and in soils containing a high concentration of gypsum, sodium and calcium exchange occurs without a change in soil permeability ratio.If SAR is greater than 26 and EC is greater than 2250 µs/cm, the water has a sufficiently low dissolved salt content and sodium level that will not cause problems when used for irrigation.[8] Its division is as follows:

1-Excellent**Excellent)**The water in it is suitable for use for all crops.

2-Good**Good**The water is suitable for use on most crops and under most conditions.

3- Permitted**Permissible**Water can be used successfully for most crops if it is used carefully to prevent the accumulation of dissolved salts, including sodium, in the soil.

4-Marginal**Marginal**The water in this type of water is confined and used in permeable soils and in the production of crops that tolerate high salinity. The use of this type of water must be done cautiously to prevent the accumulation of salts in the soil, and drains must be present to remove excess water.

5- Poor**Poor**Water is contained within it for irrigation use in sandy soils.

6-Very bad (**Very Poor**This type of water is not recommended for crop irrigation.

Richard developed a guide in which he determined that groundwater depended on the value of the electrical conductivity and (SAR) as in Table (14) and (15)

Table (14) Determining groundwater according to classification (Richard)

SAR	The guide	EC	The guide
10<	S1	**100 ≤ 250**	C1
10≤18	S2	**250≤750**	C2
≤2618	S3	**750≤2250**	C3
>**26**	S4	>**2250**	C4

Richard. LA, Diagnosis and improvement of saline and Al kali soils, Agric. H and book60 to, US Dept of Agric, wishing ton, DC 1954, P.16.

Table (15) Types of water according to classification (Richard)

Water classification **Water class**	The symbol **Index**	Water classification **Water class**	The symbol **Index**
permitted Admissible	C3S1	excellent Excellent	C1S1
It can be used marginal	S3S2	good Good	C1S2
It can be used marginal	C3S3	permitted Admissible	C1S3
poor Poor	C3S3	poor Poor	C1S4
poor Poor	C4S1	good Good	C2S1
poor Poor	C4S2	good Good	C2S2
Very poor Very Poor	C4S3	permitted Admissible	C2S3
Very poor Very Poor	C4S4	poor Poor	C2S4

Richard. LA, Diagnosis and improvement of saline and Al kali soils, Agric. H and book60 to, US Dept of Agric, wishing ton, DC 1954, P.16.

And after thatApplicationAccording to Richard – 1954, groundwater quality is classified as SAR and EC based on the studied well water samples, as shown in Table (16). The groundwater quality in Safwan District and Basia Sub-district is poor according to Richard's classification due to the large increase in electrical conductivity (EC) values, resulting from the dry geological and climatic conditions and the dominance of evaporated rocks. Meanwhile, the sodium adsorption ratio values remained within acceptable limits. Therefore, the deterioration of water quality according to this classification is due to the total salinity factor and not to the danger of sodium, as the use of this water is limited to permeable soils and in the production of crops that tolerate high salinity, and the irrigation process must be done carefully to prevent the accumulation of salts in the soils.

Table (16) Application of classificationRichard) for water according to ((SAR and ((EC)) on the studied well models for the year (2024-2025)

Validity Suitability	**Type TYPE**	**EC INDEX**	**SAR INDEX**	**EC µs/cm**	**SAR**	**Name of the well owner**	**Its location**	**Sample number**
badpoor	C4S1	C4	S1	4803	5.22	Martyr Ali Nasser School	Safwan	W1
badpoor	C4S1	C4	S1	9934	6.6	Safwan Sports Club		W2
badpoor	C4S1	C4	S1	5976	6.9	Luthan area		W3
badpoor	C4S1	C4	S1	10300	6.6	The highway cutter, Al-Lahis		W4

((7Damia, previous source, p. 252

LA Richard Diagnosis and improvement of Saline Al Kali Soils. Agric. Handbook 60 US Dept. ((8
Washington DC 1954, p160.

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badpoor	C4S1	C4	S1	19420	7.9	Al-Burjasiya Research Station		W5
badpoor	C4S2	C4	S2	4320	11.5	Shawqi Abdel Nabi Abdel Hussein		W6
badpoor	C4S1	C4	S1	8102	2.75	Walid Abdul Hussein Radhi		W7
badpoor	C4S1	C4	S1	4500	3.0	Aziz Saud		W8
badpoor	C4S1	C4	S1	6843	8.2	Well of Umm Anij village, farms school		W9
badpoor	C4S1	C4	S1	7789	6.9	Well of Umm Anij village, Al-Nidaa Agricultural Association		W10
badpoor	C4S1	C4	S1	9018	3.2	Abdul Jabbar Mazal Dughaim		W11
badpoor	C4S1	C4	S1	8967	4.1	Ghanem Shehaib Hawa		W12
badpoor	C4S1	C4	S1	4650	6.4	Wissam Taleb Dali		W13
badpoor	C4S1	C4	S1	4656	5.0	Zaid Malik Kamel		W14
badpoor	C4S2	C4	S2	6020	12.9	Aker Jalida police station		W15
badpoor	C4S1	C4	S1	8587	6.9	Car Company		W16
badpoor	C4S1	C4	S1	3534	4.36	chastity		W17
badpoor	C4S1	C4	S1	3422	9.7	Ali Kazem Askar		W18
badpoor	C4S1	C4	S1	6022	7.4	Alaa Ali Obaid		W19
badpoor	C4S1	C4	S1	4021	3.8	Thaer Marzouk Salah		W20
badpoor	C4S2	C4	S2	5025	10.2	Ismail Hashish Razzaq		W21
badpoor	C4S1	C4	S1	6589	5.0	Aqeel Jassim Karim		W22
badpoor	C4S1	C4	S1	3933	6.3	Water leakage system	Basya	W23
badpoor	C4S1	C4	S1	4689	5.3	leg		W24

Source: From the researcher's work based on Table (14), (15) and the value of ((SAR

4- Suitability of groundwater for industrial purposes

Water plays a major and essential role in various industries through its effect on generating the steam necessary to operate machinery and cooling processes. Some industries have a large water consumption, such as the sugar, paper, and fertilizer industries. The purity of the water used by some industries is of great importance because some industries require high water purity, and the pharmaceutical industry requires different specifications that differ from the permissible limit for human drinking.[9]) Water quality for industrial purposes is also very important, especially since the amount of salt leads to corrosion of machinery parts and pipes, in addition to the deposition of a percentage of it inside the pipes. Therefore, studying groundwater for industrial purposes is important because the concentration of salts in the groundwater in the study area greatly affects its use in industry. Sulfates, bicarbonates, chlorides, magnesium, and calcium salts are among the main causes of pipe blockages and malfunctions in the systems of devices, factories, and equipment. Comparing the pH results (pH, total hardness (HT), and positive and negative ions in groundwater samples from the study area, with the permissible standard specifications for various industries according to the classification of (Salvato, 1982) as shown in Table (17), and the quality of water used for industrial purposes.

Table (17) Permissible Standard Specifications in Various Industries According to Classification (Salvato, 1982)

Fe	Mg	Ca	SO4	CI	TH	PH	Type of industry
0.40	100	100	500	500	316	8.5-6.5	Food canning factories
5	9.98	9.98	17.96	14.10	1000	9-6	Chemical industries
25	600	600	250	250	600	8.5-6.5	Cement plants
15	6.99	10.97	300	13	350	9-6	oil refineries
2.60	50	100	500	500	300	6.0-7.5	paper industry
0.3-2.56	98-608	202-881	408-3654	490-3623	1087-13245	7.1-80.8	The ratio of elements in the measured samples (highest - lowest)

1-Salvato, PE, Environmental Engineering and Sanitation, New York, USA, 1982, p1163.

2- Laboratory test results

Comparing the results of the laboratory analyses of the upper and lower limits with the standard specifications of Table (17) reveals that the results of the chemical analyses of the groundwater in the study area show a significant increase in total salinity, hardness, and concentrations of calcium, magnesium, chloride, and sulfate ions, which makes this water unsuitable for use in most sensitive industries according to the classification.Salvato) (1982) and especially the food, beverage and paper industries, while remaining relatively suitable for heavy industries such as cement and oil, or for industrial uses after processing.

5- The suitability of groundwater for construction purposes

Determining the suitability of groundwater for construction purposes depends on the concentration of ions in the groundwater, as these can be harmful to buildings. To determine water suitability, the concentration of negative and positive ions is used, since an increase in any ion concentration renders the water unsuitable for use in the construction field.[10]Because high salt content leads to the contamination of building facades and walls with layered salt deposits, according to the proposal of (1962)Altoviski) Table (18) states that increasing the concentration of any of the ions is unsuitable for use in the field of building and construction. Comparing the table with the values of ion concentrations in the well water of the study area, it became clear that the well water is suitable for one element and unsuitable for another. While we find some sites that are suitable and all the criteria apply to them, especially during the wet period, their suitability decreases during the dry season due to the high concentrations of elements in the dry season for all sites.

((9Ali Hassan Al-Shalash, Freshwater Economics, University of Basra, 1986, p. 98.

10Ayman Shehab Hassoun, Hydrogeomorphology of the Wadi Abu Mreis Basin in Al-Muthanna Governorate and its impact on economic development, Unpublished PhD Thesis, College of Arts, University of Baghdad, 2016, p. 246.

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Table (18) Groundwater Use Suitability According to Classification (1962) Altoviski

Minimum and maximum sample sizes studied	The concentration is a milligram./liter	ions
302-1778	1160	Na+
202-881	437	Ca++
98-608	271	Mg++
490-3623	2187	Cl-
408-3654	1460	So4-
24-923	150	HCo-3

1-ME,Altoviski,hand book of hydrology,gosgoelitzdt, Moscow,1962,p.614

2- Laboratory test results

Conclusions

The study concluded the following:

1- The results proved that the study area is located within the stable platform in the southwestern part of Iraq. The area is covered by formations dating back to the Tertiary period, ranging in age from the Middle Eocene to the Pliocene-Pleistocene, from oldest to newest, represented by the Dammam, Euphrates, Ghar, Zahra, Dabdaba, Umm Ardhama and Jeel Sanam formations, and Quaternary periods containing aeolian deposits, valley filling, alluvial plain deposits and alluvial fans that are characterized by high porosity, allowing large quantities of water to penetrate into groundwater reservoirs.

2- The study area is characterized by a dry desert climate, which is represented by the fluctuation of rainfall from the general average. Part of it penetrates into the soil, and the other part forms torrential floods. These floods fill the main valleys spread throughout the study area.

3- The wells in the study area are characterized by high groundwater productivity, and the reservoirs in the study area extend within the limestone and dolomite rocks of the Umm Ardhama, Dammam, and Al-Dabdaba formations.

4- It appears that the water in most wells is not suitable for human drinking according to international and Iraqi standards, except for the elements copper (Cu), zinc (Zn) and nitrates (NO3) were less than the permissible limit, which means that the groundwater is not contaminated with them. Also, the pH and HCO3 elements were within the permissible limits for the suitability of the water for drinking.

5- It is concluded that the groundwater in the study area is suitable for animal drinking, except for poultry, whose consumption was limited to a small number of wells. As for positive and negative ions, according to the proposed specificationsAltoviski1962) stated that the water in the study area is suitable for animal consumption and can be used for all types of livestock.

6- It appears that the groundwater in the study area is suitable for all types of agricultural crops and vegetables, but it is not suitable for growing fruits.

7- It is clear that groundwater is unsuitable for use in most sensitive industries according to the classification (Salvato1982) particularly the food, beverage and paper industries, while remaining relatively suitable for heavy industries such as cement and oil, or for industrial uses after processing.

Suggestions:Recommendations

1- Studying the impact of drought and climate change on groundwater levels: Low rainfall, high temperatures, and increased evaporation have a significant impact on groundwater depletion and depletion.

2- Establishing water desalination plants (RO) on wells for the purpose of providing large quantities of groundwater to meet the needs of the region.

3- Raising awareness among farmers and encouraging them to use modern irrigation systems such as sprinkler and drip irrigation in order to provide a larger quantity of water and move away from incorrect agricultural methods.

4- Constructing dams on the valley courses in order to store water for times of scarcity and to use it to feed the groundwater reservoirs in the study area.

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