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ASSESSMENT OF WATER QUALITY IN WELLS AND SPRINGS OF THE AL-RAHALIYAH REGION FOR AGRICULTURAL AND HUMAN USE

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Abstract: The study was conducted during the fall of 2019 to study the quality of groundwater, well water, and springs in the Al-Rahaliya area of Anbar Governorate and their suitability for agricultural and human exploitation. The results showed that well water has a very high salinity water quality that can be used to irrigate very tolerant crops (C4). The well water was classified as low sodium (S1), so the water of these wells is suitable for irrigating most crops. In terms of sodium's danger, the study wells' water is free of residual sodium carbonate R.S.C, which means that the well water is suitable for irrigation. As for the suitability of Ain Al-Zarqa water for human exploitation, the results showed that Ain Al-Zarqa water is suitable for human exploitation. Regarding salinity value, a slight increase in the electrical conductivity values was observed above the permissible critical limit (0.5 dS.m-1); even after filtration, it is unsuitable for drinking. Laboratory results showed that Ain Al-Zarqa water is unsuitable for human consumption due to its high sodium concentration above the critical limit. As for the concentration of (magnesium and calcium), it is suitable for irrigation because it does not exceed the permissible limit. The results showed that Ain Al-Zarqa water is not suitable for drinking purposes in terms of the concentration of sulfates and chlorides because it is higher than the critical limit permitted by the World Health Organization. The results showed an increase in total dissolved solids in Ain Al-Zarqa water, so it is unsuitable for drinking because it exceeds the permissible limit according to the classification of the World Health Organization. The results of the isolation and diagnosis conducted on water samples taken from Ain Al-Zarqa showed the presence of Coli from fecal coliform bacteria E. Coli during the study period.

Keywords: Water quality of springs and wells, Rahaliya area, human and agricultural uses, soil properties.

1. Introduction

Water plays an essential function in the life of humans and living organisms and is the most determining factor in farming production. It is one of the primary pillars for reaching food security purposes, and therefore,

the survival of living organisms relies on the presence and abundance of water. Iraq is exposed to extreme poverty of freshwater resources due to its geographical location within the arid and semi-arid region and the low rainfall, as the waters of the Tigris and Euphrates rivers are inadequate to meet water requirements. As a result of international control over their sources, in addition to the increase in population and the expansion of the agricultural area, it has become necessary to find alternative sources of freshwater [1]. Groundwater is the water collected in the pores and cavities of the rocks under the earth's surface. This water occurs naturally on the surface, such as springs, or through human intervention by digging wells. This water is considered the most influential factor in areas with no surface flow of water resources. Therefore, this water becomes an essential natural resource that impacts social and economic life, particularly in agricultural production. It requires expanding the areas where it is found and utilizing it best [2]. Water resources are among the major elements impacting population distribution in all regions, particularly in dry and semi-dry regions. These sources are groundwater that appeared in the form of springs, and the study area is an example of this type of communities that depend on rainwater and groundwater for their accommodation [3]. The safe use of groundwater needs specialized investigations to assess the quality of this water for irrigation goals to enhance its efficiency and receive the best agricultural production in terms of quantity and quality. On the one hand and with the least problems on the other hand [4]. The US Department of Agriculture (USDA) indicated in its classification [5] that the most influential indicators of water quality are the electrical conductivity value, the sodium adsorption rate, and the degree of toxicity of some ions. The total concentration of dissolved salts is an essential factor in estimating irrigation water suitability, as examining the irrigation water quality is a crucial subject when placing new land under the irrigation system and improving the attributes of the land to increase its productive efficiency. Presently, work is being done in most world regions to exploit water sources, whether by operating groundwater or mixing fresh irrigation water with more saline water. Understanding the attributes of the used water and studying them in irrigation cannot be overlooked in plant growth and the extent of characteristics improvement of the land [6].

There are many springs on the western plateau, and their geographical distribution is along the springs that start from the Kabisa and Hit (Haqlan Springs). It extends southward along the Euphrates River and continues to the Al-Rahaliya region, where many springs are spread, some small and some large. They irrigate the famous palm orchards in the study area, especially Rawdat Ayoub and the western Rahaliya, Qasaba Al-Rahaliya, and northern and southern Al-Rahaliya orchards. Among the springs in the study area are the Blue Spring, Abeer Spring, Jaffa Spring, and Aweena Spring, which vary in production capacity and water quality. The study [7] evaluated the wells of Al-Khafajiya village in Anbar Governorate, finding that this water is not suitable for irrigation-drinking purposes, in addition to the high concentrations of sulfates.

Numerous studies have been accomplished to determine water quality for irrigation purposes based on chemical analysis and total salt concentration [6], [8], [9]; they set different standards for evaluating irrigation water for agricultural purposes, which include salinity and sodicity, in addition to determining the concentrations of dissolved ions [10], [11]. Water standards for drinking depend on the main dissolved elements concentration of positive and negative ions and chemical and microbial properties. The microbial groups searched for when evaluating the microbial water quality and examined in this research are coliform bacteria, known as aerobic and facultative anaerobic Gram-negative rods. The aerobic bacteria examination is widely operated, particularly in routine water monitoring. It is utilized to calculate the significance of all the stages in the water filtration process and as an indicator of the health and safety of drinking water. Adhere to the standard criteria the World Health Organization [12] sets to define the usefulness of drinking water and human use to preserve public health. The research aims to evaluate the spring and well water quality in the Al-Rahaliya area for agricultural and human uses.

2. Materials and Methods

The study was conducted during the fall of 2019 to study the quality of groundwater, well water, and springs in the Al-Rahaliya district of Anbar Governorate and their suitability for agricultural and human exploitation. The study included Al-Rahaliya district to study the suitability of Ain Al-Zarqa water from a human perspective; the second included a farm about 20 km west of Al-Rahaliya to study the suitability of irrigation water. Water samples were taken from Ain Al-Zarqa Oasis before and after filtration in sterile plastic containers. The following tests were conducted after transferring the samples directly from the sampling site: Chemical and ionic estimates were used to measure the reaction degree, electrical conductivity, dissolved ions, and sodium adsorption rate according to the methods mentioned in [11] Total dissolved solids were measured as mentioned in [13]. Bacterial tests were conducted on Ain Al-Zarqa water samples according to the methods mentioned in the bacterial tests study [14], [15].

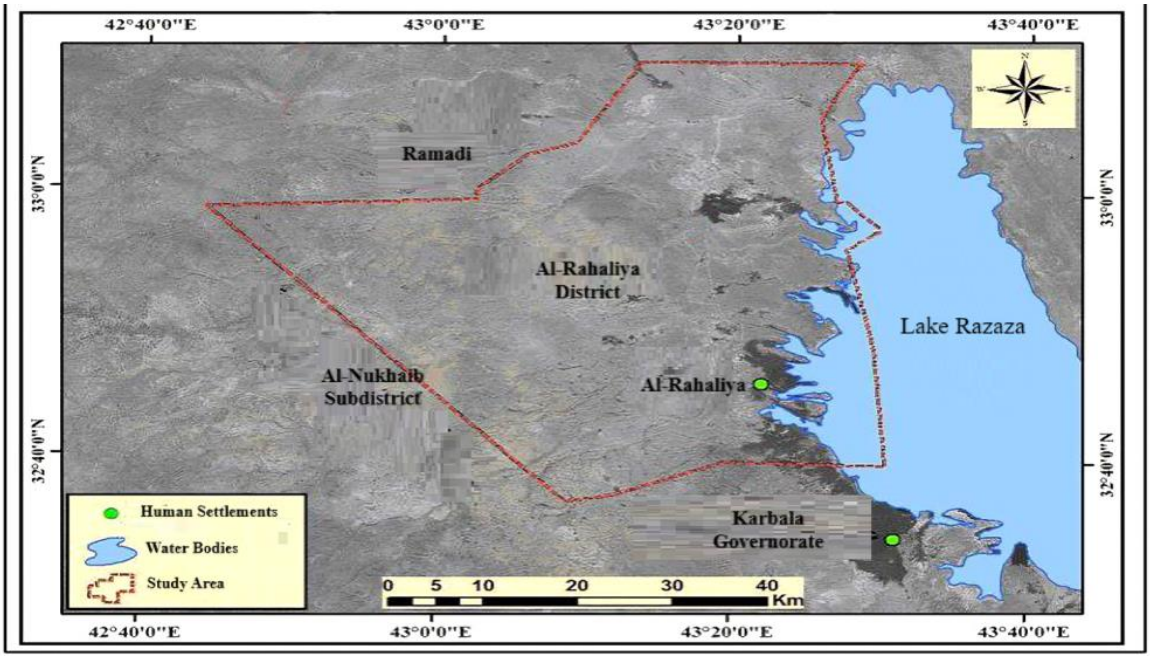

Figure 1: Map of the study area.

3. Results and Discussion:

Table 1 shows the results of laboratory tests of Ain Al-Zarqa water in the study area, where the results were compared with the results of international standard specifications:

- pH: The values ranged between (7.9-7.1) before filtration and between (8.3-8.0) after filtration, which are within the permissible limits (8.5-6.5) for human use.

- Electrical conductivity: The EC values of Ain Al-Zarqa water ranged between (3.1-3.9) dSiemens $m1^{-}$ before filtration, and the reason for the increase is attributed to the saline nature of the rocks surrounding the water, as the values ranged between (1.1-0.6) dSiemens $m1^{-}$ after filtration, which shows that the values exceeded the permissible limit of 0.5 dSiemens $m1^{-}$ and are unfit for human consumption according to the World Health Organization [12].

-Total dissolved solids (TDS): The values exceeded the upper limits for drinking water quality according to the World Health Organization [12], and the reason for the high concentration of dissolved salts in the water is due to the high rate of dissolution of the rocks through which the water passes.

-Positive ions (Na+, Mg2+, Ca2+): Sodium is one of the main causes of salinity and has special importance in drinking water, especially when it is present in high concentrations. The results indicated that the values of

sodium concentrations before filtration ranged between (372.46-172.48) mg/L. Noticing a high increase in sodium concentration in the study area, and the reason is due to the nature of the salt rocks in the depths of the area that release sodium ions. The values of concentrations after filtration reached (110-60.28) mg/L, which may have exceeded the critical limit (20 mg/L) permitted by the World Health Organization [12].

Calcium is one of the soil components and is found in dolomite and gypsum rocks. Increasing the calcium concentration in water changes the taste of water, reduces its ability to dissolve soap, and increases its hardness. The study's results showed a difference between the values of calcium concentrations before filtration, as they ranged between (100-200) mg/L, and their concentration depended on the type of rocks they passed through. The values of calcium concentration after filtration reached (50-80) mg/L, which is within the permissible limits of 100 mg/L according to the classification of the World Health Organization [12]. Mineral springs and seawater contain high magnesium concentrations, while natural water contains lower magnesium levels. The interaction of the effect of magnesium ions is similar to calcium ions, as their presence in water at high concentrations causes hardness [16]. The results showed that the values of magnesium ion concentrations in Ain Al-Zarqa water before filtration ranged between (120-324) mg/L, thus exceeding the permissible limit for human drinking (30 mg/L) according to the classification of the World Health Organization [12]. The high magnesium concentration in Ain Al Zarqa water is attributed to the nature of rocks and minerals containing magnesium and the contribution of agricultural areas spread around the spring. The values of magnesium ion concentration after filtration reached (30-54) mg/L.

-Negative ions:

•Chlorides Cl: According to the World Health Organization, the concentration values of chloride ions exceeded the permissible limit for drinking water, which is 25 mg/L [12]. The concentration of chloride ions in Ain Al-Zarqa water before filtration ranged from (560-315) mg/L, and the primary source of chloride ions in the spring water is the salts washed into the soil during the irrigation process and rainfall, which in turn seeps into the groundwater. The chloride concentration values after filtration reached (175 mg/L) outside the permissible limits.

• Sulfates $SO4^{2-}$: The results showed that Ain Al-Zarqa water contains large amounts of sulfates, as they ranged before filtration (936-528) mg/L. This change is attributed to the nature of agricultural use of the lands surrounding Ain Al-Zarqa or biological activity by sulfur-reducing bacteria [17]. The sulfate concentration values after filtration reached (288-108 mg/L) outside the permissible limits and exceeded the critical limit of 25 mg/L according to the World Health Organization classification [12].

Table 1: Concentration of cations and anions in the studied Ain Al-Zarqa water (mg/L).

Test	Unit	Date of Sampling							
		25th of July		24th of August		25th of September		25th of October	
		Before infiltration	after infiltration	Before infiltration	after infiltration	Before infiltration	after infiltration	Before infiltration	after infiltration
Ec	ds/m	3.9	0.6	3.3	1.0	3.1	0.8	3.1	1.1
PH	-	7.3	7.6	7.0	7.5	7.1	7.5	7.1	8.0
TDS	Mg/L	2640	390	2115	700	2025	520	2015	750
Ca		100	80	200	50	100	50	140	50
Mg		340	30	180	54	120	30	186	30
Na		172.48	66	174.02	110	372.46	60.28	241.56	88
Cl		560	175	315	175	525	175	381.5	175
SO_4		305	91.5	244	61	305	30.5	274.5	61
Co_3		0	0	0	0	0	0	0	0
Hco_3		936	108.48	528	240	676.8	79.68	864.96	288

-Microbial tests:

The results of the biological tests (Table 2) were conducted on water samples taken from Ain Al-Zarqa to study the presence of E. coli and E. coli in drinking water samples from the Al-Rahaliya area. It showed that this water is unfit for drinking, as these bacteria cause severe and persistent watery diarrhea, leading to significant bodily fluids loss. The contamination of Ain Al-Zarqa water with these types was due to the influence of humans and their various activities. In addition, these areas are agricultural, where throwing dead animals near them is common, thus becoming a primary source of spring water contamination with these types of bacteria. The presence of these bacterial groups that were isolated and diagnosed in drinking water samples from the area provides evidence of the unsafety of this water for drinking, and this was due to the lack of attention to sterilizing drinking water in the filtration station.

Table 2: Microbial tests of the studied drinking water samples.

Microbial tests MPN/100	Springs water	Tabe water
E.Coli	**9**	**2**
Coli from	**6**	**2**

- Well water in the study area:

• Electrical conductivity (EC): The results in Table 3 showed that the average electrical conductivity values of the well water were (3.7) dS1- during the study period. The high electrical conductivity values may be due to the increased solubility of ions and the nature of the geological components surrounding the water. In general, the electrical conductivity values of the well water exceeded 2.25 dS1- and according to the American Salinity Laboratory [11] classification, the well water met within the very high salinity class C4. The specifications of this class use its water only in the case of well-permeable soils, and it is not suitable for irrigation under normal conditions. It can be used under special conditions and for crops that are very tolerant to salinity with the addition of washing requirements. The study results were less than what was reached by [7] in evaluating the water quality of some wells in the village of Al-Khafajiya in Anbar Governorate, as the values ranged between 3.9-7.9 dS1-.

• Water reaction degree (PH): it measures the acidity and basicity of solutions and expresses the hydrogen ion's activity and effectiveness resulting from the diluted acid/base balance due to different concentrations of dissolved compounds. It is essential to know the quality of water and the quality of the decomposition processes taking place in it [18], as the study showed that the average pH value is 7.4, which is within the appropriate limits for agricultural use purposes and that there is no problem in the field of irrigation because it did not exceed the required upper limits of (8.4) according to classification [19] Table 3.

• Total dissolved salts TDS: as for the total salts, it showed a difference in the quantities of the irrigation water studied, as the average values were (2621) mg/L, and this may be attributed to the high rates of water withdrawal in the season, which are higher than the feeding rates for these wells, in addition to the increase in temperature, which leads to an increase in the solubility of various salts and an increase in evaporation rates and salt concentration. When comparing the results with classification [6], finding that the studied irrigation water exceeded the upper limits required to evaluate the quality of irrigation water, which is 2000 mg/L, Table 3.

• Sodium adsorption ratio SAR: The results in Table 3 showed that the average sodium adsorption ratio values for the study water were (3.02), which met within low sodium water (S1) low sodium according to classification [5]. Hence, the water is suitable for irrigating most regions except those sensitive to sodium. The variation in (SAR) values is attributed to the difference in the values of sodium, calcium, and magnesium, and the results were less than what [20] reached in their study of the quality and quantity of groundwater in Anbar Governorate, as they ranged between (5.79-2.71).

Table 3: Qualitative characteristics of the region's well water.

Location	EC	PH	SAR	TDS mgL^{-1}
A	3.0	7.9	3.02	1925
B	3.9	7.8	2.94	2530
C	3.8	7.0	2.92	2510
D	3.6	7.0	2.74	2350
average	3.7	7.4	3.02	2621

- Evaluation and classification of the quality of well water in the study area for agricultural uses: To classify water for irrigation, the essential criteria were relied upon to evaluate the suitability of the water in the study area for irrigation purposes after comparing it with the specifications proposed by those systems.

Among these systems that were used in this field are:

• American Salinity Laboratory Classification (1954, Richard): It is one of the most widely used systems in the world to date, as it relies on the two fundamental indicators for evaluating water, which are the electrical conductivity value expressed in ds/m unit and the sodium adsorption ratio (SAR). When applying the data of this classification to the irrigation water studied in Table 4, it was found that the water met within the category C4 (very high salinity water). Therefore, it is considered, in terms of salinity, unsuitable for irrigation under normal conditions. However, it can be used in well-permeable soils with an efficient drainage system and low temperatures (winter season). It is also preferable to grow crops with a high tolerance to salinity. The reason for the low SAR value is the high concentration of calcium and magnesium, which leads to a decrease in the dominance of sodium ions [21]. When classifying the well water quality based on the salinity of irrigation water EC and sodicity SAR according to the [5] system, the water in the study area is classified as C4-S1, i.e., water with very high salinity and low sodium content.

• Eaton system (1950): This system relied on the amount of residual sodium carbonate to evaluate the quality of irrigation water in terms of its content of carbonates and bicarbonates. The results shown in Table 4 indicate

that irrigation water's residual sodium carbonate values are negative due to the dominance of calcium and magnesium ions compared to the concentration of carbonates and bicarbonates. The irrigation water of the studied wells was free of sodium carbonate and therefore considered suitable for irrigation purposes, as the water was classified as one of the best types of water, so the studied irrigation water is considered suitable for irrigation according to classification [19]. The study's results were consistent with what was stated in [1].

Table 4: The suitability of irrigation water, according to the American Salinity Laboratory system.

Location	EC	Water Class	SAR	Water Class	Class	R.S.C	Water Type
A	3.0	C_4	3.02	S_1	C_4- S_1	-9.25	The best water type
B	3.9	C_4	2.94	S_1	C_4- S_1	-11.75	
C	3.8	C_4	2.92	S_1	C_4- S_1	-16	
D	3.6	C_4	2.74	S_1	C_4- S_1	-1.346	

4. Conclusion

This study concluded that the quality of groundwater and springs in the Al-Rahaliya region of Anbar Governorate varies significantly in terms of suitability for agricultural and human uses. The results revealed that well water is characterized by very high salinity, making it suitable only for irrigating highly salt-tolerant crops under controlled conditions. On the other hand, Ain Al-Zarqa water was found unsuitable for human consumption due to high concentrations of sodium, sulfates, and chlorides, as well as contamination with fecal coliform bacteria, indicating biological pollution. Moreover, the study highlighted the importance of chemical and microbial assessments in evaluating water quality prior to its use. It recommended enhancing groundwater and surface water treatment systems in the region to meet World Health Organization standards. These findings can serve as a guideline for managing water resources and developing strategies for effective water use, particularly in arid and semi-arid areas like Al-Rahaliya.

Declaration of Competing Interests:

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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No Supplementary Materials.

Author Contributions:

Y. K. Al-Hadithi; methodology, writing—original draft preparation,W. K. Al-Falahi ; writing—review and editing, Y. K. Al-Hadithi; paraphrasing. All authors have read and agreed to the published version of the manuscript.

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