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Effect of Using Different Types of Well Water in Karbala Governorate on Soil and Plant

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ABSTRACT

This study was conducted in order to assess the water quality of 12 wells for irrigation purposes in Karbala Governorate, central Iraq. Well water samples scattered throughout the governorate were collected and analyzed chemically and physically. And by comparing the results with the Iraqi determinants of irrigation water, as the values of pH, positive ions (K^+, Na^+, Mg^{+2}, Ca^{+2}) and negative ions (Cl^-, SO_4^{-2}, HCO_3^-) are within the above determinants for all wells, as for electrical conductivity (EC) It is within the determinants of all wells, and dissolved salts (TDS) are higher than the determinants of all wells. According to the American Salinity Laboratory, 5 wells are classified as C4S1, 5 wells are classified as C4S2, one well is classified as C4S3, and one well is classified as C3S1, meaning that most of the well water had a high sodium content. By comparing the classification of the Food and Agriculture Organization, it was found that most of the wells were highly saline and all wells had very soluble salts, except for some of them are medium. Therefore, from what was presented in the study of well water, solutions and ways must be found to improve the use of this water for irrigation purposes by reducing the sodium and salinity values for this water.

Keywords: Water quality, ground water, wells, irrigation, sodium rate.

INTRODUCTION

The assessment of water quality has become a sensitive issue due to the great concern that countries express to threaten the existence, use, security and management of water resources, and that countries today are fully convinced that fresh water will be a scarce resource in the future (Bonanno and Giudice, 2010). High availability of water suitable for irrigation of agricultural lands. It became necessary to study water resources of all kinds to be exploited in agricultural production and thus food. Groundwater is considered one of the water resources that is used as irrigation water, but this is done after assessing its quality and suitability for irrigation, as it may be a cause of increasing problems (Alaaddin et al., 2001; Chabuk et al., 2022; Mukheef et al., 2022). Iraq's water need in the future was estimated at 82 billion cubic meters annually, divided into 60 billion cubic meters for irrigation, 6.7 for drinking, 0.7 for industrial purposes, 5.6 for preserving the river's living environment, and 8.7 as evaporation requirements (Ewaid and Abed, 2017). When judging the quality of well water as being suitable for irrigation, attention must be paid to the physical and chemical properties of water, which differ from one place to another depending on the type of prevailing ions and the salt concentration of the water (Ayers and Wescot, 1985). In a study carried out by Abdul Hamza (2015) of 15 wells in Al-Qadisiyah governorate showed that most of them fall within the category C4S1 within the classification of the American Salinity Laboratory, and this means that it is highly saline water with little soda. Also, 68 wells were studied in locations confined between the Tigris and Lower Zab rivers and their villages south of Mount Makhmour. The results showed that this water was not suitable for drinking due to the high content of salts and the severe hardness that exceeded the limits of the Iraqi specifications. The results also showed that only 36 wells were suitable for irrigation and agriculture, provided that taking Precautions in using it as the high salt content (Saleh et al., 2016).

A study was conducted by Al-Hayani (2009) for the purpose of evaluating water for irrigation and drinking purposes for eight wells in the village of Al-Khafajia in Haditha District of Anbar Governorate, where concentrations of positive ions (Mg^{+2}, Na^{+}, K^{+}, Ca^{+2}) and negative ions (SO_4^{2-}, Cl^{-}, HCO_3^{-}) were measured. HCO_3^{-}, CO_2^{-}, total hardness (TH), total dissolved salts, pH, and electrical conductivity. The study showed that this water is not suitable for drinking and agricultural purposes according to the approved specifications. In addition, it has high concentrations of sulfates. In a study conducted by Kazar (2017) to assess the quality of Shatt al-Kufa water for irrigation using the Canadian Program and the Quality of Irrigation Index (WQI), it was found that most of the sites throughout the year had water containing molten salt that exceeded the permissible limits for irrigation. Assessment of the water quality of Mehrut River in Diyala Governorate by Al-Obaidy et al. (2015). Fifteen variables were taken into consideration, and it was found that the water quality is marginal for irrigation purposes in the first site, and it was found that the other sites are poor. Study by Moyle and Hussain (2015) to show the water quality of the Shatt al-Arab, they found a noticeable deterioration and they attributed this deterioration to several reasons, including the discharge of fresh water from the Tigris and Euphrates rivers, salts added from the Arabian Gulf, and the addition of oil and effluents in urban areas that pollute the water. In a study conducted by Elnazer et al. (2017), he confirmed that agricultural and industrial waste and liquid waste reduce the suitability of water for use.

In a study carried out by Al-Hadathi et al. (2011) to assess the quality of well water in the Jadriya area in Baghdad, three classifications were adopted to assess the suitability of irrigation water, which is the classification of the American Salinity Laboratory. Severe and medium were also classified within the classification of the Food and Agriculture Organization of the United Nations (1992) and were placed under the category of medium salinity and under the type of primary sewage and groundwater. In a study of the importance of evaluating water suitability for irrigation for the purpose of determining the suitability of Al-Razzaza drainage water for the purpose of irrigation Taher et al. (2011) took 12 sites along the course of the Al-Razzaza drainage to analyze 96 water samples. Low saline water of medium salinity and does not affect the increase in soil salinity. Jahad (2014) also found that it is necessary to study the water quality with the amount of water in the Euphrates River. Two methods were used: Bhargava and the Canadian model to test the water quality of the Euphrates River, starting from the north of the city of Hilla. Al-Khuzai (2014) studying four types of water in the Karmat Ali area in Basra governorate using the classification of the American Salinity Laboratory, the US Environmental Protection Agency system and the Food and Agriculture Organization of the United States.

In a study carried out by Bazrafshan et al. (2016) for 31 samples to show the importance of using the Canadian model in testing water suitability for irrigation and concluded that most of the study water is valid. The quality of groundwater in this region needs to be treated before consumption, in addition to protecting it from pollution damage. The rate of poor water quality was 28%. He indicated that there should be continuous protection due to the increase in industrial practices. Abdul Qader (2010) also relied on the values of salinity, acidity, sodium adsorption rate, sodium percentage, potential residual sodium carbonate, and magnesium risk and permeability index.

MATERIALS AND METHODS

Twelve wells were selected from different regions of Karbala governorate and for different depths, as detailed in Tables 1 and 2. Water samples were collected from each well in plastic bottles and transferred to the laboratory for the purpose of conducting chemical tests on them, represented by the degree of acidity, electrical conductivity, positive and negative ions, and dissolved salts. The total. The value of the sodium adsorption ratio (SAR) was calculated according to the following relationship, and the water class was also found according to the classification of the American Salinity Laboratory:

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

The percentage of magnesium was also calculated according to the following equation:

$$\%Mg = \frac{Mg + Ca}{Mg} * 100\% \quad (2)$$

The percentage of sodium was also calculated according to the following equation:

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

The amount of remaining carbons was also calculated using the equation:

$$RSC = (HCO_3 + CO_3) - (Ca + Mg) \quad (4)$$

For the purpose of classifying water to determine its suitability for irrigation, the proposed classification was adopted by the American Salinity Laboratory, which is one of the most important classifications that depends on the amount of salts and the percentage of sodium adsorption. for irrigation purposes.

RESULTS AND DISCUSSION

USDA salinity laboratory rating

We note from Table 1 the classification of well water according to the American Salinity Laboratory, which indicates that about 5 wells are classified under C4S2 and C4S1 classification, 1 well is under C4S3 classification, and 1 well is under C3S1 classification. The best type of well was the Location 8 well of C3S1 and by its classification it is described as high salinity water with low sodium that cannot be used in irrigation of sensitive crops, especially citrus, and it should only be used in the lands where there are no solid layers that prevent leaching because it needs washing after that. A well in Location 1 within the category C4S3 and described as high salinity water with medium sodium, and there were five wells within the category C4S2 and it was classified as high salinity water with high sodium, which is of poor quality and thus creating a problem of permeability, also five wells were classified under the category C4S1 which is high water. The salinity is very low and

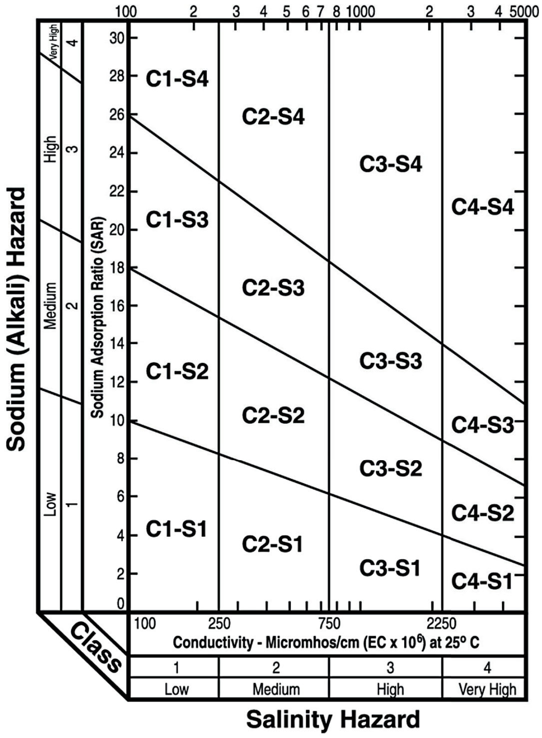

Figure 1. The classification for EC and SAR by USDA

Table 1. Classification of well water according to the American Salinity Laboratory

No.	X	Y	Arabic Gov.	SAR	EC (µs/cm)	Class
Location 1	44.096667	32.539889	Karbala	7.75	11300	C4S3
Location 2	44.054861	32.519028	Karbala	7.52	4700	C4S2
Location 3	44.162444	32.453778	Karbala	6.38	5490	C4S2
Location 4	44.174056	32.331972	Karbala	7.06	4420	C4S2
Location 5	43.862722	32.510500	Karbala	4.75	3340	C4S1
Location 6	43.971361	32.635778	Karbala	2.11	5001	C4S1
Location 7	43.508028	32.438083	Karbala	4.01	2420	C4S1
Location 8	43.498833	32.558083	Karbala	1.90	1125	C3S1
Location 9	43.488139	32.574272	Karbala	2.69	2890	C4S1
Location 10	44.121194	32.696472	Karbala	2.02	1628	C4S1
Location 11	43.503694	32.572222	Karbala	7.85	2870	C4S2
Location 12	43.663250	32.465306	Karbala	4.99	2820	C4S2

is used only for well-drained lands with a coarse soil texture, as sodium causes a little permeability problem and the presence of organic matter is necessary in addition to its use only for crops that are highly tolerant to salinity, the presence of high sodium causes an increase in the problem of permeability and the presence of a high content of salts (Fig. 1). It makes washing necessary and the areas of its use are few and cannot be used in the long term. These results came close to the findings of many researchers in their study of some areas of the middle Euphrates (Zwain et al., 2021, Abdul Hamza 2015, Abboud and Tawfiq 2012; Alsaleh et al., 2022).

International Food and Agriculture Organization

The statistics and values shown in Table 1 and 3, when compared with the Table of the Food and Agriculture Organization of the United Nations (Table 2), show that most of the wells were highly saline and all wells had very soluble salts, except for some of them are medium (Hassan et al, 2019). As for the sodium content of this water, it was of high sodium, so all the values were greater than 9 mEq·L^{-1}, as well as the chlorides were of high values for all wells (Hassan et al., 2022).

Disadvantages of bicarbonate in well water

A term was proposed to describe the evaluation of the quality of well water by Eaton (1950) in terms of its carbonate and bicarbonate content Table 3, and it is called the amount of residual sodium carbonate (RSC) and its chemical concept that carbonate and bicarbonate bind when precipitated with calcium and magnesium ions first and that what remains will bind with sodium and thus constitute a danger To be free sodium carbonate, Na_2CO_3, water that contains a value of more than 2.5 mEq·L^{-1} is not considered suitable for irrigation purposes. Water containing a value ranging between (1.25–2.5) is considered marginal, as all areas are considered good in terms of this measure in avoiding the risk of sedimentation Carbonates and bicarbonates in the form of free sodium carbonate (Hassan et al, 2021; Al-Rideh etal., 2021).

The danger of both the proportion of sodium and magnesium

The results of the Table 4 show the percentage of sodium that ranged from 30.05% to 73.27%, as there were some sites that contained a percentage of sodium that exceeded 50%, namely, Location 2 – 55.40%, Location 4 – 51.81%, and Location 11

Table 2. Specifications of the Food and Agriculture Organization (FAO, 1989) for determining the suitability of irrigation water

Potential irrigation problem		Units	Degree of restriction on use: None	Slight to moderate	Severe
Salinity (affects crop water availability)					
EC_w (or)		dS m^{-1}	<0.7	0.7–3.0	>3.0
TDS		mg l^{-1}	<450	450–2,000	>2,000
Infiltration (affects infiltration rate of water into the soil. Evaluate using EC_w and SAR together)					
SAR 0–3	and EC_w		>0.7	0.7–0.2	<0.2
3–6			>1.2	1.2–0.3	<0.3
6–12			>1.9	1.9–0.5	<0.5
12–20			>2.9	2.9–1.3	<1.3
20–40			>5.0	5.0–2.9	<2.9
Specific ion toxicity (affects sensitive crops)					
Sodium (Na)					
Surface irrigation		SAR	<3	3–9	>9
Sprinkler irrigation		mel^{-1}	<3	>3	
Chloride (Cl)					
Surface irrigation		mel^{-1}	<4	4–10	>10
Sprinkler irrigation		mel^{-1}	<3	>3	
Boron (B)		mg l^{-1}	<0.7	0.7–3.0	>3.0
Trace Elements					
Miscellaneous effects (affects susceptible crops)					
Nitrogen (NO_3-N)		mg l^{-1}	<5	5–30	>30
Bicarbonate (HCO_3)					
(Overhead sprinkling only)		mel^{-1}	<1.5	1.5–8.5	>8.5
pH				Normal range 6.5–8.4	

Table 3. Classification of well water according to the RSC

No.	X	Y	Arabic Gov.	HCO_3 (Meq/l)	CO_3 (Meq/l)	Mg (Meq/l)	Ca (Meq/l)	RSC
Location 1	44.096667	32.539889	Karbala	14.61	0	34.17	39.05	-58.61
Location 2	44.054861	32.519028	Karbala	4.59	0	7.50	10.60	-13.51
Location 3	44.162444	32.453778	Karbala	6.77	0	13.25	18.00	-24.48
Location 4	44.174056	32.331972	Karbala	6.07	0	10.83	10.50	-15.27
Location 5	43.862722	32.510500	Karbala	3.66	0	8.33	11.25	-15.93
Location 6	43.971361	32.635778	Karbala	1.02	0	7.50	6.40	-12.88
Location 7	43.508028	32.438083	Karbala	2.97	0	4.25	8.05	-9.33
Location 8	43.498833	32.558083	Karbala	0.38	0	2.92	3.00	-5.54
Location 9	43.488139	32.574272	Karbala	2.92	0	10.08	8.80	-15.97
Location 10	44.121194	32.696472	Karbala	1.56	0	5.58	4.60	-8.63
Location 11	43.503694	32.572222	Karbala	3.20	0	1.83	1.91	-0.55
Location 12	43.663250	32.465306	Karbala	4.92	0	8.50	11.20	-14.78

– 73.27%. These sites will work on the effect of Harmful to the stem and its growth, and also has a detrimental effect on soil properties by dispersing soil particles (Fadel, 2012). As for the results of magnesium, its value ranged from 34.55% to 54.83%, and it exceeded 50% for each of the locations: Location 4 – 50.78%, Location 6 – 53.96%, Location 8 – 53.40%, and Location 10 – 54.83%. Thus, it has a detrimental effect on plant growth and soil properties (Jalal et al., 2012; El-Nazer et al, 2017).

CONCLUSIONS

Based on the above results, we can conclude the following. All well water in terms of pH, negative ions (Cl^-, SO_4^{2-}, HCO_3^-), and positive ions (K^+, Na^+, Mg^{+2}, Ca^{+2}) conform to the specifications. As for electrical conductivity, the water from wells of some sites is within the Iraqi standard specifications, while the rest of the wells are above the permissible limits. On the contrary, the measured total dissolved solids values exceeded the limits of Iraqi and non-Iraqi specifications for all well water within the study area and attic, and for this reason, all well water is considered an unsuitable source for drinking purposes. The reason for its unsuitability is due to the dry climate, which leads to excessive irrigation and high evaporation resulting from high temperatures, and consequently the accumulation and sedimentation of salts, and then their exudation to groundwater during irrigation operations. The statistics and values shown when compared in the table of the Food and Agriculture Organization of the United Nations indicate that most of the wells were very saline with high sodium. The evaluation of the quality of well water in terms of its carbonate and bicarbonate content, called the amount of residual sodium carbonate, most of the wells were fairly good. According to the classification of the

Table 4. show the percentage of sodium and magnesium

No.	X	Y	Arabic Gov.	K (ppm)	Na (ppm)	Mg (ppm)	Ca (ppm)	Na%	Mg%
Location 1	44.096667	32.539889	Karbala	0.28	46.91	34.17	39.05	38.96	46.67
Location 2	44.054861	32.519028	Karbala	0.10	22.61	7.50	10.60	55.40	41.44
Location 3	44.162444	32.453778	Karbala	0.21	25.22	13.25	18.00	44.49	42.40
Location 4	44.174056	32.331972	Karbala	0.10	23.04	10.83	10.50	51.81	50.78
Location 5	43.862722	32.510500	Karbala	0.08	14.87	8.33	11.25	43.07	42.55
Location 6	43.971361	32.635778	Karbala	0.26	5.57	7.50	6.40	28.22	53.96
Location 7	43.508028	32.438083	Karbala	0.09	9.96	4.25	8.05	44.56	34.55
Location 8	43.498833	32.558083	Karbala	0.05	3.26	2.92	3.00	35.34	49.30
Location 9	43.488139	32.574272	Karbala	0.35	8.26	10.08	8.80	30.05	53.40
Location 10	44.121194	32.696472	Karbala	0.11	4.57	5.58	4.60	30.72	54.83
Location 11	43.503694	32.572222	Karbala	0.18	10.74	1.83	1.91	73.27	48.98
Location 12	43.663250	32.465306	Karbala	0.10	15.65	8.50	11.20	44.15	43.15

American Salinity Laboratory, the best type of well was a C3S1 well, and through its classification, it is described as high salinity water with low sodium that cannot be used in irrigation of sensitive crops, especially citrus fruits, and it should only be used in lands where there are no solid layers that prevent leaching, being It needs washing, but the rest is harmful to agricultural production.

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