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Geomorphological Features the Basin of Valley ''Wadi'' Tawil Al-Ukla in Najaf Governorate

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ABSTRACT

This study examined the geomorphological features in the Wadi Tawil Al-Akla Basin in Al-Najaf Governorate, which covers an area of 608.74 square kilometers. It explored the natural data of the area, including geological, topographical, and climatic characteristics, as well as soil properties, and their geomorphological role in responding to geomorphological processes such as weathering and erosion in their various forms. The study revealed that according to the application of the rainfall erosion quotient, the area is subject to minimal erosion according to the Thornthwaite equation, with an annual value of 13.71 millimeters, which is considered weak. As for the impact of wind erosion and its extent in the study area, the Schipl equation was applied to extract the climatic susceptibility quotient for wind erosion, which reached 763.01, classifying it as very high. This is attributed to the low precipitation, high temperatures, and wind speed, especially in the summer season. As a result of these geomorphological factors and processes, various geomorphological forms have emerged, some of which are due to the original formation with subsequent modifications, while others resulted from environmental influences such as weathering, erosion, and aeolian deposition, leading to the distribution of several geomorphological features in the study area, including rock outcrops, channels, wind caves, and others.

Keywords: Geomorphological forms, Wadi Tawil Al-Akla Basin, Schipl equation.

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1. Introduction:

Geomorphological studies have attracted the attention of many researchers, whether geographers or others, due to the potential usefulness of their information in various projects related to human life and activities closely linked to the natural processes occurring in their surroundings. The surface features of the earth serve as a measure for geomorphological studies, which involve investigating landforms and the factors that contributed to their formation and development, as well as explaining the reasons behind their distribution. Accordingly, geomorphology helps deepen our understanding and perception of landform features. It is now recognized among specialists that geomorphology is no longer a purely descriptive science limited to describing and classifying landforms but has shifted towards an applied approach due to technological advancements in quantitative study methods and a focus on map design and field visits. The study area stands out for the diversity of its geomorphic units considering the geographical factors and variables that have influenced and shaped it over time. Various landform features, both structural and erosional in origin, have emerged, illustrating the relationship between the natural factors affecting the region, such as geological structure, surface features, climate, and soil, and the geomorphological processes that shape landforms.

Problem of the study:

The problem of the study revolved around questioning the nature of the factors and processes that led to the formation and shaping of the geographical phenomena in the basin of Wadi Tuweil Al-Aklah in the province of Najaf.

Hypothesis:

The climatic factors, geological structure, and other natural factors, along with geomorphological processes such as weathering and erosion, are considered the primary causes in shaping the landforms that have formed within the basin.

Importance of studying:

The importance of this study lies in its exploration of the field of applied geomorphology, which is one of the most important branches of physical geography. It involves uncovering the geomorphological features within the basin of Wadi Tawil Al-Akla, located in the province of Najaf. Additionally, it involves studying and analysing the natural characteristics that provide a detailed and clear picture of the valley and the geomorphological processes that have influenced it, leading to the formation of its landforms.

The study area is located astronomically between the latitudes (N 30º .20′ .03″) to (N 31º. 00″ .05) North and the longitudes (43º. 40′ .22″ E) to (44º. 40′. 08″ E) East, situated within the province of Najaf. The basin's area is 608.74 square kilometers. The sources of the basin are located to the southwest, and most of the watercourses in the basin flow north-eastwards until they converge into the Umm Burr basin. From there, water channels emerge, culminating in the Euphrates River. This is illustrated on Map (1).

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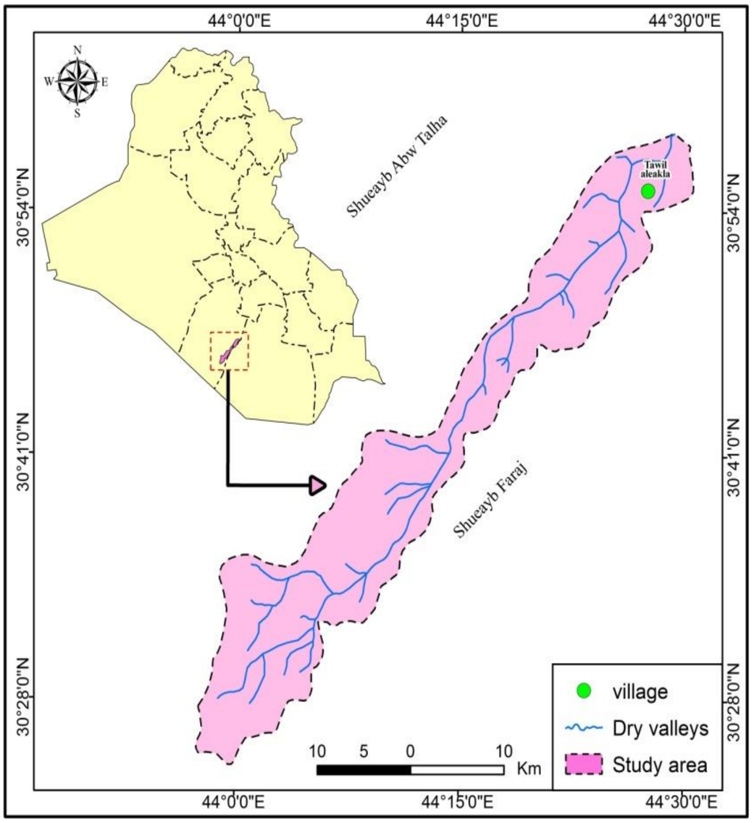
Map (1) Geological location of the study area



Source : 1. Republic of Iraq , Iraqi Ministry of Water Resources, General Authority of Survey, Map Production Department, Administrative Map of Iraq, scale 1 :1000000, 2020.
2- Digital elevation model, Using the Arc Map 10.8.4 program.

2. Natural characteristics of the study area:

Through studying the natural features of the study area, it is possible to identify the landforms that have emerged because of their variation and changes. By observing the geological rock formations of the region, which refer to the physical and chemical properties of rocks, their homogeneity, and shapes, it becomes possible to determine the extent to which rocks are affected by weathering and erosion processes and their susceptibility to decomposition and dissolution. Additionally, the structure and deposition nature of rocks play a significant role. Sedimentary rocks, which form thick or thin layers and consist of fragile and hard rocks, are prevalent in the study area. The inclination of layers also facilitates the process of erosion horizontally or

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vertically.
The layers present in the study area are sedimentary, with an age ranging from the third period to the Quaternary deposits. The Dammam Middle Formation, belonging to the Middle Eocene (third period), is the most widespread formation in the study area. It consists of basal basaltic breccia or conglomerates, followed by highly crystalline limestone at its lower part, with an estimated thickness of 20-25 meters, deposited in a shallow marine environment. The second formation, also from the third period, is the Upper Dammam Formation, located in the northwest of the study area. It consists of limestone, marl, and gypsum, with fossils indicating shallow continental environments. The third formation represents the depressions deposits, found very minimally in the study area, composed of clay-rich materials with aluminium oxides and green materials carried by seasonal rivers along with wind deposits. Their thickness varies between 0.5 to 1.5 meters, depending on the type of rocks and their derived deposits. The fourth formation belongs to wadi deposits, a part of the Quaternary formations. These sediments accumulate at the bottom and sides of the valley, consisting of rock fragments of various sizes mixed with sand and fine gravel, with a thickness ranging from 20 cm to 1 meter. The wadi deposits are formed by river erosion and vary in thickness and type depending on the rocks and the valley's order. This information is illustrated on Map (2).

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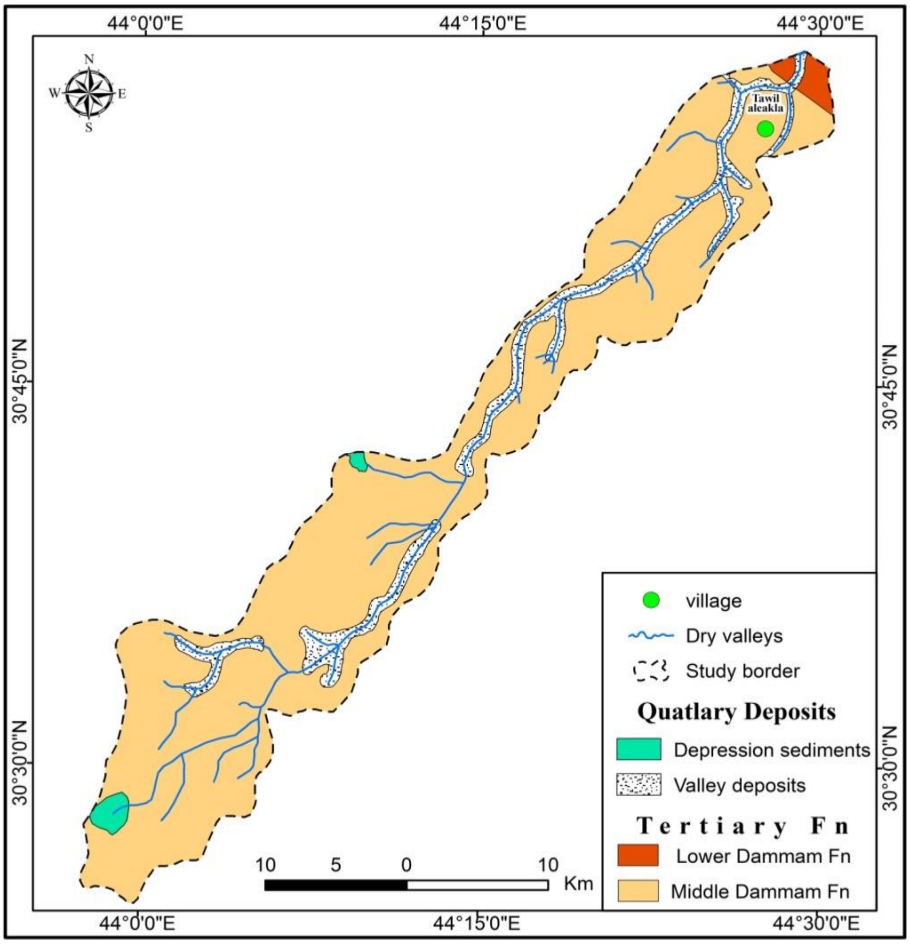
Map (2) Geological structure of the Wadi Tawil al-Ukla basin



Source : Republic of Iraq , Ministry of Industry and Minerals, Iraqi Geological Survey, Al-NAJAF QUADRANGLE, SHEET NH-38-2, (GM 32) SCALE 1:250 000, 1994.

As for the topographic characteristics, the basin of Wadi Tawil Al-Akla is located within an area characterized by its plateau nature, extending in a (southwest-northeast) direction between elevation lines ranging from (180 m to 370 m) above sea level. The boundaries of the elevations appear to be relatively equal and undulating, indicating surface variation and irregularity in elevation levels. Consequently, it is considered one of the basins with semi-regular slopes. This information is depicted on Map (3).

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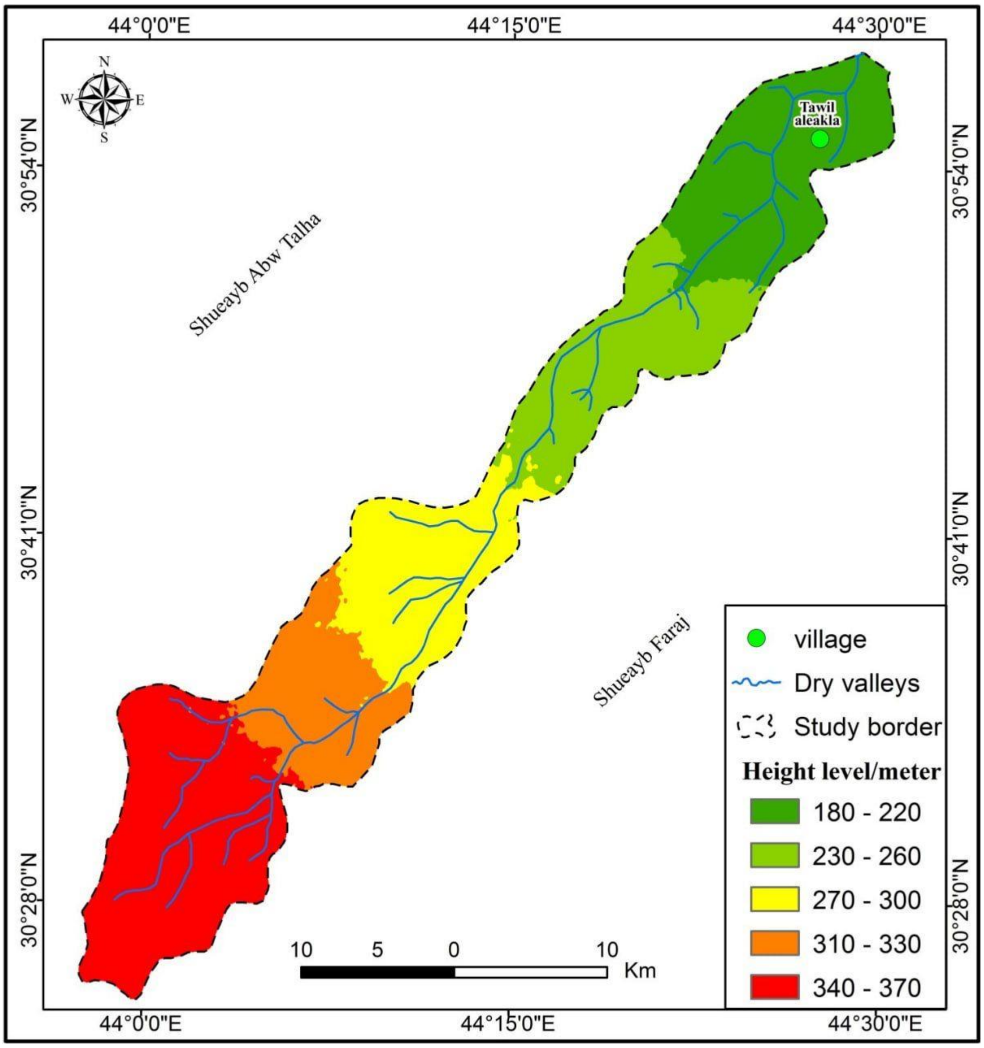
Map (3): Contour Lines of Elevations for the Basin of Wadi Tawil Al-Akla.



Source : Digital elevation model, Using the Arc Map 10.8.4 program.

Climate is one of the most significant factors influencing the formation of surface features through its impact on various geomorphological processes such as weathering and erosion. Understanding the climatic conditions allows us to identify the prevalent processes in the area. Referring to Table (1), we observe that temperatures vary between the summer and winter seasons. The maximum temperature reached its peak in July at (44.8°C), while it decreases in January to (16.8°C). The minimum temperature for the same months was (29.4°C) in July and (5.8°C) in January, indicating high thermal gradients. Temperature, being one of the key elements of

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climate, directly affects all geomorphological processes and is also important for other climatic elements. It influences atmospheric pressure, wind movement, rainfall, and evaporation intensity, thereby impacting the type and activity of geomorphological processes.

Moreover, the study area is influenced by winds (north to northwest) throughout the year. Wind speed increases in the summer season, reaching (2.8 m/s) in July due to the high temperatures and decreased relative humidity, which accelerates wind speed. Conversely, in winter, wind speed decreases, reaching (1.2 m/s) in December. This wind influence affects the exposed rock faces as wind acts as an erosional agent, besides explaining the movement and direction of transported dust within the research area.

Table (1): Monthly Averages and Totals of Climatic Elements for Al-Najaf Station for the Period (2000-2020).

Evaporation (mm)	Rain (mm)	Relative humidity %	Wind		Temperatures C			Months
			direction	Speed M/S	Normal	min	mix	
82.3	296.8	67.0	NW	1.3	10.9	5.8	16.8	January
118.2	219.2	57.1	NW	1.8	13.7	8.0	19.9	February
197.1	154.5	48.0	NW	2.1	18.3	12.1	25.0	March
273.6	278.8	40.9	NW	2.2	24.5	17.9	31.2	April
387.2	82.9	31.0	N	2.2	30.8	23.4	37.9	May
497.9	0.0	24.0	N	2.8	35.2	27.1	42.4	June
540.8	0.0	21.9	N	2.8	37.6	29.4	44.8	July
508.2	0.0	23.3	N	2.3	36.8	28.7	44.3	August
374.9	0.0	27.9	N	1.7	32.7	25.3	40.8	September
255.2	128.2	39.5	NW	1.4	26.4	19.8	33.7	October
131.0	403	56.5	N	1.2	17.8	12.3	24.4	November
84.1	292.6	66.7	NW	1.2	12.6	7.5	18.4	December

Source: Researchers' work, Ministry of Transportation and Communications, Meteorology and Seismology Authority, Climate Department, Unpublished data, Iraq, Baghdad.

Regarding the annual total rainfall amounts, as depicted in Table (1), they reach their highest values in the winter season, reaching (14.8 mm) in January, and become negligible during the four summer months (May, June, July, August). Despite the scarcity of precipitation in the area, most rainfall periods are characterized by their suddenness, resulting in flash floods that erode rocks and wash away soil particles, the quantity of which varies depending on soil specifications, rainfall amounts, and slope gradients. The rainfall in the study area falls within the Mediterranean precipitation regime, characterized by winter rains starting from October until the beginning of May, with the duration of rainfall linked to the arrival of atmospheric depressions to the country in general. As for evaporation and humidity, it can be observed from the same table that they have an inverse relationship. Humidity increases in winter and decreases in summer, while evaporation increases in summer and decreases in winter, affecting the effectiveness of chemical weathering with an increase in its proportion in winter and mechanical weathering (abrasion) in summer due to the fluctuations in their proportions.

Regarding the soil, four types of soil are distributed in the study area. The first type is limestone soil, which is the most prevalent in the study area compared to other soil types. It consists of basaltic rocks, gravel, and sand, with a very thin thickness due to severe wind erosion resulting from seasonal aridity and the absence of vegetation cover, which facilitated soil drift. It has a coarse texture due to the high sand content, making it highly permeable, i.e., it has low water retention capacity, and it is characterized by poor organic matter content. The second type comes second in terms of prevalence and is desert limestone soil. It is characterized by its high gypsum content, reaching up to 25.5%, due to insufficient rainfall to leach the soil, in addition to the large thermal range and accompanying weathering processes, making it appear in rings or crystals. It is a sandy, mixed type with high permeability and high salinity, lacking organic matter. (Lahmoud, 2011, p. 50).

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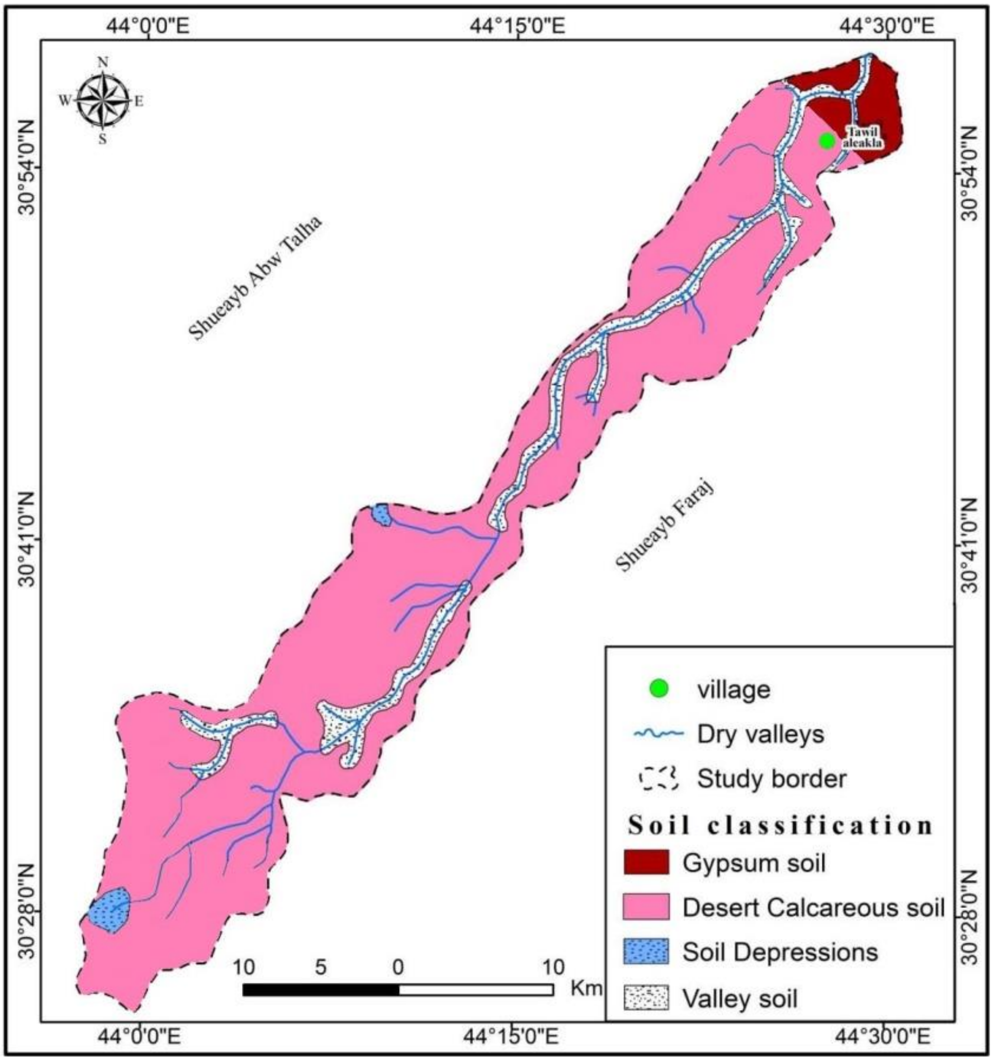
Map (4) Soil types in the Wadi Tawil al-Ukla basin.



Source: Buringh, (1960). Soils and Soil Conditions in Iraq, Republic of Iraq, Ministry of Agriculture, Directorate general of agricultural research and projects. Baghdad.

As for the third type, it is valley soil. As can be observed from the previous map (4), it ranges from loamy and clayey mixed soils to clayey soils. It is characterized by soil hardening and cracking due to its physical properties and the high groundwater level. It is considered one of the best soil types in the study area. However, depression soils cover the study area to a small extent and generally have a higher salt content due to increased temperatures. Some parts of these soils retain water for longer periods and are rich in organic matter due to the presence of natural vegetation. (Al-Yasiri, 2022, p. 38).

3. Geomorphological Processes and Resultant Landforms

Geomorphological processes are the means by which surface rocks of the Earth's crust are affected, resulting in various landforms. Therefore, they include all chemical and physical changes that lead to the formation, alteration, or removal of landforms. (Al-Khashab, 1987, p. 39).

The scientist Wopenck was the first to classify geomorphological processes into internal and external processes. He considered processes occurring within the Earth's interior that result in changes in surface landforms as internal processes, while those that alter the shape of the Earth due to external conditions and factors are considered external factors (Thornbury, 1962, p. 32). Therefore, it can be said that the surface landforms in the research area are the result of multiple and varied processes that rocks in the area have undergone over time, in addition to the nature of the rocks in the research area and tectonic movements. Weathering and erosion, in their various forms, are among the most important external processes that have a significant impact on surface landforms in the research area, as we will explain below:

Weathering process:

It is a process of disintegration of rocks chemically, physically, or both on the Earth's surface. There are multiple factors that determine the type and extent of weathering, such as climatic conditions, the geological composition of rocks, and the topography of the terrain, in addition to biological weathering, which is the influence of humans and animals. These factors create suitable conditions or environments for the breakdown and decomposition of rocks in their locations or nearby. This is the first step preceding any geomorphological activity carried out by various geomorphological processes. Therefore, the activity of any type of weathering at the expense of the other is due to the influencing factors and the aforementioned contributions. Weathering is divided into two types:

Physical weathering

It is a process of breaking down original rocks into smaller-sized materials without any significant chemical or mineralogical changes. It is more widespread than chemical weathering and less complex because its effect is limited to the physical breaking and disintegration of rocks without altering their chemical composition. Physical weathering in the research area has a clear impact on rocks due to the factors and conditions causing it. There is physical weathering due to the following reasons:

A. Physical weathering due to thermal expansion and is called thermal weathering:

The temperatures in the study area vary from one season to another, exhibiting seasonal fluctuations where temperature levels rise during the hot season (summer) and decrease during the cold season (winter). The annual average for the maximum temperature in the research area reaches 44.8°C at the Najaf station, as shown in Table (1). Additionally, there is a daily variation in temperatures, with temperatures rising during the day and dropping at night. When radiation reaches the surface, rocks heat up, causing the minerals within them to expand to a certain degree, leading to rock spalling and disintegration. The temperature range can penetrate into the Earth's

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surface to a depth of approximately 1 meter (Tawon, 1976, p. 105). Therefore, physical weathering, resulting from thermal expansion, intensifies in summer due to the temperature gradient, decreased humidity, and increased evaporation.

B. Physical weathering due to freezing and thawing:

This type of weathering occurs during the cold season due to the filling of rock fissures with water, concurrent with temperature decreases. This leads to crystalline growth, and the freezing of water causes a 9% increase in volume (Abu Samour, 1991, p. 121). The increase in volume generates pressure on the rocks, contributing to their fracturing and fissuring, particularly in rocks containing water or those adjacent to water-bearing rocks. Such phenomena are observed in the rocks of the study area.

C. Physical weathering due to living organisms:

Biological weathering occurs due to the activities of living organisms, including humans, animals, and plants, through their diverse activities. Human activities contributing to weathering in the study area include road construction, agricultural activities, and industrial operations involving land cultivation and excavation. Additionally, animal activities, such as those of worms, which are abundant and penetrate the soil or rocks, contribute to increasing physical weathering processes. Animals also create burrows, further enhancing physical weathering. Moreover, plants play a significant role as their roots grow, causing the removal and displacement of rocks or creating cracks in them as they penetrate.

4. Physical weathering due to salts:

The process is called salt weathering, and one of the necessary conditions for it is a dry climate and hot seasons, as is the case in the study area, to ensure heating and thus increase the longitudinal axis of the salts. The salts do not separate from the rock; the process begins with crystalline growth, which leads to rock cracking and the separation of some of its parts. Salt weathering is similar to thermal weathering in that salt crystals sense the heat, expand, increase surface area, and then grow in size, leading to the separation of granules. This type of weathering is commonly found on gypsum rocks.

Chemical weathering:

It is the occurrence of a reaction between the components of mineral rocks and water or water vapor, resulting in the transformation of rock compounds or some of them into new structures different from the original material of the rocks. Chemical weathering is the process of breaking down rock minerals and converting them into other minerals that differ in composition and shape from the original minerals. Water, carbon dioxide, and some organic materials work to dissolve the original minerals of the rocks. Moisture, along with heat, is required for chemical weathering, and as the temperature rises above zero degrees Celsius, it activates the chemical reactions of the rock components. There are various types of chemical weathering, including:

1. Chemical weathering due to dissolution: This refers to the ability of rock minerals to dissolve and decompose in water. This type of weathering is prevalent in the study area in regions where the rocks are limestone, as found in the Um Al-Arma formation.

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2. Chemical weathering due to hydration: This involves the acquisition of water molecules by rock materials, causing them to expand and become susceptible to decomposition. When these molecules lose water, they return to their rocky nature. This process occurs in the presence of moisture or rainfall water. An example of a mineral susceptible to hydration is anhydrite, which is an anhydrous calcium sulfate that transforms into gypsum, a hydrous calcium sulfate, when combined with water. Gypsum rocks are widespread in the study area, as indicated in the following equation:

$$Caso4 + 2H2o \text{ ------------ } Caso42H2o$$

gypsum + Water anhydrite

The cracks, fractures, and fissures in rocks contribute to the effectiveness of this type of weathering because they facilitate the penetration and entry of water into the rocks.

3. Chemical weathering due to oxidation: This process requires specific conditions, including high temperature, moisture, and the presence of oxidizable minerals. One such mineral is pyrite, which is iron sulfide. This process occurs when atmospheric oxygen combines with the minerals in the rocks, causing changes in the properties of the original rocks, resulting in softer and less resistant rocks to weathering. The study area contains many rocks that have oxidized due to the presence of iron in their chemical composition. (Al-Daraji, 2011, p. 100).

4. Chemical weathering due to carbonation: This is one of the prevalent processes in the study area due to the presence of limestone rocks affected by acid rain, which contains carbon dioxide gas. Alternatively, it may result from the reaction of water vapor with atmospheric carbon dioxide with limestone rocks, forming carbonic acid. This acid then combines with limestone rocks, which have the ability to dissolve them. As a result, cavities form in the rocks due to this acid, especially in the Damam and Um Ardhma formations in the central part of the study area. (Al-Daraji, 2011, p. 101).

Erosion process:

$$H_2o \quad + \quad C0_2 \quad \text{————} \quad H_2Co_3$$

$$CaCo_3 \quad + \quad H2Co_3 \quad \text{————} \quad Ca\,(HCo3)_2$$

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The process of erosion is one of the significant geomorphological phenomena that influence changes in the Earth's surface features and landmarks. The impact of erosion varies depending on several factors, including the geological formation of the exposed surface and its resistance, as well as the topographic and vegetative characteristics of the area. Moreover, the type of erosion force, whether it be wind or water erosion, also plays a crucial role. In the research area, the geographical location and nature have made water and wind significant factors influencing the erosion process over different periods.

1. Water Erosion (Hydraulic Erosion):

Water erosion refers to the process by which sediment is detached, transported, and deposited by the action of flowing water, including streams, rivers, and rainfall. In this context, it's essential to distinguish between two terms: "River's Load" and "River's Load Carrying Ability" or "River's Competence." River's Load refers to the amount of sediment carried by a river at a given time, while River's Competence refers to the river's capacity to carry sediment, which depends more on its size than its velocity. Generally, water erosion results from heavy rainfall and runoff, which carve and disintegrate rocks into smaller particles, transporting them to other locations. The impact of water erosion varies depending on the terrain. For instance, in plateau areas, sheet erosion predominates, whereas in regions with elevated slopes like hillsides and rocky cliffs, gully erosion is dominant. Key geomorphological features resulting from water erosion include watercourses and Badlands. To determine the potential of water runoff, the Fournie coefficient is commonly used and can be calculated using the following equation (Goody, 1964, p. 45).

Given:

- A.F.I = Potential of water runoff
- Pi = Monthly rainfall expressed in millimeters
- P = Annual rainfall expressed in millimetres

When applying the equation to the research area and calculating the amount of rainfall, it became evident that rainfall-induced erosion in the area is very weak. It falls within the Fournie criterion as having a "low gradient," as shown in Table (2). The results for the annual total were 13.71 millimeters at the Najaf station. The highest value for the runoff potential was recorded in November (4.37 millimeters), while the lowest results were in May (0.19 millimeters). Table (3) indicates that the reason for the high value in November is attributed to exceptional rainfall in the area during November 2013, when heavy rainfall occurred throughout the research area, resulting in a total rainfall of 103.3 millimeters at that time.

$$A.F.I. = \sum_{i=1}^{12} \frac{(Pi)^2}{P}$$

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Table (2) Standards for the actual precipitation capacity according to the Fournet criterion

	Description	**Standard Value**
1	Little Drift	Less Than 50
2	Moderate Drift	500 – 50
3	Extreme Drift	1000 – 500
4	Very Severe Drift	More Than One Thousand

Source: Sarhan Naeem Al-Khafaji, Hydrogeomorphology of the Euphrates River between Al-Khader and Qurna Districts, doctoral thesis (unpublished), College of Arts, University of Baghdad, 2008, p. 62.

Table (3) The actual capacity of rainfall according to the Fournet criterion for the Wadi Tawil al-Ukla basin.

total	December	November	October	September	August	July	June	may	April	March	February	January	Months
92.81	14.63	20.15	6.41	-	-	-	-	4.15	13.94	7.73	10.96	14.84	Rain rate
/	2.31	4.37	0.44	-	-	-	-	0.19	2.09	0.64	1.29	2.38	A.F. I

Source: From the work of researchers based on Table (1).

The process of wind erosion (Aeolin Erosion):

In this process, two phenomena contribute, making it difficult to determine which one has a stronger impact. Abrasion involves the lifting and carrying of fragmented rock materials such as sand and dust with specific sizes, while the process of sculpting occurs through the influence of winds laden with rock particles, often resulting in sandstorms that carve and erode rocks (Jouda, 1964, p. 23). This erosion occurs on the exposed surface of the earth, where the layer is fragmented and dry, especially in dry or semi-arid regions. Wind erosion can be described as the transportation of fine dry particles due to the kinetic energy of the winds. It has played a significant role in shaping many geomorphological features in the research area due to its effect on the region's rocks, including features such as wind caves and rocky beds.

The work of the winds here involves the demolition and erosion of rocks, particularly in the lower parts of the rocks, as winds cannot carry rock particles or

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sand to significant heights except in some cases where the rocks are brittle and more responsive to the process of demolition and erosion (Karbala, 2011, p. 211).

Climatic susceptibility to wind erosion:

The impact of climatic factors and their contribution to wind erosion, which includes wind speed, temperature, actual rainfall, and evaporation rate, can be estimated using the climatic susceptibility equation proposed by the Food and Agriculture Organization (FAO) in 1979. This equation is widely used in most dry and semi-arid regions to assess climatic susceptibility. It allows for the estimation of monthly climatic susceptibility values, formulated as follows (Yang Fengbo, 2016, p. 29):

$$\mathbf{C = 386\frac{(V)^3}{(PE)^2}}$$

Where:

- C represents the climatic susceptibility index for wind erosion.
- \ (V^- \) is the average wind speed in miles per hour.
- PE is the actual precipitation, obtained using the following Thornthwaite equation:

The value of effective precipitation for Thornthwaite is obtained using the following equation (Al-Janabi, 2011, p.115):

PE=115$\left(\frac{\mathbf{P}}{\mathbf{T-10}}\right)$

Given:

- \ (PE \) = Effective precipitation for Thornthwaite.
- \ (P \) = Actual precipitation.
- \ (T \) = Average temperature in Fahrenheit.

When applying the equation to the study area using the climatic data in Table (1), it is evident that the region has an extremely high wind erosion susceptibility value, reaching (763.01), classified as extremely high erosion susceptibility according to the climatic susceptibility index. Table (4) shows that the precipitation rate was \ (3.66\) inches, the wind speed was \ (4.29\) miles per hour, and the average temperature was (76.6) degrees Fahrenheit. This is attributed to the high wind speed, low precipitation, high temperatures, and evaporation.

Table (4): Degree of erosion according to the climatic susceptibility index for wind erosion

Presumption of climatic susceptibility to wind erosion	**Degree of erosion**
17 – 0	Very little erosion
35 – 18	Little erosion
71 – 36	Moderate erosion
150 – 72	High erosion
More than 150	Very high erosion

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Source: Adnan Hazza Al-Bayati, and Kazem Musa, Climate and Wind Capabilities in Iraq, Journal of the Iraqi Geographical Society, No. 23, Al-Ani Press, Baghdad, 1989, p. 79.

Classification of Landforms in the Study Area:

The natural factors that contributed to shaping the landforms in the study area varied in their geomorphological characteristics, in addition to the influence of other processes that significantly affected the formation of land features. Therefore, the classification and analysis of landforms are related to land units and geomorphological factors, which constitute a balance between land and environmental units (ITC, 1986, p. 30).

1. Rocky Outcrops:

Rocky outcrops are small, flat-topped hills with steep sides, characterized by the accumulation of rocky debris at their lower edges resulting from weathering of rock fragments, sand, and soil. This phenomenon represents an advanced stage of rock tables due to the intense wind erosion of rocky surfaces. When rock tables are continuously exposed to weathering and erosion processes, especially on rocks with low cohesion, they may lose equilibrium, causing the upper solid portion to collapse, resulting in the elevation of these rocky outcrops higher than their upper surface extension. They are then referred to as rocky outcrops or buttes (Plummer & McGeary, 2001, p. 321). These geomorphological features are found near rock tables in the study area because they originated from them. Their height ranges from 5 to 10 meters. Since these rocky outcrops are composed of limestone rocks, they are less affected by various weathering factors except for the upper layer, which is thin.

Picture (1) rock evidence in the search area

Source: Field study - photo dated 11/6/2023

2. Sand Dunes:

Sand dunes are accumulations of sand found within a defined area, with their peaks taking various shapes, sometimes resembling domes or circles. These formations are the result of strong wind erosion of sand, leading to the lowering of the

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sand dune and its adoption of a dome shape (Al-Daraji, 2019, p. 219). These dunes are widespread in the study area, exhibiting prominent geomorphological forms, and are used by the local Bedouins as landmarks within the area due to their distinctive natural features, as depicted in Image (2).

Image (2): Sand dunes in the study area.

Source: Field study - photo dated 12/4/2023

3. Badlands:

Badlands refer to desert lands that have been affected by water erosion, resulting in the formation of a network of gullies and ravines due to seasonal floods. Consequently, these areas have become difficult to exploit or utilize, earning them the name "Bad Land" due to the impact of water erosion. Badlands are found in various areas within the study area, particularly in the southern part, with water erosion, especially sudden rainfall, being the primary cause of their formation.

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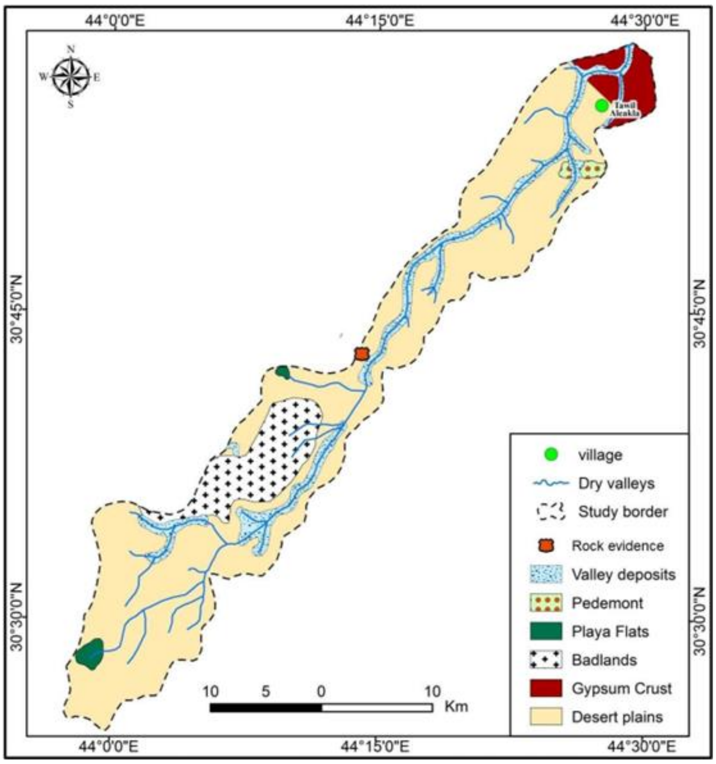
4. Hamada (Rock Pavement):

Hamada refers to flat lands composed of rock fragments and gravel, where the rock pieces are closely packed, giving the appearance of a paved surface in sandy soil (Nasif, 2016, p. 189). This phenomenon covers extensive and flat surface areas, characterized by coarse stones and gravel that cannot be moved by the wind due to their weight and size, thus remaining in place. Hamada formation is associated with the presence of desert pavement, which is formed by wind erosion, transportation, and deposition of fine sediments, leaving behind gravel and large stones. This phenomenon is depicted in Image (3) and is located in the northeast of the study area, as indicated on Map (5).

Image (3): Hamada phenomenon in the study area.
Source: Field study - photo dated 12/4/2023

Map (5) Geomorphological Forms of The Wadi Tawil Al-Ukla Basin



Source: Republic of Iraq , Ministry of Industry and Minerals, Iraqi Geological Survey, Geomorphological map Iraq, SCALE 1:000 000, 1997.

5. Wind Erosion Caves:

Wind erosion caves are geomorphological features found in the study area, formed on the sides of rocks with varying hardness. They are the result of wind

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abrasion, especially on the sides of rocks facing the prevailing winds in the study area, which are the northern and northwestern winds. Wind erosion caves vary in size depending on the nature of the rocks and the intensity of wind erosion. They are found on rock outcrops and cliffs in various areas of the study region, particularly in the central part. Refer to Image (4) for an illustration.

6. Gypsum Crust:

Gypsum crusts are sedimentary deposits consisting of needle-shaped crystals formed due to the low activity of water in leaching salts from the surface. This accumulation of salts, along with high evaporation rates, contributes to the formation of gypsum crusts. These crusts are composed of secondary gypsum or soils containing a high percentage of gypsum, forming fine-grained particles mixed with greener soil. The presence and distribution of gypsum crusts indicate alternating periods of dry and wet climates. During wet periods, rainwater dissolves gypsum components in the formations, transporting and depositing them in the underlying layers. In times of drought, groundwater rises to the surface through capillary action, causing the dissolution of previously deposited gypsum formations. Upon evaporation, solid gypsum materials accumulate on the surface in crust-like layers. Gypsum crusts are found in the northern part of the study area, as depicted in Image (5).

Picture (4) wind cavitation in the research area

Source: Field study - photo dated 12/6/2023

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Picture (5) Gypsum Veneer in The Search Area

Source: Field study - photo dated 1/13/2024

7. Salt Pans:

Salt pans are soils enriched with salts, formed as a result of the combination of dryness and heat. The evaporation of their water or moisture content leaves behind salts with varying chemical compositions, which form the salt crust. The thickness of this crust depends on the location of the salt pan, the rate of evaporation, and the number of deposited salts. Several factors contribute to the formation and composition of salt pans, affecting their physical and chemical properties. The impact of these factors varies depending on the general environmental conditions under which the salt pans formed. Salt pans may result from natural factors such as geological and topographical formations, or they may be influenced by climate, water resources, or inherent formation characteristics. Salt pans are in the southwestern corner of the study area, as shown in Image (6).

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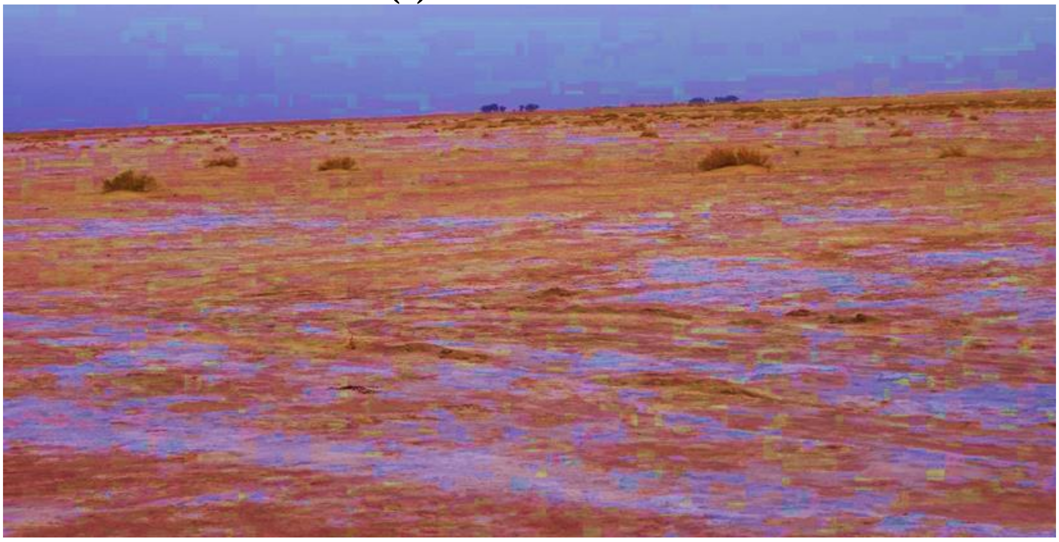
Photo (6) Sabkha in The Search Area



Source: Field study - photo dated 1/13/2024

8. Valley Bottom Deposits:

Valley bottom deposits consist of a variety of rock debris carried by flowing water during the rainy season. These deposits include large rock fragments found at higher elevations, which decrease in size as they approach lower elevations due to reduced water flow towards the downstream end. This reduction in water flow occurs either due to water infiltration into the ground or evaporation, weakening the ability of the flowing water to carry and transport larger rock fragments. Consequently, these fragments begin to settle according to their size. Therefore, large rock fragments are predominantly found in the bottoms of valleys closer to their source rather than their mouth.

Additionally, the characteristics of the valley channel, such as its depth and width, play a significant role in determining the size of the deposits. Deeper and narrower valleys increase the velocity of flowing water, enhancing its ability to carry larger rock fragments. Moreover, the type of rocks presents in the valley and their response to water erosion or dissolution, particularly limestone rocks, influence the nature of the deposits. Similarly, the type of sediment at the bottom of the valley and the degree of slope also affects the water's capacity to transport sediments.

Natural vegetation density impedes the transport of materials, leading to their deposition. In the research area, valleys near the mouth contain sandy materials mixed with silt and clay, along with some rocks characterized by their high permeability and porosity, allowing water to seep into the ground. Some natural plants grow in these areas. All these factors contribute to the reduced capacity of water to transport rocks. This phenomenon is observed in a north-eastward-oriented strip in the research area.

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6. Conclusions:

1. The research indicates that the formations in the study area belong to the third era, represented by the Middle Dammam Formation, the Upper Dammam Formation, and deposits from the Quaternary period.
2. The study reveals that the elevations in the basin of Wadi Tayyil Al-Akla range from the highest elevation of 350 meters to the lowest elevation of 170 meters, with a difference of 180 meters.
3. The research compares the natural factors in the study area with the geomorphological features shaped by these factors.
4. It is evident from the research that chemical and physical weathering processes in the study area vary depending on the type of rocks and climatic factors. Both water and wind erosion vary based on factors such as surface slope, rock type, sediment quantity and size, and the force of water flow for water erosion, while wind erosion is influenced by wind speed, direction, aridity, type and size of sediments, and natural vegetation.
5. The study unveils that geomorphological features diversify with natural processes, including structural landforms, erosional landforms, and depositional landforms. These features are associated with the type of process that contributed to their formation and evolution.

Recommendations:

1. Improve existing climate stations and establish new stations to obtain up-to-date and systematic climate data scientifically. This is essential for studying and understanding climate and its elements to benefit various human activities and future practical studies.
2. Construct some earthen dams to channel water during flash floods in specific low-lying areas within the region. This serves the purpose of utilizing excess water for later use and reducing water seepage into the ground, benefiting human activities such as agriculture and grazing.
3. Take measures to mitigate the risk of wind erosion and sand encroachment on agricultural and pastoral lands, as well as the hazards of dust storms. This can be achieved through planting trees to act as windbreaks and sand barriers, digging trenches, and constructing fences to prevent sand movement into other areas.

References

1. Abu Al-Azz, Hamad Safi Al-Din, Earth Crust (Geomorphological Study), Nahdet Al-Nahda, Cairo, 1976.
2. Abu Samour, Hassan and Ali Ghanem, Introduction to Physical Geography, Safaa Printing, Publishing, and Distribution House, Amman, 2015.
3. Al-Daraji, Saad Ajil, Fundamentals of Landform (Geomorphology), Knowledge Treasures House, Jordan, 1st ed., 2011.
4. Al-Janabi, Basma Ali Abdul Hussain, Climate and Its Impact on Surface Features in Wasit Governorate, University of Baghdad, Ibn Rushd College of Humanities,

DOI: https://doi.org/10.33193/JEAHS.44.2025.632
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www.jeahs.com
Volume (44) April 2025
العدد (44) أبريل 2025

Unpublished Master's Thesis, 2011.
5. Al-Khashab, Wafiq and others, Geomorphology: Definition, Evolution, Fields, and Applications, Vol. 1, University of Mosul Press, Mosul, 1987.
6. Al-Samaraie, Qusay Abdul Majid, The Climate of Iraq in the Past and Present, Al-Adab Journal, Issue (50), 2000.
7. Al-Yasiri, Mohammed Rawi Yasir, The Impact of Climatic Characteristics on Rice Cultivation and Production in Najaf Governorate, Unpublished Master's Thesis, University of Kufa, College of Arts, 2022.
8. Barwari, Anwar Mustafa, Nasir Aziz Salwiya, General Directorate of Geological Survey and Mining, Geological Report of Najaf Plateau, IG 38-3, and IG AM 32, Iraq, Baghdad, 1995.
9. Gouda, Hassanein Gouda, Wind Erosion, Faculty of Arts Journal, Alexandria University, Volume 18, Issue 2, 1964.
10. International Institute for Aerial Survey and Earth Sciences (ITC), Textbook VII-6: Terrain Analysis and Classification Using Aerial Photographs, 1976.
11. Karbal, Abdul Ilah Ruzouqi, Earth Forms (Geomorphology), Dar Al-Nomouzajiya, Beirut, 1st ed., 2011.
12. Lahmood, Asaad Salim, Geographic Analysis of Desert Tourism Components in Najaf Governorate, Unpublished Master's Thesis, University of Kufa, College of Arts, 2011.
13. Nsaif, Falah Shamkhi, Geomorphology of Al-Huweimi Basin, University of Baghdad, Ibn Rushd College of Education, Doctoral Dissertation, 2016.
14. Plummer, Charles C., David McGeary, and Diane H. Carlson, Physical Geology, McGraw-Hill Higher Education, New York, 2001.
15. Shateet, Jabbar Hussein, Geomorphology of Aeolian and Evaporative Features (Sabkha) in Al-Muthanna Governorate and Its Impact on Human Activities, University of Baghdad, Ibn Rushd College of Education, master’s Thesis, 2019.
16. Thornbury, W.D., Principles of Geomorphology, 2nd ed., USA, John Wiley and Sons, New York, 1962.
17. Wattoun, Kenneth, Arid Regions, translated by Ali Abdulwahab, Bor Said Printing House, Alexandria, 1976.
18. Yang, Fengbo, Lu Changhe, Assessing Changes in Wind Erosion Climatic Erosivity in China's Dryland Region during 1961-2012, Journal of Geographical Sciences, September 2016.