IOSR Journal of Applied Geology and Geophysics (IOSR-JAGG)
e-ISSN: 2321–0990, p-ISSN: 2321–0982.Volume 7, Issue 6 Ser. II (Nov. – Dec. 2019), PP 13-28
www.iosrjournals.org

Sedimentological and Environmental Studies of the Recent Sediments of Some wadis in Qena and Luxor Governorates, Upper Egypt

Mohamed R. Osman and Khaled A. Abu el-ella
Geology Department, Faculty of Science, South Valley University, 83523 Qena, Egypt
Corresponding Author: Mohamed R. Osman

Abstract: *The study aims to sedimentological and geomorphological studies of the recent sediments in seven wadis draining throughout Qena and Luxor Governorates, Upper Egypt to recognize their textural and mineralogical composition, assess the flash flood risk zones, to define highly risk basins. Furthermore, suggestion some precaution measures to benefit from the vast quantities of floodwater in the development of the neighboring villages and towns.*

Grain size analysis data revealed that most of the analyzed sediments in the investigated wadis are poorly sorted and composed of gravely sand and sandy gravel. The sediments were transported by rolling mode and fall within the traction population (surface creep population) regime.

The heavy mineral assemblage has revealed that the sediments of the studied wadis were derived from both acidic and basic igneous rocks, and metamorphic rocks, as well as from the pre-existing sedimentary rocks.

The structural lineament and the drainage lineament maps of the studied wadis deduced that most of the drainage lines are structurally controlled. The study has revealed that the area was located within the Egyptian hyper-arid zone. According to the morphometric parameters, the study area is occasionally subjected to heavy showers, commonly followed by floods of substantial magnitudes. Such torrential floods are sporadic, unpredictable and usually of short-lived, high velocity and sharp peak discharges that may cause devastating impacts on roads, farmlands and settlements. According to the estimated degrees of hazards, the studied basins and sub-basins were classified into five areas. Extremely highly hazardous, highly hazardous, moderately hazardous, slightly hazardous and weakly hazardous. The main roads, cultivated lands, urban areas and development projects in the study area are virtually under threat of flash floods that occur in the courses of the main wadis, especially in the absence of hazard awareness and precautions. To reduce the staggering damages and problems caused by torrential floods the present authors recommend some solutions and applicable measures.

Date of Submission: 18-11-2019 Date of Acceptance: 04-12-2019

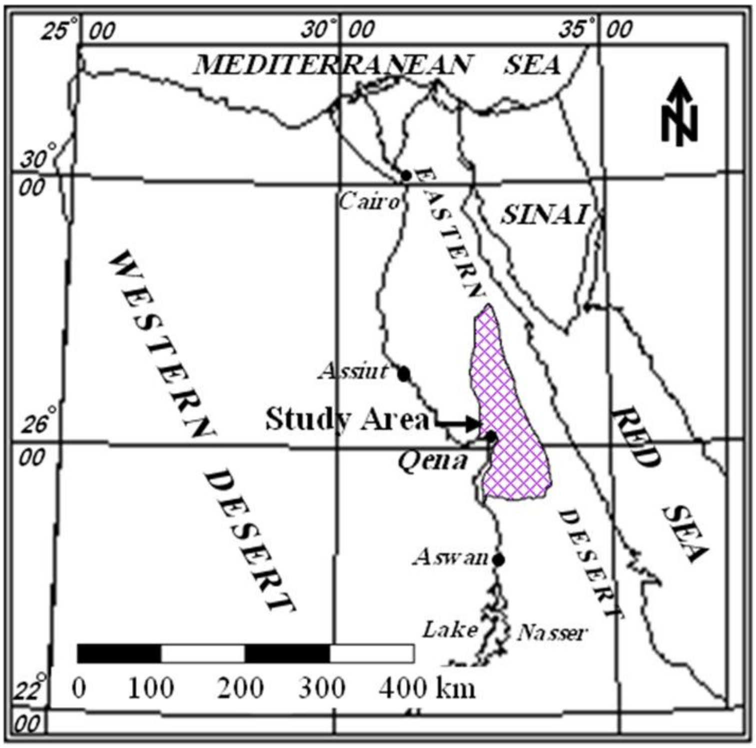
I. Introduction

The study area lies between latitudes 25º 15` and 28º 04` N and longitudes 32º 21` and 34º 04` E (Figure no 1). It is located on the eastern side of the River Nile and includes seven wadis. All the wadis are draining throughout villages and towns of Qena and Luxor Governorates. These wadis cover thousands of square kilometers and have extensive areas of flat lands with low relief covered by recent stream sediments. The lands of the wadis are favorable for the agriculture, establishing new cities and new industrial communities. On the other hand, many villages that lying at the downstream areas of these wadis were threatened by the frequent flash flood hazards and subjected to great damages. Accordingly, the official authorities gave a great attention to those villages to protect the habitants and houses from the hazards of flash floods. Furthermore, the authorities gave a significant interest to the development of these regions through addition new areas favorable for agriculture, building new cities to create a new habitation away from Qena city and building new industrial regions to solve the problem of unemployment.

However, seven wadis which drain their water to the villages and towns were selected for the present study. The selected wadis from south to north are Wadi El-Shoki, Wadi El-Madamod, Wadi Banat Birri, Wadi Higaza, Wadi El-Matula, Wadi Qena and W. El-Sheikh Issa (Figure no 2). One hundred and thirty nine surface and pit samples were collected from the recent stream sediments of the studied wadis. Sedimentological, mineralogical and geomorphological studies were carried out on the collected samples.

Geology of the study area: Geology of the southern part of the study area that extends from Wadi El-Shoki to Wadi El-Matula was compiled after [1- 5]. The basement rocks of granites, diorites, granodiorites, gabbros, serpentinites, schists and gneisses cover the upstream region in the eastern Desert. To the westward direction, Nubia sandstone unconformably overlies the basement rocks with progressively increasing thickness. Nubia sandstone thickness was recorded 200 m. by [3] in Wadi El-Mishash (sub-basin of Wadi El-Matula). A great thickness reaches about 700 m. of Upper Cretaceous-Lower Tertiary rocks composed of alternation of limestones, shales, marls, clays and gypseous marl unconformably overly the Nubia sandstone. Quaternary deposits in the form of wadi fillings and wadi terraces cover wadi floors and the low land areas.

Figure no1: Location map of the Study Area.

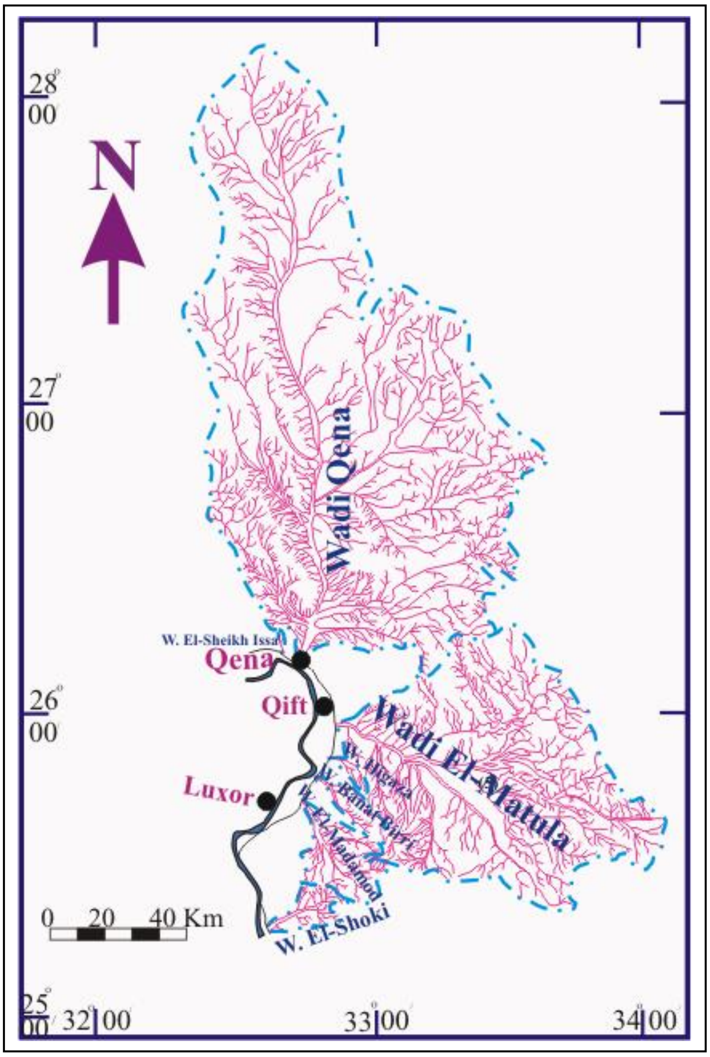


The geology of Wadi Qena; which represents the northern part of the investigated area was given after[1], [4], [6]. The main channel of Wadi Qena is bordered along its eastern and western sides by different formations. The eastern side is occupied by the Red Sea Mountains, which composed mainly of igneous and metamorphic rocks. The western side of the channel is outlined by sedimentary succession from Paleozoic to Quaternary. Paleozoic rocks occur in the far northern parts of Wadi Qena. Jurassic rocks cover areas north latitude 27º 10`. Nubia sandstone; which represents the basal part of the Cretaceous-Tertiary succession; unconformably overlies basement rocks in the middle and the southern areas. Nubia sandstone unconformably underlies Paleocene, Eocene and Pliocene rocks which forming the downstream hills and the western calcareous plateau. On the other hand, the Quaternary sediments exist as alluvial fillings and alluvial terraces. Figure no3 shows the geological map of the study area.

Wadi Qena area was studied by many authors. The early studies were essentially of stratigraphic interest, which include; [7], [8] as quoted in [1]. [9] studied the epeirogenesis and sedimentation in the area between Safaga, Quseir and southern Wadi Qena area. [10] studied the micropaleontological fauna of the stratigraphic sequence in G. Abu-Had in W. Qena. [11] studied the sedimentology of the Upper Cretaceous-Lower Tertiary rocks at Wadi Qena area. [12] studied the sediments of Wadi Qena from the Paleozoic deposits up to the Paleocene and Eocene deposits. [13] classified Wadi Qena hydrographic basin into seven main sub-basins and studied the quantitative geomorphometric analysis of the whole basin and its sub-basins. [14] studied the drainage basins and flash flood hazard in selected parts of Egypt (including Wadi Qena).

Previous Work: Many workers studied the southern part of the study area which extending from Wadi El-Shoki to Wadi El-Matula. [1],[8],[15],[16],[17],[18]classified the sedimentary sequence in the central part of the Egyptian Eastern Desert into several formations. [18],[19] studied the structure of the area and stated that the region east of Qena is characterized by faults, trending NW-SE as the most dominant structural elements. [20]classified the Egyptian Central Eastern Desert into six distinct geomorphic units. [5] classified the area between Wadi El-Matula and Wadi Abbad into three principal geomorphic units. [21] made an assessment of the hydrographic system of the Eastern Desert. [22] used Remote Sensing (RS) and Geographic Information Systems (GIS) methodologies to delineate groundwater potential zones in W. Qena and classified the region into six categories of groundwater potentiality from excellent to very low. Recently [23] also used Remote Sensing and GIS techniques to make mapping of flash flood hazards at Wadi Qena basin and stated that the majority of Wadi Qena sub-basins range from low to medium hazard degree.

Figure no 2: The studied wadis in the area of study.



Scope of the present study:

It is evident from the aforementioned previous works that the studies of the recent stream sediments in the area under consideration are very rare. Although they may be of economic interest as large areas of lands are favorable for agriculture especially after increasing the development at the mouths of wadis that drain towards the river Nile. The present study aims to carry out sedimentological and geomorphological studies of the recent stream sediments in the selected seven wadis (Figure no 2). The present geomorphologic study is important to assess the flash flood risk zones, distinguish the suitable land use sites, define high-risk basins and suggest flood precautionary measures.

II. Materials and Methods

Field Sampling: One hundred and thirty nine surface and pit samples were collected from the considered seven wadis. Surface sediment samples were taken from the stream courses of the wadis, beginning from the upstream towards the downstream area (Figure no 4a). On the other hand, pit sediment samples were taken from excavated pits at downstream area of wadis. The depth of the excavated pit sediments vary from 1.0 m to occasionally more than 3.0 m (excavated by farmers for digging wells of ground water supply (Figure no 4b). The studied pit sediments exhibited different lithologies ranging between muddy sand, sand, gravely sand and sandy gravel reflecting different sedimentation cycles due to the oscillation of velocity, strength and magnitude of the frequent torrential flash floods that occurred in the studied wadis (Figure no 4b & Figure no 5).

Figure no3: Geological map of the study area after Geological Survey (1979).

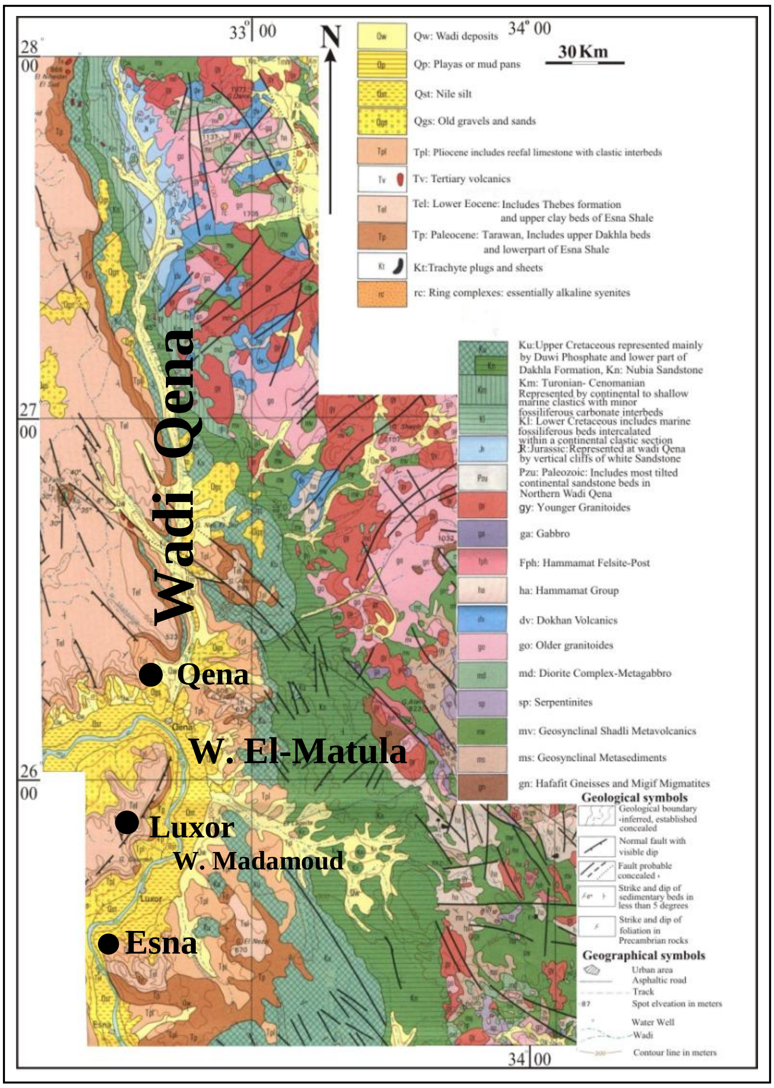
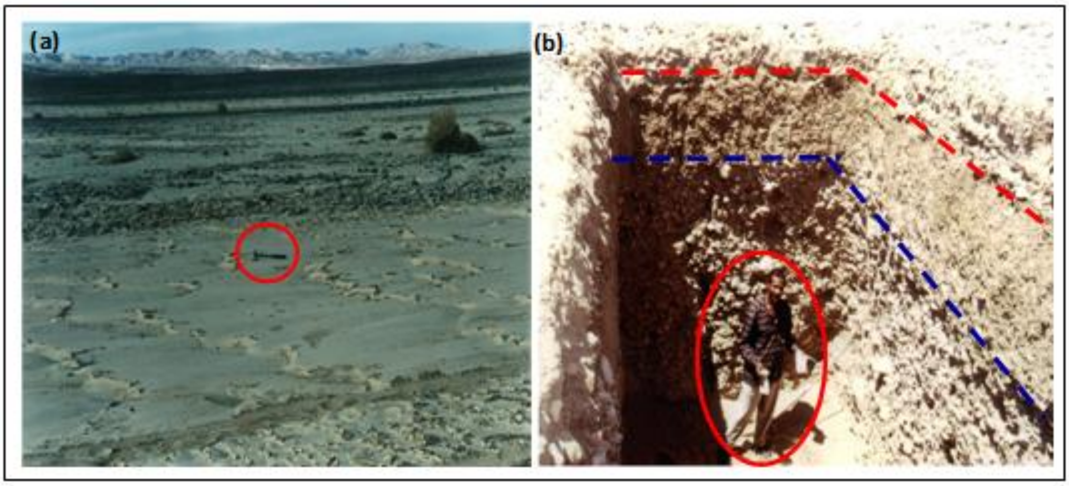


Figure no 4: a. Shows surface sediments deposited by recent flash flood in Wadi Qena, hammer is a marker, b. shows different cycles of sedimentation in Wadi Banat Birri excavated pit.



Laboratory techniques:

Grain size analysis:

Mechanical analysis was carried out on hundred and thirty nine samples representing surface and pits sediments by dry sieving method, using ASTM sieves placed at one Phi interval from -1ϕ (2mm) to 4ϕ (63µm). The average percentages of gravel, sand and mud of the analyzed samples of the studied wadis were classified and plotted on triangular diagram, according to[24] (Figure no 6). The cumulative frequency graphs of each sample were plotted and the values of ϕ5, ϕ16, ϕ25, ϕ50, ϕ75, ϕ84 and ϕ95 were obtained. The grain-size parameters including median, standard deviations (sorting), skewness and kurtosis were calculated, following [25]using Grain-Size Statistics Program (GSSTAT) proposed by[26]. The average results are listed in Table no 1.

Mineralogical study:

Two size fractions, namely fine sand fraction (2ϕ - 3ϕ) and very fine sand fraction (3ϕ - 4ϕ) representing sixty four samples of surface and pit sediments were selected to study the heavy mineral suites in the sediments under consideration. The separated heavy mineral were subjected to microscopic investigation using the transmitted polarizing light microscope. The different heavy mineral suites were identified according to the optical properties of the heavy minerals mentioned in[27]. Three hundred grains were counted in each slide, using point counter to determine the percentages of opaques and different types of non-opaque heavy minerals.

Geomorphlogical study:

Landsat images of scales 1:100,000 and 1:250,000 were used to trace the drainage maps of the studied wadis. A digital planimeter was used to measure the area of each studied drainage basin and sub-basin in (Km^2). Based on [28] cited in [29], the different drainage basins were classified into different stream orders and stream order maps were drawn for the studied drainage basins. Using the digital chartmeter, the lengths of tributaries of individual orders, the perimeter of each drainage basin, the main stream length and the basin length of each drainage basin were measured. The morphometric parameters; basin length, basin width, basin perimeter, basin area, stream order, stream lengths, stream numbers, weighted mean bifurcation ratio, drainage density, frequency, circulatory ratio, elongation ratio, shape index, sinuosity, relief ratio, ruggedness number and slope index were calculated.

Table no 1: Average data of grain size texture, parameters and C-M values of the analyzed samples.

Wadi	Sample Type	No. of Samples	Graine size texture			Graine Size Parameters (ϕ) Folk & Ward (1957)					Passega & Byramjee (1969)	
			Gravel %	Sand %	Mud %	M_Z	σ_I	Sk_I	KG	KG`	C (µm)	M (µm)
El-Shoki	Surface	4	47.40	48.37	4.24	-0.17	1.74	0.47	1.00	0.61	4043.8	1793.8
	Pit	5	37.85	42.47	19.68	2.32	2.68	0.36	1.30	0.52	3765.3	1286.7
El-Madamoud	Surface	5	25.87	72.23	1.90	0.93	1.41	0.15	1.05	0.49	3435.0	922.8
	Pit	6	33.98	63.19	2.83	0.80	1.18	0.36	1.77	0.58	3570.7	1326.5
Banat Birri	Surface	4	23.26	62.36	14.39	1.91	2.15	0.19	1.27	0.55	3312.5	689.9
	Pit	12	39.74	58.53	1.73	0.22	1.33	0.25	1.27	0.51	3773.5	1022.4
Higaza	Surface	10	12.40	86.12	1.48	1.05	1.16	-0.11	1.25	0.53	3435.2	467.3
	Pit	7	29.97	60.35	9.68	1.00	1.62	0.18	1.00	0.49	3676.5	1143.9
El-Matula	Surface	14	22.90	70.81	6.28	1.25	1.55	-0.03	1.35	0.55	3693.8	728.9
	Pit	7	22.31	71.33	6.36	1.08	1.42	0.27	1.21	0.52	3232.6	979.3
Qena	Surface	38	14.52	77.07	8.40	1.27	1.63	0.06	1.21	0.53	3296.8	623.5
	Pit	15	20.43	74.21	5.36	1.34	1.28	0.20	1.09	0.51	2920.9	837.2
El-Sheikh Issa	Surface	7	26.49	68.46	5.05	0.46	1.68	0.24	1.02	0.50	3750.24	1099.70
	Pit	5	33.07	56.17	10.76	0.72	1.40	0.25	1.17	0.56	3418.1	1126.3

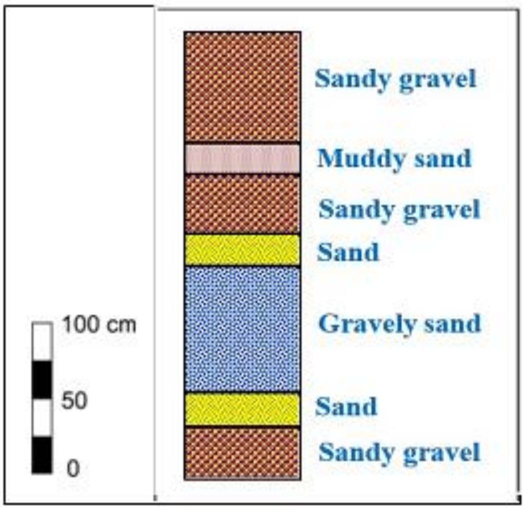
III. Results and Discussion

Grain size analysis:

Grain size is an important physical property of sediments and vital for our understanding of intrinsic properties and dynamic forces that operated during deposition. Moreover, grain size parameters also help to probe the depositional environment and energy flux of diverse agents that transported the sediments[30]. From the ternary diagram of [24], it is noted that the average of surface sediments of the studied wadis are scattered in the fields of sandy gravel, muddy sandy gravel and gravely sand, whereas most of the average of pit sediments lie within the field of gravely sand and the rest are located in sandy gravel and gravely muddy sand.

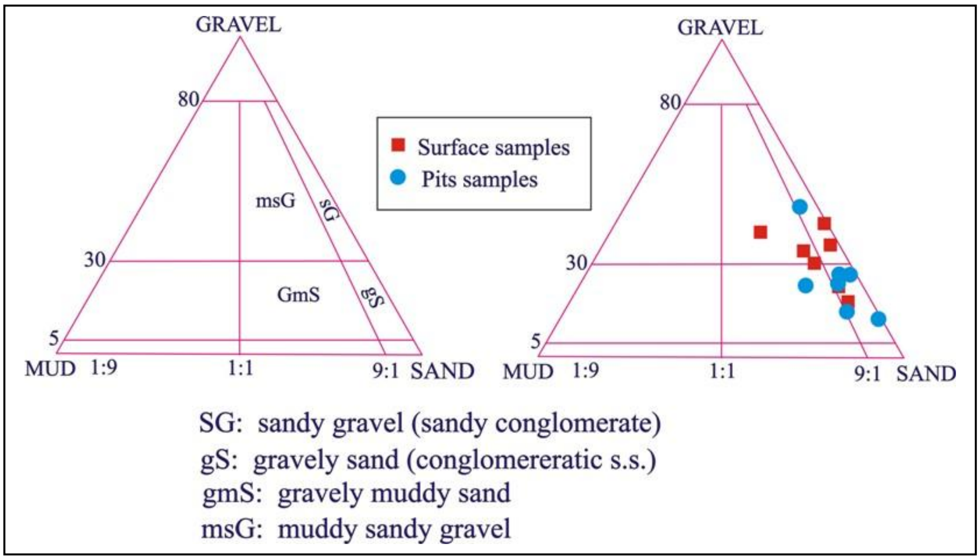
Following [31], the average values of the surface and pit samples were plotted on C-M diagram using C (coarser one-percentile value in micron) versus M (median value in micron) on a logarithmic scale. However, all the analyzed surface and pit samples are falling in the rolling sediment field (Figure no 7).

Figure no 5: Shows cycles of sedimentation during different stages of flash floods as shown in excavated pit in Wadi Banat Birri (total thickness of the excavated layers = 2.8 m).



[32] proposed plot using the cumulative curve of grain size against the percentage of fractions to indicate the transportation mechanisms by which the sediments transported. [31] classified the log-probability cumulative curve; according to the mode of particles transportation into three different populations namely, surface creep, saltation and suspension. The analyzed samples of the investigated wadis, exhibited different modes of transportation when they were plotted on [32]'s curve. Anyhow, figures no 8a & 8b show the mode of transportation of Wadi El-Shoki surface and pit samples as a representative of the studied wadis. It is clear that the particles are transported by three distinguishable populations are; surface creep, saltation and suspension populations.

Figure no 6: Nomenclature of average of the surface and pits analyzed samples, after Folk (1980).



Mineralogical study (Heavy minerals):

The study of heavy mineral suites is very useful in the following purposes: determining the source area provenance, tracing sediment transport paths, outlining and correlating sand bodies, indicating the action of particular hydraulic regimes and concentrating processes, locating potential economic deposits and elucidating diagenetic processes[27]. Investigation under polarizing microscope revealed the presence of opaque and non-opaque minerals in the heavy fractions. The non-opaque minerals include amphiboles, pyroxenes, epidotes, mica, chlorite, zircon, tourmaline, rutile, garnet, sillimanite, andalusite, kyanite, sphene, staurolite and apatite. According to the stability of non-opaque heavy minerals, they include unstable (amphiboles, pyroxenes and andalusite), moderately stable (epidotes, kyanite, sillimanite and sphene), stable (mica, garnet and staurolite) and ultrastable (zircon, tourmaline and rutile)[33]. Table no 2 exhibits the percentages of opaque and non-opaque heavy minerals of the analyzed surface and pit samples at the different wadis. Figures no 9a & 9b show the content of non-opaque heavy minerals in the fine sand fraction. [34] and [35] classified sandstones provenance according to their index heavy mineral suites. [34] pointed out that apatite, sphene and zircon represent the acidic igneous rocks terrain; pyroxenes and rutile represent the basic igneous rocks terrain, whereas epidotes, staurolite, sillimanite and kyanite represent the metamorphic rocks terrain. [36]stated that many heavy mineral species notably the ultrastable minerals (zircon, tourmaline and rutile) are most commonly polycyclic (derived from pre-existing sedimentary rocks). In general, it is noted, from table (2) that almost all the wadis are enriched in the average contents of amphiboles and pyroxenes, despite both of pyroxenes and amphiboles are unstable and more susceptible to alteration by weathering than the other types of minerals. This may attributed to the proximity of the basement rocks to the locations of the studied wadis and/or due to the inheritance of high content of these minerals in the clastic sedimentary rocks bordering the wadis.

However, most of the studied wadis are surrounded by sedimentary rocks, except the igneous and metamorphic rocks that exposed at the eastern side of Wadi Qena and the upstream areas of Wadi El-Matula (Figure no 3). Following [34], [35] and [36], and according to the observed heavy mineral suite in the studied sediments, it is suggested that the sediments of the studied wadis were derived from both acidic and basic igneous rocks, metamorphic rocks as well as the pre-existing sedimentary rocks.

Figure no 7: C-M pattern of the analyzed surface and pits averages samples of the studied wadis after Passega and Byramjee (1969).

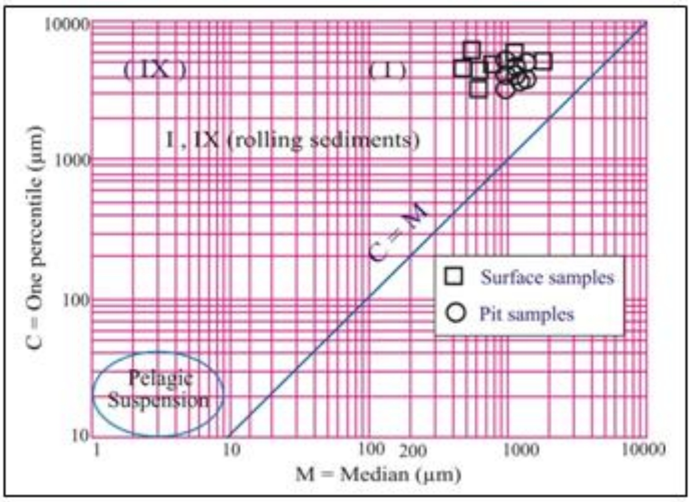


Figure no 8a: Log-probability curves of analyzed surface samples in Wadi El-Shoki; (1) Surface Creep Population, (2) Saltation Population, (3) Suspension Population.

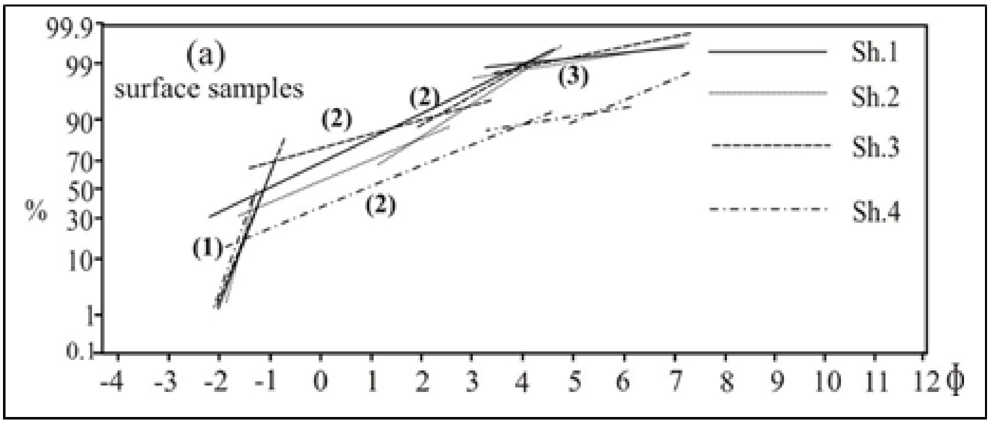


Figure no 8b: Log-probability curves of analyzed pit samples in Wadi El-Shoki (Sh); (1) Surface Creep Population, (2) Saltation Population, (3) Suspension Population.

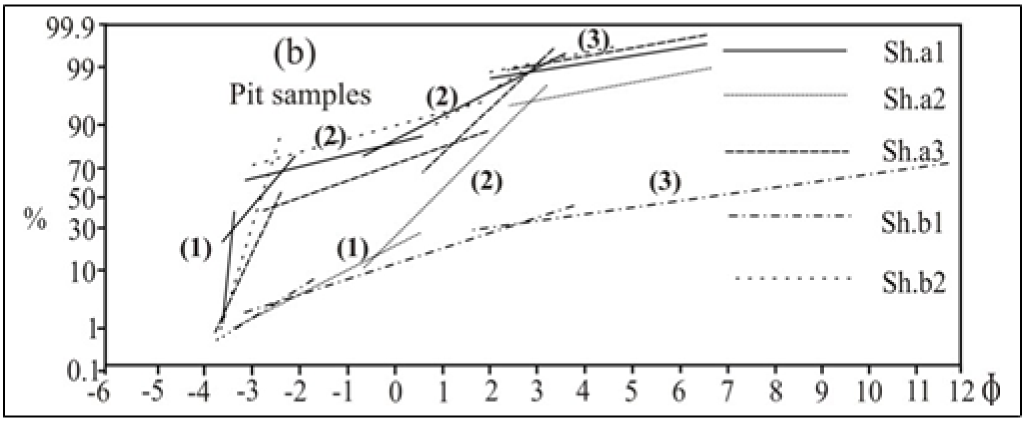


Table no 2: Average of heavy minerals percentages of fine sand fraction (>3ϕ) and very fine sand fraction (>4ϕ) of the studied surface and pit samples at different wadis.

Wadi	Fraction	Sample Type	No of Samples.	Am	Py	Ep	Mi	Ch	Zr	To	Ru	Ga	Si	An	Ky	Sp	St	Ap	OP	NOP
El-Shoki	F. S.	surface	2	4.4	10.0	2.3	0.2	0.7	0.0	0.0	0.0	1.0	0.5	0.0	0.0	0.2	0.0	0.6	80.2	19.8
		pit	2	7.9	14.4	2.1	0.0	1.3	0.0	0.4	0.8	0.4	0.0	0.0	0.0	0.0	0.0	0.0	72.6	27.4
	V. F. S.	surface	2	24.7	9.3	6.1	1.3	4.8	0.8	0.7	1.3	0.2	0.8	0.5	0.5	0.8	0.5	2.3	45.4	54.6
		pit	2	16.1	12.6	5.4	0.3	3.8	1.3	0.0	2.5	1.2	2.2	0.6	0.0	1.6	0.3	0.0	52.1	47.9
El-Madamoud	F. S.	surface	2	19.0	20.6	9.1	0.1	1.7	0.1	2.1	0.0	1.2	0.3	0.1	0.0	0.1	0.3	0.2	45.2	54.8
		pit	2	25.0	9.8	2.0	0.0	0.0	0.0	0.0	0.0	1.3	0.0	0.0	0.0	0.7	0.0	0.2	60.9	39.1
	V. F. S.	surface	2	25.6	17.5	4.2	0.4	5.9	1.9	0.3	2.3	1.4	1.0	0.0	0.2	3.4	0.5	0.5	34.8	65.2
		pit	2	19.8	12.3	5.6	0.2	4.7	3.2	1.2	2.8	1.4	0.0	0.0	0.0	1.4	0.0	2.5	44.8	55.2
Banat Birri	F. S.	surface	2	15.4	13.6	3.0	0.4	1.6	0.0	0.3	0.0	0.8	0.2	0.0	0.2	0.6	0.0	0.4	63.4	36.6
		pit	2	13.3	21.8	5.2	0.0	3.9	0.1	1.0	0.1	1.0	0.0	0.1	0.4	0.8	0.0	0.0	52.2	47.8
	V. F. S.	surface	2	26.4	13.4	3.7	0.4	6.2	1.2	1.3	1.5	0.8	0.1	0.0	0.3	2.1	0.1	1.2	41.1	58.9
		pit	2	22.3	10.9	3.8	0.1	4.1	0.8	0.3	2.2	1.6	0.0	0.1	0.2	1.0	0.0	1.1	51.5	48.5
Higaza	F. S.	surface	2	23.6	19.6	6.5	0.1	4.4	0.1	1.2	0.2	3.6	0.2	0.7	0.0	2.9	0.2	0.4	36.3	63.7
		pit	2	23.6	8.6	1.2	0.0	2.4	0.5	1.0	0.8	3.6	0.0	0.2	0.7	4.4	0.0	0.2	52.8	47.2
	V. F. S.	surface	2	22.5	10.4	5.2	0.6	3.2	3.3	0.6	1.7	1.1	0.9	0.2	0.1	2.1	0.4	1.2	46.5	53.5
		pit	2	19.1	6.6	6.7	0.9	2.8	7.7	1.5	2.2	1.7	1.0	0.5	0.2	1.7	0.7	1.0	45.6	54.4
El-Matula	F. S.	surface	3	10.2	2.6	1.2	0.9	0.6	0.1	0.4	0.1	0.2	0.1	0.0	0.0	0.5	0.0	0.4	82.7	17.3
		pit	3	14.0	2.3	2.4	0.5	0.9	0.2	1.0	0.0	1.8	0.0	0.0	0.0	2.4	0.0	0.0	74.5	25.5
	V. F. S.	surface	3	22.4	7.1	3.9	1.0	2.5	2.4	1.3	1.9	1.4	0.4	0.6	0.0	1.5	0.3	1.4	51.8	48.2
		pit	3	25.2	5.1	3.3	0.5	3.0	4.5	0.7	2.6	0.9	0.8	0.1	0.0	1.4	0.1	1.5	50.1	49.9
Qena	F. S.	surface	3	10.1	1.0	1.8	1.2	1.7	0.1	0.3	0.3	0.2	0.0	0.0	0.1	1.1	0.1	0.7	81.3	18.7
		pit	3	9.9	1.4	3.2	2.2	1.4	0.0	0.4	0.9	0.0	0.0	0.0	0.0	1.3	0.0	1.1	78.2	21.8
	V. F. S.	surface	3	20.4	5.5	4.0	0.7	5.0	1.7	0.7	1.5	0.2	0.1	0.1	0.0	1.6	0.2	1.9	56.3	43.7
		pit	3	12.0	4.1	4.4	0.6	2.7	4.1	1.1	2.6	0.6	0.0	0.0	0.0	1.3	0.0	2.3	64.3	35.7
El-Sheikh Issa	F. S.	surface	2	5.8	6.4	4.0	0.3	0.4	0.3	0.1	0.4	2.6	0.7	0.1	0.4	0.5	0.7	0.6	76.6	23.4
		pit	2	6.4	6.3	4.5	0.0	1.1	0.7	0.3	1.3	1.0	0.7	0.2	0.5	1.0	0.6	0.6	75.1	24.9
	V. F. S.	surface	2	28.6	9.5	4.8	0.6	5.5	2.4	0.4	2.0	1.1	0.3	0.1	0.0	1.2	0.1	1.5	42.0	58.0
		pit	2	29.5	3.8	6.6	0.4	4.3	6.3	1.3	3.5	1.0	0.6	0.0	0.3	1.0	0.5	0.9	39.8	60.2

Am = Amphiboles Py = Pyroxenes Ep = Epidotes Mi = Micas Ch = Chlorite Zr = Zircon
To = Tourmaline Ru = Rutile Ga = Garnet Si = Sillimanite An = Andalusite Ky = Kyanite
Sp = Sphene St = Staurolite Ap = Apatite OP = Opaques NOP = Nonopaques
F. S. = Fine sand V. F. S.= Very fine sand.

Geomorphological studies:

Rainfall: Rainfall in the area under investigation is extremely rare, it is less than 4.5 mm/year. The present study area is occasionally subjected to heavy sporadic showers as flash floods, during the period from October to March. Along the Nile Valley, Qena station receives a relatively high precipitation about 3.94 mm/year, while towards the northwest it reaches 2.73 mm/year at Assiut station. At Luxor station, it reaches 3.43 mm/year (data collected from meteorological authority of Egypt for seventeen years (1978-1994).

Structural and drainage lineaments Analysis: The structural and drainage lineament maps of the studied wadis (Figures no 10a, 10b) were constructed based on [37]'s map which was based on landsat images scale 1:1000,000. The dominant trends of structural lineaments of the seven wadis were determined and the drainage network of the studied basins was traced. From the correlation between structural lineaments (Figure no 10a) and drainage lines (Figure no 10b), it can be concluded that most of the drainage lines are mostly structurally controlled. However, in some sectors the drainage lines are believed to be controlled by the general dip. The difference in drainage orientation as well as structural lineaments from one sector to the other in the studied area refers to the major structural trends controlling Egypt [38] and was not affected by the local geology. This feature is obvious in Wadi Qena when changed from N-S in its northern part to NE-SW in its southern part due to the effect of Qena-Safaga shear zone[38].

Figure no 9: Distribution of non-opaque heavy minerals average in fine sand fraction of the studied wadis; a- surface sediments, b- pit sediments.

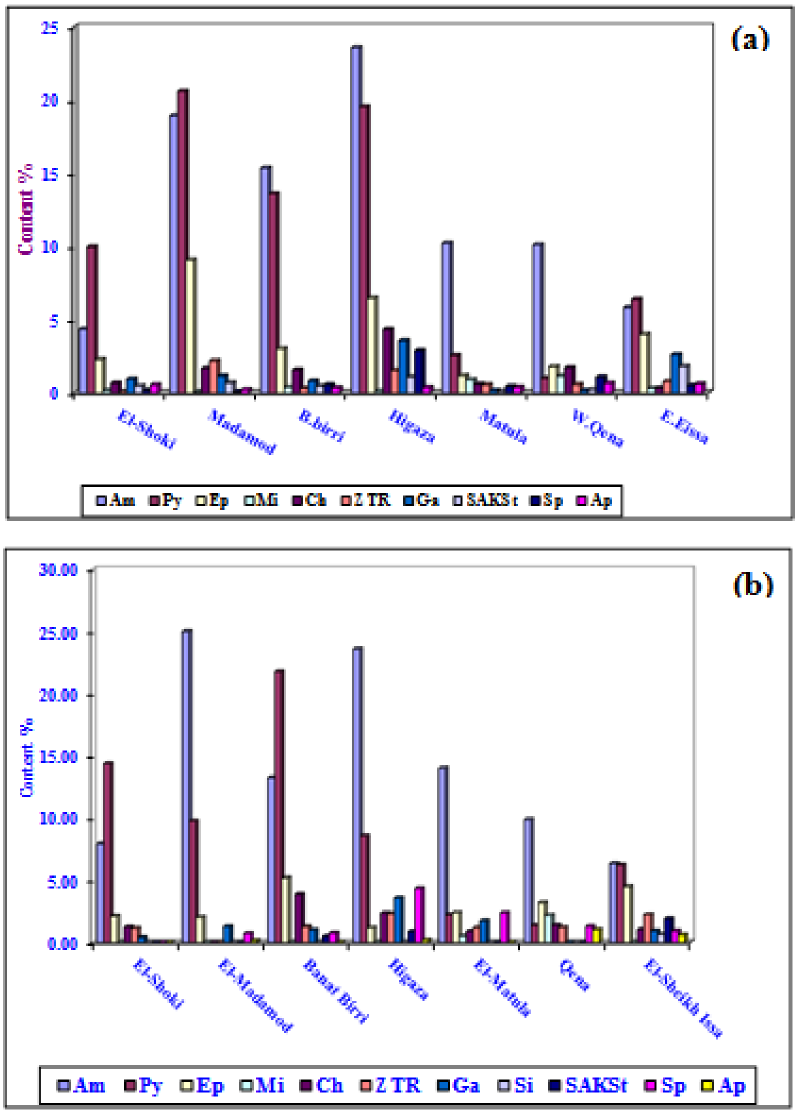
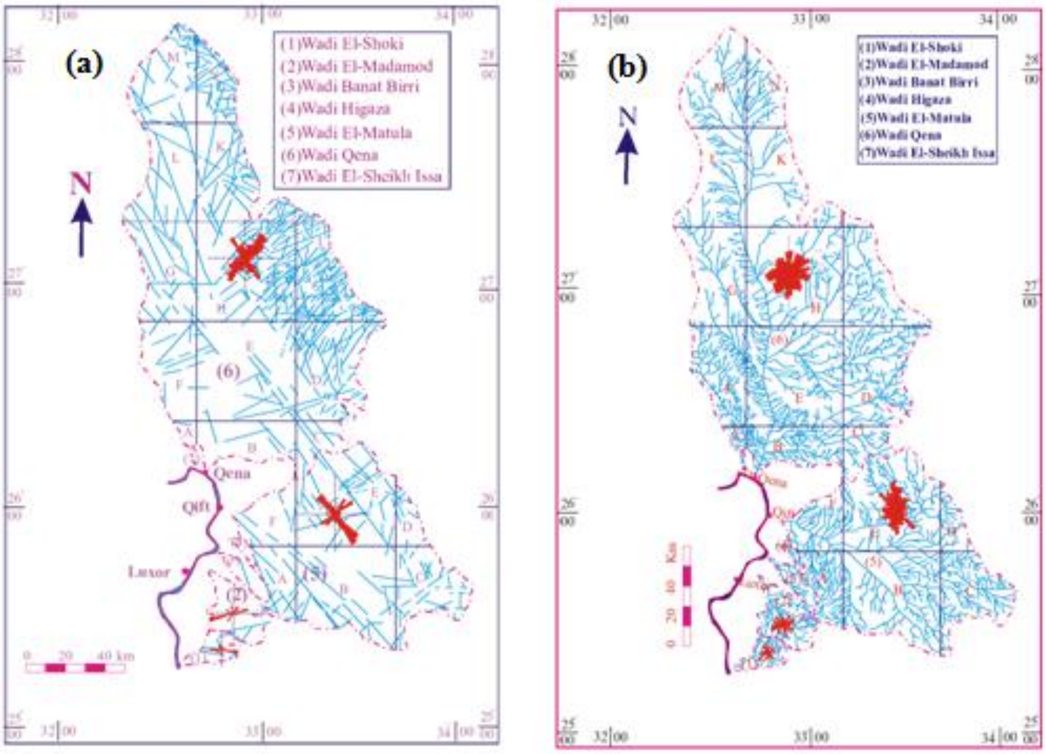


Figure no 10: a) Structural lineaments map of the studied wadis; b) Drainage lineaments map of the studied wadis.



Morphometric analysis: Based on Landsat images scales 1:100.000 and 1:250.000, the drainage maps were drawn for the studied basins and sub-basins. According to [28],[29], stream order maps were drawn (Figures no 11a & 11b). The studied basins and sub-basins were quantitatively analyzed to calculate seventeen morphometric parameters namely; basin length, basin width, basin perimeter, basin area, stream order, stream lengths, stream numbers, bifurcation ratio, drainage density, stream frequency, circulatory ratio, elongation ratio, shape index, sinuosity, relief ratio, ruggedness number and slope index. All the studied basins and sub-basins have bifurcation ratio values greater than 3 reflecting well dissected and elongated drainage basins and sub-basins. The studied drainage basins and sub-basins show drainage densities in the range of poorly drained basin [39]. This indicates high flood flow with small amount of groundwater contribution to the discharge[40]. According to [39], the drainage densities of the studied drainage basins and sub-basins are less than 5, indicating that they are most probably structural controlled. The drainage frequencies of the studied basins and sub-basins are of high values, reflecting more possibility of runoff water without a big chance for downward infiltration due to the rapid flow out.

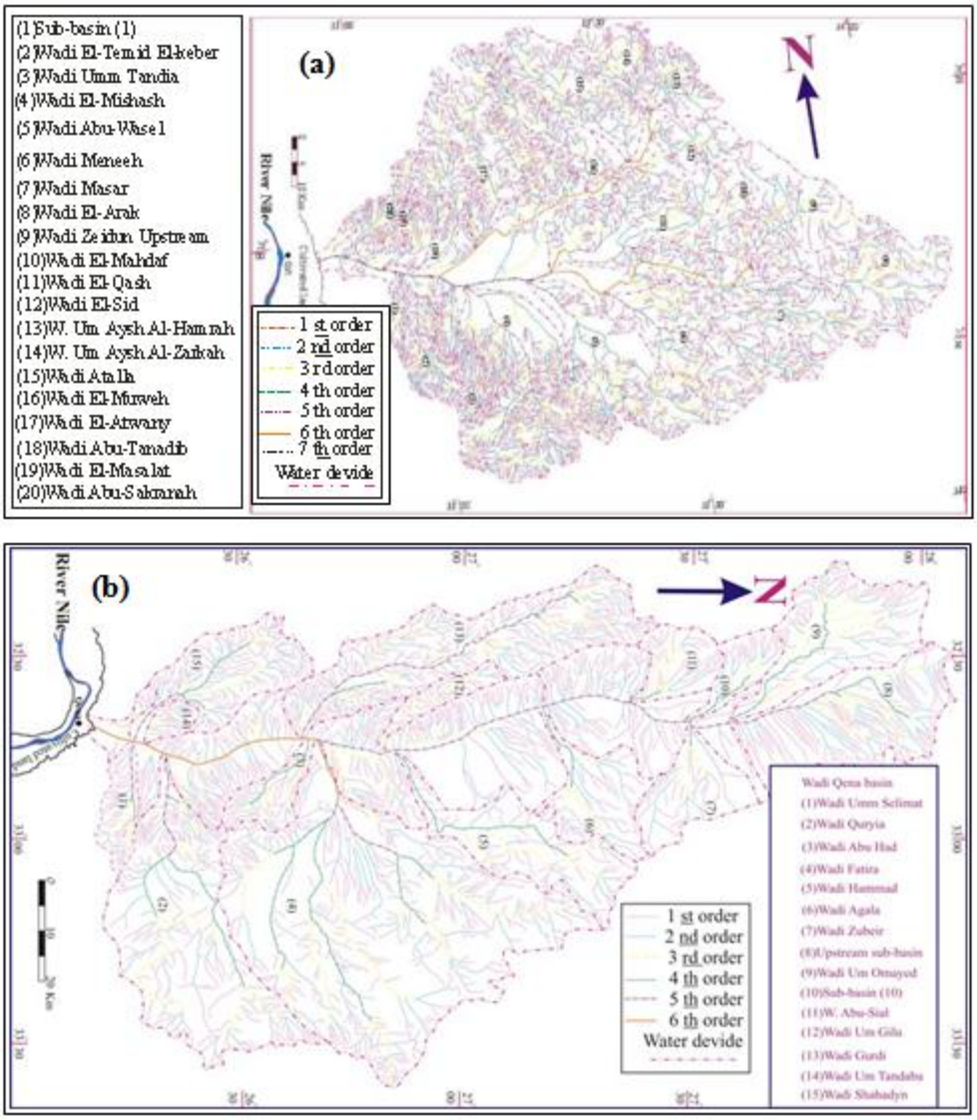
Flash Flood Hazard Evaluation: An assessment of the degree of hazards due to flooding was estimated for the studied drainage basins and sub-basins, depending on ten selected morphometric parameters which have an influence on the flooding. Seven of these parameters, which are drainage density (D), stream frequency (F), area (A), relief ratio (Rr), ruggedness number (Rn), shape index (Ish) and slope index (SI) are directly proportional with the hazard. On the other hand, three parameters have an inverse relation with hazard. These parameters are bifurcation ratio (Rb), length of overland flow (Lo) and sinuosity (Si). However, the mathematical formula of all these parameters are listed in Table no 3. A scale for the degree of hazard has been given for the two above groups of the studied wadis, according to the values range of the ten parameters. The scale is starting with 1 (lowest) to 5 (highest) (Tables no 4a & 4b).

Flash Flood Vulnerability: The study area is occasionally subjected to short-lived heavy showers, commonly followed by floods of substantial magnitudes, which may cause devastating impacts on roads, farmlands and settlements (Figures no 12, 13). Such torrential floods are sporadic, unpredictable and usually of short-lived, high velocity and sharp peak discharges. The study area is crossed by some main roads and encompasses cultivated lands, urban areas and development projects located at the lower reaches of the trunk wadis of the drainage basins.

Table no 3: Mathematical formula of morphometric parameters

Morphometric parameter	Formula	Reference
Stream lengths (L_u)	$L_u = L_1 + L_2 + \ldots\ldots + L_n$ (km)	[39]
Stream numbers (N_u)	$N_u = N_1 + N_2 + \ldots\ldots + N_n$	[39]
Bifurcation ratio (Rb)	$Rb = N_u/N_u+1$, where Nu = total no. of stream segments of order "u", Nu+1 = no. of segments of the next higher order	[28]
Drainage Density (D)	$D = L_u/A$	[41]
Stream frequency (F)	$F = N_u/A$	[28]
Length of overland flow (L_o)	$L_o = 1/2D$	[28]
Shape index (Ish)	$Ish = 1.27\ A / BL^2$, where A = area of the basin in km^2, BL = length of the basin in km	[42]
Ruggedness number (R_n)	$Rn = D * R$	[43]
Sinuosity (Si)	$Si = VL/BL$	[44]
Slope index (SI)	$SI = E_{85} - E_{10} / 0.75\ VL$, where E_{85} = the elevation in meters of point at 85% of the valley length from its mouth, E_{10} = the elevation in meters of point at 10% of the valley length from its mouth,VL = the valley length in kilometers.	[28]
Relief ratio (Rr)	$Rr = R / BL$, where, R = the difference in elevation between the head and the mouth of the basin, BL = length of the basin.	[45]

Figure no 11: Stream order map of : (a); wadi El-Matula basin and its sub-basins; b) Wadi Qena basin and its sub-basins stream orders map.



Many significant parts of such places are virtually threaten by flash flooding due to the absence of hazard awareness of fluvial impacts of desert wadis during development planning. Their presence in the courses of the main channels of basins subject them to the flash flood vulnerability. According to the estimated degrees of hazards, the studied basins and sub-basins were classified into five areas, as follows; 1) extremely highly hazardous such as Wadi El-Sheikh Issa and Wadi Um Selimat sub-basin of Wadi Qena, 2) highly hazardous as Wadi El-Mallah sub-basin of Wadi El-Madamod and Wadi Qena basin, 3) moderately hazardous as Wadi El-Madamod basin and Wadi Gurdi sub-basin of Wadi Qena. 4) slightly hazardous as Wadi El-Shoki basin and Wadi Quriya sub-basin of Wadi Qena. 5) weakly hazardous as Wadi Maasar sub-basin of Wadi El-Matula and Wadi Fatira sub-basin of Wadi Qena (Figures no 14,15, 16).

Table no 4a: Determination of the hazard degrees of the selected parameters for basins and sub-basins of wadis: El-Shoki, El-Madamod, Banat Birri, Higaza, El-Matula and El-Sheikh Issa.

Prameters	The values of parameters and their related hazard degrees					
Rb	Value	6.18 - 6.85	5.50 - 6.18	4.82 - 5.50	4.14 - 4.82	3.46 - 4.14
	Hazard degree	1	2	3	4	5
D	Value	0.92 - 1.29	1.29 - 1.65	1.65 - 2.02	2.02 - 2.38	2.38 - 2.75
	Hazard degree	1	2	3	4	5
F	Value	0.42 - 1.17	1.17 - 1.92	1.92 - 2.67	2.67 - 3.42	3.42 - 4.16
	Hazard degree	1	2	3	4	5
Lo	Value	0.47 - 0.54	0.40 - 0.47	0.33 - 0.40	0.25 - 0.33	0.18 - 0.25
	Hazard degree	1	2	3	4	5
SI	Value	0.12 - 0.34	0.34 - 0.56	0.56 - 0.78	0.78 - 1.00	1.00 - 1.22
	Hazard degree	1	2	3	4	5
A	Value	17 - 1390	1390 - 2763	2763 - 4136	4136 - 5509	5509 - 6882
	Hazard degree	1	2	3	4	5
Rr	Value	0.00 - 0.01	0.01- 0.01	0.01- 0.01	0.01- 0.01	0.01- 0.02
	Hazard degree	1	2	3	4	5
Rn	Value	0.07 - 0.17	0.17 - 0.27	0.27 - 0.36	0.36 - 0.46	0.46 - 0.56
	Hazard degree	1	2	3	4	5
Si	Value	1.44 - 1.56	1.33 - 1.44	1.22 - 1.33	1.11- 1.22	1.00 - 1.11
	Hazard degree	1	2	3	4	5
Ish	Value	0.15 - 0.33	0.33 - 0.51	0.51- 0.69	0.69 - 0.88	0.88 - 1.06
	Hazard degree	1	2	3	4	5

Table no. 4b: Determination of the hazard degrees of the selected parameters for Wadi Qena basin and its sub-basins.

Prameters	The values of parameters and their related hazard degrees					
Rb	Value	5.69 - 6.18	5.20 - 5.69	4.71 - 5.20	4.22 - 4.71	3.73 - 4.22
	Hazard degree	1	2	3	4	5
D	Value	0.48 - 0.60	0.60 - 0.71	0.71 - 0.83	0.83 - 0.94	0.94 - 1.06
	Hazard degree	1	2	3	4	5
F	Value	0.08 - 0.13	0.13 - 0.19	0.19 - 0.24	0.24 - 0.29	0.29 - 0.35
	Hazard degree	1	2	3	4	5
Lo	Value	0.92 - 1.03	0.81 - 0.92	0.70 - 0.81	0.58 - 0.70	0.47 - 0.58
	Hazard degree	1	2	3	4	5
SI	Value	0.20 - 0.43	0.43 - 0.65	0.65 - 0.87	0.87 - 1.10	1.10 - 1.32
	Hazard degree	1	2	3	4	5
A	Value	86.5 - 3226	3226 - 6365	6365 - 9504	9504 - 12643	12643 - 15782
	Hazard degree	1	2	3	4	5
Rr	Value	0.00 - 0.01	0.01 - 0.01	0.01- 0.01	0.01- 0.02	0.02 - 0.02
	Hazard degree	1	2	3	4	5
Rn	Value	0.11 - 0.19	0.19 - 0.27	0.27 - 0.35	0.35 - 0.43	0.43 - 0.51
	Hazard degree	1	2	3	4	5
Si	Value	1.24 - 1.29	1.18 - 1.24	1.13 - 1.18	1.08 - 1.13	1.03 - 1.08
	Hazard degree	1	2	3	4	5
Ish	Value	0.16 - 0.25	0.25 - 0.35	0.35 - 0.44	0.44 - 0.54	0.54 - 0.63
	Hazard degree	1	2	3	4	5

Rb = Bifurcation ratio
D = Drainage density (km^{-1})
F = Stream frequency (km^{-2})
Lo = Length of overland flow (km)
Ish = Shape index
Rn = Ruggedness number
Si = Sinuosity (km)
SI = Slope index
A = Area of the basin (km^2)
Rr = Relief ratio

Figure no 12: a- Photo shows the flash flood water filling the excavated discharge channel in the downstream of Wadi Qena near Qena town in autumn 2016; **b-** Photo shows the filling of the excavated discharge channel by the sediments deposited by flash floods of Wadi Qena.

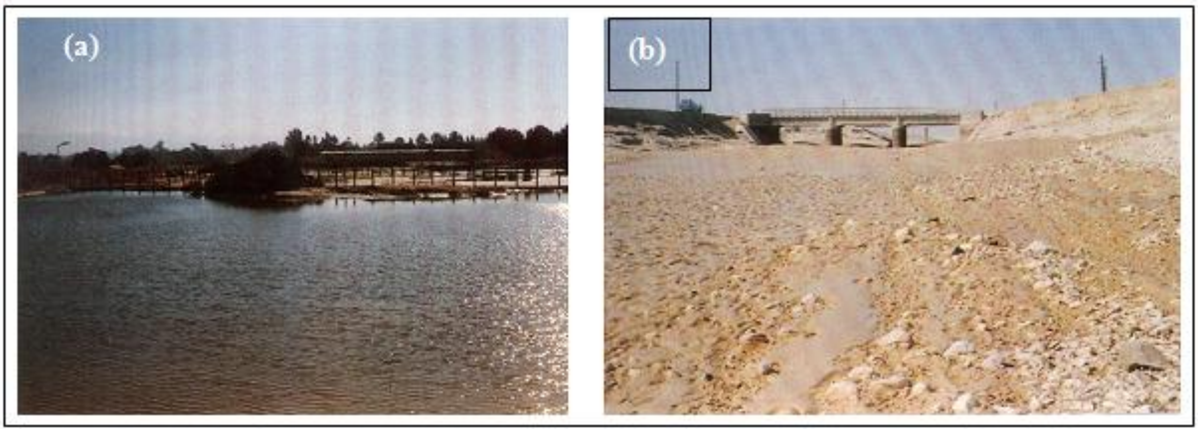


Figure no 13: a- Photo shows the collapse of the Qift-Qusseir asphaltic road (Arrows); **b-** damage of houses of the farmers at wadi El-Matula due to the effects of flash floods.

Flash Flood Mitigation: For mitigation the staggering damage and losses caused by torrential floods, it is recommended to do the following applicable measures:

1- At the upstream portion of the studied basins and sub-basins it is recommended to erect set of artificial barriers in a zigzag pattern across the channels from the upstream towards the downstream using the local rock materials resulted from the disintegration of the rock masses. This will reduce the runoff velocity and allow the replenishment of groundwater.

2- Digging artificial reservoirs at the outlets of the tributaries in the extremely highly and highly hazardous sub-basins which store water that can be used in various purposes.

3- Digging artificial channels at the mouth of the main basins to collect the runoff water dispersed in the braided shallow channels to drive them into artificial reservoirs.

4- Excavation of artificial reservoirs or retention cisterns which are lined with an artificial cement in the downstream parts of the main basins that can be used for development of the adjacent areas for reclamation and agriculture.

5- Construction of diversion dams as versatile gabions in a stacked fashion and spillway canals at the outlets of the main channels of the extremely highly, highly and moderately hazardous basins in the western downstream areas. This will diverts the courses of the main channels away from the nearby villages, industrial regions or farmlands to protect the habitants from flash flood damage.

6- For protection the paved roads that lie across the channel courses of the studied basins or sub-basins, it is recommended to make the following:

a- Increase the construction of large culverts underneath the roads or bridges instead of culverts, which are failed to pass the great quantities of runoff through it.

b – Protect the sides of paved roads, which face the erosion by lining with suitable local rock materials.

7 – Intensive studies are recommended before erection of any new project in the downstream portions of the study basins.

Figure no14 : Landuse map of Wadi El-Shoki (1), Wadi El-Madamod (2), Wadi Banat Birri (3) and Wadi Higaza (4).

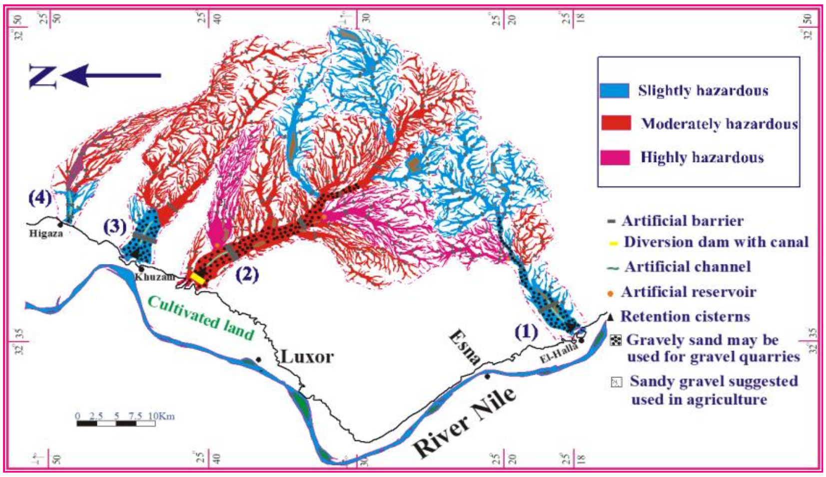


Figure no15: Landuse map of Wadi El-Matula.

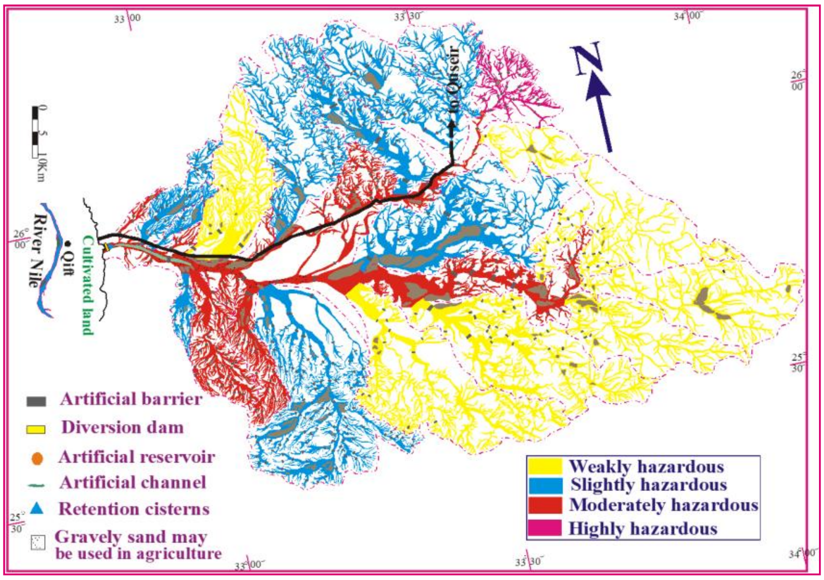
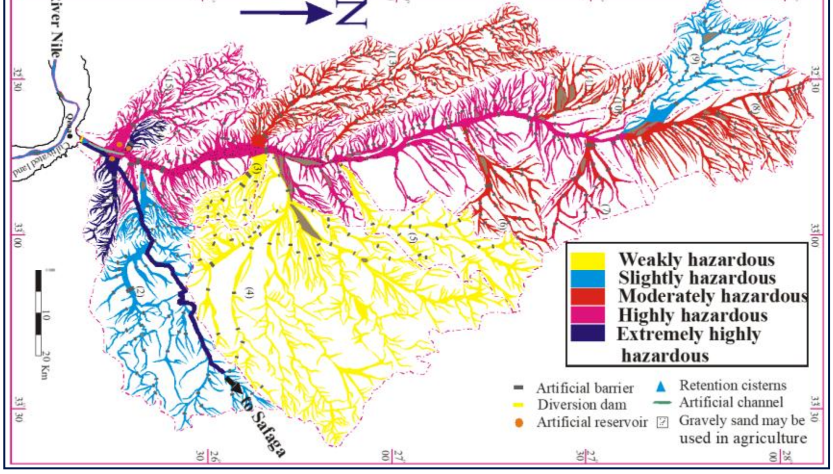


Figure no 16: Landuse map of Wadi Qena.



8 – Prevention any licenses of building without permission of the governmental authorities which are responsible for this target to determine the suitable areas for building.
9 – Awareness of people to avoid building in the downstream areas across the channel courses of the basins.
10 – The constructed culverts and channels or canals should be examined annually to remove the eroded rock materials, which transported by floods and deposited within culverts and channels.

IV. Conclusion and Recommendations

Grain- size analysis proved that most of the analyzed sediments in the investigated wadis lie in the range of gravely sand and sandy gravel. The abundance of gravel in some wadis, particularly at the downstream parts is an important factor for exploiting gravel as building materials. The analyzed samples showed that they are restricted in the range of poorly sorted. This may be attributed to velocity changes and the rapidsedimentation from viscous flows that incorporate fine and coarse materials during transportation. Plotting the analyzed samples on the log-probability curves revealed the presence of three populations in the studied wadis, namely, saltation population, suspension population and traction population (surface creep population). Plotting the analyzed samples on C-M diagram revealed that most of the studied sediments were transported by rolling transportation mode. This transportation mode is conformable with the log-probability results of the studied sediments, hence most of samples are represented by the traction (surface creep) population.

The heavy mineral suite revealed that the sediments of the studied wadis were derived from the pre-existing sedimentary rocks, both acidic and basic igneous rocks and from metamorphic rocks.

The correlation between drainage lines with structural lineaments revealed that most of the drainage lines of the studied wadis are structurally controlled. The studied drainage basins and sub-basins show drainage densities in the range of poorly drained basin. This indicates high flood flow and small amount of the contribution of groundwater to the discharge. The drainage frequencies of the studied basins and sub-basins are of high values, reflecting more possibility of runoff water but without a large chance for downward infiltration due to the rapid flow out. According to the estimated degrees of hazards, the studied basins and sub-basins were classified into five areas, namely extremely highly hazardous, highly hazardous, moderately hazardous, slightly hazardous as and weakly hazardous.

The considered wadis contribute huge quantities of water and large amounts of sediments during flash floods. Wadi Qena, Wadi El-Matula and Wadi El-Madamod contribute the highest amounts of sediments during flash floods due to the high strength of their flash floods. Wadi El-Shoki, Wadi El-Madamod, Wadi El-Sheikh Issa and Wadi Banat Birri contribute large amounts of coarse sediments most of them are gravel. Therefore, their sediments could be used as building materials by establishing gravel quarries in their downstream areas, which are valuable in the development of the nearby areas. Wadi Higaza, Wadi Qena and Wadi El-Matula contribute large amounts of fine sediments most of them are of sand size. Therefore, their sediments are valuable for agriculture purposes when water will be available. Furthermore, it is noticed that, most of the studied pit samples are of gravely sand and sandy gravel, which have high porosity and permeability. Consequently, these sediments may give a good chance for downward infiltration into the groundwater. The erection of artificial barriers in a zigzag pattern across the channels from the upstream towards the downstream of the studied wadis will reduces the runoff velocity and allows the replenishment of groundwater. It is suggested that the sediments that are frequently deposited in the flood plains of the studied wadis may be favourable for agriculture due to their enrichment with fine sediments when the water source will be available.

References

[1]. Said R. The geology of Egypt. Elsevier Pub. Co., Amsterdam, New York, 1962; 337.
[2]. El-Ghawaby M A. Structural geology and radioactive mineralization of Wadi Zeidun area, Eastern Desert, Egypt. Ph.D. Thesis, Ain Shams Univ., 1973; 211.
[3]. Issawi B, Abdallah AM., Said M. Geology of Wadi El-Mashash area, Eastern Desert, Egypt. Ann. Geol. Surv. Egypt, 1978; 8: 163-185.
[4]. Geological Survey of Egypt. Geological map of Aswan, scale 1:1000.000 Geol. Surv. of Egypt, Cairo, Egypt. 1979.
[5]. El-Shamy IZ. Quantitative geomorphology and surface water conservation in Wadi Matula-Wadi Abbad area, Central Eastern Desert, Egypt., Ann. Geol. Surv. Egypt. 1985; xv: 349-358.
[6]. Issawi B, Jux U. Contributions to the stratigraphy of the Paleozoic rocks in Egypt. Egyptian Geol. Survey, Cairo. 1982; 62.
[7]. Zittel AK. Beitráge zur Geologie und Paláontologie der Libyschen Wüste und der angrenzenden Gebiete von Agypten. Paliionto graphica.1883; l-1t2.
[8]. Barron T, Hume WF. Topography and geology of the Eastern Desert of Egypt (Central portion). Survey Dept. Cairo. 1902; 331.
[9]. El-Tarabili E. General outlines of epeirogenesis and sedimentation in Region between Safaga, Quseir, and Southern Wadi Qena Area, Eastern Desert, Egypt. AAPG Bull. 1966; 50(9):1890-1898.
[10]. Faris M. Geological and paleontological studies on the Late Cretaceous-Early Tertiary succession in the Qena region and Kharga Oasis. M.Sc. Thesis, Assiut Univ.1974.
[11]. Ahmed EA. Sedimentology and tectonic evolution of Wadi Qena, Egypt., Ph. D. Thesis, Assiut Univ.,1983;136.
[12]. Bandel K, Kuss J, Malchus N. The sediments of Wadi Qena (Eastern Desert, Egypt). J. Afr. Earth Sci.,1987; 6(4):427-455.
[13]. El-Shamy, IZ. Quantitative geomorphometry and surface runoff control for Wadi Qena, Central Eastern Desert, Egyptian Geoph. Soc., Proc.6 th Ann.1988:13-26.

[14]. El-Rakaiby M L. Drainage basins and flash flood hazard in selected parts of Egypt. Egypt. J. Geol. 1989;33(1-20):307-323.
[15]. Hume WF. The effects of secular oscillations in Egypt during the Cretaceous and Eocene Periods. Q. J. Geol. Soc., London, 1911; 67(265):118-148.
[16]. Hume WF. Explanatory notes to accompany the geologic map of Egypt: Egypt Survey Dept. Cairo, 1912; 51.
[17]. El-Naggar ZR. On a proposed lithostratigraphic subdivision for the Late Cretaceous-Early Paleocene succession in the Nile Valley, Egypt, U. A. R. 7 th Arab Petrol. Congr., Kuwait. 1970; 64(B-3):50.
[18]. Abd El-Razik TM, Razvaliave AV. On the tectonic of the Nile Valley between Idfu and Qena. Egypt. J. Geol. 1972;16(2):235-245.
[19]. Abdallah AM, Abu Khadra AM, Abdel Razik TM. New light on the geologic structure of East Qena region, Upper Egypt. Proceeding of the VI colloquium on the geology of the African region, Athens. 1977; VII:767-778.
[20]. El-Etr HA, Yousef MSM, Dardir AA. Utilization of "Landsat" images and conventional aerial photographs in the delineation of some aspects of the geology of the Central Eastern Desert, Egypt, Ann. of Geol. Surv. of Egypt, 1979; ix:136-162.
[21]. El-Shamy IZ. Recent recharge and flash flooding opportunities in the Eastern Desert, Egypt. Ann. Geol. Surv. Egypt. 1992; xviii: 323-334.
[22]. Abdelkareem M, El-Baz F, Askalany, M, et al. Groundwater prospect map of Egypt's Qena Valley using data fusion. International Journal of Image and Data Fusion, 2012; 3(2):169-189
[23]. Tahaa MMN, Elbarbary SM, Naguib DM, El-Shamy IZ. Flash flood hazard zonation based on basin morphometry using remote sensing and GIS techniques: A case study of Wadi Qena basin, Eastern Desert, Egypt. Remote Sensing Applications: Society and Environment, 2017; 8:157–167.
[24]. Folk RL. Petrology of Sedimentary Rocks. Hemphill Pub. Co., Austin, Texas. 1980: 182.
[25]. Folk RL, Ward W. Brazos River Bar; A study in the significance of Grain Size Parameters J. Sed. Pet. 1957;27:3-26.
[26]. Poppe LJ, Eliason AH, Hastings ME. A Visual Basic program to generate grain-size statistics and to extrapolate particle distributions. Computers & Geosciences. 2004;30:791–795.
[27]. Mange MA, Maurer HFW. Heavy minerals in colour. Chapman & Hall, London. 1992:147.
[28]. Strahler AN. Quantitative analysis of watershed geomorphology. Trans. Am. Geophys. Union. 1957;38(6):913-920.
[29]. Strahler AN. Quantitative geomorphology of drainage basin and channel networks. In: Chow VT (Ed.). Handbook of Applied Hydrology. McGraw Hill Book Co., New York. 1964:4–76.
[30]. Ghaznavi AA, Quasim MA, Ahmad AHM, et al. Granulometric and facies analysis of Middle–Upper Jurassic rocks of Ler Dome, Kachchh, western India: an attempt to reconstruct the depositional environment. Geologos . 2019;25: 51–73.
[31]. Passega R, Byramjee R. Grain-Size Image of Clastic Deposits. Sedimentology, 1969;13:233-252.
[32]. Visher GS. Grain size distributions and depositional Processes. J. Sed. Pet. 1969;39(3):1074-1106.
[33]. Pettijohn FJ; Potter PE, Siever R. sand and sandstone. Springer-Verlag, New York, Heidelberg, Berlin. 1973:618.
[34]. Pettijohn FJ. Sedimentary rocks. 3 rd ed. Harper and Raw, New York.1975; 628.
[35]. Friedman, G.M. and Sanders, J.E. principles of sedimentology. John Wiley and Sons, Inc., New York. 1978: 792.
[36]. Morton AC. Geochemical studies of detrital heavy minerals and their application to provenance research: In Morton A C, Tood SP, Haughton PDW (eds.) " Developments in sedimentary provenance studies". Geol. Soc. Spec. Publ., 1991; 57: 31-45.
[37]. El-Shazly EM, Abdel Hady MA, El-Ghawaby MA, et al. Drainage Maps of Egypt scale 1:1000.000 Southern east sheets based on landsat satellite imagery interpretation and field investigations published by the Remote Sensing Center Academy of Scientific Research and Technology, Cairo, Egypt and Oklohoma state University, Stillwater, Oklahoma, U. S. A.1980.
[38]. El-Gaby S, List FF, Tehrani R, Salachourian MH. Ancient Fracture systems and Red Sea tectonics. - 3 rd Int. Conf. Arab World, Cairo Univ. 1996:143-160.
[39]. Horton RE. Erosion development of streams and their drainage basins: hydrophysical approach to quantitative morphology. Geol. Soc. Am. Bull. 1945;56:275-370.
[40]. Orbson JF. Drainage density in drift–covered basins. American Society Civil Engineers. 1970;96:183-192.
[41]. Horton RE. Drainage basin characteristics. Trans. American Geophysics Union. 1932;13:350-361.
[42]. Hagget P. Locational Analysis in Human Geography. Edward Arnold Ltd, London. 1956:339
[43]. Melton MA. An analysis of the relation among elements of climate. Surface properties and geomorphology. Technical office of Natural Research, Geography Branch Project NR. 389-042, Columbia Univ., New York. 1957:34.
[44]. Aggour TAO. Priorities of flood insurance, Gulf of Aqaba Region, Southeast Sinai, Egypt. Desert Inst. Bull., Egypt. 1999;49(2):371-400
[45]. Schumm SA. Evolution of drainage systems and slopes in badlands at Perth Ambay, New jersey, Geol. Soc. Am. Bull. 1956; 67: 596-646.