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Spatial Analysis of Groundwater and Hydrological Characteristics of the Babylon Jadwel using GIS

By

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Abstract

Groundwater is an important water resource and an ideal alternative to surface water, especially in the dry areas. In order to clarify the importance of this resource and the reason for resorting to it despite the presence of a water source, which is the Babylon Jadwel (Creek), we decided to study and analyze the various natural and human phenomena in the region and clarify their impact on the distribution of well sites as well as their impact on the waters in the Babylon Creek, in addition to analyzing samples from Creek water and groundwater alike to show the impact of the quality of this water on different uses (drinking, agriculture, industry), especially that the region is predominantly agricultural in nature, evident in the spread of many orchards in it. Through a detailed comparative study for each of the two sources based mainly on Various hydrological analyzes to determine the characteristics of both groundwater and surface water, as they have an important and essential role in the development of various human activities in the region, due to the concentration of a large number of residents in it and their urgent need for groundwater, especially in the region located at the end of the Nile River estuary due to the weakness of the Creek water in it due to the lack of Water releases from the Hindiya dam, which led to the drilling of many underground wells to fill the water shortage due to the high area in the foreground. In order to complete the work successfully, it was relied on Geographical Information Systems (GIS) to facilitate the task and obtain accurate results.

Keywords: Babylon Jadwel, Creek, groundwater, river, water, hydrology, salinity, pollution.

1. Introduction

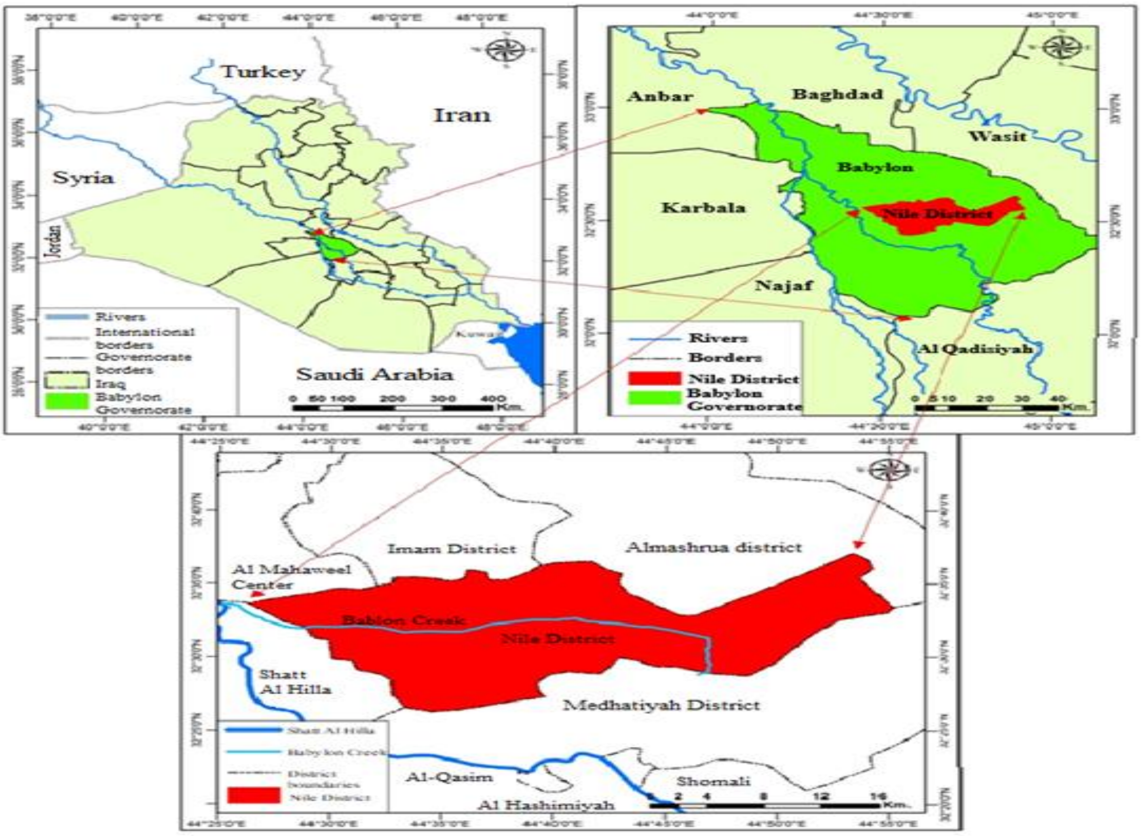
Through the preparation of integrated data collected from the relevant government departments and through the field study and meetings with the people of the region in the preparation of maps and various tables to reach a detailed study on the quality of this water. Water (surface and ground), as well as determining the degree and type of pollution found by various hydrological analyzes (chemical, physical).

There is a main question that the study tries to answer through data review and analysis: Do natural and human factors have an impact on the hydrological characteristics of surface and ground water in the study area? Do the hydrological characteristics of the waters of the Babylon Creek affect the characteristics of groundwater in the region?

The study developed a scientific hypothesis that natural and human factors have a clear impact on the hydrological characteristics of both surface and ground water in the study area.

Because it became clear that there is a reciprocal relationship of the characteristics of the water in the Babylon Creek with the characteristics of groundwater in the region. The study also assumes that there is a clear influence of the elements of climate and different terrain on the quantity and quality of groundwater, and the diversity of causes of water pollution in the waters of the Babylon Creek chemically appear through the study data.

The geographical location of the study area was determined with the surface water of the Babylon Creek and its groundwater, which has an area of (120 km2) in the Nile sub-district of the Babylon governorate, as shown in map (1), which is located in the center of Iraq in the alluvial plain area.



Map (1): *Location of the study area according to Iraq*
Source: Researcher based on ArcGIS 10.4.

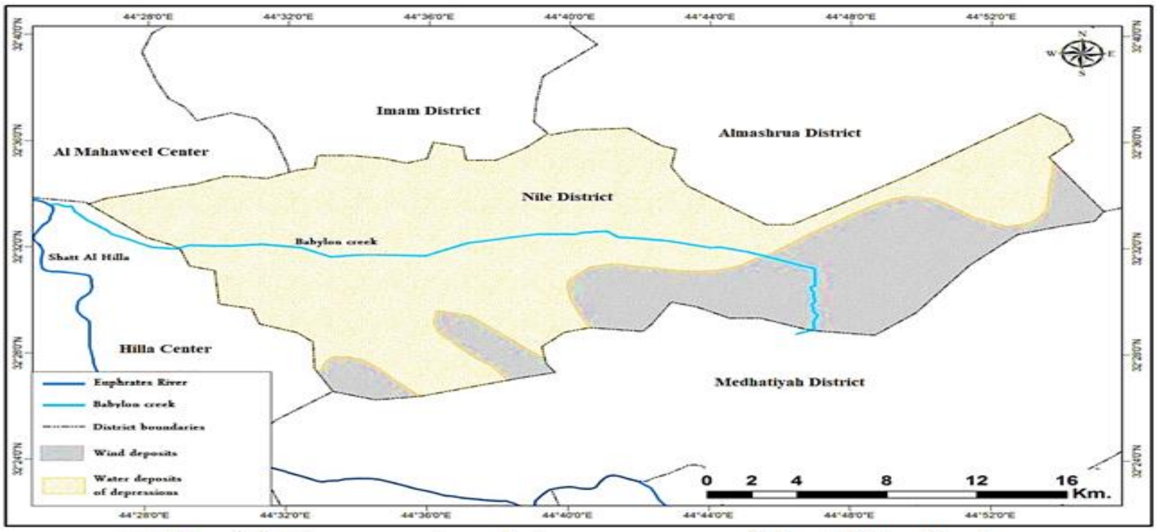
2. The natural geographical characteristics of the study area

The study of the natural characteristics of the area in terms of the geological structure, rock formations, stratigraphy and its system is important in identifying the quality of the environment that hosts the aquifer, and to determine the characteristics of this water through the analysis and study of the quality of the rocks containing it and its reflection on the characteristics of the aquifer, as well as the importance of the geological structure in the formation of features the surface of any area through the time stages and the relationship that affects the formation of the soil and surface appearances, which we will study successively, as follows:

2.1 Geological structure

The geological structure is an important factor in determining Groundwater and geological studies indicate that Iraq was exposed at the beginning of the fourth time (the Pleistocene) to torsional movements that formed the mountains of northern and eastern Iraq. As the cliff increased to the concave area, the sediments of rivers and torrents gathered and formed the sedimentary plain (Al-Khalaf, Muhammad Jassim, 1959, p. 41). Evidence indicates that the Tigris, Euphrates and Karun rivers did not create a delta that moved forward, but rather unloaded its load of sediment in the depressions of the southern parts of the plain, which is still continuing to decline due to the accumulated sediments and the internal movements that were followed by the convexity of its accumulation (Al-Sahaf, Mahdi Muhammad Ali, 1974; Motgi et al., 2021).

As it appears from the hydrogeological division of Iraq in the Mesopotamian region that the sediments of the Quaternary age represent an open aquifer that consists of alternating layers of clay, silt and sand with a few fine gravel and forms different interventions between them, which includes the following formations: as in map (2) and table (1) (Pandey et al., 2020; Patil et al., 2021).



Map (2): *Geological formations in the study area*
Source: Researcher based on the table 1 and ArcGIS 10.4.

Table (1). *The stratigraphic sequence of the Nile district*

Era	Time	Age	Formation	Depositional Environment
Modern	The Fourth	Holocene	Depress Fill Sediments wind Deposits	Continental Continental
		Name	Area	Percentage
		Wind Deposits	125.9	27.6
		Depress Fill Sediments	330.2	72.3

Source: Source: Al-Sayyab, Abdullah. (1982). Geology of Iraq, University of Mosul, Mosul Press, Iraq.

2.2. The surface

The surface is characterized by the diversity of topographic characteristics, which is an essential part of the characteristics of the sedimentary plain. The phenomena of the erosion are represented in areas, some of which rise slightly from the general level of the surface, and the level of the other decreases from it. As the area surrounding the river and its branches rises and is known as the brooks of the rivers, it leads to the formation of a sedimentary strip along the length of the river valley, which leads to the formation of floodplains due to frequent river floods, as sediments accumulate on both sides of the river (Al-Muttalib, Nassif Jassem, 1995, p. 94).

Within the sedimentary plain range, which affected the water flow, we note that the course of the river is within the high lands, which tend to gradually decline with the course of the river. From the above, we conclude that the course of the river in the western and central parts is active, which has the ability to carry that load and deposit it in the low-rise parts and the large homogeneous lack of homogeneity in the natural surface phenomena of the study area. and droughts.

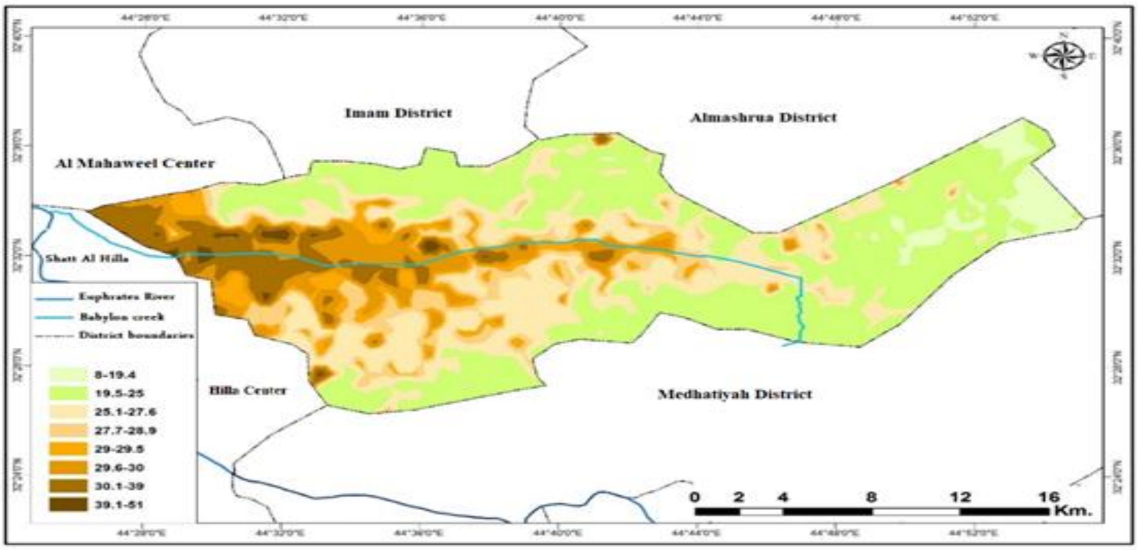
The study area also prevailed in the characteristic of general extroversion, except in some of its parts, which slope slightly, and this is evident in the lands located along the course of the river, as the slope reached (zero-1.1) m as in map (3) and for this simple slope whose levels range as the table (2) It reached the highest level of the slope from (6.1-23) m, which is observed in very small areas scattered in the center of the north and southwest of the region, its impact on the flow of river water and the amount of river load during transport and sedimentation operations.

Table (2). *Regression Ratios*

Category	The ratio	Area / km2
1	38.04	173.57
2	37.44	170.82
3	18.82	85.85
4	5.32	24.25
5	0.38	1.73

Source: Researcher based on Excel 2019.

Through what has been clarified about the geological formations and surface manifestations, the validity of the third hypothesis was confirmed, which confirms that the factor of height and dentition has an important impact on the movement and direction of surface and ground water in the region.



Map (3). Geological formations of study area
Source: Researcher based on table (2) and ArcGIS10.4.

2.3. The climate

The climatic characteristics in the study area do not differ from the characteristics of the central part of Iraq, whose climate is characterized as it appears in all the climatic classifications based on which the climate of Iraq was classified as being within the dry desert climate as it is moderate with little rain in the winter and hot and dry in the summer (Al-Naqshbandi, Azad Muhammad, 1991, pp. 390-431).

Rain is one of the most important elements of the climate because it is the basis that nourishes the groundwater in its reservoirs, as it is important in increasing the rates of surface runoff, the greater the amount of rain, the greater the amount of water drainage. The average monthly totals of the amount of rain falling in the stations of the study area vary, as the rains begin in the month of October. It reached (2.8) mm in Al-Hilla station, it reached (4.6) mm in Najaf and (2.8) mm in Karbala. Rain increases in November until it reaches its highest rates in January, reaching (20.7) mm in Al-Hilla Station and (17) mm in Najaf station and (17.2) in Karbala station, and the rains begin to decrease until they stop in July. As shown in Table (3) and Figure (1).

Table (3). *Average monthly totals of rain (mm) in stations (Hilla, Najaf, Karbala) for the period2019-1988)*

Rain Rate	January	January	February	March	April	May	June	July	August	September	October	November	December
Hilla	20.7	15.2	13.0	12.5	2.0	0.0	0.0	0.0	0.2	2.8	15.5	18.1	100.3
Najaf	17.0	12.6	9.9	14.4	2.2	0.0	0.0	0.0	0.0	4.6	16.8	13.3	91.1
Karbala	17.2	14.5	12.0	12.3	1.9	0.0	0.0	0.0	0.4	2.8	10.1	14.1	85.7

Source: Republic of Iraq, Ministry of Transport and Communications, General Authority for Meteorology and Seismic Monitoring, Climate Department, Baghdad, unpublished data., 2019.

Figure (1). Average monthly totals of rain (mm) in stations (Hilla, Najaf, Karbala) for the period (1988-2019).
Source: Researcher based on table (3).

Evaporation also affects the determination of the volume of rain feeding into the groundwater aquifers, and the amount of water losses in these aquifers because the effectiveness of rain precipitation depends on the amount of lost from it by evaporation, which depends on the amount of temperature, relative humidity and wind speed (Allaby, Michael, 2009, P. 29). The highest rate was recorded in the study area in July (349.7) mm in Hilla station. As for the lowest rate of evaporation, it was during the month of January, when it recorded (52.5) mm in the same station. As for the Najaf station, its highest average was in July, reaching (3.551) mm, and the lowest rate was in January, reaching (78.2) mm, while Karbala station had its highest average in July, reaching (469) mm, and the lowest rate in January was (62.9) mm.

Our knowledge of rainfall amounts does not give a clear idea of its actual impact on surface or groundwater resources unless its effectiveness is analyzed. Because the amounts of rain falling within a region with a temperate climate are more useful than in a dry tropical region, and the term effective rain means that useful part of the total amounts of rain falling (Al-Amoay, Falih Hassan, 1991, p. 45). Therefore, the actual value of rain means the remaining amount of rain is subtracted including water losses (Al-Jubouri, Salam Hatef, 2007, p. 173). For the purpose of extracting the effective rain coefficient, the following was applied (Al-Waeli, Ali Abdel-Zahra, 2012, p. 233):

Actual value of rain ER = Effective rain factor F × Total precipitation (mm) P

From the effective rainfall data calculated according to the Russian method of Solkhizprom, and the values of evapotranspiration according to the Penman Months, the values of the climatic water balance were extracted, and its water deficit was calculated. The results of calculating the water-climate budget are included in appendices. Because it became clear through its results that it suffers from a permanent deficit, whether at the monthly or annual level. In the cold season of the year, a monthly water deficit is observed, despite the low temperature, rainfall, high relative humidity, low wind speed and its reflection on evaporation-transpiration, which are all factors affecting the budget deficit values.

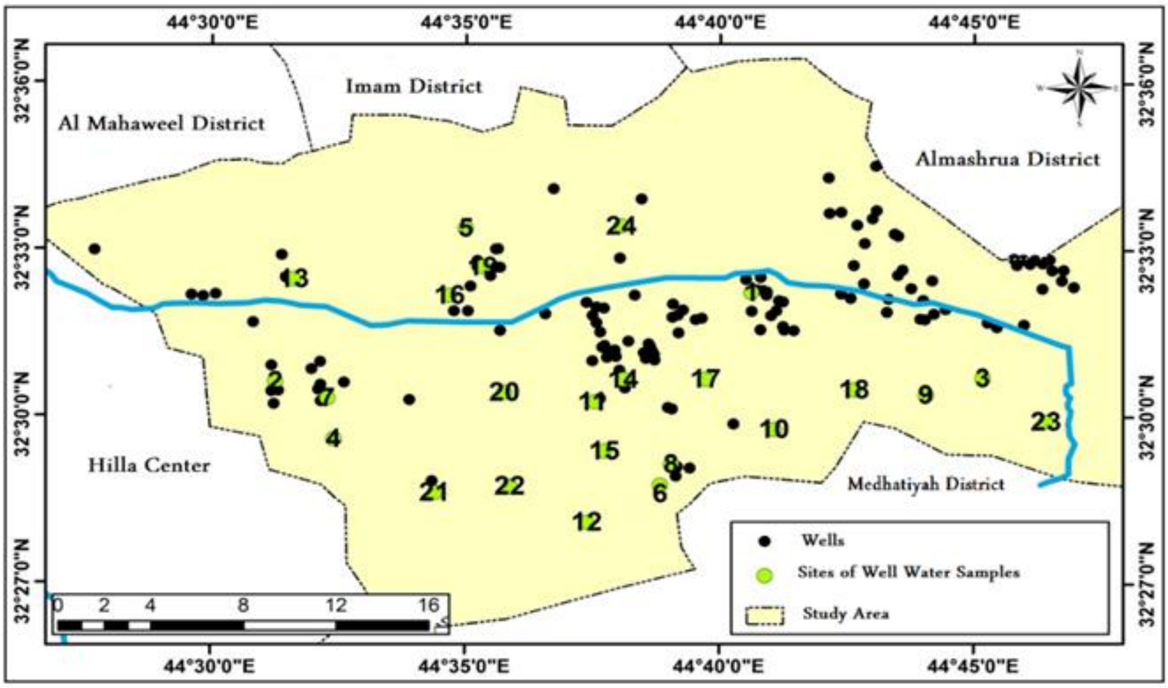
3. Spatial analysis of groundwater and hydrological characteristics of the Babylon Creek

The spatial analysis of groundwater has its effect in determining the characteristics of this water and its geographical distribution, determining its direction and depth, and indicating its levels (stability and mobile) and the discharge energy (productivity). These indicators are a statement of the availability of water in the region in its quantity and quality. After the chemical and physical analyzes and the determination of the pollution rates, the hydrological characteristics of the waters of the Babylon Creek will be analyzed in terms of its water flow system and the characteristics of the monthly and annual discharge, and the percentages of pollution in the water will be shown through chemical and physical analyzes.

3.1. Numerical distribution of wells

A well is defined as: an opening dug by a person to reach the depths of the earth in order to extract water from it. (Gouda, Hassanein Gouda, 2002, p. 405).

The number of wells in the area reached about (218) wells, and after filtering them to (131), complete data without shortages, and from map (4) that shows the spatial distribution of underground wells, it becomes clear to us the concentration of samples in all parts of the study area.

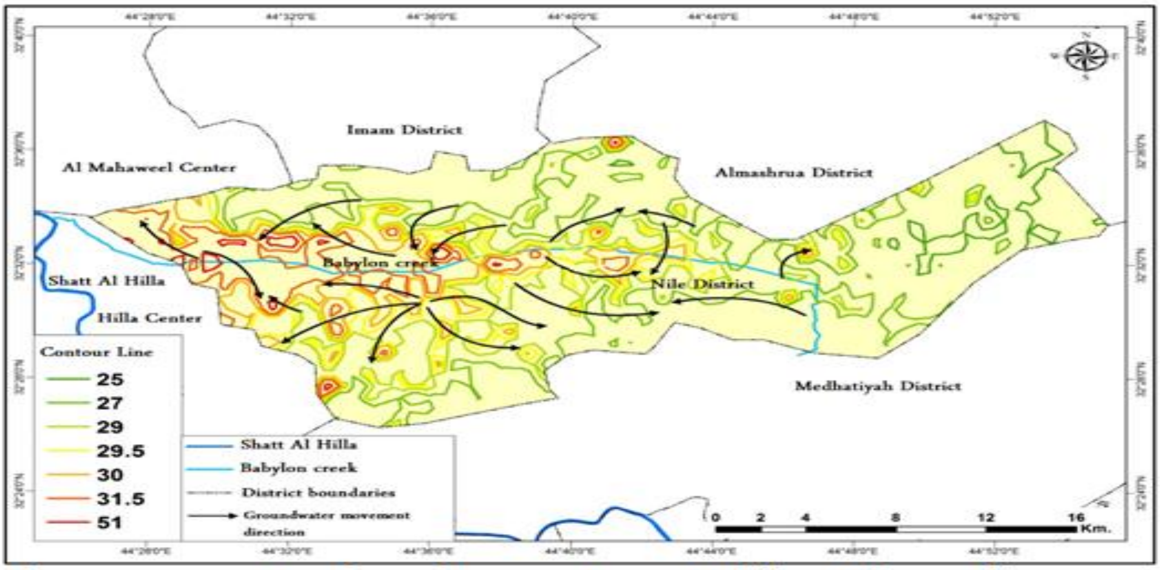


Map (4). The spatial distribution of wells in the Nile District.
Source: researcher based on ArcGIS 10.4

3.2. The direction of the movement of groundwater

Groundwater generally moves from high pressure levels towards lower pressure levels after water enters the unsaturated aeration zone between the surface of the earth and the saturation level. Groundwater is divided based on movement into confined water, which is directly connected to the atmospheric air through the pores of the surface layer of rocks or soil. The second type is suspended water, which lies above the normal level of groundwater. The third type is confined water, which is between two layers of low permeability, rise due to pressure upwards at drilling (Dradakah, Khalifa, 1988, p. 111).

The most important characteristic of groundwater Its slow movement under the influence of attraction from feeding areas to the discharge areas and the geological structure of the study area which has a role in determining the movement of surface waters. Whiles The sediments of the Quaternary age these sediments and their thickness differ from one place to another as the dividing line of surface and groundwater alike. so that the direction of groundwater movement varies according to the regression factor (Todd, David K, 1983, P. 17). A contour (51) meters above sea level in the western and central region on the one hand, as shown in the red color inside the map (5).



Map (5). The direction of groundwater movement
Source: researcher based on ArcGIS 10.4

3.3. Ground Water Level

It is a phenomenon of great importance to know the groundwater level and represents the upper limit of the saturated range. Predicting the behavior of wells also depends on the level of the water level in them and on the change in the strength of the flow, as it is parallel to the topographical surface in the region, so it is near the surface in low areas and rises under high areas and rivers.

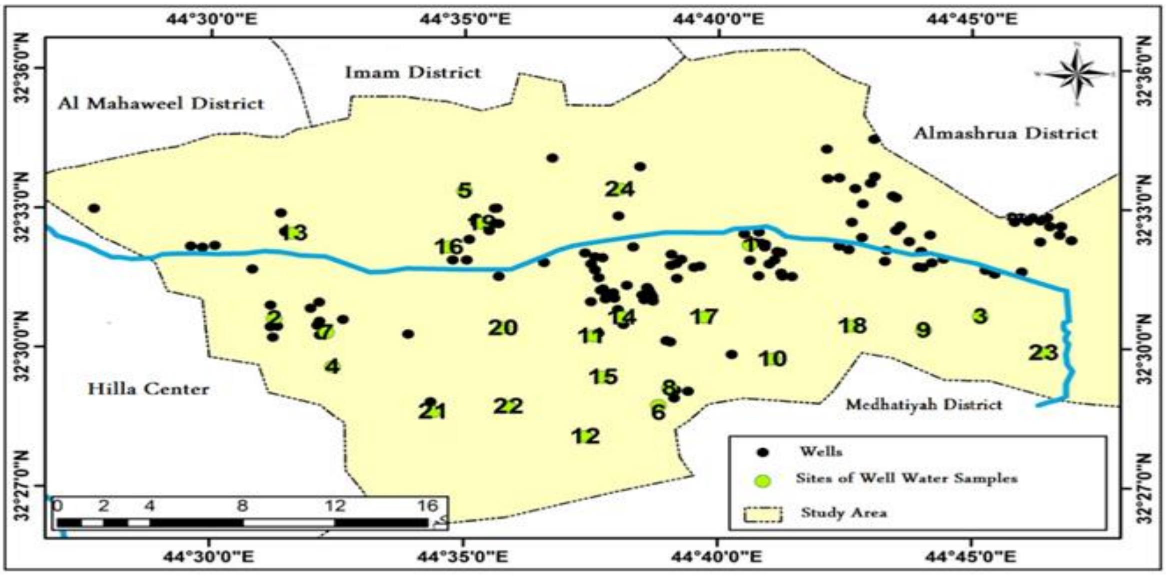
3.4.1 Water Level

It is the level at which the water stops when the well is at rest (the water is not withdrawn from it, whether by pumping or by self-flow). It is expressed as the distance from the surface of the earth to the level of the water in the well. In self-flowing wells, the level of all water is constant above the surface of the earth (Khalil, Mohamed Ahmed El-Sayed, 2005, pg. 139). The depths of groundwater levels in wells in the Nile region, as shown in table (4), range from the lowest values, which are (1) liter/second, map (6).

Table (4). *The highest and lowest values of the constant level l/sec*

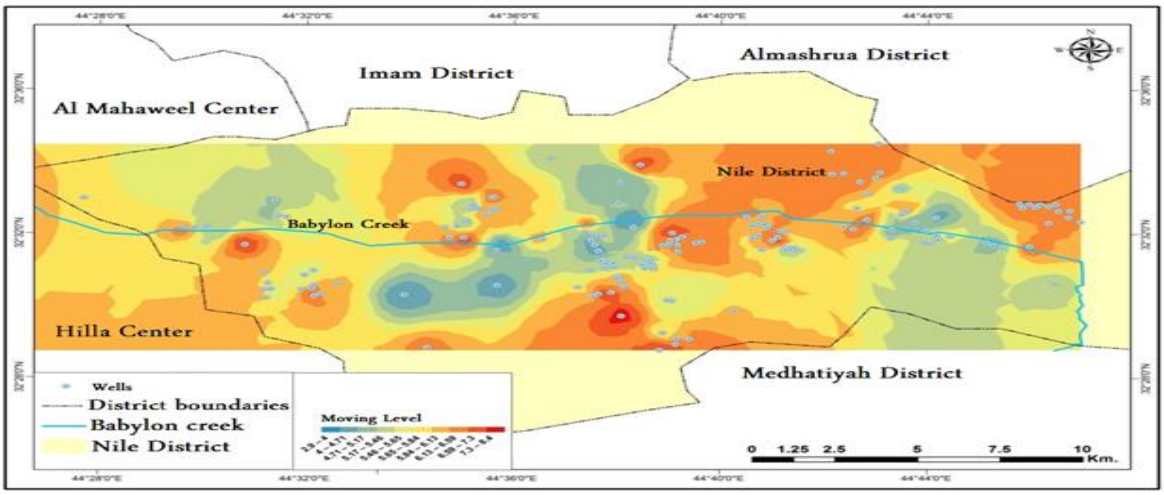
Top	lower	circle length	Latitude
	1	4.8.41.44	37.6.31.32
4,56		20.3.32.32	57.8.46.44

Source: Researcher based on tabl (3).



Map (6). depth of wells in the study area
Source: Researcher based on ArcGIC 10.4.

From other side the constant water level value ranging between (2.44) liters / sec (2.93) liters / sec is concentrated in the yellow color in the south and east of the district, while the lowest values indicated in blue are concentrated in the east of the district and southwest of the region and a little north of it as shown in map (7). As for the higher values indicated in orange and its gradations, they were concentrated in the eastern sides, while the other sides were scattered differently. The constant water level is affected by several factors:



Map (7). Constant water level of grandmother in the study area.

Source: Researcher based on ArcGIS 10.

The climate, as the water level changes according to the years and seasons. Rain plays a major role in increasing the groundwater level, but it takes time to occur due to the presence of the sediment layer that separates the surface and the saturation zone, and the other reason is the evaporation that occurs in the surface water when temperatures rise in the summer.

The plant has an effect on the quantity of water, as it absorbs surface water before it leaks into the groundwater.

Human activity clearly affects groundwater levels through drilling wells and the use of water for irrigation, especially in the summer, when human settlements are concentrated (Khalil, Muhammad Ahmad Al-Sayed, 2005, p. 139).

The depths of the moving water levels range in either between the lowest value of (2.9) liters / second and the highest moving level (8.4) liters / second in sequence No (77) as shown in the table (5).

Table (5). *The highest and lowest values of the variable level liter / sec*

Highest	Lowest	latitude	longitude
8.4		32-32-27.5	44¯-46°-43°.8
	2.9	44.39164	32.29452

Source:Ministry of Water Resources, General Authority for Ground Water, unpublished data, 2020.

3. 6. Pollution of well water:

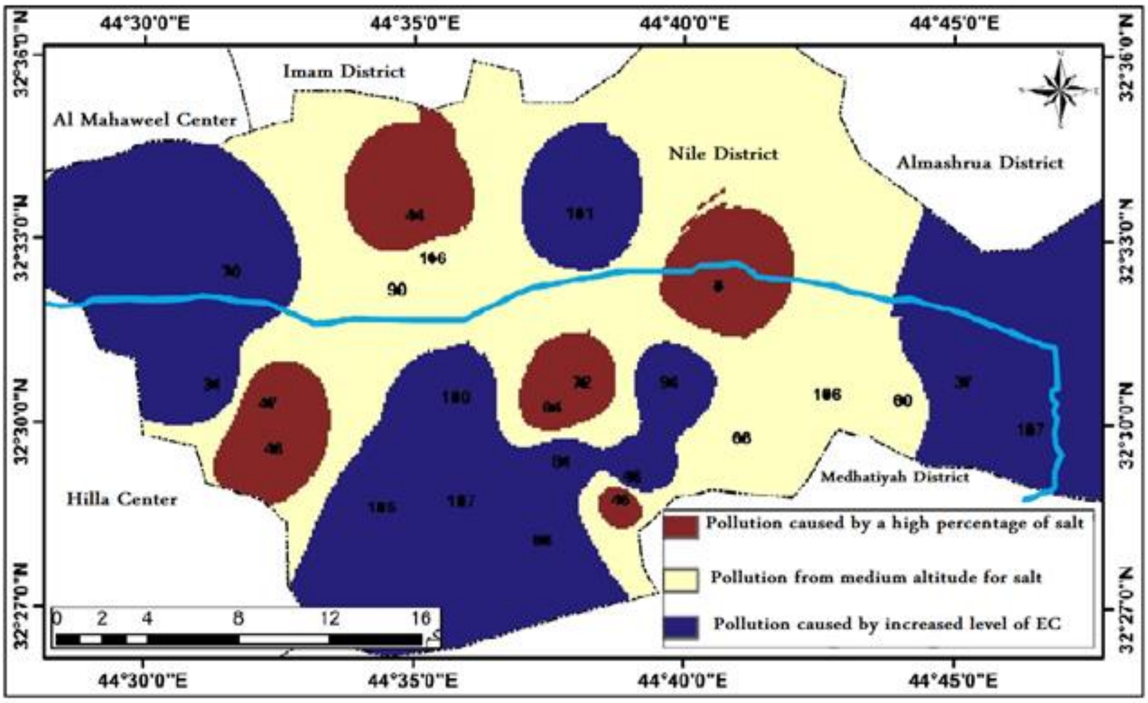
Water pollution is any chemical or physical change that occurs to water and its quality and affects living organisms negatively and makes the water unfit for drinking for most uses. Groundwater becomes polluted when pollutants are released on the ground and make their way to groundwater. Sometimes this pollution occurs naturally due to the presence of an undesirable secondary component. In this case, it is likely to refer to it as a physical or chemical change in the quality of the water instead of considering it pollution. In this case, it is divided into two types: physical pollution and chemical pollution based on the global analyzes of groundwater compared to the analyzed ratios within all samples, we separate the conclusion of pollution within wells as follows:

3. 6. 1. Physical pollution of the water wells of the study area

It means the pollution resulting from changing the nature of water and its qualitative characteristics, and it becomes unpalatable for human high uses. As for the pH ratios, they did not exceed the global limit specified for them with all their analyzed values. We note map (8) of physical pollution inside well water, the dark red color showed the percentage of very high salts, and the yellow color showed the high percentages of salinity in irrigation and medium salinity in other uses, depending on the previously mentioned global limits, the dark blue color showed the electrical conductivity ratios.

3. 6. 2. Chemical pollution of water wells in the study area

It is one of the most important types of water pollutants in general. And it has a significant impact on the quality of water, which is completely linked with agricultural activities, including industrial ones, in which chemicals are frequently used that contain heavy toxic elements and are directly and indirectly released. We note that the positive chemical elements have exceeded the international permissible limits within the element calcium and potassium. In all samples, as well as the element magnesium and sodium, except for a few values that did not exceed these limits within the analyzes of magnesium and sodium.



Map (8). of the physical pollution of the study area
Source: Researcher based on ArcGIS 10.8

4. Results

1. It becomes clear to us that the geological structure and the surface of the study area are effective and important, which clearly affects the quantities of water in the area connecting to the Babylon Creek and groundwater.
2. Rain has a clear effect on the quantities of water within the study area based on the study of the amounts of rainfall with the losses from evaporation from the month of July, in which the high evaporation equations are, until the month of January. And through the equation of the effective rain coefficient and the nature of weather and climate elements, especially temperatures and their height, we conclude that there is a water deficit within the study area.
3. The quality and quantities of groundwater within the wells of the region were determined due to the cracked, poorly drained clay soil in addition to its dryness due to the increase in temperatures most of the months of the year, and thus the increase in evaporation rates.
4. The distribution of wells is concentrated in the southern regions of the region and random in the rest of the regions. The regions of the south and east of the region suffer from insufficient amounts of water from the Babylon Creek due to the scarcity of water coming from the Shatt al-Hilla and the lack of water releases from the Hindiya dam.
5. Through the chemical and physical analysis of well water and the water of Babylon Creek, we conclude that the most polluted water is well water because its chemical elements exceed the permissible limits globally.

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