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Dissolved Minerals and Salts in Groundwater of Al- Adhaim Basin Region Hydrological and Hydro Chemical Study

Suzan Salim Suhail Al Tamimi[1], Dr. Kadhim Abdullah Attia Al-Zaidi[2], Dr. Suhaila Najm Abd Al Ibrahimi[3]

Abstract

Al- Adhaim Basin collects rainwater from inside Iraq, as the basin is located between the Lower Zab River, which transports regular waves of water from the Dokan Dam in the west and Al-Khasa River in the east. The main role of these two former rivers is in transporting water from outside the region to Tigris and Al- Adhaim rivers, respectively, as they are of great importance in providing water to the people who live near these rivers to cover their partial water needs and cover the surface runoff during the wet seasons, as Al Nafit valley collects surface water during the rainy season and flows into the basin to drain its water in southern part of the Khasa river, and the population within Al- Adhaim Basin depends mainly on rainfall to meet their water needs, especially for agricultural purposes. Therefore, surface irrigation is difficult in most areas of Al-Adhaim basin due to its wavy topographic nature, so the residents of Al- Adhaim Basin are accustomed to dig wells to depths, often reaches 100 m or more in search of rich layers to cover water needs.

Keywords: *Al- Adhaim River, Bai Hassan Formation, Qara Dagh heights.*

Introduction

Water is considered the backbone of life, as the ancient civilizations were founded on the banks of rivers, which is the Mesopotamian civilization, as water was used for various purposes in life in conjunction with science, technical development, and the steady increase in population.

Al-Adhaim river is considered one of the ancient rivers and is considered the only tributary. It is one of the tributaries of Tigris River, whose water sources are from inside Iraq from the rain falling on the basin, as it originates from the southern slopes of the Qara Dagh, Tasluba and Shwan highlands in Sulaymaniyah governorate, which reach an altitude between (1400-1800 m), and the width of this river's basin expands, and reaches (100 m) during the flood season and (30 m) during the dry season, and its length reaches (230 km), It pours its waters into Tigris river in an area (30 km) south of the city of Balad and It contributes (%1.6) of the Tigris River's water and consists of four main tributaries: Al Khasa Shai, Taooq Shai, Kozi Shai, and Tooz.

Al-Adhaim River

Al-Adhaim River is considered one of the most important rivers of Iraq that originates from within Iraqi territory, Its name was mentioned in ancient cuneiform texts in the form of Dur-Fih or Radano, and it is the only tributary of Tigris River whose water sources are

[1] University of Baghdad / College of Arts / Department of archaeology, Suzan.Saleem1108a@coart.uobaghdad.edu.iq
[2] University of Baghdad / College of Education for Girls / Department of History, Dr.kadhim.abdullah@gmail.com
[3] University of Baghdad / College of Arts / Department of Geography and Geographic Information Systems, Suhaila.alibrahimi@gmail.com

located inside Iraq, as it consists of torrents of rain in the northeastern region of Iraq, the river originates from the southern slopes of the Qara Dagh heights, Tasluja heights, and the Shawan heights in Sulaymaniyah Governorate, whose height ranges between (1400-1800 m) above sea level, It is characterized by its steep slope at its tops and gradually decreases, Its average is (1.5 m/km), while the basin area of the study area reached (678.3 km2), as shown in map (1).

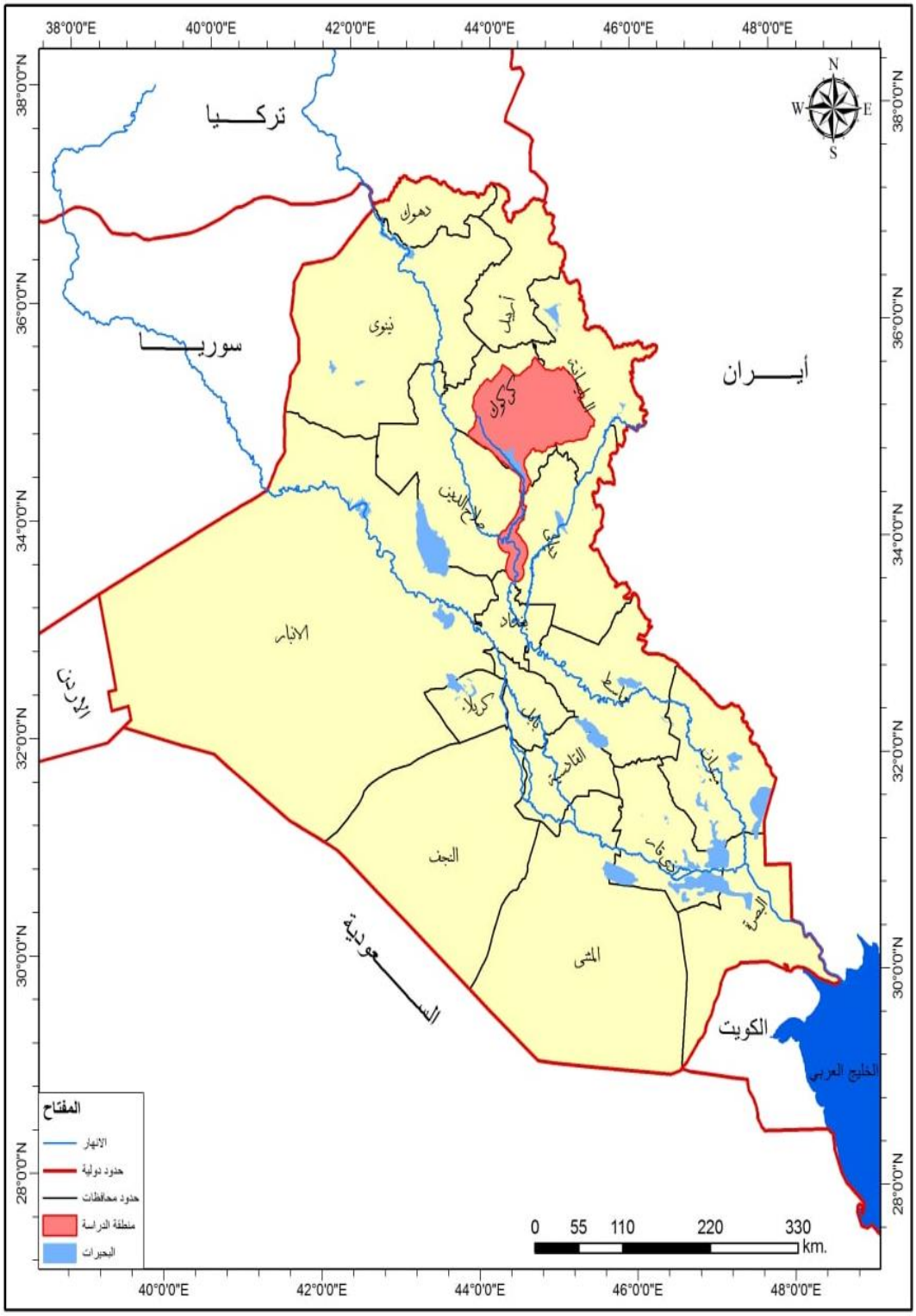
Floods that occur from time to time pose a threat to what surrounds them, so humans work to reduce the severity of these floods by creating dams, reservoirs, and water drains, dams and reservoirs play a major role in influencing the morphology of the stream, as it leads to limiting water after the construction of dams and reservoirs that change the flow regime in the stream and whose effects are reflected in the river work of erosion, sedimentation and transport, and whose activity increases with the increase in the amount of discharge and decreases with its decrease, so it is active in the flood season and weakens with normal drainage, including Al-Adhaim Dam. Which was built on Al-Adhaim river.

This project is located north of Dhuluiya district on the western bank of Al-Adhaim river, the total area of the project is (167,000) dunams and is used to irrigate agricultural lands north of Dhuluiya district, the project was established in 1994 and in several stages, in the first stage, two canals were constructed, one of which is southern receives water from Tigris river until the project is completed and irrigates an area of (4145) dunams. As for the second canal takes water from Al-Adhaim river using large pumps, the length of the canal is (15 km), and it is temporary until the submersible dam project in the south of the Al- Al-Adhaim Dam is completed (10 km).

The dams

Earthen dams are man-made structures used for several purposes such as electricity production, control on floods and irrigation, Dams may vary in size and designs according to the function of the dam and the size of the water source.

Its length can range from a few meters to several kilometers, and the water level in the dam’s reservoirs fluctuates throughout the year between high levels in the winter to low levels in the summer and during the irrigation season, a sudden decline may occur in the Teton Dam, in addition to the construction of new dams on the same water source caused an additional loss of water in the dam reservoir, and finally, the rise in summer temperatures leads to the season, especially in the Middle East, increasing the evaporation of a large amount of water in the rivers and a significant decrease in the levels of these rivers in short periods, human activity is involved in the effect on the river’s water by investing the water in agriculture and exploiting the floodplain in agricultural operations, the basin is characterized by the presence of water stacks at the river’s sources that divert the water into the main stream after rainfall, which is reflected in the occurrence of high and sudden flood peaks after (12-72) an hour of rain falling on the basin.



Map (1) Determine the location of Al-Adhaim river basin in relation to the map of Iraq

The map was made by the researcher, using the Arc Gis 10.8 program, General Authority of Meteorology, unpublished data, 2022.

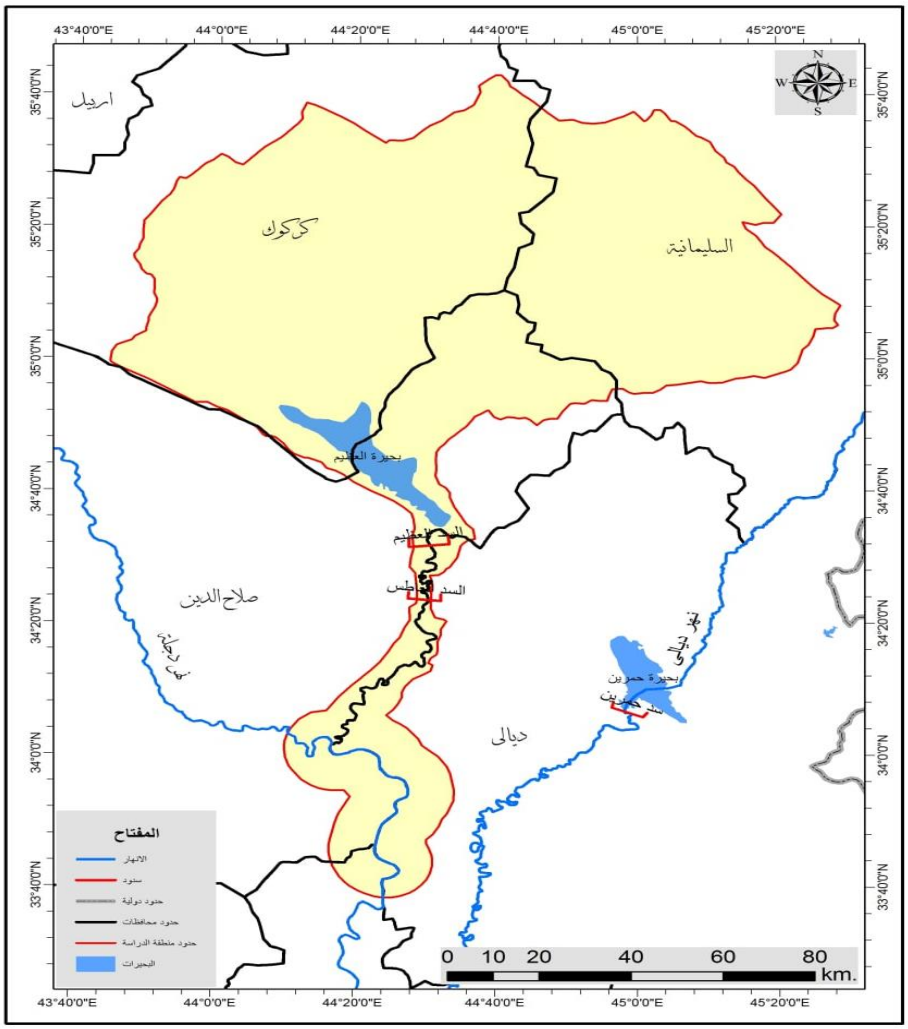
1. Al-Adhaim Dam

This dam was established on Al-Adhaim River before it empties into the Tigris river within Diyala governorate, It is an earthen water dam, and great precautionary capabilities were added to treat the flood due to the intensity of the waves in the river and

its direct impact on the city of Baghdad, which requires decisive treatment, Al-Adhaim Dam is located on the course of the Al-Adhaim river, at a distance (15km) from the junction of the Zaghitoun and Tuz Gay branches, near the intersection of Al-Adhaim river with Himrin mountain range, It is considered the main dam on the river after the convergence of its three tributaries, Taouk Shay, Tuz Shay, and Al-Khassa Shay, as for the lake It continues with the extension of the northern Himrin Mountains to about (50 km), as it is located within the area enclosed between two latitudes (36 34° - 34 44°) north and longitudes (20 44°- 44 36°) east, as shown on the map(2).

Rivers are one of the important sources of water in nature and the center of human activities since the beginning of civilization, however, they are an important vital source that is exposed to many problems that result from natural phenomena or from human intervention, therefore, the need has emerged to establish various hydraulic facilities to control and protect water sources. Among these facilities are dams, regulators, and others.

However, despite the importance of these facilities, they lead to changing the flow system in the rivers and thus the emergence of many problems, such as the phenomenon of sediment accumulation, this phenomenon occurs if the rate of sediment load entering the stream is greater than that leaving it, then the watercourse will be unable to carry all the sediments, which leads to a rise in the level of the river bed.



Map (2): Locating Al-Adhaim Dam

The map was made by the researcher, using the Arc Gis 10.8 program, General Authority of Meteorology, previous source, 2022.

2. Submersible dam

Submersible dams are used to retain and raise water levels, measure discharges in canals, or control steep slopes in rivers and canals as waterfall structures, the submersible dam was constructed with a length of (137.20 m) and a height of (5.50 m) at the front of the dam, and the length of its floor. (42.00 m), and its top level is (89.50 m) above sea level, the length of the closure plug, which is not gated, is (200 m) and has a drainage of (1150 m3/s), and its highest discharge is (3500 m3/s). The limited importance of Al-Adhaim Dam is limited to.

1. Store water for irrigation, industry, and drinking purposes and release it regularly when needed.

2. Preventing the dangers of floods by storing flood water.

3. Generating electrical energy by taking advantage of the available pressure difference and the absolute flow of the dam.

4. Exploiting the dam for tourism purposes, like other lakes.

5. Development of fish wealth and waterfowl.

Environmental effects resulting from the effect of water bodies generated from storage in softening the atmosphere through its effect on lowering temperatures in neighboring areas.

Second: The natural valleys of Al-Adhaim River Basin

There are many valleys in Al-Adhaim Basin in which there are strong natural streams that flow, especially during storms, Al-Khasa river stream collects water from the Kirkuk stream, the Wadi Al Nafit collects water from the areas northeast of Himrin Mount, and, Riyadh Valley is a natural depression that collects water from the southern part of watersheds in Kirkuk during floods, the main valleys transport water from the different watersheds to a larger valley located south of the basin to pour their loads into the so-called Zaghitoun Shay tributary, in general, these valleys can naturally absorb the impact of incoming flood waves, as they sometimes reach to (3000 M3/S) by transporting water to Al-Adhaim River, which in turn joins to Tigris River, putting the city of Baghdad in an unstable position against flood incidents.

Third: Groundwater

It is the water collected in the ground and under the surface as a result of the seepage of rainwater and snow, as well as its internal movement according to the inclination of the rock layers, thus, it depends on the factors of rain and snow and the horizontal extension of the layers containing the water, Its type depends on several factors, the most important of which is the mineral composition of the rocks containing the water, this water helps the population to engage in agricultural activity for domestic purposes in areas where there is little or no surface water. It is found in the upper, central and southern regions of Al-Adhaim River Basin, and its number reaches more than (26) springs, including one spring, Kazau, which is suitable for recreation and treatment of skin diseases.

Groundwater sources

The confined aquifer in the region consists mainly of the Bai Hassan Formation, which covers the entire basin area, It begins near the syncline of Mount Kani Dumilan in the north and ends at Mount Himrin in the south, the east-west extension of the confined layer continues beyond the natural boundaries of Khasa and Lower Zab rivers, respectively, Bay Hassan Formation consists of alluvial deposits represents the impermeable layer between the limestone and the conglomerate represents the upper limit of the confined aquifer, represents the lower limit of the confined aquifer between Muqdadiya and lower Bakhtiari Formation, The wells in Al-Adhaim River Basin region

are all deep wells are automatic wells where pumps are used to raise water to the surface of the earth, there are two types of groundwater levels:

1. The stable groundwater level: It is the level at which the groundwater in the wells stabilizes, and at which the atmospheric pressure and the hydrostatic pressure at the surface of the unconfined groundwater are equal.

2. The stable groundwater level: It is the limit of the decrease in the water level when drawing water from the well or when pumping from the well, that is, it is the change in the water level from the surface of the well during pumping, and the depths of the changing groundwater levels of the wells in the region vary from one place to another.

That groundwater has an impact on the archaeological and heritage buildings is that most of these buildings are located in low areas relative to the lands surrounding them,this water is formed under the surface of the earth, the foundations and clay floors close to the groundwater level are usually saturated with water, as this water collects under and inside the building, the building fell as a result of rising moisture from groundwater into the pores of the soil, and one of the most important archaeological facilities threatened by groundwater is the ancient city of Babylon and the Emirate Palace in Kufa.

Al-Adhaim River Basin area contains many wells distributed between Kirkuk and Salah al-Din Governorates, as shown in Map (3). We have chosen fifteen wells from the wells in Al-Adhaim River Basin area, specifically in the Salah al-Din Governorate, Al-Touz District, and from different areas, as water of these wells in Al-Adhaim River Basin region contained many dissolved salts and minerals (carbon trioxide (CO3), bicarbonate (HCO3), sulfate (SO4), chlorine (CI), calcium (CA), magnesium (MG), sodium (NA), and potassium (K), as shown in Table (1) and Table (2).

Table (1): Wells in Al-Adhaim River Basin Region

S/N	Governorate	District	Sub-district	longitude	latitude	Height	Depth	Well type	Detected Deposits	Penetrating geological formation
1	Salahaddin	Al-Touz	Albu Hassan	460359	3847997	170	85	Automatic well	quaternary deposits	Bai Hassan
2	Salahaddin	Al-Touz	Brawjly	464055	3853568	195	90	Automatic well	quaternary deposits	quaternary deposits
3	Salahaddin	Al-Touz	Albu Hassan	460789	3848710	195	64	Automatic well	quaternary deposits	Bai Hassan
4	Salahaddin	Al-Touz	Albu Hassan	195	3849930	183	35	Manual well	quaternary deposits	Bai Hassan
5	Salahaddin	Al-Touz	Bastamli	458355	3848104	185	100	Automatic well	quaternary deposits	Bai Hassan
6	Salahaddin	Al-Touz	Sarat	476729	3844434	179	145	Automatic well	quaternary deposits	Quaternary deposits
7	Salahaddin	Al-Touz	Albu Hassan	462694	3849957	188	40	Manual well	quaternary deposits	Bai Hassan
8	Salahaddin	Al-Touz	Habash	467711	3843663	177	16	Manual well	quaternary deposits	Quaternary deposits
9	Salahaddin	Al-Touz	Amerli	460554	33083	169	142	Automatic well	quaternary deposits	Bai Hassan
10	Salahaddin	Al-Touz	Brawjly	462265	388451067	184	72	Automatic well	quaternary	Quaternary deposits

									deposits	
11	Salahaddin	Al-Touz	Khassa Darlie	466590	3853805	198	105	Automatic well	quaternary deposits	Bai Hassan
12	Salahaddin	Al-Touz	Habash	469594	3842528	190	100	Automatic well	quaternary deposits	Quaternary deposits
13	Salahaddin	Al-Touz	Cookz	466644	3855429	206	65	Automatic well	quaternary deposits	Bai Hassan
14	Salahaddin	Al-Touz	Suleiman Pak	468421	3851881	202	140	Automatic well	quaternary deposits	Quaternary deposits
15	Salahaddin	Al-Touz	Suleiman Pak	470681	3851662	201	140	Automatic well	quaternary deposits	Quaternary deposits

Table prepared by student, Ministry of Water Resources, General Commission for Underground Water, Unpublished data 2023

Table (2): Percentage of minerals and salts found in selected wells from Al-Adhaim River Basin Region

S/N	CO3 (PPM)	HCO3 (PPM)	SO4 (PPM)	CI (PPM)	CA (PPM)	MG (PPM)	NA (PPM)	K (PPM)	TDS (PPM)	EC (µs/cm)	PH
1	35	39	36	56.7	107.142	65.234	34.01	1	470	940	7.71
2	26	35	93	141	111.428	79.09	37.5	1	340	7200	7.94
3	32	47.5	81	93	128.571	63.636	91.5	1.2	470	940	7.8
4	14.5	18.1	118	98.5	137.912	95.454	20.405	1.4	490	9700	7.81
5	76	188	106	202	209.999	145.454	113	1.4	770	1680	7.92
6	10	450	571	2	208	106	383	2	2645	3430	7.17
7	42	89	188	185	310.1	129.09	62	2	1060	2000	7.94
8	203	225	305	132	524.285	200.909	120	2.2	1270	2470	7.96
9	42	103	63	123	129.99	55.454	111	2.2	650	1290	7.82
10	28	33	92	150	117.142	62.727	45	2.2	400	8200	7910
11	68	79	163	192	225.714	101.781	85	2.4	840	1890	791
12	63	692	412	830	307.142	113.572	805.12	2.6	4760	9370	7.99
13	97	105	118	120.1	287.142	109.09	111.5	2.6	990	2000	7.95
14	128	163	178	289	511.428	199.09	224	2.8	1790	3400	7.89
15	4	308	770	531	221	100	371	3	2522	3550	711

Table prepared by student, Ministry of Water Resources, General Commission for Underground Water, Previous source, 2023

The detailed study of salt concentration of individual scientific results for each ion in groundwater in general over the area of the basin indicates some important observations, which are as follows: -

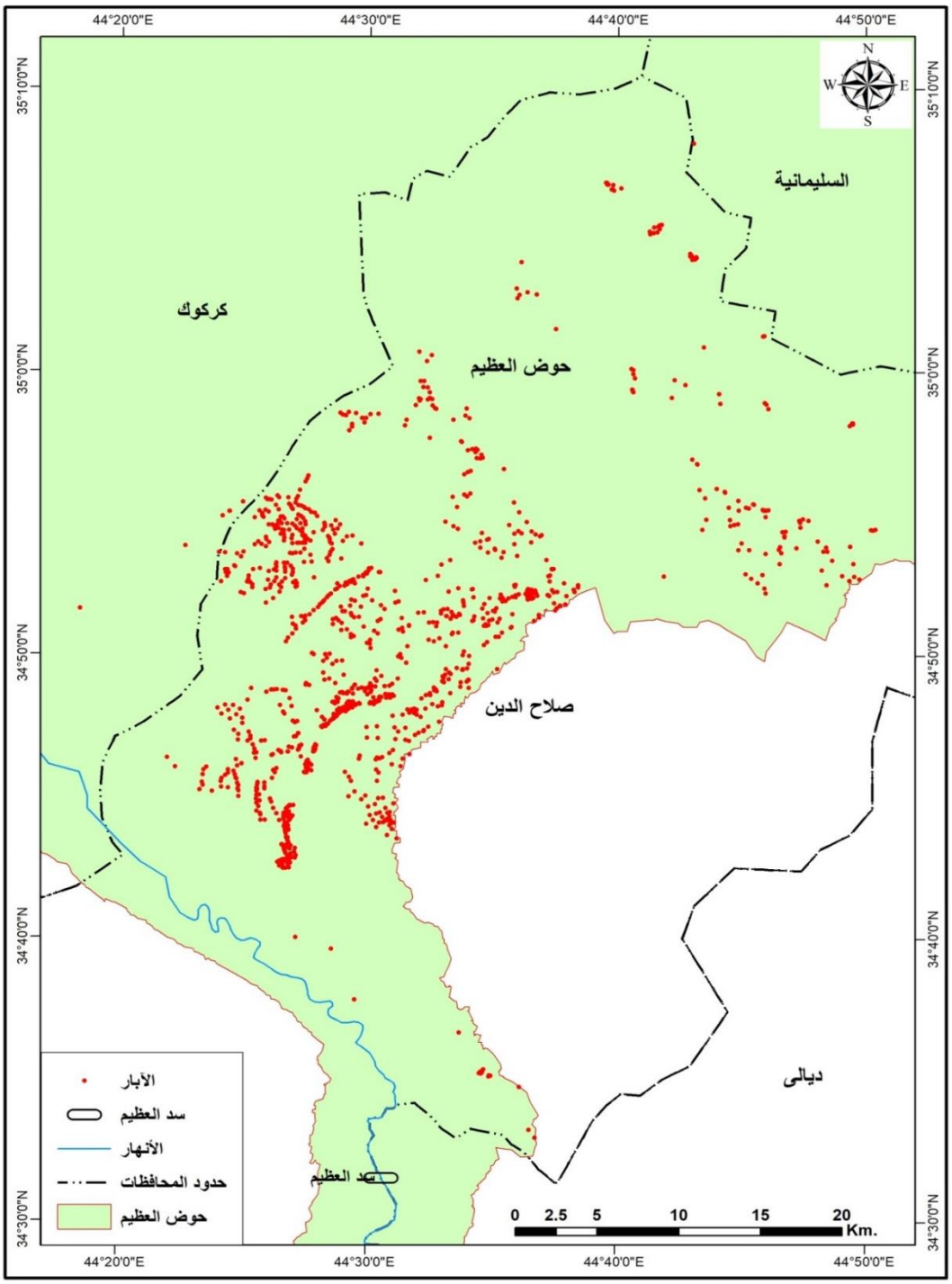
1. There is a large variation in salt concentration during the four seasons because rainfall has a significant impact on the concentration of groundwater, which is less concentrated during the wet seasons and vice versa.

2. Positive ions for both magnesium and calcium have smaller differences.

3. The concentration of carbonate ions has less effects in some samples, and there is a noticeable increase in the concentration of sulfur dioxide during the spring.

Field measurements confirmed that the Kirkuk canal led to an increase in salt concentration along the course of the canal, many wells that were used for human purposes were neglected in the seventies after the construction of the Kirkuk Irrigation Canal.

The water quality in Al-Adhaim Dam was studied for the months (January, February, June and July) of 2020, by the General Authority for Dams and Reservoirs from different sites of the dam, and the results are shown in Table (3) and Table (4), as well as the chemical analyzes of Al-Adhaim Dam site.



Map 3: Spatial distribution of wells in Al-Adhaim Basin region

The map was made by the researcher using the Arc Gis 10.8 program, General Authority of Meteorology, previous source, 2022.

Table (3): Data for measuring temperature and relative humidity of waters of Al-Adhaim Dam for the year 2023

Directorate	Site	Number	Date of book	EC/Ds/m	T.D.S
General Authority for Dams and Reservoirs - Al Adhim Dam Project Management	Front of the dam 13/2		26/2/2023	2.42	1549
	Back of the dam 13/2			2.68	1715
				5.81	4067
				7.07	4949
		Environmental conditions	Temperature C	20.7	
			Humidity%	44	
		Examination method		EC meter	Wight method

Table prepared by the student, Ministry of Water Resources, National Center for Water Resources Management, previous source, 2023

Table (4): Average concentrations of TDSS (PPM) in Al-Adhaim Dam for the years 2018-2022

S/N	Month/Year	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June	July	August	Sep.
1	2018-2019	1533	1658	1522	1148	1099	1089	861	937	997	1120	1082	1048
2	2019-2020	1325	1364	1944		1519		1236		1292	1283	1323	1365
3	2020-2021	1478	1542	1658			1676	3536	1742	1768	1711	1455	2056
4	2021-2022	1881	2032	2088	1966	1784	1784	1964	1972	1461	2004	2018	1112

Table prepared by the student, Ministry of Water Resources, National Center for Water Resources Management, previous source, 2023

Hydrochemistry of Al-Adhaim Basin

Through the previous study, the qualitative assessment of groundwater for Al-Adhaim Basin region and on the basis of scientific analyses, of total dissolved solids (TDS) for groundwater samples taken from some existing wells, and it was pointed out to the dissolved substance (TDS) for unconfined and confined groundwater reservoirs ranging between (1000–6000) and (500–5000) ppm, respectively, and the groundwater reservoir have a large spatial variation in terms of dissolved materials, salinity decreases in general in the north of the study area and increases gradually towards the south.

The variation in dissolved substances (TDS) also varies with depth, especially in agricultural areas in the region, the pumping operations that took place in the study area demonstrated that salt concentrations in the extracted groundwater vary with time during pumping, laboratory analyzes of water samples show high variation in salt concentrations between the beginning and the end of pumping, and an annual model to measure the percentage of salts and dissolved substances (T.D.S.), and the electrical conductivity was measured in the international unit decimonds (EC\Ds\m) in the water of Al-Adhim Dam basin, according to the Al-Adhim Dam project management schedule and the resident engineer at Al-Adhim Dam, as shown in Table (5).

Table (5): Data for measuring the percentage of dissolved substances in the water of Al-Adhim River in Al-Dhuluiya for the year 2021

Operating Division							
Number of book 6535	**26/10/2021**			**Book no.6535**			
S/N	**Site**	**Coordinates**		**Date**	**EC**	**T.D.S**	
		X	**Y**				
11	**Al Adhaim River in Dhuluiya**	**438577**	**3773404**	**26/10**	**2050**	**1025**	
Directorate	**site**	**Date of book**		**Number of book**	**EC/Ds/m**	**T.D.S**	
Resident engineer management Al Adhaim dam	**The front**	**24/10/2023**		**528**	**2.6**	**1664**	
	The back				**2.62**	**1676.8**	
	Hadar				**5.52**	**3864**	
	Finger				**6.89**	**4823**	
Resident engineer Management Al Adhaim dam	**The front**	**21/10/2023**		**621**	**2.67**	**1708.8**	
	The back				**2.69**	**1721.6**	
	Hadar				**5.54**	**3878**	
	Finger				**6.72**	**4704**	

The table is the work of the researcher, Ministry of Water Resources, National Center for Water Resources Management, previous source, 2023

When rainwater penetrates into the ground, its quality will be affected by a number of processes, such as the amount of water that infiltrates underground and the amount of evaporation from the surface, which in turn affects the quality of water in the soil. Thus, the evaporation process affects chemical corrosion, which leads to the dissolution of many minerals underneath different temperatures and this process continues until the water comes into contact with the minerals and rocks that form the underground water reservoir until it reaches a stable state of chemical equilibrium.

Table (7) shows the percentage of dissolved materials in Al-Adhim River in Al-Dhuluiya for the year 2021, and the measurements of these percentages are monthly, as it show the extent of their variation from one period to another.

Conclusions

1. A-The study area is located between the Lower Zab River and the Khasa River in the east, the topographic nature of the area is undulating, so surface irrigation is very difficult, so they relied on digging wells.

2. Due to the frequent floods that occur in the basin area, they pose a great danger to the population, so humans create dams to ward off the danger of flooding.

3. The rise in temperatures leads to the loss of a large percentage of the water confined in the dam's reservoir, so humans have taken advantage of this water by investing it in agriculture.

4. The concentration rate of salts and minerals in the groundwater of Al-Adhaim River, which is located in the basin area, is due to the presence of mineral rocks inside the ground, When the water flows and rubs against the rocks, it leads to dissolving these minerals in the water, likewise, rain has a role in dissolving the minerals present in the soil, which leads to Its penetration into soil from there into groundwater.

References

AL- Ibrahimi, Suhaila Najem, The Impact of Groundwater Salinity on Quality of Agricultural Crops in the Ishaqi Area, Talent Development & Excellence, Vol.12, No.2s, 2020, 3812-3832,p. 3812, http://iratde.com/index.php/jtde/article/view/1287/986

Nader, Boutros Mansour Yousif, dissolved loads and chemical erosion rates in the Al-Adhaim River, Master's thesis, College of Science, University of Baghdad, 1985.

AL- Mamuri, Najah Mahdi Lateef, Optimum Management Of Suface & Subsurface Water Of AL- Adhaim Basin, ph. D. Thesis, The University of Baghdad, 2005, p.94.

Al-Khashab, Wafiq Hussein and Al-Sahhaf, Mahdi, Water Resources, their nature, definition, types, and maintenance, Baghdad, 1979, p. 212.

Al-Hakim, Saeed, Hydrology of the Tigris River Basin in Iraq, unpublished doctoral thesis, University of Baghdad, 1989, p. 100.

Al-Hammadi, Munim Majeed, Water Resources in the Al-Adhaim River Basin and Its Investments, Hydrogeographic Study, Unpublished Master's Thesis, College of Arts, University of Baghdad, 1984, p. 78.

Fath Allah, Medhat, Study of the relationship between annual flow and rainfall in the Al-Adhaim River Basin, Al-Muhandisin Magazine, No. 38, Baghdad, 1968, p. 33.

AL – Labban, Salama, Seepage and Stability Analysis of the Earth Dams under Drawdown Conditions by using the Finite Element Method, STARS, University of Central Florida, 2018, p. 112.

Al-Sahhaf, Mahdi, the quarterly distribution of the flow of Iraq's rivers and its relationship to irrigation projects and works, Al-Ustad Magazine, College of Education, Volume 15, Baghdad, 1996, p. 355.

Amana, Raghda Shamran, The effect of some climatic elements on changing the values of the water supply of Al-Adhaim Dam Lake. Keywords: water supply, Al-Adhaim Dam, Diyala Magazine, issue 87, 2021, p. 382.

Jassim, Sami Majeed, The natural components of Al-Adhaim Dam Lake and its impact on developing tourism demand, Journal of the College of Administration and Economics, No. 71, Al-Mustansiriya University, 2008, p. 209.

Mohamed, Akram Khalaf and Khalil, Muayyad Saadallah, a laboratory study to estimate the sediments removed from the front of submersible dams using the lower outlets Al – Rafidain Engineering, Vol. 23, No.1, FEB. 2015, p. 63.

Ministry of Water Resources, General Authority for Dams and Reservoirs, Encyclopedia of Dams in Iraq, Annex No. 2, p. 32.

Ministry of Water Resources, General Authority for Dams and Reservoirs, Encyclopedia of Dams, part. 1, p. 40.

Ministry of Water Resources, General Authority for Dams and Reservoirs, previous source, p. 28.

Al-Amiri, Ayat Saeed Hussein, Groundwater and the Possibility of Investing in it in Abu Ghraib District, University of Baghdad, College of Arts, 2015, p. 55.

Ibid, p. 56.

Al-Kaflawi, Sami Abdul Hussein, Groundwater and Archaeological Buildings, Sumer, vol. 43, Baghdad, 1984, p. 240.

Giovanni, Mazzari, Humidity in Historical Buildings, Translated. Abdul Wahed, Nasser, Regional Center for the Preservation of Cultural Property in the Arab Countries, Baghdad, 1984, p. 5.

AL-Mamuri, Najah Mahdi Lateef, Op.Cit.P,57.

Ministry of Water Resources, General Authority for Dams and Reservoirs, unpublished data, 2023.

Ministry of Water Resources, National Center for Water Resources Management, previous source, 2023.

AL- Ibrahimi, Suhaila Najem, The effect of groundwater salinity on the soil in the district of Dhuluiya by using (GIS), EM International,25 (4) : 2019; pp. (1871-1884) p.393, http://www.envirobiotechjournals.com/article_abstract.php?aid=10151&iid=287&jid=3