Quality Assessment of Groundwater for Agriculture in the Hail Region, Saudi Arabia

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ABSTRACT

As a result of the arid climate of Saudi Arabia, groundwater is the most precious natural resource, providing reliable water supply for the resident population and the development of irrigated agriculture where surface water resources are insufficient and little to meet the water budget requirements of the Kingdom of Saudi Arabia. Therefore, this study was carried out to evaluate the quality of groundwater resources in selected locations of Hail region. This study focused on the important chemical analysis of the available groundwater resources in Hail region. Groundwater samples were collected from 61wells at different locations that cover the Hail region for chemical analysis. Parameters such as pH, electrical conductivity (EC), sodium (Na), potassium (K), calcium (Ca), magnesium (Mg), carbonate (CO_3^{--}) bicarbonate (HCO_3^-), chloride (Cl^-), and heavy metals were analyzed moreover the calculation of sodium adsorption ratio (SAR) to assess the suitability of groundwater for agricultural purposes. The pH values were between 7.10 and 8.23 (M = 7.66). The salinity of groundwater, as a primary indicator of water quality for irrigation, ranged between moderate and high (between 0.27 to 8.99 dS m^{-1}) in most studied water samples. Besides salinity, 31.1% of Hail groundwater samples have the potential risk of chloride hazard (chloride > 10 meq L^{-1}). SAR values were less than 9 for all groundwater samples while the heavy metals were within acceptable levels.

Key words: Groundwater, water quality, salinity, heavy metals.

INTRODUCTION

The Kingdom of Saudi Arabia, known as one of the countries with the highest water scarcity in the world, depends mostly on groundwater as the main water source due to its limited surface water resources and average annual rainfall of less than 100 mm (Al-Omran, 2002).. The quality of groundwater is a major constraint against the development of irrigated agriculture (Oster and Jayawardane, 1998). In other words, Kumaresan and Riyazuddin (2006) reported that the chemical and physical parameters of groundwater play an important role in assessing water quality. Salts affect the yield as well as the suitability of the soil for growth of plant. The suitability of particular irrigation water is highly dependent on the actual need and economic return that can be obtained from salt water irrigation compared to other options, as well as the limited conditions of use. Important conditions of use include the crop being grown, cropping management practices, various soil properties and management practices, irrigation, climatic changes. Moreover, salinization of groundwater due to overuse, increased population growth rate, high water loss by evaporation, limited recharge, and the overlap between seawater–freshwater (Sheikhy Narany et al., 2014). A study of the acidic and alkaline properties for water, gives an indication of the extent water interaction with different materials (Hem, 1985). Ayers and Westcot (1985) reported that the greatest direct hazard of water with an abnormal pH, is the impact on irrigation equipment. So, it is necessary to choose irrigation equipment properly, when handling water of unusual pH. An adverse pH may need to be corrected by the introduction of chemical substances into the water.

In some environments, increased (Cl^-) concentrations have killed off the native vegetation and allowed invasive salt-tolerant species to thrive (Panno et al., 1999). Chloride can damage plants from excessive foliar absorption (sprinkler systems) or excessive root uptake (drip irrigation). The concentration of ion chloride restriction (Cl^-) in irrigation water with lower than 4 meq L^{-1} is considered light, while it is moderate between 4 and 10 meq L^{-1}, and higher than 10 meq L^{-1} are considered severe. The maximum limit is 30 meq L^{-1} (Palacios et al., 1997).

The concentration of carbonates in natural waters is a function of the amount of dissolved carbon dioxide, temperature, pH, cations and other dissolved salts. The concentration of bicarbonate in natural waters is generally held within a moderate range by the effects of the carbonate equilibrium (Kumar et al., 2017).

Groundwater is the major resources for irrigation in most of the Hail region, where used deep wells water from the Saq Aquifer, which forms one of the major aquifers and extends for 1200 km approximately, in the northwest-southeast direction, in Northwestern Saudi Arabia (Hereher et al., 2012).

The Saq Aquifer it is confined or leaky in deeper layers but is unconfined in shallow layers. Except a few areas, Saq Aquifer has very good water quality. (Sharaf and Hussein, 1996). The values of TDS are ranged between 300-1000mg L^{-1}. The Saq groundwater is classified into different water types, the most dominant are Ca(HCO$_3$)$_2$ or NaHCO$_3$ and NaCI types (Alawi and Abdulrazzak, 1993; Mohammed et al., 2011). Sharaf and Hussein (1996) and Abdel-Aal et al. (1997) reported that the groundwater of Saudi Arabia is deteriorating at an alarming rate due to the increasing water salinity. Its electrical conductivity has increased from 1.93 dS m^{-1} in 1983 to 2.76 dS m^{-1} in 1997 in the Saq Aquifer; if this depletion continues unabated, the agricultural land may not be able to survive. Consequently, the assessment of the quality of such limited water resources has become an imperative tool for managing these resources in the best possible manner for any future sustainable development.

In the present study, the objective was to evaluate the quality of groundwater for irrigation in the Hail region.

MATERIALS AND METHODS

Study area:

Hail is a city in north-western Saudi Arabia. It is largely agricultural, with significant grain, date, and fruit production. A large percentage of the kingdom's wheat production comes from the Hail region. It has a continental desert climate with hot summers and cool winters. As a result of its higher altitude, it has a somewhat milder climate than other Saudi cities.

Sampling sites

In this study, water samples were collected from 61wells at different locations that cover the Hail region (Map. 1). And the GPS was used to record the absolute positions of collected samples as shown in Table 1. The water samples were analyzed in the Department of Plant Production and Protection, College of Agriculture and Veterinary Medicine, Qassim University, Buriydah, Saudi Arabia.

Water samples were transported immediately to the laboratory in ice boxes and chemical analyses were carried out to assess the water quality, Map 1. Location of the studied areas.

Water quality measurements

The pH, EC, soluble ions, and heavy metals were determined as follows:

The pH was determined using a pH meter (pH meter –Jenway 3310).

The total soluble salts were measured by using an electrical conductivity meter (EC) in dSm^{-1} at 25ºC (Jenway 4310).

Chloride concentration was measured by Mohr's titration method. Total alkalinity, Calcium and Magnesium were measured by the titration methods (Jackson, 1967)

The soluble potassium and sodium were determined using a flame photometer apparatus (PFP7, Jenway LTD, Felsted, England). The heavy metals (Zn, Cu, Ni and Pb) were determined using ICP, ThermoModel7000.

Water quality evaluation for irrigation in Hail was conducted according the criteria of (Ayers and Westcot, 1985) and U.S. salinity laboratory (Richard, 1954).

RESULTS AND DISCUSSION

Water pH

The pH of water is an indicator of its acidity or basicity, but it rarely constitutes a problem by itself. The main use of pH in water analysis is for the detection of abnormal water. The normal pH range for irrigation water is from 6.5 to 8.4. An abnormal value is a warning that the water requires further evaluation. Irrigation water with a pH outside the normal range may cause a nutritional imbalance or may contain a toxic ion (Ayers and Westcot, 1985). The water pH values for the study area are presented in Table 2. The maximum pH value was 8.23 while the minimum was 7.10, (M = 7.66). The lowest pH value was found in location 3 while the highest value was found in location L5. It was found that the pH of water was in the normal range 6.5 – 8.4 (Ayers and Westcot, 1985).
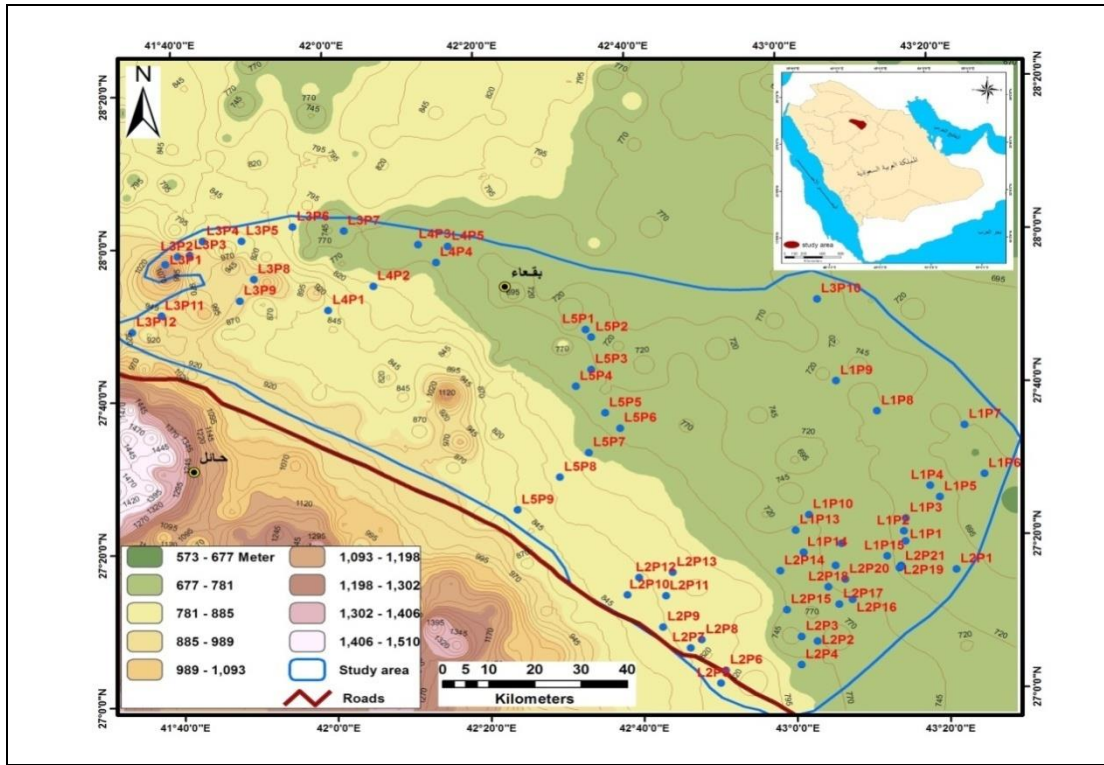
Water salinity

The salinity of water was presented as EC values (dS m^{-1}). Highly saline irrigation water reduces osmotic potential of the soil solution, plant available water, seed germination, rooting, growth, establishment, and fruiting of plants (Duncan et al., 2009, Hillel, 2000).

Table 2 shows the irrigation water salinity (EC) of Hail farms (study area). There are a wide variations among the salinity levels in different samples. The results showed that the EC values ranged from 0.27 to 8.99 dS m^{-1} in the study area. The lowest value was found in location 5, while the highest was in location 4.

Table 1. Sampling location of the study area.

Location	Altitude	Location	Altitude	Location	Altitude
*L1** P1	N27 19 29.1 E43 14 55.0	L2P6	N27 03 158 E42 50 480	L3P6	N28 02 383 E41 55 372
L1P2	N27 20 48.6 E43 14 42.8	L2P7	N27 06 189 E42 46 175	L3P7	N28 01 585 E42 02 212
L1P3	N27 22 29.1 E43 15 02.8	L2P8	N27 07 209 E42 47 446	L3P8	N27 55 523 E41 50 191
L1P4	N27 26 40 E43 18 23.6	L2P9	N27 09 077 E42 42 459	L3P9	N27 53 041 E41 48 245
L1P5	N27 25 82.9 E43 19 37.8	L2P10	N27 13 276 E42 38 124	L3P10	N27 51 287 E41 42 430
L1P6	N27 28 0.1.9 E43 25 35.3	L2P11	N27 13 120 E42 43 181	L3P11	N27 51 189 E41 38 017
L1P7	N27 34 29.9 E43 23 14.3	L2P12	N27 15 407 E42 39 487	L3P12	N27 49 133 E41 34 087
L1P8	N27 36 36.6 E43 11 48.3	L2P13	N27 16 153 E42 44 153	L4P1	N27 51 375 E42 00 017
L1P9	N27 40 43 E43 06 34.5	L2P14	N27 16 043 E42 58 203	L4P2	N27 06 035 E 42 00 017
L1P10	N27 23 17.8 E43 02 21.2	L2P15	N27 10 568 E42 59 038	L4P3	N27 59 577 E42 12 063
L1P11	N27 19 25.7 E43 06 30.4	L2P16	N27 12 044 E43 07 404	L5P1	N27 48 194 E42 33 502
L1P12	N27 16 33.2 E43 05 37.3	L2P17	N27 11 299 E43 05 546	L5P2	N27 47 181 E42 34 345
L1P13	N27 21 19.8 E43 00 32.3	L2P18	N27 13 470 E43 04 324	L5P3	N27 43 039 E42 34 246
L1P14	N27 18 23.5 E43 01 28.3	L2P19	N27 15 596 E43 13 596	L5P4	N27 40 555 E42 32 205
L1P15	N27 17 35.7 43 12 24.9E	L2P20	N27 14 438 E43 06 492	L5P5	N27 37 215 E42 36 050
L1P16	N27 16 18.9 E43 14 12.5	L2P21	N27 16 101 E43 14 115	L5P6	N27 35 170 E42 37 577
L2P1	N27 15 383 E43 21 262	L3P1	N27 58 045 E41 38 426	L5P7	N27 32 116 E42 33 470
L2P2	N27 06 43.9 E43 02 542	L3P2	N27 59 017 E41 40 193	L5P8	N27 29 049 E42 29 524
L2P3	N27 07 235 E43 00 508	L3P3	N27 59 103 E041 41 566	L5P9	N27 24 560 E42 241001
L2P4	N27 07 342 E43 00 418	L3P4	N28 00 580 E41 43 405		
L2P5	N27 01 355 E42 50 046	L3P5	N28 00 551 E41 48 508		

*L=location, **P= position of well

Map 1. The map of the study area was prepared using Arc GIS 9.3 software.

Table 2. Descriptive statistics of the chemical properties of water from Hail region.

L.		pH	EC dS m⁻¹	Na meq/L	Ca meq/L	Mg meq/L	K\ meq/L	HCO₃⁻ meq/L	alkalinity mg/L	Cl meq/L	SAR
L1	Mini.	7.12	0.55	3.14	1.02	1.01	0.15	1.02	51	2.03	2.93
	Maxi.	8.11	3.66	15.8	17.2	5.55	0.56	2.23	111	14.0	4.68
	M- SD	7.78-0.83	1.18-0.26	6.52-3.57	4.08-3.99	1.99-1.35	0.33-0.15	1.44-0.43	72-21.5	5.74-3.82	4.62-2.275
L2	Mini.	7.53	0.69	3.43	2.18	0.52	0.12	1.1	55	4.1	2.54
	Maxi.	7.94	3.57	18.4	9.91	10.9	0.53	2.54	127	25.2	5.71
	M- SD	7.77-0.114	1.74-0.97	8.72-4.32	5.41-2.66	4.16-3.26	0.21-0.1	1.68-0.45	82-22.5	11.6-7.07	4.0-3.34
L3	Mini.	7.10	0.89	4.03	3.08	1.35	0.11	1.13	56.5	4.02	2.72
	Maxi.	7.63	5.94	25.2	20.3	17.7	0.28	2.13	106	34.0	5.79
	M- SD	7.42-0.194	1.91-1.4	9.59-5.66	6.3-4.71	4.61-4.58	0.16-0.05	1.76-0.36	88-18	10.0-8.19	4.11-2.63
L4	Mini.	7.55	1.24	6.65	3.4	3.3	0.12	1.08	54	4.85	3.63
	Maxi.	7.66	8.99	50.9	26.6	23.5	1.48	2.34	117	48.5	10.1
	M- SD	7.59-0.056	5.67-3.99	31.7-22.7	16.8-12.0	16.7-11.6	0.93-0.71	1.88-0.69	94-34.5	29.3-22.3	7.75-6.61
L5	Mini.	7.72	0.27	0.74	0.39	0.11	0.05	0.03	1.5	0.65	1.48
	Maxi.	8.23	6.8	38.6	20.0	22.2	0.76	1.98	99	40.3	8.40
	M- SD	7.68-0.147	1.77-2.04	9.2-9.87	5.6-5.73	4.6-6.87	0.18-0.22	1.04-0.53	52-26.5	9.13-12.2	4.08-3.9

L: Location, Mini: Minimum, Maxi: Maximum, M-SD: Mean-Standard Deviation.

Figure 1 shows that there are no water samples with a salinity concentration of less than 0.25 dSm^{-1}, which can be classified according to the US Department of Agriculture (Richard, 1954) to Low Salinity Water (C1). The results also indicated that 18.7% of water samples with salinity ranged between 0.25 and 0.75 dSm^{-1}, can be classified according to the US Department of Agriculture (Richard, 1954) to (C2) moderate Salinity Water.

It is also clear that 52.5% of saline water samples are located between 0.75 and 2.25 dSm^{-1}, which can be classified as high salinity water (C3) and 28.8% of water samples have salinity concentration greater than 2.25 dSm^{-1}, which can be classified as very high salinity water (C4) according to the US Department of Agriculture (Richard, 1954). This water is not suitable for irrigation under normal conditions, but it can be used under specific conditions, such as high permeability and good drainage conditions. Ayers and Westcot (1985) reported that the salinity of water is greater than 3 dSm^{-1} becomes difficultly for using it in irrigation systems.

However, throughout the world under widely different conditions of soil, irrigation, yields and climate, waters of many different compositions ranging in salinity up to at least 6000 mg/l TDS (8 dSm^{-1}) are being used productively for irrigation in numerous places (Rhoades et al., 1992).

The results depicted in Figure 1, exhibited higher values of water salinity in location 2 compared to other locations. This represents a very rapid and severe water quality deterioration in location 2. This is due to the continuous agricultural expansion and development in this part compared to other locations and the increased demands on water supplies, which is manifested in more groundwater abstraction and deterioration.

Cations

In Hail groundwater, the major cations' abundance order is $K^+ < Mg^{2+} < Ca^{2+} < Na^+$, where the main composition of groundwater is highly affected by the lithology of rocks rather than human activities (Toumi et al., 2015).

The calcium ion concentrations ranged between 0.39 and 26.6meq L^{-1} (Table 2). Ingram(2014) and Will and Faust(1999) reported that calcium levels below 40 mg/L will typically need fertilizers containing calcium to prevent deficiency while high levels of calcium above 100 mg/L may lead to antagonism and result in the deficiency of phosphorus and or magnesium. High levels of calcium may also lead to clogged irrigation equipment due to scale formation (CaCO$_3$ and other compounds precipitating out of solution). Consequently, 9.83% of farms require fertilization with calcium.

The magnesium ion concentrations ranged from 0.11-23.5meq L^{-1} (Table 2). Ingram (2014) and Will and Faust(1999) reported that like calcium, magnesium in water tends to originate from the rock and generally only causes problems when it is below 25 mg/L, necessitating the addition of a magnesium fertilizer. Consequently, there are 47.5% of farms which require fertilization with magnesium.
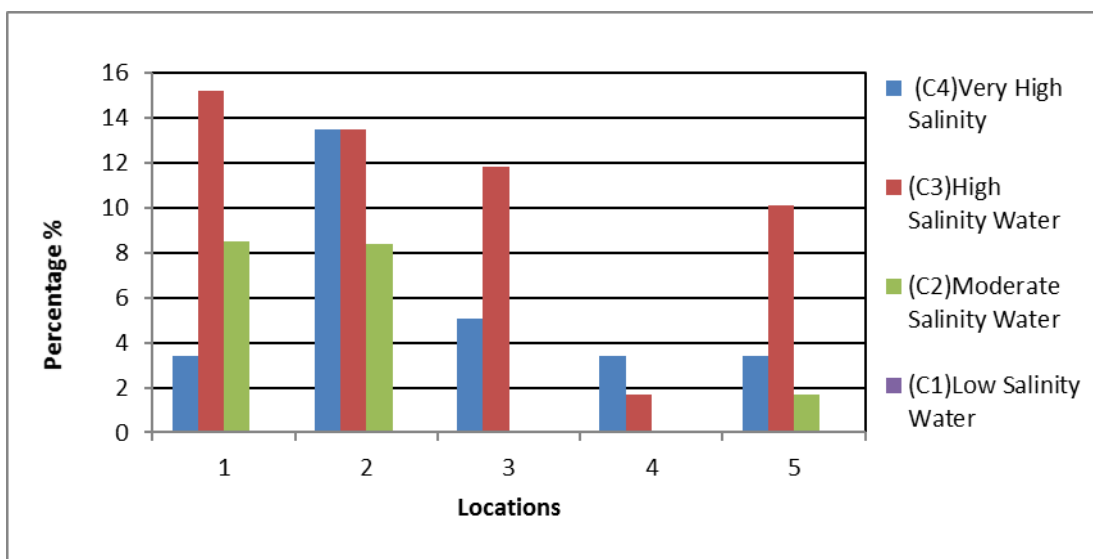

Figure 1. Status of salinity in irrigation water of Hail region.

The sodium ion concentrations ranged from 0.74 to 50.9 meq L^{-1} with a mean value of 16.0 meq L^{-1}. The main reasons for the increase in Na^+ level in groundwater are the cation exchange through water–rock interaction supported by human activities (Ramkumar et al., 2013).

The sodium/alkali hazard is expressed as the sodium adsorption ratio (SAR). This index quantifies the proportion of sodium to calcium and to magnesium ions in a sample. The sodium hazard of water can be properly predicted by determining the SAR. SAR values were calculated following to SAR= Na/ (Ca+Mg) 0.5 (Richard, 1954). Table 2 shows that there is no sodicity problem in all locations (all water samples had SAR values of less than 9) excluding one sample in location 4 which had a severe sodicity problem (SAR > 9).

Total Alkalinity, Bicarbonates, and Carbonates

Alkalinity is a measure of the dissolved materials in water that can buffer or neutralize acids. These include carbonates (CO_3^{--}), bicarbonates (HCO_3^-), and hydroxides (OH^-, rarely present in that form).

The concentration of bicarbonate (CO_3^{--}) and carbonate (HCO_3^-) in groundwater resulted from the dissolution of carbonate weathering and carbonic acid in the aquifers (Kumar et al., 2009). The observed average value of bicarbonate concentration obtained in Hail was 1.52 meqL^{-1}, and ranged between 0.03 and 2.54 meqL^{-1}. The carbonate ion was not detected in all water samples (Table 2). Also, the alkalinity ranged between 1.5 and 127 mg/L. Ingram (2014) and Will and Faust(1999) reported that the ideal range for total alkalinity is approximately 30 to 100 mg/L but levels up to 150 mg/L may be suitable for many plants. High alkalinity above 150 mg/L tends to be problematic because it can result to elevated pH of the growth media which can cause various nutrient problems (e.g., iron and manganese deficiency, calcium and magnesium imbalance) (Leinauer and Devitt, 2013). Consequently, bicarbonate values were in the safe and normal range.

Chloride

In Hail groundwater, the order of abundance of the major anions was as follows: $Cl^- > HCO_3^- > CO_3^{--}$. A similar trend was found by Tanvir et al. (2017).

Chlorides are leached from various rocks into the soil and water by weathering. The chloride ion is highly mobile and is transported to closed basins or oceans (WHO, 1996). Chloride behaves as a conservative ion in most aqueous environments, meaning its movement is not retarded by the interaction of water with soils,

sediments, and rocks. Therefore, chlorides were common of natural water. As expected, the trend of chloride distribution follows the water salinity trend. The observed average value of chloride concentration obtained in Hail was 15.5meq L^{-1}, and ranged between 0.65 and 48.5meqL^{-1} (Table 2). In fact, 31.1% in Hail groundwater samples have the potential risk of chloride hazard (chloride > 10 meq L^{-1}) (Ayers and Westcot, 1985).

According to Palacios et al. (1997) the effect of chloride concentration on usable water in cultivation was analyzed. The degrees of restriction for irrigation water samples are presented in Table 3. The degree of ion chloride restriction (Cl^-) in irrigation water with concentrations lower than 4 meq L^{-1} is considered light (13.3%), between 4 and 10 meq L^{-1} is moderate (55.7%), and concentrations higher than 10 meq L^{-1} are considered severe (24.5%). The maximum limit is 30 meq L^{-1} (6.5%).

Heavy metals

Heavy metals are the one of the most important pollutants and when entering the food chains they can cause serious problems to human health (Mkude, 2015). Table 4 presents the descriptive statistical data. The order of metal levels in groundwater of Hail was as follows: Pb > Zn > Cu > Ni. The concentrations of Pb, Zn, Cu and Ni concentrations ranged from 1.29 to 94.5, 1.05 to 63.3, 1.98 to 83.8 and 0.75 to 9.21 µg L^{-1}, respectively. The highest heavy metals concentrations were obtained in location 4. The results concluded that in all areas, heavy metals in groundwater were within the acceptable levels, according to Ayers and Wesotcot (1985).

Table 5 showed the correlation coefficients between some chemical properties of groundwater and groundwater EC. Groundwater EC correlated positively with Cl, Mg, Ca and Na at a significance level of 1%.

EC (dS/m) is correlated with Cl, Na^+ , K^+, and SAR (ranges from 0. 985 to 0.585) while EC is poorly correlated with pH. pH is poorly negatively correlated with EC, Na^+, K^+, Ca^{+2} Mg^{+2}, Cl^-, and HCO_3^- (ranges from -0.323 to -0.05). This result coincides with the study of Bodrud-Doza et al. (2016). A highly positive correlation was observed between Cl and Mg, Ca, Na and HCO_3^-. A similar relation was observed between Mg and Ca, Na and HCO_3^-. Calcium was highly positively correlated with both Na and HCO_3^-. Sodium was highly positively correlated with HCO_3^-. Similar results were obtained by Ashiyani et al. (2015).

Table 3. Status of chloride in water irrigation of the Hail region.

The degree of ion chloride restriction	Light	Moderate	Severe	The maximum limit
Approx. water chloride, meq L^{-1}	<4.0	4-10	10-30	>30
Location 1	5.0	9.0	2.0	-
Location 2	-	11.0	10.0	-
Location 3	-	9.0	2.0	1.0
Location 4	-	1.0	-	2.0
Location 5	3.0	4.0	1.0	1.0
Total(samples)	8.0	34	15.0	4.0

Table 4. Descriptive statistics of the heavy metals (ug L^{-1}) of groundwater from Hail region.

L.		Zn	Cu	Ni	Pb
L1	Mini.	4.7	4.33	1.98	3.83
	Maxi.	33	51.3	6.95	78.4
	Mean	17.3	16.9	3.7	25.8
L2	Mini.	1.05	4.76	0.75	2.87
	Maxi.	3.57	35.8	31.1	54.9
	Mean	17.7	24.3	6.04	20.8
L3	Mini.	1.07	1.98	0.95	1.53
	Maxi.	25.1	41.6	7.44	34.2
	Mean	12.9	18.1	4.7	13.7
L4	Mini.	11.9	12.4	1.59	11.8
	Maxi.	60.4	83.8	9.21	94.5
	Mean	35;5	46.5	6.68	50.9
L5	Mini.	12.1	11.7	1.27	1.29
	Maxi.	63.3	33.1	8.33	78.1
	Mean	26.6	17.6	5.55	23.7
Acceptable levels		5ppm	0.2ppm	0.2ppm	0.2ppm

L: Location, Mini: Minimum, Maxi: Maximum. Acceptable levels according to (Ayers and Westcot, 1985).

Table 5. Simple correlation between EC and chemical properties.

	EC	Cl	K	Mg	Ca	Na	HCO$_3^-$
Cl	0.976						
K	0.595	0.511					
Mg	0.966	0.960	0.567				
Ca	0.976	0.941	0.572	0.914			
Na	0.985	0.953	0.636	0.950	0.947		
HCO$_3^-$	0.0.00	0.976	0.596	0.966	0.976	0.985	
pH	-0.322	-0.285	-0.050	-0.303	-0.321	-0.280	-0.323

*Significant correlation between EC & TDS, EC & Salinity, TDS & Salinity, TDS & Turbidity, TH & Chloride

CONCLUSION

The quality of groundwater resources in the selected Hail regions indicated that the groundwater salinity for irrigation was relatively high in most studied water samples, and the EC values ranged from 0.27 to 8.99 dS m^{-1} in the study area. The lowest value was found in location 5, and the highest was found in location 4. However, pH values, SAR and heavy metals in groundwater in all areas were within acceptable levels.

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الملخص العربي

تقييم جودة المياه الجوفية للزراعة بمنطقة حائل بالمملكة العربية السعودية

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نتيجة للمناخ الجاف في المملكة العربية السعودية، تعد المياه الجوفية أثمن مورد طبيعي، حيث توفرإمدادات مياه موثوقة للسكان المقيمين وتطور الزراعة المروية حيث موارد المياه السطحية غير كافية وقليلة لتلبية متطلبات الميزانية المائية للمملكة المملكة العربية السعودية. لذلك أجريت هذه الدراسة لتقييم جودة موارد المياه الجوفية في مواقع مختارة من منطقة حائل. ركزت هذه الدراسة على التحليل الكيميائي الهام لموارد المياه الجوفية المتاحة في منطقة حائل. تم جمع عينات المياه الجوفية من ٦١ بئراً في مواقع مختلفة تغطي منطقة حائل للتحليل الكيميائي. تم تقدير الـ pH، التوصيل الكهربائى (EC)، الصوديوم (Na⁺)، البوتاسيوم (K⁺)، الكالسيوم (Ca⁺⁺)، المغنيسيوم (Mg⁺⁺)، كربونات (CO₃⁻⁻)،

بيكربونات (HCO₃⁻)، كلوريد (Cl⁻)، نسبة الصوديوم المدمص (SAR)والعناصر الثقيلة لتقييم مدى ملاءمة المياه الجوفية للأغراض الزراعية. كانت قيم الـ PH تتراوح بين ٧.١٠ و٨.٢٣ وتراوحت ملوحة المياه الجوفية كمؤشر أولي لنوعية المياه لأغراض الري بين متوسطة وعالية في معظم عينات المياه المدروسة. وإلى جانب الملوحة، فإن ٣١.١% من عينات المياه الجوفية في حائل لديها مخاطر محتملة لخطر الكلوريد (كلوريد > ١٠ ملليمكافئ فى اللتر). كانت قيم SAR أقل من ٩ لجميع عينات المياه الجوفية بينما كانت المعادن الثقيلة فى حدود المستويات المقبولة.