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The Spatial Relationship Between Landforms (Geomorphological Features) and Variations in Groundwater Levels in Al-Muthanna Desert

Asst. Prof. Dr Walaa kamel sabri

Walaa.alasdy@mu.edu.iq

AL Muthanna University/ Desert Studies Center & Sawa Lake

Abstract

Groundwater is one of the precious and indispensable support of life in most dry and semi-arid environments, particularly in desert zones. In those areas, most water sources are dependent on groundwater, Their depths, levels, and quality vary in accordance with the diverse topographic elevations and soil classifications. Therefore, this study aims to elucidate this relationship, as it has been observed that areas with higher elevations above sea level generally exhibit a deeper water table compared to lower-altitude areas. If the groundwater has higher height, the depth will also be higher. Therefore, this study find that the deepest point of groundwater in this area is located in the southwest at the superficial level of (350) m at a land advancement of (400) m above sea level. This reduction is a slow process from the south to the north of the area under study until they reach the lowest depth of about (6)m in the north at the contour line, where the land elevation was less than (10)m above ground level. The study also indicated that there are some additional factors that impact on the variation of the groundwater levels like the underground geological procedure

including fractures, breaks and cracks such as the Abu al-Jir fault (north of the study area). This affected the underground reservoirs and result to the occurrence of water in abundance in the area as well as the variety of land. The coarser the surface, the deeper the water, unlike lowland and flooded areas like the Al-Salman, Al-Sa 'a, and other lowlands, which are low-lying areas with permeable soils. In which the groundwater level upsurges and the depth reductions in comparison with the adjacent and higher hills.

Keywords: Groundwater, , underground gomorphological processes. Under surface water

Introduction:

The study of groundwater and its various types from one region to another considering great importance , particularly in some areas that are dependent on groundwater for human consumption and what the world is suffering from lack of surface water especially in general dry areas in relation to climate changes and the effect of natural factors for human misuse. This level varies from one region to another particularly after the expansion of the projected drilling groundwater wells in the previous decade for the purpose of agriculture and different human activities in the area especially after independence (**Thamer, 2017**). New studies have similarly tended to analyse the groundwater and the variation in the levels of reservoirs from one region to another and to observe them with the

use of modern innovations (GIS) to provide precise data to decision (Kamil ,Al-Zamili ,2014). It worth noting that the groundwater in the area under study is accessed in an exhausted manner for agricultural purposes because it experiences the scarcity of rainwater and cultivates huge areas in dry basins like Wadi Kharaz, Abu Ghar, and the cultivation of despairs such as Al-Salman Low, and others, that are used on watering from underground wells. Thus, the water level in the reservoirs got decreased a lot in recent times.

The problem of research:

The research problem deals with the connection between the geomorphic forms that spread in the area of desert of Muthanna and how these potential forms may affect the variation and fluctuation of the groundwater level in

relation to levels, depths and altitudes between them.

Research Objective:

The aims of the research is to study the spatial connection with regards to ground components affecting them and the possible impact on the variation in levels in groundwater in the desert with the use of GIS technology (GIS) to determine the ground form that comprises the closest groundwater level to assist decision-makers offer precise data that can enable them to invest it now and in the near future to attain development.

Setting of the study area.

The study area is at the geographical limits of Muthanna Governorate and occupies the southwestern area of Iraq with an area coverage of (46,935 km²), which is (90.7%) which is the complete area of Muthanna Governorate (Muthanna Statistics Directorate,2011). The plateau is geologically served as an extension of the Najd Plateau, that inhabits the main heart of the Arabian Peninsula, in the northeast in the Rafidain Valley (Al-Saadi, 2009). Astronomically, it is located between latitudes (29.00) and (31.2.00) north, and longitudes

(43.30.00) and (46.4.00) east. (Al-Asadi ,2016)

Surface-Burning Characteristics:

The surface of the desert will be categorised generally by the relative eccentricity in the same direction from north to south and adds to its maximum height in the southwest of it. By covering various rocks and stones as well as the layer of sand obtainable from the actions of erosion and weathering processes. It is will be spread by other natural factors especially in the ancient geological periods represented by the climate, at the ages as the rainy Palistocene era (Al-Asadi ,2018). In the north of the area, it is submerged by sand, limestone and plasterboard. It is featured by its flatness, height and low velocity which ranges to around (60-180m) above sea level.

The lower valleys are categorized by the existence of a refractive line that extends along the eastern edge of the entity to form a number of eyes on the west of Samawah, which is vital in the proposed feeding area with the substantial groundwater that offers the cultivated crops as well as meeting the demand for the population in these cones of water for human and natural

uses. To the consistent south of the area of the stone the surface that is higher than (200-400) is covered by some rocks, residual coarse and gelamids from the wind ablation agents (Alasadi, 2018) whose surface comprised the sand formations as the dunes cover large zones of it.

- **Features of the climate of the study area:**

The area of study is the north of the Tropic of Cancer which made it the subject of dry tropical climate in the summer and is categorized by the hot and dry desert nature in general it is vital in most climatic elements which include:

Temperature: Temperatures upsurge in the summer and often it is up to July

and August to above 40 degrees Celsius, especially in recent years it reaches up to 50 degrees Celsius. The annual average may be up to (25,3) Celsius and peaks in the summer, as its average in July stretched to (37,05). and declines in winter to record in January (12,4) Celsius.

Rainfall is considered by a lack of precipitation, as it falls within the hot dry period of the dry climate in the summer as well as the rain in the winter and the next summer begins in the month of October with a total of (84,7) mm,

Table (1) Average normal temperature and Rain Humidity% Evaporation mm Speed wind m\scd in Salman stations (2013-2015)

Month	Average Temperature (° C)	Rain Fall (mm)	Humidity %	Evaporation mm	Speed wind m\scd
Jan	12.45	9.91	52.06	79.47	2.89
Feb	13.68	14.01	46.1	102.5	3.08
Mar	19.33	26.3	40.48	166.7	3.44
Apr	24.46	9.5	33.1	207	3.36
May	31.93	0.74	22.18	272.7	3.56
Jun	35.58	0	15.6	302.7	3.66
Jul	37.05	0	15.74	348.4	3.99
Aug	36.56	0	18.56	278.6	3.44
Sep	33.37	0	20.02	211.7	2.82
Oct.	27.27	5.2	27.7	166.1	2.73
Nov.	18.67	11.0	47.18	101.3	2.59
Dec.	13.41	7.8	54.5	73	2.69
Avreg	25.3	84.7	32.76	192.51	3.18

Source Agricultural Air Station in Al-Salman, unpublished data (2013-2025)

Humidity: The uppermost humidity rates were recorded around December with almost (54.05%), , but it decreases by the interruption of rain in July which amounts to almost (15.7) %, so the humidity work will be low in comparison with the humid areas.

Evaporation: Dry areas are categorized with an increase in the total number of evaporations from their

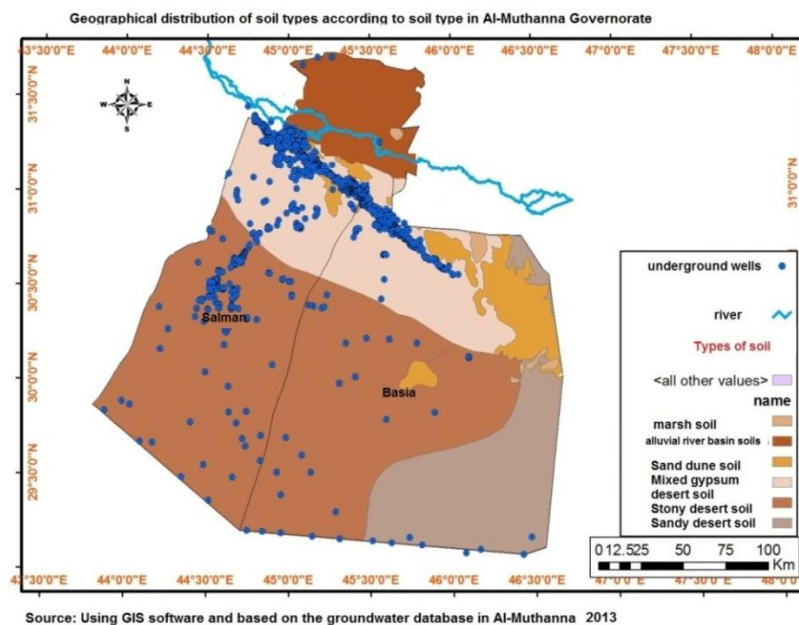
water contents and also the increase in evaporation in the atmosphere as in Table (1). The evaporation /transpiration process increases during the dry season can reach (348.4) mm, in July and it will decrease as the amount of evaporation was observed in Jan at (79.4) mm,.

- Soil Features in the Study Area

The desert area is enclosed with desert soils and it can be grouped as a poor soil in organic matter which reaches 1% in part of the land. It contains low salinity and rich in calcerous and gypsum elements. It has lack of moisture, and it is often disintegrated. As a result of the absence of vegetation. The stone soil can be spread to cover the gelamides. It also contains shallow soil of little thickness and organic materials that is appropriate for agricultural usage. This desert soil is infused with sandy mixed soil that covers the simple bellows of the valley which spreads to various

areas of the desert and it will be appropriate for agriculture. Likewise, the collection of rainfall water, groundwater and floods can recharge the sand dunes of a large area of the east of the desert of the Busayyah sub-district are spread (Alasadi, 2011) shaped by erosion operatives and the formation of the sand-earring bear map (1). And this will be supported by lack of water retention because it has high porosity and disintegration of the sediments. This makes the reservoir for the rainwater infiltration into the ground and the basic recharge of sub-surface reservoirs.

Map 1



Hydrological features of the area:

Hydrogeological studies which consist of groundwater reservoirs and their

distinct locations in different geological compositions and the recharge areas of these reservoirs the way of flow of these waters, their open

quality, and hydraulic treatments (conductivity coefficients, permeability and storage coefficients).

Groundwater:

Groundwater is that extensive water-bearing part which is located above the

first layer from the earth's surface. And for the water reservoir, which is soft or cracked water-bearing rocks may furnished under the bearing layer, or in voids and cracks between soil grains, gravel, sand and rocks Al-Mudhaffar

Wells and eyes in Al-Rehab area north of the study area



- Water containers

Groundwater is originated in the Umm Al-Raduma and Dammam reservoirs, which is the basic reservoir in the area and it is within the which is the Euphrates and Al-Zahra reservoirs.

1- Umm Ardham Reservoir

The visible area in the reservoir that is located at far south of Muthanna Governorate at the Saudi-Iraqi border. It plays a key function in the aerial feeding of the reservoir which is not restricted to Saudi border and later turns into a restricted reservoir around the east and north, the tanker plants in the reservoir around $(0.88 - 1719) \text{ m}^2/\text{day}$ and the storage plants 403×10^{-2}

) - 6×10^{-3}) (National Program for the Optimum Use of Groundwater Resources, 2002).

2- Al Dammam

It is considered one of the most vital groundwater reservoirs in the governorate because:

- * Wide extension of the tank.
- * It comprises cracks and cavities, which assist to significantly free the flow of water.
- * Surface contact to large areas, which eases its feeding from rainwater and surface floods.

* It is situated in contact with the layers that form a single multi-layered underground system, as similar to Umm Al-Radumah reservoir at the bottommost of the reservoir and the Euphrates reservoir above it.

* It is sited near the surface of the earth and at low depths.

3- Euphrates and Venus Reservoirs

It is one of the water common reservoirs that contain small quantity of water as a result of its lithological nature because it comprises large quantities of marl that do not contain water. Therefore, the water reservoirs are not categorized as economical due to their limited quantity of water in them. Thus, the Euphrates and Venus reservoirs are not measured major reservoirs in the area (National Program for the Optimal Use of Groundwater Resources 2002).

A part of the rainwater gathers in the zones of depressions known as floods and spread in the zone, the most essential part of which the flood of Al-Zahra and the flood of Al-Hadanai which is also the flood of Al Zahra. The natural drainage areas at Wadi Amid are situated along the Abu Al-Jeer fault in the form of a wide belt of

depressions and water springs. The most vital of these springs are (Al-Battah, Ghadari, Al-Qasr, Ibn Assaf, Al-Nakheel, Rafi ', and Uyun Bani Salama) in consonance with the drainage of wells formed in the self-flow area and the Euphrates River. The drainage of groundwater in the governorate is projected at 50775000 m³/ year, while the groundwater calculations of the Dammam reservoir only in the governorates of Muthanna and Najaf Ashraf are assessed at 86.4x10⁹ m³/ year.

- The spatial association between landforms and diverse groundwater levels

Ground forms and linked to geomorphological procedures such as weathering, erosion and underground procedures can regulate the diverse groundwater levels. The effect takes numerous aspects which are:

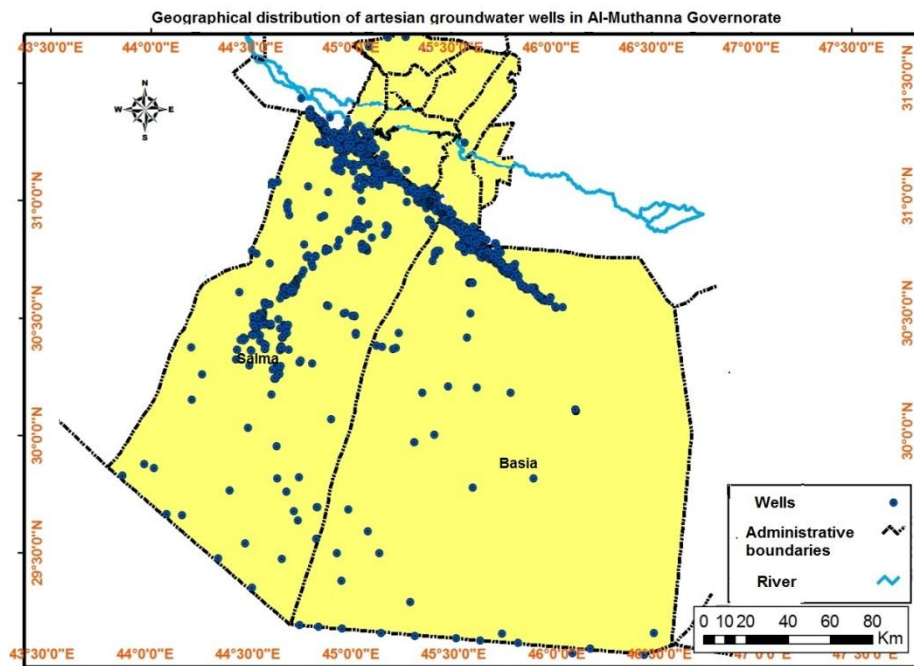
1- Internal Geomorphic Operations:

The underground measures where the rock patterns are represented and exposed by faults, fractures can be influenced by several factors as well as the composition of underground water reservoir. The flow may affect the underground layers of the rock and

impact on the underground factors owing to the cracks, faults and fractures that take place within the rock layers. This will help in the penetration of the underground water reservoirs and their release from the water points. Thus, it was found out the certain areas may become exposed to the potential underground flows in the desert as one of the richest zones in the underground flows within the areas around the desert, comprising the line of refraction that has become more exposed to the part of the north of the desert zone close to Abu Al-Jir fault, as a longitudinal fissure, from the other part, especially the Muthanna desert

and the other parts of the extension, around the west and east, the fault realized a dense and broad groundwater flow and the line of sparking which is in consonance with the natural eyes and underground wells in connection with this fault. As indicated in Map (2), the south of the plain between Samawa and Al-Khader, the meeting eyes are in Al Salman district to represent the desert. This zone was apportioned to the activity of underground flows particularly, in the Abu Al-Jir faults and this will assist in the formation of the density of the underground wells in this zone.

Map 2



The underground may also have effect in the existence of the groundwater and the formations in the areas under study which contain limestone rocks and the Venus as well as laurels, which can result to the exit of underground well of Wajja and it may subside to the

spread in the various wells of Umm Dhal, that bears the below coordinates E 45° 25 '27.2" , N 30° 54' 04.6" in the well area of Kazem et al.,2011) . As can be seen in the picture below

Lacks and cracks in Umm Dahl well



2- Grounding factor:

The terrain factor should be one of the major determinants of the level of the groundwater and it may be related to the inverse level. The greater the level of the terrain, the lower the level of groundwater, however the reverse may be the case of the groundwater increases. In the map of equal upliftment, it was noted that the surface of the governorate can get increased to the level in the north towards the south southwest in accordance with the contour line which range from the positioned altitude of 10 from the north of the desert to reach the middle of the said desert as well as

the line of (200) m and then to the direction in the south and southwest to reach the projected contour line (340-400)m above the sea level. For the broader slope of the slope the contour line is around (400) m above the sea level however in the southwest the contour line may reach (25) m above the regular point of contact to the desert containing the sedimentary plain area, with a consistent slope of up to (1/753.6) m and the surface slope rate is (1)m per (753.6) m. As for the slope, it is (79.6) degrees. Rendering to the law of regression and as in the following equation:(Satahiah, M1974)

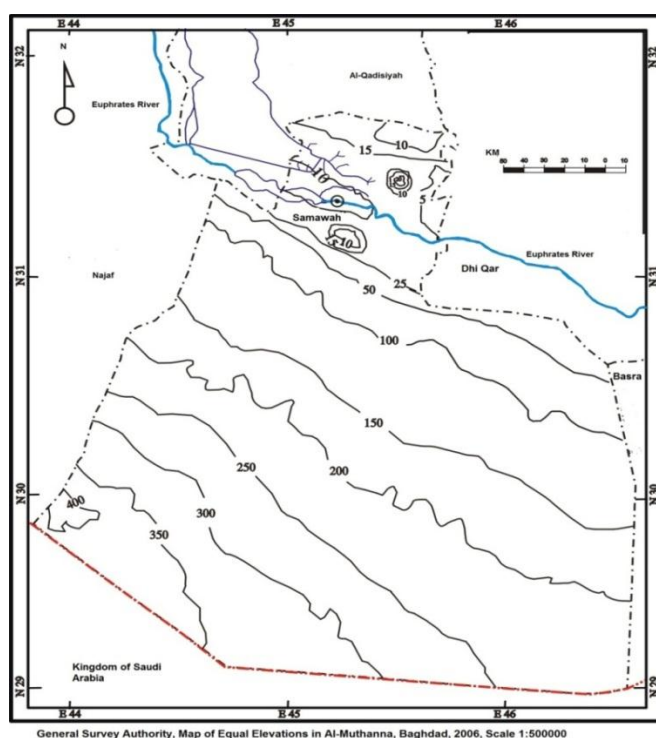
$$\text{Slope rate} = \frac{\text{Spacer Vertical}}{\text{Distance Horizontal}} \quad \text{either the degree of slope} \quad \frac{\text{Spacer x 60}}{\text{Distance Horizontal}}$$

The nature of the surface as contained in the study has a significant effect on the groundwater preservation and the direction of the flow of the groundwater. The system of flow from the southwest to the northern part and the general slope of the ground surface in the zone.

Moreover, if we compare between map number 3 and map number 4 it will be established that the relationship in ground level and the basic difference in the depth of the groundwater will be lower than the sea level. In the area, the heights of (25) above the ground level, and the depth will not exceed between (6-73) m as contained in maps

(3 and 4). As the height of the ground surface keeps on increasing in the middle, near the area and center of Al-Salman district, the contour line will go up to reach the peak of the ground between (200 to 250) m. These areas are compatible with the above contour line and it will increase to nearly (150 to 210) meters and therefore the depths of the groundwater may continue to go up above the sea level as it continue to advance towards the direction of the southwest of the zone of Muthanna desert until it finally reach the depth of more than (280 to 340) meters considering the height of the desert in the contour line of (350 to 400) meters above the sea level in the south and southwest.

Map 3



3- Surface Type (Surface Roughness) :

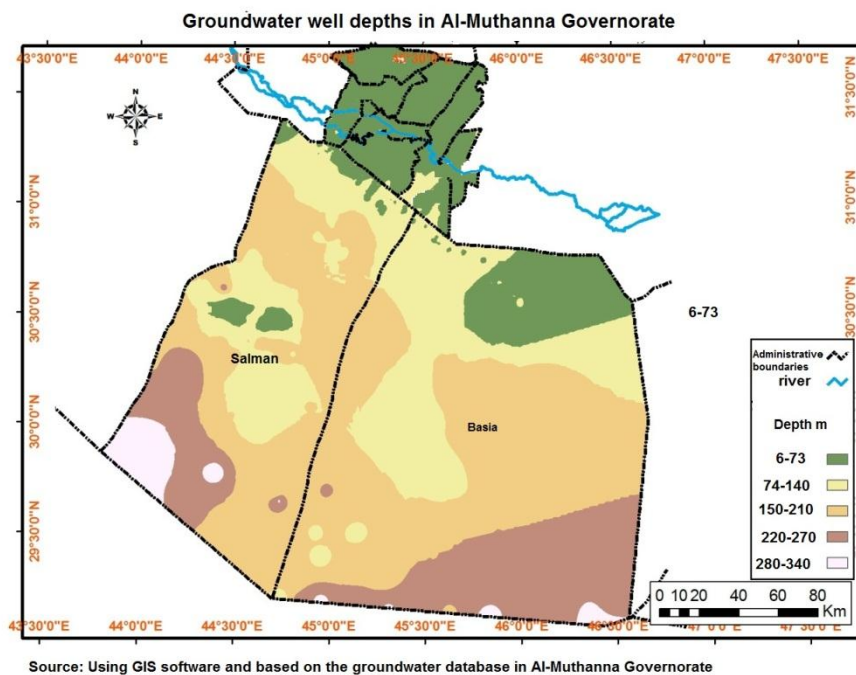
This means the condition and nature of the proposed surface and the components will make up the ground components. The course covering the surface of the assigned stones which include dolomites and gelamides with the less rainwater and the ground water will infiltrate into the ground in such areas. The stones are located in the southwest of the zone and the area is the deepest in the groundwater and containing the depth of (300 to 400) meters below the normal surface. However, the surface that covers the soft part to the medium coarse

sediments like silt that is featured by high porosity and the passage to allow for the easy leak of water into the high ground. Thus, the groundwater level may increase to the surface and it will close to the other surface which is prevalent in the area such as by high porosity and permeability. the dry Oudian basins and bellies like the Wadi As-Sadir, Wadi Hadir, Al-Hassam, Wadi Khar, Wadi Kharz and others. It can also occupy the floods or desert and eventually depressure areas such as Hadawiya, Shawiya, Rifa 'iyah, Rifa 'iyah, Al-Zah and others. In this sense, the water level will be low in comparison with the other side that is

located within the same area like Salman district, at Al Salman depression in the well can be located at these coordinates (44 32 40.0) and (30 31 20.3) and situated at the elevation of the ground 188, the level of the well may reach 38 meters whereas in the same area, of Al Salman depression the

altitude of 246 meters of the well may reach 120 meters within the geographical coordinates (44.34.338 and (30.33.48.8) . In Hudayyah depression, east of Al-Salman depression, at an altitude of 194, the depth of the well in the depression reaches 30m.

Map 4



Conclusions

1- The study concludes that there is a connection between the terrain and the groundwater levels. The higher the groundwater the deeper the groundwater. This highlights the issue of proximity of the water depth to the ground in the north of the area owing to the

reduction of the ground surface to the sea level and its slow increase in the same direction of southward with the increment in ground height.

2- The depth of groundwater differs based on the nature of the terrain, whereas the approximate level of the groundwater in the dry zones and the valley as well as the

land depressions is lesser to the surface of the lands located on the same contour line. The depth may as well increase in the rocky areas in comparison with the low area.

- 3- The underground ground flows that will affect the geological aspect of the area such as faults and cracks in the ground layers, to exit the groundwater in the form of eyes and spread to the north of the area under analysis owing to the availability of the Abu Al-Jeer fault.

The recommendations

- 1- There should be rationing of the groundwater to prevent waste as the region suffers from drought and massive agricultural expansion in recent time. There are almost 1800 wells affected by the water levels in the reservoir.
- 2- Random drilling of potential wells should be avoided in order to rehabilitate and maintain the excavated ones by the competent departments.
- 3- There should be an establishment of smaller dams in the valley to benefit from the

potential rain water to recharge the exploitation of different regions for some purposes during the period of water shortage in consonance with the ministry of water resources and the general authority of Dams and reservoirs.

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