Journal of Geoscience and Environment Protection, 2023, 11, 197-219
https://www.scirp.org/journal/gep
ISSN Online: 2327-4344
ISSN Print: 2327-4336

Analysis of Morphometric Parameters and Radioactive Characteristics Using Remote Sensing Data and GIS Techniques in the Wadi Wizr Basin Area, Central Eastern Desert, Egypt

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How to cite this paper: Hammouda, S. A. I., & Mahmoud, S. A. E. A. (2023). Analysis of Morphometric Parameters and Radioactive Characteristics Using Remote Sensing Data and GIS Techniques in the Wadi Wizr Basin Area, Central Eastern Desert, Egypt. *Journal of Geoscience and Environment Protection, 11,* 197-219.
https://doi.org/10.4236/gep.2023.116014

Received: May 4, 2023
Accepted: June 27, 2023
Published: June 30, 2023

Abstract

The purpose of this study is to demonstrate how modern technologies such as geographic information systems (GIS) and digital elevation models can help in the creation of a geographic database for the Wadi Wizr basin in Egypt's Central Eastern Desert, in addition to examining and analysing the radioactive properties of various rocks. This was accomplished with the help of a digital elevation model (DEM) with a 30 metre accuracy and GIS software in 10.8 Arc Map. The RS-230 was also used to measure uranium and thorium concentrations. GIS softwares and digital elevation models have been shown to be more effective than the traditional method. This was demonstrated by the flexible and quick working method, the accuracy of the parameters used, and the results of the morphometric analysis of the basin river network. In addition to, the main drainage pattern from subtype to tree type, where the branching ratio was (1.59). This basin could also cause flooding. Similar studies, according to the results of this study, should make greater use of geographic information system technology and modern data sources. Wadi Wizr also has a radioactive anomaly, with uranium equivalent concentrations reaching 70 ppm in some fault parts.

Keywords

Wadi Wizr Basin, Morphometric Analysis, Drainage Pattern, Radioactive Characteristics, Remote Sensing, Geographic Information System

1. Introduction

In all areas of comprehensive development, applied GIS research, particularly geomorphological investigations are becoming increasingly relevant. Where, geomorphology study is aided by substantial scientific and technological advancements in the realm of services given by specialised GIS programs, satellite imagery, and digital elevation models (DEM). These cutting-edge techniques have proven crucial in geomorphological research, notably in the study of morphometric features. Advanced methodologies, in addition to field studies, are one of the pillars on which geomorphological research is founded (Mahsoub & Dahi, 2006).

When studying drainage basins, morphometric analysis becomes more important because the results can be used to identify drainage network characteristics that are useful in determining the basin's size and breadth, as well as the amount of water that drains and the predictability of that water in any part of the basin. Additionally, estimates of flow speed and the ability to predict flood risks are linked to an increase in the volume of erosion and sedimentation within water basins. It is also useful in determining relief and regression. All of this is accomplished through the creation of a digital geographical information base, which serves as the foundation for geographic information systems in order to make the best use of data, particularly data that varies in terms of type, quantity, quality and source and is difficult to manage without information integration.

These study elements and their results are required by drainage basin planning and development management projects, which are concerned with ministries of planning and development such as planning, environment, water resources, and agriculture. Finally, these findings provide measurements and statistical analyses that reveal the role of geomorphological processes in shaping the basin's topographic features and the stage of erosion it has reached. It is also useful in determining the various uses of land, the possibility of planning for natural resource investment, and the construction of dams and aquifers. As a result, the subject of this study is important in developing an accurate morphometric database for the river network of the Wizr basin area while saving time and effort due to its high speed and accuracy in extracting the morphometric variables for this basin, order of river tributaries, measuring these tributaries, and their directions. Furthermore, the creation of digital maps for Wizr basin area morphometric characteristics can be used to manage this basin's natural resources in a developmental manner and achieve sustainable development.

Interest in river basin morphometric studies has grown since the publication of pioneering studies in the first half of the twentieth century, such as (Horton, 1945), followed by (Schumm, 1956), and (Strahler, 1964). Horton classified the river tributaries in 1945, and Strahler did so in 1964. The method of categorising river tributaries was altered by (Yang & Lee, 2001). Several researchers conducted morphometric analyses, using either topographic maps (e.g., Azab, 2009; Ismaeil et al., 2010) or remote sensing and GIS (e.g., Masoud, 2004; Arnous et al., 2011; Youssef et al., 2011; Eleiwa et al., 2012).

Many authors have conducted studies on the Wadi Wizr area, including field geology, remote sensing, structural setting, and mineralogy (e.g., Hassan, 1990;

Ramadan et al., 1999; El-Assmar & Abdel-Fattah, 2000; Abu Elatta & Mansour, 2018). Ramadan et al. (1999) investigated radioactive anomaly zones in Egypt's Central Eastern Desert, including the studied area, using remote sensing and GIS.

The higher radioactive zones are found in Miocene clastic-carbonate sediments at Wadi Wizr, Wadi Abu Gherban, Um Greifat, and Wadi El Sharm El Bahari along normal faults trending NW-SE. Additionally, Ramadan et al. (1999) and Abu Elatta and Mansour (2018) demonstrated that higher radioactive zones are associated with intense hydrothermal alterations.

Given the Egyptian state's interest in the Egyptian coastal region along the Red Sea coast in recent decades, as well as the start of an intensive development process that included mining, industry, and tourism, investors were permitted to build several tourism projects along the Red Sea coast at a distance of about 50 to 300 metres from the beach. It was necessary to develop these areas in order to conduct flood and flood risk management. In addition to conduct radiometric measurements that has an impact on humans. To determine whether or not there are radioactive anomalies in the study area, radiometric measurements were taken in the Wadi Wizr basin by measuring eU and eTh for all rocky units and stream sediments. As a result, this research was carried out in the Wadi Wizr basin as a case study on the western coast of the Red Sea in Egypt's Central Eastern Desert, and the geographer will play an important role in determining the positive and negative effects, as well as the changes that may occur in the near future and in the distant future.

2. Geological Setting

The Wadi Wizr basin research area is located in Egypt's Central Eastern Desert, between the foothills and the Red Sea coast. This area is located between latitudes 25˚41'20" and 25˚47'50"N and longitudes 34˚20'00"E and 34˚29'10"E. (**Figure 1**). The inland part of the Wadi Wizr basin is covered with chains of basement and sedimentary rocks that run parallel to the Red Sea coast. It is distinguished by a number of distinct masses and peaks. Slope gradients are generally steeper to the west in the upper drainage reaches and gentler to the east. The slope gradients are generally steeper in the upper streams and gradually decrease as one approach the Red Sea.

The geomorphologic features of the basin include basement rocks overlain by a sequence of sedimentary rocks (**Figure 2**). Metasediments, metavolcanicas, gabbro, and alkali feldspar granite are the mappable exposed basement rocks (Ali, 2001). The metasedimentary rocks have been highly altered and have a low to moderate relief.

The metasedimentary rocks are highly altered and characterized by a low to moderate relief. They are composed of schists, metagreywackes, slates and minor masses of polymictic metaconglomerates that are characterized by yellowish to greenish-gray coloures.

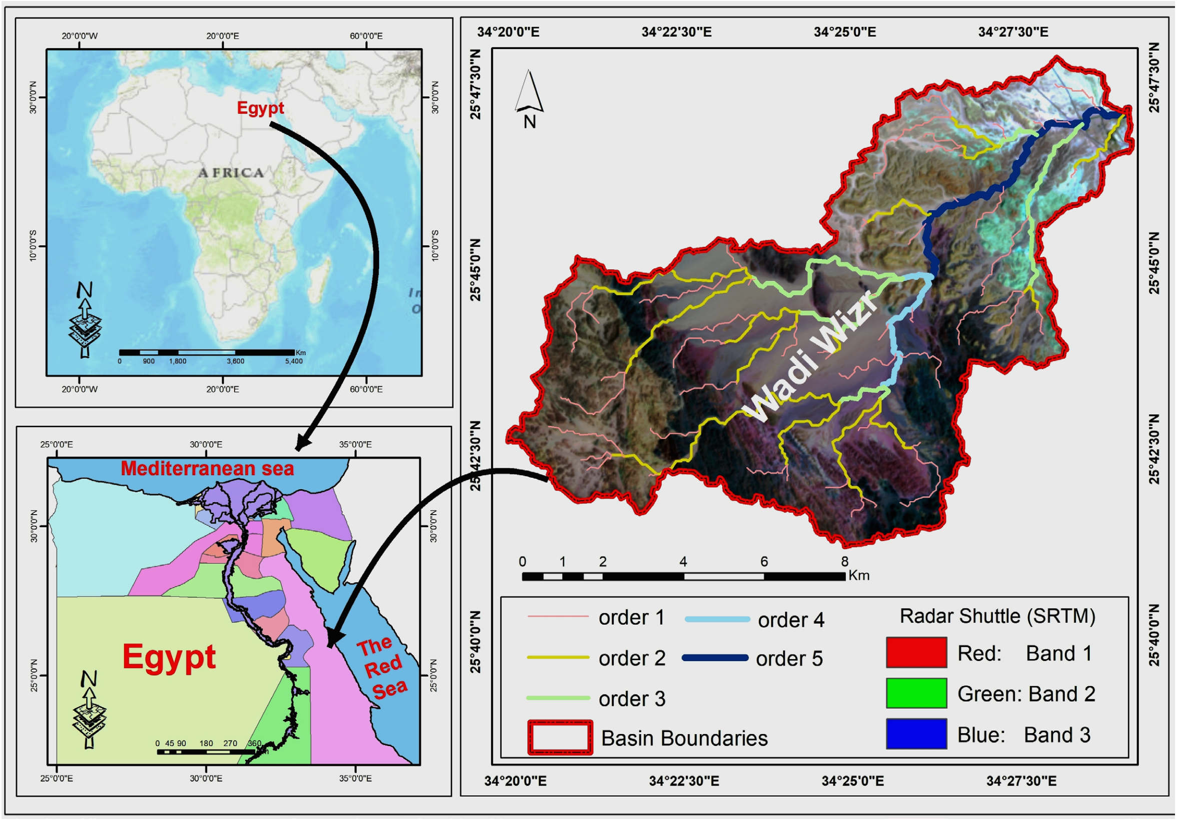


Figure 1. Location map of the Wadi Wizr basin area, Central Eastern Desert of Egypt.

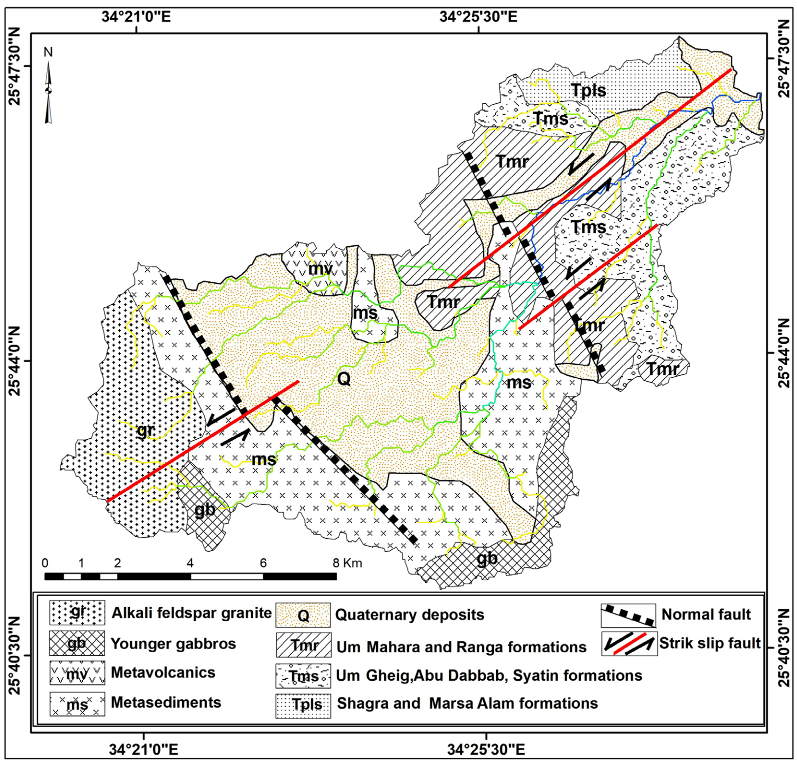


Figure 2. The geological map of the Wadi Wizr basin area, Central Eastern Desert of Egypt (modified after Ali, 2001; El-Assmar & Abdel-Fattah, 2000).

In the Wadi Wizr basin, metavolcanics comprise a sequence of stratified lava flows intruded by alkali feldspar granites and interbedded with associated pyroclastics. They are made up of a thick succession of dark green to grey meta-andesite lava flows, as well as metabasalt, metadacite, and metarhyolite to a lesser extent. The pyroclastics are very fine-grained and come in a variety of colours, including greyish green, light to dark green, black, and buff. They've been banded, jointed, exfoliated, weathered, and altered significantly. The tuffs are made up of ash and lithic lapilli. The compositions of these rocks range from basaltic to andesitic, dacitic to rhyolitic.

Younger gabbros are medium- to coarse-grained and range in colour from greenish-black to black. They include olivine gabbro, hornblende gabbro, and leucogabbros. They're massive, hard, and compact, with boulders and spheroidal blocks visible.

Alkali feldspar granites have a medium to coarse grain, a buff to reddish brown colour, and are jointed, fractured, and weathered. They have well-observed porphyritic textures. K-feldspar, quartz, plagioclase, mafic minerals, and iron oxides make up the majority of these rocks.

Wadi Wizr's exposed sedimentary rocks formed during the Miocene and Pliocene epochs (Said, 1990; Hassan, 1990). These formations are listed in chronological order as follows: Shagra, Marsa Alam, Um Gheig, Abu Dabbab, and Um Mahara.

The Shagra Formation is primarily composed of yellowish to red and dark brown sandstones. It is underlain by Marsa Alam formation, which is composed of fine- to coarse-grained siliciclastic and lacustrine limestone. The Um Gheig Formation is primarily made up of crystalline carbonate, algal matter, and local reefal limestone. It is composed of anhydrite and is underlain by the Abu Dabbab Formation. It is supported by the Syatin Formation, which is primarily composed of fine-grained calcareous silisiclastics. The reefal and algal carbonates, as well as bioclastics, make up the majority of the Um Mahara Formation. Ranga Formation, which is mostly made up of siliciclastic agglomerates, sandstones, and siltstones, lies beneath it.

The Wadi Wizr basin's Quaternary sediments are mostly covered by dry drainage networks that are linear as a result of structural control. They vary in width and length and are filled with sands and gravels as well as angular, subangular, and sub-rounded basement and sedimentary rock fragments.

The Wadi Wizr basin has the same climate as the Red Sea coastal plain, between El Qusseir and Marsa Alam towns, with arid climate conditions and annual temperature ranges of 30˚C - 15˚C in winter and 50˚C - 35˚C in summer. Furthermore, in the winter, the nighttime temperature can fall below 10˚C. Rainfall precipitations are uncommon and typically occur once every few years in the form of a torrent over a short period of time. The relative humidity ranges from 28% in the summer to 57% in the winter. In the winter, the average evapotranspiration rate is 8.7 mm/day, while in the summer; it is 28 mm/day

(El-Anwar, 1983). As a result, terrace sediments form in Wadis, with little reworking.

Uranium and other mineral deposits were discovered in the oxidised sequence of Phanerozoic sedimentary rocks (**Figure 3**) that overlain basement rocks. They are found along normal fault zones running NNW-SSE, particularly near the contacts between basement and sedimentary rocks. These deposits could have formed as a result of oxidised fluids originating from younger igneous rocks hidden beneath the sedimentary sequence. Where hydrothermal solutions move along normal faults, they react with the surrounding rocks, resulting in the precipitation of redox-sensitive materials (Abu Elatta & Manssour, 2018).

The vegetation cover in the Wadi Wizr basin is sparse and is primarily dependent on the drainage channels that collect and contain runoff water. As a result, plant life can be divided into two categories: fast-growing and ephemeral plants that rely on rain, and perennial plants that can exploit moisture stored underground in the soil.

3. Methods

Geographic information systems and their advanced digital data sources were used due to the accuracy of morphometric measurements, the vast amount of data and information, and the diversity of their sources. They are automated technical means that achieve measurement accuracy, classification speed, and processing and analysis diversity. By utilizing the digital elevation model (DEM), a geographical database with variables was constructed.

Figure 3. Field photos showing, (a) Panorama of sedimentary rocks, Wizr basin, looking NE (b) a part of U anomaly zone and, limonitization, looking N (c) a part of U anomaly zone and hematitization, looking SE.

This study went through several stages, beginning with the collection of official data from previous studies and other sources. Then, the data from the shuttle radar topographic mission (SRTM), which includes the three-dimensional digital elevation models, were obtained and extracted from the American Satellite. This was followed by field studies and a radiometric survey to determine the equivalent uranium and thorium in various rock units and stream sediments. Finally, the information base is being built, indicators are being applied, digital maps and results are being extracted (Figure 4).

3.1. Geographical Information System (GIS) Analysis

Technical research steps were prepared by relying on the ARC GIS programme, which is one of the geographic information systems programmes. This programme was produced by the American company (ESRI) in its latest version (Arc Map 10.8) and its accessories, which are based on the SRTM radar visual, which includes altitude values (Digital Elevation).

Three-dimensional models with a distinction of 30 metres were extracted from the Shuttle Radar Topographic Mission (SRTM) satellite for the year 2021 AD. These were obtained from the US Geological Survey (USGS) website in order to derive the basin and river network. As a result, the stream order was automatically determined by performing the treatment with the hydrological tools in the 10.8 Arc Map programme, defining the study area, and making an approximate shear of a basin and a button. Then, using the (Fill) command, performs the height correction process and extract the flow direction layer, flow accumulation layer, conditional layer, and flow arrangement. The flow arrangement was then converted from the raster layer to the vector layer.

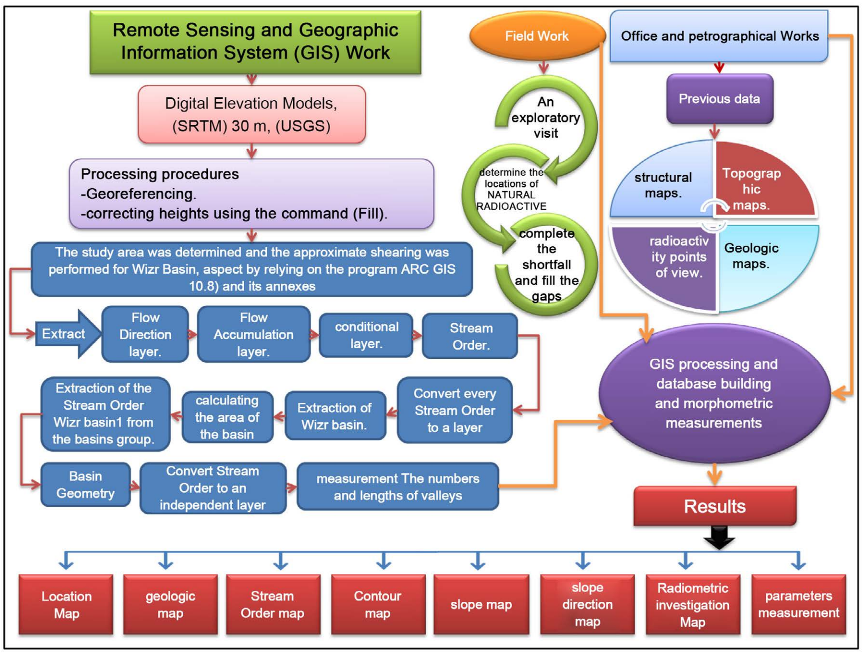


Figure 4. A flowchart showing the different techniques used in the current study of the Wadi Wizr basin area, Central Eastern Desert, Egypt.

(DEM) was used to create the drainage network's ranks and dispose of drainage basin subsidiary basins. The process of converting the drainage network ranks into an independent layer and merging for each rank resulted in the extraction of the number and length of valleys for each rank. Finally, the area, perimeter, length, and width of the basin, as well as the lengths of the river ranks, were calculated. Then, based on those fundamental elements, construct morphometric equations to reach the study's conclusions. Digital maps and morphometric characteristics are used to represent the results.

Furthermore, the extraction of slope maps and their trends on SRTM Digital Elevation Models using surface tools in the 10.8 Arc map programmer. Where we used the Egyptian General Petroleum Corporation's geological map of the Mount Hamata Plate (1:500,000) Cairo, Egypt, 1987.

3.2. Field Observations and X-Ray Spectrometric Measurements

When maps and aerial images fail to describe certain phenomena, field studies are always the most essential source of geomorphological research.

The Egyptian Nuclear Material Authority (NMA) conducted extensive geological exploration in Egypt's Eastern Desert. This includes taking notes on erosion and sedimentation sites as milestones in the evolution of the phenomenon and their effects on the study area's environment.

Continuous visits to the study area can reveal the locations of natural radioactive occurrences and their characteristics, diversity in geographical directions, and monitoring the features of the map of these occurrences. A field investigation trip was conducted for 35 high radioactivity sites, 15 of which were from stream sediments. These locations were determined by digging holes to a depth of approximately 60 cm with a stone cutter and shovel. Furthermore, 20 Miocene sedimentary rock sites (6 in carbonates, 9 in mudstones, and 5 in rocks) representing the rocky outcrops in the study area were radiometrically measured. A portable gamma-ray spectrometer, model RS-230, manufactured by Canada, was used for field investigations. The term "equivalent," or its abbreviation (e), refers to the assumption of equilibrium between the radioactive daughter isotope monitored by the spectrometer and its relevant parent isotope. U^{238} was measured using gamma rays emitted by Bi^{214} at 1.76 MeV, and Th232 was measured using gamma rays emitted by Tl208 at 2.62 MeV.

4. Results and Discussion

4.1. Formal Characteristics of the Drainage Network

The river drainage network (drainage network) is a collection of streams and tributaries that feed into one main stream (Salama, 2010).

The study of the drainage network's characteristics is critical because it reflects structural characteristics of the rocks in terms of fractures, torsion, and separations, as well as types of rocks in terms of porosity and permeability, and climatic characteristics (especially rain), and it is a direct factor in the formation of river tributaries. It also reflects the basin's geomorphological stage (Abdel Aziz, 2008).

1) Derivation of the river network and determination of the order of its streams

When river tributaries (streams) near the river are divided and classified into ranks according to a specific system and hierarchy within the basin, the process of studying and analysing the river tributaries and providing a clear picture of the drainage network system is facilitated (Table 1 & Figure 5).

Table 1. Length and bifurcation ratios of the stream order of the Wizr basin area, Central Eastern Desert, Egypt.

Stream Order	Stream Number	Bifurcation Ratio (*BR*)	Sum Stream Lengths (km)	Sum Stream Lengths (%)	Stream Length Rate (km)
Order 1	57	-	55.37	44.07	0.97
Order 2	27	1.38	40.18	31.98	2.87
Order 3	12	2.40	16.77	13.35	2.79
Order 4	6	3.63	4.61	3.67	2.31
Order 5	1	0.53	8.71	6.93	8.71
Sum	103	7.94	125.64	100 %	-

Source: Measurements are based on a digital elevation model using Arc Map 10.8.

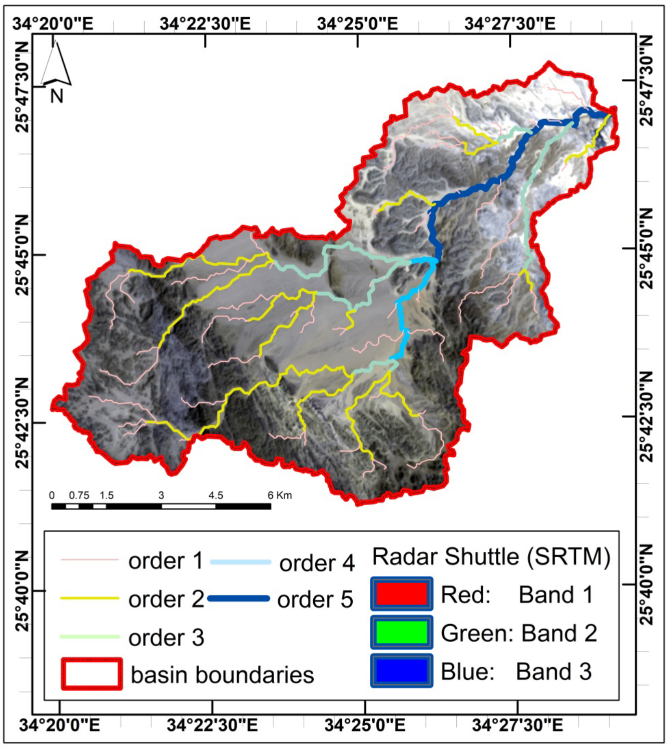


Figure 5. The tree form of the drainage network is shown in the riverine, the Wizr basin area, Central Eastern Desert, Egypt.

The drainage network is depicted in tree form in the riverine, where this morphological model of the drainage network spreads in river basins with equal resistance to the erosion process.

This model includes river branches and elbows in various directions, ensuring that water reaches all parts of the basin equally from the source to the estuary, and the waterways are thus distributed in an orderly sinuous basin. Where is the basin?

It starts with small and numerous streams representing the first rank, and then they merge to represent the second rank.

This rank is less numerous and more spacious than the first, and it joins the third rank and its tributaries to form the fourth rank, from which the fifth rank, which represents the valley or the mainstream, is formed.

According to Strahler's classification, the number of river ranks in the Wadi Wizr basin has reached five. The mainstream is the highest river rank where water and sediments reach from the rest of the river drainage network's tributaries. The basin is in each rank, where the average area of the basin increases with the increase of rank, according to Horton's 1945 law of the area of river basins "low of area basin," which states that the average area of a river basin for rivers of successive groups is a geometric sequence beginning with the average area of a basin of the first order and increasing according to a fixed area ratio (Strahler, 1964; Abu El-Enein, 1981).

2) Number of river tributaries

The total water flow in the basin is included in the number of river tributaries, regardless of size or location within the water basin (Salama, 2004).

The total number of stream segments in the Wadi Wizr basin is (103), with a total length of (125.64 km), of which 57 are first-degree flows, accounting for 44.07% of all segments.

The upper basin is the culmination of the connection of the first rank, the formation of the streams, and their growth as a result of river sculpture, in addition to the fact that the first-order streams are the sewers, the longest and most numerous.

This is an indication of an increase in their ability to erosion on the basin's slopes in comparison to the sewers of this rank, which are the shortest individually (Chorley et al., 1984), followed by the second rank (27) streams with a rate of 31.98%. The third and fourth ranks are comprised of a number of (12-6) streams with a low rate of (13.35% - 3.76%). Meanwhile, the fifth position was reserved for the mainstream, with a rate of (6.93 %).

3) Total stream lengths

The total length of the stream was determined using an automated method within the ARC MAP10.8 geographic information system program.

It was discovered that there is a direct relationship between the total lengths of the waterways in the basin and its area, where it increases with increasing area and decreases with decreasing area (125.64 km). This is because the watercourses of various levels work to increase the basin area through sculpting, which increases its capacity as its lengths and numbers increase, particularly the lower level courses (Abu Raddy, 1991). As a result of this, the volume of water drainage is proportional to the size of the basin and the sum of stream lengths, and it decreases in the basin due to its small area. This reflects the severity of erosion processes and the evolution of the stream, indicating the steepness of the surface and the degree of erosion in its areas.

Meanwhile, the ducts of higher ranks, particularly the main ones, are characterised by their flow and extension over much larger flat areas.

4) Bifurcation Ratio (*BR*)

The bifurcation ratio is the ratio of the number of tributaries in one rank to the number of tributaries in the next rank.

This ratio is an important parameter that affects the hydrological characteristics of the basin because it controls the rate of discharge in the basin and can be used to estimate flood incidence (Mahsoub & Dahy 2006; Abu El-Enein, 1981). According to Strahler (1964), the previous ratio ranges between (3 - 5) in the case of the basin's rocky composition being homogeneous (Chauhan et al., 2013). When the ratio (*BR*) is less than (3), it indicates an increased likelihood of flooding in the basin because it produces rapid surface runoff. The bifurcation ratio (*BR*) is calculated using the following equation:

$$\text{Bifurcation Ratio}\left(BR\right)=\frac{N1}{N2}$$

where $N1$ = order 1, and $N2$ = order 2.

When the previous equation is applied to the Wadi Wizr basin, the bifurcation ratio (*BR*) ranges from 0.53 - 3.63 (**Table 1**). The average bifurcation rate for the entire basin was found to be (1.59). As a result, the geological structure has a significant impact on the drainage pattern, and the basin is a source of flood risk.

5) Drainage Density (*D*)

The degree of contact of the earth's surface with rivers, as well as the amount to which it is affected by downstream activity, is expressed by the density of the river drainage network.

$$\text{Drainage Density}\left(D\right)=\frac{\sum Ls}{A}$$

where $\sum Ls$ = sum of the longest tributaries, and A = total area of the basin.

When this equation is applied to the Wadi Wizr basin, it can be shown that the river drainage network has a density of 1.32 km/km^2, which is low and so the surface formations are very permeable.

4.1.1. Spatial Characteristics

The dimensions of the basin are used as the foundation for interpreting morphometric properties in morphometric investigations. The basin's dimensions provide a natural reality for analysing aspects such as temperature, soil, rock quality, and lithological composition that make it up.

The basin's dimensions were determined using an automated method in the ARC MAP10.8 programme from the ARC GIS programmes package. The surface area and circumference of the pelvis were calculated automatically using the command (Attributes-Calculate Geometry), whereas the length of the pelvis and a button was measured by measuring the straight line between the estuary and the maximum point located on the pelvic circumference in an average subject using the tool Measure.

By dividing the basin's surface area by its length, the width of the pelvis was estimated. As a result, the Wizr basin has a surface area of 95.51 km^2, with a length of 17.07 km, a circle of up to 60.08 km, and an average width of 5.6 km (Table 2).

1) Topography characteristics of the Wizr basin

Topographic features are crucial in the study of water basins and their morphometric properties because they reveal several geomorphological processes as sculpting and sedimentation. It also aids in the comprehension of the water basin sculptural cycle and the evolution of the hydrological network.

a) Basin Relief Topography

The highest and lowest points in the Wizr basin area are 400 metres and 0 metres, respectively. As a result, the basin's topographical value was 400 m. Using the ARC MAP10.8 programme, the height categories in the basin were divided into eight groups. Each category's area, as well as the area of the height difference, the accumulated area, and the ratio of the height difference area and the percentage of the cumulative area for each category, were all measured independently (Table 3 & Figure 6).

b) Relief Ratio

Lower values for this ratio reflect the activity of erosion processes and the retreat towards the sources, while higher values show the extent of erosion for the surfaces of drainage basins. As a result of the basins' progress through their erosion cycle, where high values imply significant erosion of the basin surfaces and, as a result, a delay in the basins' erosion cycle. The difference between its highest and lowest points to its actual length was used to calculate the value of this ratio for the Wizr basin area (Cooke & Doornkamp, 1974).

This rates overall value for this basin was (23.4), which is low and indicates that drifting and retreating processes are active towards the source.

Table 2. Spatial and morphological characteristics of the Wadi Wizr basin area, Central Eastern Desert, Egypt.

Surface area (km^2)	Length of streams (km)	Basin Length (km)	Basin perimeter (km)	Maximum elevation (m)	Minimum elevation (m)	Total length of streams	Basin width (km)
95.51	94.64	17.06	60.08	400	0	125.64	5.60

Source: Measurements are based on a digital elevation model, using (Arc Map 10.8).

Table 3. Distribution of elevation categories in the Wadi Wizr basin area, Central Eastern Desert, Egypt.

Ser. No.	Minimum elevation	Maximum elevation	Height elevation area (km²)	Accumulated space (km²)	Height difference area ratio	Accumulated area percentage
1	0	50	108538.44	2151490.32	5.04%	100.00%
2	50.01	100	527648.35	1623841.97	24.52%	94.96%
3	100.005	150	613231.01	1010610.95	28.50%	70.43%
4	150.002	200	439614.09	570996.86	20.43%	41.93%
5	200.052	250	285609.87	285386.99	13.27%	21.49%
6	250.110	300	147206.65	138180.35	6.84%	8.22%
7	300.076	350	27747.51	110432.84	1.29%	1.38%
8	351.005	400	1894.41	108538.44	0.09%	0.09%
			2151490.32		100.00%	0%

Source: Measurements are based on a digital elevation model, using (Arc Map 10.8).

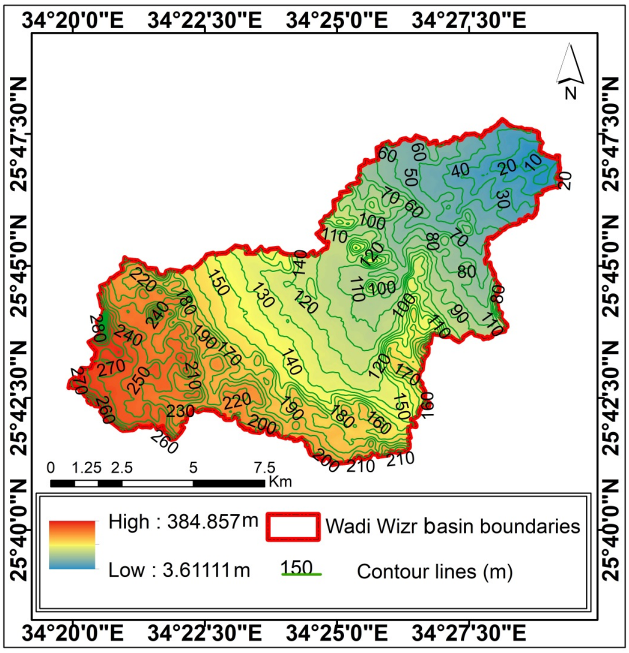


Figure 6. The topographic contour map of the Wadi Wizr basin area, Central Eastern Desert, Egypt.

c) Relative Relief

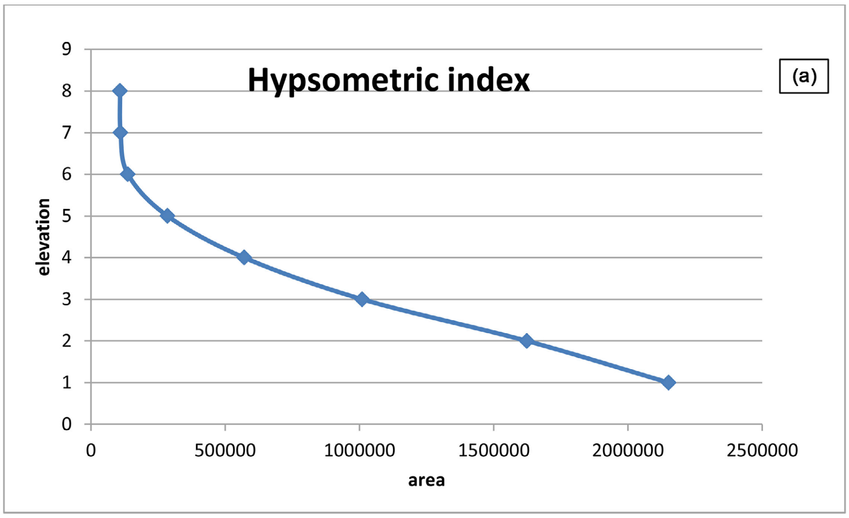
The link between the value of the basin topography and the basin perimeter is depicted by this ratio. Low values indicate weak rock resistance and erosion factor activity, whereas high values suggest rock resistance and erosion factor activity. At constant climatic conditions, Schumm (1956) proved the existence of a negative (inverse) correlation between relative topography and rock resistance. This is a significant morphometric variable in the overall assessment of the topography's morphological qualities.

Due to the high value of its perimeter and the lack of a substantial vertical difference of rocks, the value of this ratio for the Wadi Wizr basin was (0.39), which is low.

d) Hypsometric index

This parameter describes the stage (underground) sculpture that the stream basin passes through, as well as the number of materials that are still to be eroded. To know the stages that the basin goes through, Strahler (1952) separated the values of the hypsometric parameter into categories as follows: less than 40 refers to the ageing stage, 40 to 60 refers to the maturity stage, and 60 to 80 refers to the youth stage.

The hypsometric parameter of the Wadi Wizr basin area has a value of 63 percent. As a result, this basin is still in its infancy, with higher erosion than sedimentation (**Figure 7(a)** and **Figure 7(b)**).



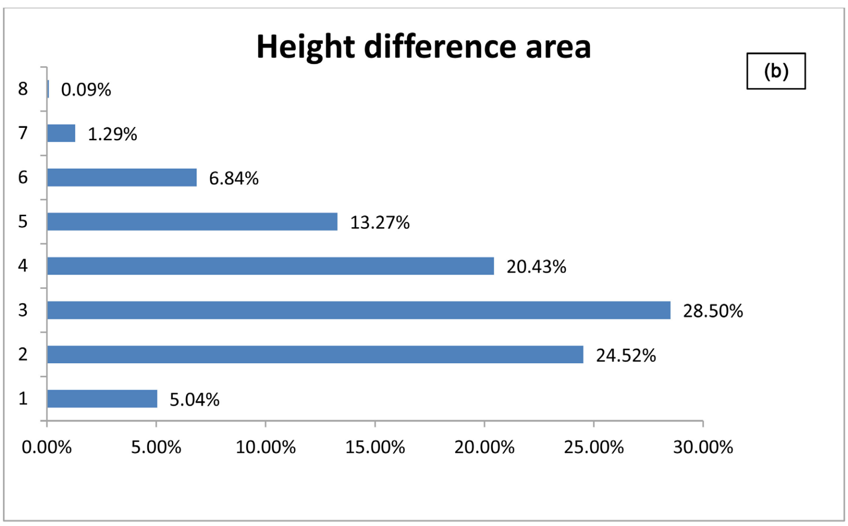


Figure 7. (a) and (b): Values of the hypsometric parameters of the Wadi Wizr basin area, Central Eastern Desert, Egypt.

e) Regression Slope

The diversity and plurality of landforms are related to their various levels and slopes, whereas regression analysis is critical in development planning for the establishment of water and development projects.

The surface of the area (study Wadi Wizr basin) generally descends from south to north and west to east, and the general average of the region's degree of slope reached (1.35 m) equivalent to (1.64; Abu Raiah, 2007). The slope angles within the studied basin varied from one zone to the next. To address this variation, a regression map was created and its zones determined (**Figure 8**).

Young's 1972 classification was used to divide the study area (**Table 4**). It is clear that the lands are soft or lightly sloped, occupying the majority of the basin area and occupying approximately (39.19%) equivalent to (36.82 km^2) of the total surface area of the basin. This is followed by lands with a medium slope (5% - 10%) in the second zone, which occupied about (25.51 percent) of the surface area (23.97 km^2). This is followed by flat and semi-flat lands with a slope value of (0 - 2), a percentage of (24.12 percent) with a surface area of (22.66 km^2), lands above the medium slope (10 - 18) ranked before the last zone with a rate of (10.66 percent) equivalent to a surface area of (10.02 km^2), and the last zone with steep slope (18 - 30). The lowest percentage (1.41 %) was achieved with a surface area of (1.32 km^2).

f) Steep lands, vertical ledges and slopes

The aspect or orientation of the shape in relation to the four primary geographic directions is known as slope.

The steepest regions of the slope directions in a particular location or site are referred to as aspect. The face of the high area or the face of the mountain is indicated by the slope's orientation (Hill face). For each cell in the cellular body of the digital topographical model, the aspect is measured clockwise in degrees, starting from the north with degrees (zero) and finishing in the north to complete a full cycle (360 degrees).

The direction of inclination of the Wadi Wizr basin area differs in the four primary geographic directions, as shown in **Table 5**.

The slope is steep in both locations (37.5 km^2 and 24.5 km^2).

g) Calculation of the direction of inclination aspect

The inclination direction is the aspect or direction of the shape in relation to the four major geographic directions. The steepest areas of the slope directions in a specific location or place are referred to as the aspect. The inclination direction denotes the face of the high region or the face of the mountain. The aspect is measured clockwise in degrees, beginning in the north (zero) and ending in the north to complete a full cycle (360 degrees), with each cell containing a digital topography model. The Wizr basin area's inclination varies in four directions, with the highest area coming from the north and south directions with areas (37.5 - 24.5), respectively, followed by the level direction, the east and west directions with areas (17.5 - 11.5 - 9), respectively, **Figure 9**.

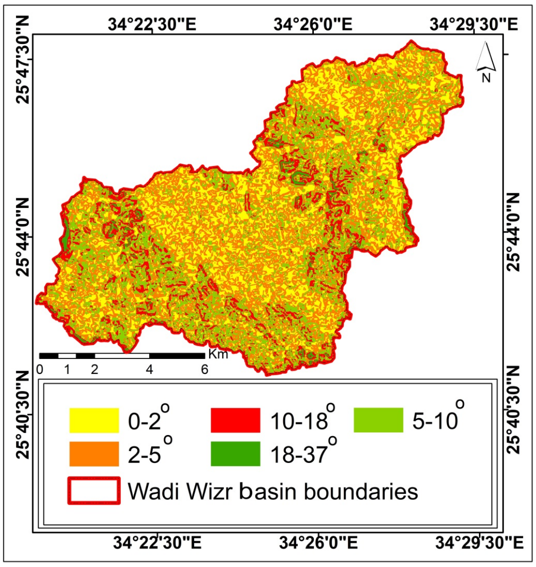


Figure 8. Slope angles within the Wadi Wizr basin area, Central Eastern Desert, Egypt.

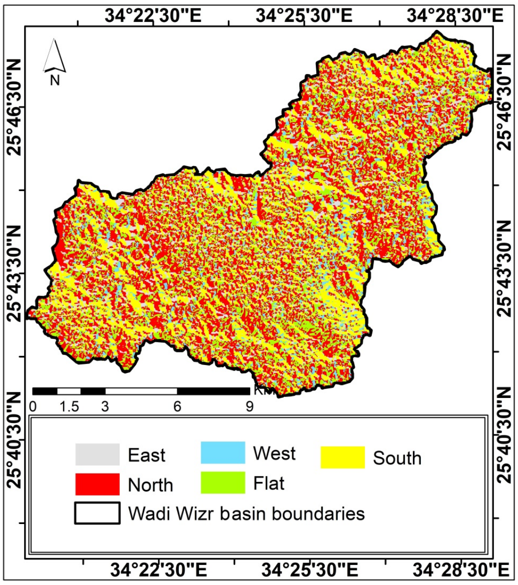


Figure 9. Directions of inclination aspect of the Wadi Wizr basin area, Central Eastern Desert, Egypt.

Table 4. Slope degrees of the Wadi Wizr basin area, Central Eastern Desert, Egypt.

Serial No.	Values in degrees	Grid code	Area	Percentage (%)
1	0 - 2	1	22.66	24.12
2	2 - 5	2	36.82	39.19
3	5 - 10	3	23.97	25.51
4	10 - 18	4	9.19	9.78
5	18 - 30	5	1.32	1.41
	Sum		93.95	100.00

Source: Measurements are based on a digital elevation model using (Arc Map 10.8).

Table 5. Radiometric studies of eU (ppm) and eTh (ppm) in faulted sedimentary rocks in the Wadi Wizr basin area, Central Eastern Desert, Egypt.

Site No.	eU (ppm)	eTh (ppm)
1	11	5
2	50	3
3	65	2
4	31	2
5	24	1.5
6	60	7
7	45	4.5
8	33	0.7
9	41	0.5
10	52	1
11	25	3
12	12	0.5
13	10	1
14	70	8
15	62	6

Source: Field measurements by the RS-230.

h) Ruggedness value

The ruggedness value summarises the relationship between drainage basin topography and drainage density, which indicates the degree of surface intersection with waterways. It also elucidates the geomorphological stage of erosion that the drainage basins pass through. The ruggedness value is directly proportional to the basin topography and drainage density, indicating an increase in ruggedness, severity, and slope length. The high value of ruggedness and drainage intensity is also related to an increase in the volume of surface runoff in drainage basins (Ahmed & Zureikat, 2015). The ruggedness value in the Wadi Wizr basin area is (0.11), and the decline in the ruggedness value was caused by a lack of water.

4.1.2. Morphological Characteristics of the Basin

The basin's shape is determined by comparing it to geometric shapes like squares, rectangles, and it's useful for understanding geomorphological evolution and formation processes.

1) Elongation ratio (*Re*)

The elongation ratio (*Re*) expresses the length of the basin in relation to the rectangular shape. Furthermore, this ratio refers to the ratio of the diameter of a circle equal to the basin's area to the maximum length of the basin. The elongation ratio increases in rectangular basins and decreases in other shapes of basins. The drainage and rectangular shape, as well as the geomorphological significance, show an inverse relationship between the value of the elongation ratio, which ranges between (zero and one), and the basin shape.

When the shape of basin resembles a rectangle, the elongation ratio falls to its lowest point and approaches zero (Ashour & Turab, 1991). The Wizr basin area has shifted away from a rectangular shape with an elongation ratio of (0.65), this is due to the lithological contrast of its rocks, as well as the presence of numerous fractures and fissures. These fractures and cracks accompanied the rifting and opening of the Red Sea, assisting in the formation of the drainage network and the extension of their courses, as evidenced by the basin's morphology. The following formula (Schumm, 1956) is used to calculate it:

$$Re = 1128\frac{\sqrt{A}}{L}$$

where

Re = Elongation ratio,

A = Area of the basin (km^2),

L = Lengths of the Basin (km),

Constant = 1.128.

2) Circularity Ratio (*Rc*)

The circularity ratio (*Rc*) indicates how close the shape of basin is to the regular circular shape, with high values indicating the basin's shape's proximity to the circular shape. The circularity ratio is an indicator that compares the area of the basin to the area of a circle with a circumference equal to the basin's circumference. It is calculated as follows (Miller, 1953):

$$Rc = \frac{4A\pi}{P^2}$$

where

Rc = Circularity ratio,

A = Area of the basin (km^2),

P^2 = Perimeter of the basin.

It has reached the circularity ratio (0.33) in the Wizr basin, moving away from the circular shape due to its small area, as well as the simplicity of its topography associated with the characteristics of the prevailing rocks and its inability to resist erosion processes, particularly water erosion.

3) Basin shape factor

The basin form factor expresses the relationship between the basin's size and length, with low values indicating tiny basins and vice versa. It also shows how the general geometry of the basin's various regions is consistent. Because the widths of the basins shift from the source to the estuary due to the expansion of one of the two dimensions of the basin over the other, the basin form factor has a low value, indicating that the shape of the basin is close to the triangle shape.

The basin shape factor for the Wadi Wizr area reached 1.72, indicating that it is moving away from the correct one and, as a result, the basin shape becomes irregular and less sensitive.

4.1.3. Radiometric Investigation

Radioactivity is a natural property of rocks caused by the presence of natural radio isotopes and/or their parent elements. As a result, in natural conditions, each rock type has its own specific radioactivity and mean background. An anomaly is defined as a fivefold or greater increase in radioactivity above the background of a specific rock. The natural radioactivity of rocks is caused by radioactive isotopes of U, Th, Ra, and K.

Radio spectrometric measurements of eU and eTh were taken for all rock units and stream sediments on the ground in the Wadi Wizr basin area to determine whether or not there are radioactive anomaly entities in the study area, particularly for checking the measurements of stream sediments, which can lead to rocks carrying radioactive occurrences.

The measurements show wide variations in radio spectrometric levels among these rock types due to differences in rock composition, intensity of alteration, and structures affecting these rocks. These radioactive surveys revealed that all rock units in the study area had normal concentrations of eU and eTh. However, an increase in eU concentrations was observed downstream of the Wadi Wizr basin towards its central part (**Table 5** & **Table 6**), where a radioactive anomaly

Table 6. Radiometric studies of eU (ppm) and eTh (ppm) in stream sediments from the Wadi Wizr basin area of the Central Eastern Desert.

Site No.		Composition	eU (ppm)	eTh (ppm)
Lower Wadi Wizr stream	1	Stream sediments are mainly derived from sedimentary rocks	0.3	0.4
	2		0.3	0.5
	3		0.4	0.5
	4		0.4	1
	5		0.5	0.5
	6		0.4	0.5
	7		0.5	0.4
	8		07	0.3
	9		4	1
	10		3	1
	11		2	2
	12		2	0.9
	13		1	3
Upper Wadi Wizr stream	14	Stream sediments are mainly derived from granitic rocks	2	2
	15		3	2
	16		2.5	4
	17		3	5
	18		5	8
	19		1.5	6

Source: Field measurements by the RS-230.

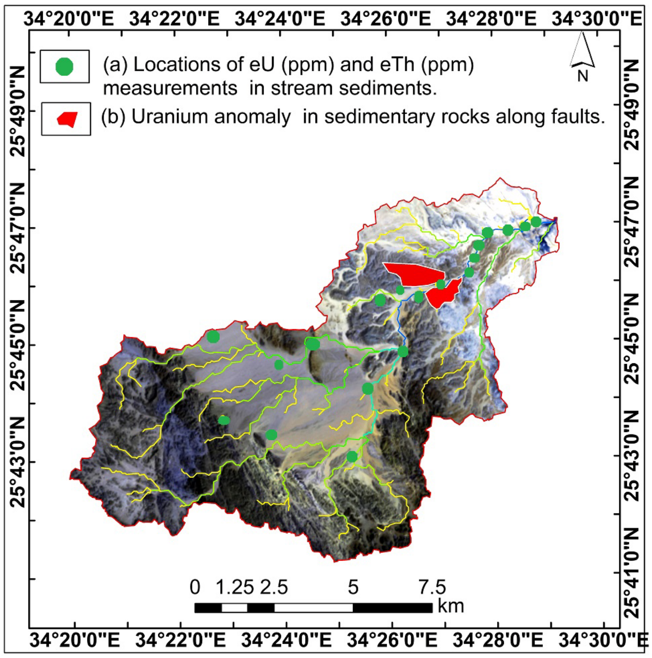


Figure 10. Sites of eU and eTh measurements in stream sediments, anomalies of U in sedimentary rocks, Wadi Wizr basin area, Central Eastern Desert of Egypt.

zone was discovered. The detailed mapping of this anomalous zone revealed that it has a larger surface area than that recorded by Abu Elatta and Mansour (2018), which occupies an area of about 1.5 km^2. Miocene clastic-carbonate sedimentary rocks cover this area, which is located at the intersection of a major NNW-SSW normal fault and another major NE-SE strike-slip fault. It was also distinguished by hematitization, limonitization, and brecciation, with eU concentrations ranging from 10 ppm to 70 ppm at the surface. In the meantime, eTh concentrations range from 0.5 to 8 ppm. According to Mn/Fe, Co/Zn, and Co/Ni ratios, the source of this uranium anomaly could be ascending hydrothermal solutions along the two previously mentioned faults that cut the Miocene clastic-carbonate sedimentary rocks (Abu Elatta & Mansour, 2018). Because of their extremely low eTh/eU ratios, these hydrothermal uranium occurrences could be subjected to supergene processes.

Furthermore, there was a difference in eTh concentrations between upstream and downstream sediments. This difference could be due to the fact that granitic rocks are the primary source of the upstream sediments, which are rich in many thorium-bearing minerals such as zircon, apatite, etc., in comparison to the downstream sediments, as well as the large distance from the granite rocks (Figure 10).

5. Conclusion

When compared to traditional methods, the effectiveness of digital elevation models and geographic information systems in studying morphometric and conducting advanced spatial analyses to achieve quick, accurate, and diverse results was demonstrated. The presence of five river levels in the Wadi Wizr basin area, with a total number of streams reaching (103), a total length of (125.64) km, and a bifurcation ratio of (1.59), indicates that the drainage pattern is greatly influenced by the geological structure, and the basin is considered a source of flood risks. The drainage density of the Wadi Wizr basin area is (1.32 km/km^2), indicating a medium density and permeable surface formations.

The study of spatial characteristics revealed that the Wadi Wizr basin area is relatively small, with a surface area of (95.51 km^2), a length of (17.07 km), a width of about 5.6 km, and a surrounding area of (60.08 km^2). In terms of the terrain characteristics of the Wadi Wizr Basin area, the relief Ratio (0.234 m), which is a high value, expresses the clear difference in heights between the basin's lowest and highest points. Meanwhile, the Wadi Wizr basin's relative relief is 0.39, which is a simple percentage. The Hypsometric index value appeared at a rate of 63% on average. This indicates that the Wadi Wizr basin area is still in its early stages, with higher erosion than sedimentation. By studying the regression, it is clear that the majorities of the lands are easy and light sloping, accounting for the majority of the basin area, and thus the Ruggedness value of Wadi Wizr basin reaches (0.11).

The lack of sewers and the relatively small basin surface area are to blame for the decline in ruggedness value. This morphological study discovered that the basin moved away from the rectangular shape, as well as away from the circular one, becoming irregular and less sensitive. Finally, measurements of eU and eTh in valley sediments and various rock units revealed that the values of these readings increase near radioactive anomalies recorded in sedimentary rocks. The highest eU value recorded is 70 ppm, while eTh does not exceed 8 ppm in faulted sedimentary rocks, and the highest eU/ eTh ratio reaches 8.75, which is very high and indicates a possible deposit. Furthermore, uranium readings near the Red Sea shore are very low and do not exceeded than 0.3 ppm at a 2 km distance from it thus having no effect on any tourist activity.

6. Recommendation

1) Use modern data sources with high spatial clarity and accuracy, such as satellite images and digital elevation models, as the foundation for building geographical databases with morphometric variables.

2) The importance of using geographic information systems technology in geomorphological studies related to morphometric characteristics of drainage basins because of the accurate results and time and effort savings they provide, as well as the shift away from old traditional study patterns.

3) Conduct future environmental studies (the effects of drought on plant and animal life, as well as flood risks and the best places to collect and use water) for the Wadi Wizr basin area based on the geographical information base and morphometric variables that have been determined.

Acknowledgements

The author is thankful to NMA for permission to use the field data and accord permission to publish this paper.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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