



Physical Sciences, Life Science and Engineering Volume: 2, Number 3, 2025, Page: 1-11

# Determination of Hydrodynamic Activity of Ground Water for Um Er Radhuma Aquifer in Al-Salman District, Southern Iraq

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DOI:

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Received: 14-04-2025 Accepted: 21-05-2025 Published: 07-06-2025



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Abstract: Six wells' samples were collected from Umm Er Radthuma aquafer distributed in the region in Al-Salman district, Al-Muthana governorate in the southern part of Iraq during November 2024 and it's compared with four wells samples collected from the same region during year 2010. Umm Er Radhuma formation is represented the major aquifers and the type is a confined aquafer. The samples of ground water were examined for major cations and anions, PH, total dissolved solids (TDS) and electrical conductivity (EC). The hydro-chemical analysis results obtained from the examined ground water samples are generally alkaline, very hard water, classified a brackish water and the excessively mineralized water. The concentration of anions and cations in the water samples indicate the dominant of Sodium ion in the cations, while the sulphate was the main anion for year 2024 and chloride anion for the year 2010 with increase all the anions and cations values during 2024. The ground water wells are a continental origin except well 3 is marine origin. Therefore, Bojarski method application shows that the all-wells samples have high hydrodynamic activity so that the hydrocarbonic accumulation is a low except well 3 have a low hydrodynamic activity and the hydrocarbon accumulations were high effect. The water type according to Kurolov formula is Na2SO4 in the most wells except well 3 is NaCl. The ground water of Al-Salman region has indicated that the sulphate group is dominated.

**Keywords:** Al-Salman District, Hydrodynamic Activity , Umm Er Radhuma Aquafer, Kurolov Formula.

# Introduction

One crucial worldwide resource is groundwater. it is the main supply of drinkable water in areas and countries without surface water and it is playing a crucial role in sustaining life (Yang L. et al., 2024 and Manii et al., 2024). Wetlands' hydrodynamic properties include variations in level of water, flow direction, recharge, discharge conditions, and quantity of both surface and groundwater throughout time and space. The hydrodynamic characteristics are central for the transmission of matter and energy between water bodies (Liu Y. et al., 2022). The hydrodynamic activity of ground water is related inversely to the hydrocarbon accumilalion, when the hydrodynamic activity is high Therefore, the hydrocarbon accumulations are very low and the hydrodynamic activity is

low so the hydrocarbon accumulations are high (Abais ,2009 & Abas ,2012). High hydrodynamic activity affects the existence of hydrocarbon accumulations, as hydrocarbons migrate from the areas of high hydrodynamic activity to the areas of low activity (Dahiberg, 1982, Hunt, 1990 & Dennis et al., 2000). Hydrodynamic groundwater model has been implemented in several studied areas such as China, Tunisia and Floodplain Area to investigate whether the regional variation in groundwater quality may be related with the spacial aspects of groundwater movement (Fang et al., 2020; Hamdi et al., 2021; Zhan et al., 2023 & Liu et al., 2023 ).

The groundwater quality characterized the existence or availability of the various components; hence, the relationship of these components and the materials, which occur in the aquifer and the hydrochemical processes are accountable for the acquisition of water quality (Al-Qaraghuli et al., 2020 & Hamma et al., 2024). It is affected by many factors such as runoff, ground water exploitation, land use type, agricultural activities and geological conditions (Lu et al, 2022; Pant et al., 2018 & Cary et al., 2015). The major ions examinated can vitally assist in finding out the origin of water resources (Vaezihir et al. 2024).

Selected region is a part from Al- Salman district which lies in Al-Muthana governorate, southern of Iraq and in the southern part of western desert between latitudes  $(26^{\circ} 00^{\circ} - 36^{\circ} 00^{\circ})$  northern and longitudes  $(44^{\circ} 00^{\circ} - 50^{\circ} 00^{\circ})$  eastern, Figure 1. The studied region is characterized by arid climate of cold winter, dry hot summer and the annual mean rainfall is about (8.42 mm) mostly during November to April and the annual mean temperature is (24.8 C°) (Al-Aajibi & Al- Jiashi ,2021). Climate change greatly impacts groundwater, varying its chemical and physical properties and leading to altering in water availability and increasing salinity (Dao et al., 2023 & Benyoussef et al., 2024).



Figure 1. The location map of ground water wells in the study region.

Geologically, the research region surroundings and the entire area is covered in Cenozoic-era sedimentary rocks, which range in date from the Early Eocene to the more recent Quaternary (Al-Khafaji et al., 2021). The exposed formations in studied region from the older to the younger as follows; Umm Er Radhuma, Dammam, Euphrates, Ghar and Zahra formations that is covered by Quaternary deposed (Jassim & Al-Jiburi, 2009). Umm Er Radthuma formation considered the confined aquifer in the studied region contains chalky limestone, marly limestone and dolomite (Al-Fatlawi & Jawad, 2011). In studied region the slopping is gently towards east and northeast. The land elevation of the studied region increases toward the western about 435 meters above sea level at the Iraqi-Saudi boundaries and the low elevation about 15 meters above sea level refer to the region involved by some depressions (Al-Aajibi & Al-Jiashi ,2021, Jassim & Al-Jiburi, 2009). The aim of this research is to determine hydrodynamic activity of ground water wells and to assess the quality of the ground water in the studied area.

# Methodology

Six well samples have been selected for this study distributed in the region which collected from selected ground water wells in Al-Salman desitrict during November, 2024 in Figure 1 and compared by ground water wells collected from the same region during the year 2010 (Al-Fatlawi & Jawad, 2011). Each of ground water samples were analyzed for 11 parameters, these are electrical conductivity (EC), pH, total dissolved solids (TDS), total hardness (TH), sodium (Na+), magnesium (Mg+2), potassium (K+), calcium (Ca+2), bicarbonates (HCO3-), chlorides (Cl-) and sulfates (SO4-2) by using standard analytical method recommended by (APHA, 2005). The results of analysis of the concentration of major and minor ions, EC, TDS, TH and pH are illustrated in Table 2.

Wel	5	PH	EC	TDS	Ca	Mg	Na	К	C1	SO <sub>4</sub>	HCO <sub>3</sub>	TH
1	rea		(µs/cm)	(mg/l)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)
No.	~		-									
1	24	7.18	6510	4213	402	297	699	60	780	1272	654	2225.9
2	202	7.16	6540	4235	404	299	702	67	781	1276	655	2239
3		7.22	3040	1978	167	108	252	12	579	639	186	861.5
4		7.17	5320	3446	220	157	712	12	655	1213	433	1195
5		7.21	3770	2448	242	124	396	2	548	787	311	1114.5
6		7.24	2690	1746	221	106	284	5	338	628	137	988
Ran.		7.16-	2690-	1746-	167-	106-	252-	2-67	338-	628-	137-	988 -
		7.24	6540	4235	404	299	712		781	1276	655	2239
Mea.		7.2	4645	3011	276	182	507.5	26.3	613.5	969.2	396	1437
7	10	8.5	2000	1570	97	57	235	10	550	170	53	476.8
8	20	8.3	2060	1647	100	60	240	12	562	183	56	496.6
9		8.5	1750	1393	95	55	230	15	540	160	49	463.5
10		7.08	3640	2388	120	44	555	13	696	566	153	480.7
Ran.		7.08-	1750-	1393-	95-	44-60	230-	10- 15	540-	160-	49 -	463.5-
		8.5	3640	2388	120		555		696	566	153	496.6
Mea.		8.1	2363	1750	103	54	315	12.5	587	269.8	77.8	479

Table 1. Groundwater properties in the studied wells in the region for years 2024 and 2010.

#### **Results and Discussion**

In this research, the chemical and physical characterizes of ground water samples are showing in Table 2. The PH value of water wells samples are ranging between (7.16-7.24), by average (7.2) which reflect alkalinity during 2024 while during 2010 ranging between (7.08-8.5) with average (8.1). The EC values are ranging from (2690-6540  $\mu$ s/cm), with average (4645 µs/cm) during 2024 while during 2010 ranging between (1750-3640 µs/cm), with average (2363 µs/cm). When comparing EC values of water wells samples with (Detay, 1997) classification, it is concluded that the water type in the region is an excessively mineralized water because of salinity. The TDS values of water wells samples are ranging from (1746 - 4235 mg/l), with average (3011 mg/l) during 2024 while during 2010 ranging between (1393- 2388 mg/l), with average (1750 mg/l). When comparing TDS values of ground water samples with (Todd, 2007) classification, it is concluded that the water type in the region is classified as a brackish water. TH values of water wells samples are ranging from (988 to 2239 ppm), with average (1437 ppm) during 2024 while during 2010 ranging between (463.5 - 496.6 ppm), with average (479 ppm). When comparing TH values of ground water samples with Boyd classification (Boyd, 2000), it is concluded that the water type in the region is classified a very hard water as a result of wide exposures of limestone in the recharge zone and based on (Todd, 2007) the lithology includes carbonate rocks mostly which are rich in magnesium and calcium concentration. Figure 2 shown the values of TDS, TH and EC for water samples.



Figure 2. Values of EC, TDS and TH for the water samples.

The major cations consist of (Ca, Na, Mg and K) where the Calcium ion concentration in samples ranging from (167 to 404 ppm), with average (276 ppm) during 2024 while during 2010 ranging between (95 - 120 ppm), with average (103 ppm), the magnesium ion concentration ranging from (106 to 299 ppm), with average (182 ppm) during 2024 while

during 2010 ranging between (44 - 60 ppm), by average (45 ppm), the concentration of sodium ion ranging from (252 to 712 ppm), by average (508 ppm) during 2024 while during 2010 ranging between (230 - 555 ppm), by average (315 ppm) and the potassium ion concentration ranging from (2 to 67 ppm), with average (26 ppm) during 2024 while during 2010 ranging between (10 - 15 ppm), by average (12.5 ppm), Figure 3.

The major anions consist of (Cl-, SO4-2 and HCO3 -) where the concentration of Chloride ion in samples ranging between (338 to 781 ppm), with average (614 ppm) during 2024 while during 2010 ranging between (10 - 15 ppm), by average (12.5 ppm), the bicarbonate ion concentration ranging from (137 to 655 ppm), with average (396 ppm) during 2024 while during 2010 ranging between (49 – 153 ppm), with average (78 ppm) and the concentration of sulfate ion ranging from (628 to 1276 ppm), with average (969 ppm) during 2024 while during 2010 ranging between (160 - 566 ppm), with average (270 ppm), Figure 4. Increasing the (SO4) concentrations in the studied region can be a result of the dissolution of anhydrite and gypsum minerals in the aquifer rocks in the recharge region.



Figure 3. Values of Cation Concentrations for ground water wells.

The Figures (2,3 and 4) appears that the all-physiochemical properties of ground water samples in the research region are increased during 2024 large than during 2010.



Figure 4. Values of Anion Concentrations for ground water wells.

The ratio of sodium concentration to chloride concentration (r Na/r Cl) in (epm) unit was calculated to determine the origin of water. (Sulin, 1946) suggest that if the ratio of (r Na/r Cl) is less than one, it means that the origin water is marine and if it is more than one, it means that continental origin. The results are reflecting all the ground water wells is a continental origin except well 3 is marine origin, Table 2.

Tuble 2. The ground water origin of water sumples in studied area.							
Well No.	r Na/r Cl	Water origin					
1	1.4	continental					
2	1.4	continental					
3	0.67	Marine					
4	1.7	continental					
5	1.11	continental					
6	1.3	continental					

Table 2. The ground water origin of water samples in studied area.

To determine the hydrodynamic activity in the research region, the Bojarski method was applied by relying on the ratio of concentration r Na/r Cl in Table 2 (BojaSrki, 1970). All the groundwater wells have high hydrodynamic activity because the ratio of r Na /r Cl was greater than 0.85. Therefore, the hydrocarbon accumulations were very low effect except well 3 have a low hydrodynamic activity because the ratio of r Na/r Cl was ranged between 0.65 to 0.75 that reflect the hydrocarbon accumulation was good as illustrated in Figure 5. The hydrodynamic activity values are considered to be variable over time due to changes in the concentrations of chemical properties in groundwater.



Figure 5. Percentage ratio of the hydrodynamic activity in the research area.

Water type was determined by using Kurolov formula (Ivanov et al., 1968) which based on the ratio of the major ions expressed by epm % that are arranged in descending order which have more than 15% ratio as the following formula:

TDS (mg/l) Anions (epm%)in decreasing order pH .....1

The results from applying Kurolov formula appears in the Table 3, which are shown the water type in the studied region are Na-SO4 in the most wells except well 3 is Na-Cl. The ground water of Al-Salman region has indicated that the sulphate group is dominated. The availability of sulfate ions is attributed to the lithological and sulfate minerals exist in sedimentary rocks like gypsum and anhydrite (Todd, 2007, Al-Dabbas, et al., 2018).

wells No.	Туре	Water type
1	$4213(mg/l) \frac{S04(45)Cl(37)HC03(17.6)}{Na(395)Mg(32)Ca(262)} 7.18$	Na -Sulfate
2	$4235(mg/l) \frac{S04(45.1)Cl (37.3)HC03 (17.6)}{Na (20.0)Mg(22.5)Ca (26.2)} 7.16$	Na -Sulfate
3	$\frac{Cl (59.8) Mg(32.3)Ca(20.3)}{Cl (50)S04(40.8)}$ $\frac{7.22}{7.22}$	Na-Chloride
	Na (38.3)Mg(31.5)Ca(29.2)	
4	$\frac{\text{SO4(49.9) Cl (36.5)}}{\text{Na (55.8)Mg(23.6)Ca(19.9)}} 7.17$	Na -Sulfate
5	$\frac{\text{SO4}(44.6)\text{Cl}(41.9)}{11} = \frac{\text{SO4}(44.6)\text{Cl}(41.9)}{11} = 7.21$	Na -Sulfate
	Na $(43.4)$ La $(30.5)$ Mg $(25.9)$	
6	1746(mg/l) $\frac{SO4(52.8)Cl(38.4)}{Na(38.2)Ca(34.2)Mg(27.3)}$ 7.24	Na -Sulfate

Table 3. The results of Kurolov formula for the ground water in the studied region

# Conclusion

The results obtained from the examined ground water samples are generally alkaline, very hard water, classified as brackish water and the excessively mineralized water. The anions and cations concentration in the ground water indicate the predominant of Sodium ion in the cations for year 2024 and 2010, while the sulphate was the main anion for year 2024 and the Chloride was the main anion for year 2010 with increase all the anions and cations during 2024. All the ground water wells are a continental origin except well 3 is marine origin. Therefore, All the groundwater wells have high hydrodynamic activity except well 3 have a low hydrodynamic activity and the hydrocarbon accumulations were high effect. The water type is Na<sub>2</sub>SO<sub>4</sub> in the most wells except well 3 is NaCl. The ground water of Al-Salman region has indicated that the sulphate group is dominated according to Kurolov formula.

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