Characteristics of the watershed and their implications for the hydrological response to water in the Nafit basin, East Iraq, Using Spatial Information Technology

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خصائص مستجمعات المياة وآثارها على الأستجابة الهيدرولوجية للمياة في حوض وادي النفط , شرق العراق, بأستخدام تقنية المعلومات المكانية

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المستخلص

ثبت ان تكنولوجيا المعلومات المكانية اي نظم المعلومات الجغرافية والأستشعار عن بعد هي أدوات فعاله في تحديد وتخطيط نمط التصريف وادارة الموارد المائية. اعتمدت نظم المعلومات الجغرافية ومعالجة الصور الفضائية لتحديد الخصائص المورفولوجية وتحليلها في حوض النفط الهيدرولوجي في محافظة ديالى , شرق العراق وغرب ايران. تم تحديد المعلمات المورفومترية للحوض مثل الجوانب الخطية والمساحية والتضاريسية وحسابها بأستخدام برنامج ArcGIS v.10.3 . تأثرت رتب المجاري بنوعية الصخور وتراكيبها والظروف الفزيوغرافية لمنطقة الدراسة. تغطي منطقة الدراسة صخور (تكوين الفتحة, تكوين انجانة, تكوين المقدادية والترسبات الحديثة) وبمساحة (3723 كم^2) ونمط التصريف للحوض شجري وبسة مراتب نهرية. تتأثر الخصائص الهيدرولوجية للحوض بنوع وتكوين الصخور وكميات الأمطار الساقطة

Abstract

It has been proven that spatial information technology, ie GIS, and remote sensing are an effective tool in the identification and planning of drainage pattern and management and planning of water resources. GIS and image processing were adopted to determine morphological characteristics and analyze them in the Nafit river basin in Diyala Governorate, east Iraq and western Iran. The basin morphometric parameters such as linear, aerial and relief aspects of the river basin were determined and computed using ArcGIS v. 10.3software. Stream orders in the basin affected to the conditions of rock structures and physiographies conditions. The study area is covered by (Fatha Formation, Injana Formation, Mukdadiya Formation and Quaternary deposits) with the area (3723km^2). It is 6th order drainage basin and drainage pattern mainly in sub dendritic to dendritic type. The hydrological characteristics of the basin are influenced by the type and composition of the rocks and the amounts of rainfall.

Keywords: Nafit river basin, spatial information technology, Morphometry, GIS

1 - Introduction

Watersheds are defined as "a geographically defined area with high elevations, the water is discharged by means of a network of sewage flowing in one point the downstream" [1].

The evolution of the drainage system and the flow pattern of the river is influenced by several variables such as "geology, structural components, geomorphology and vegetation" in the area from which they flow. GIS has already been used to evaluate different morphology and morphological parameters of watersheds because it provides a flexible environment and a powerful tool for analyzing spatial information, especially in identifying and extracting in the future[2].

Morphometric is the measurement and mathematical analysis of the configuration of the earth's surface, shape and dimensions of its land forms [3].

Analysis of morphometric parameters can be achieved by measuring the linear and air aspects and relief of basins using remote sensing and geographic information systems [4].

The morphological parameters of the hydrological Nafit basin were evaluated. The drainage pattern of the basin is a semi-tree, and has six order stream. Geologically, the basin is characterized by limestone,claystone and gypsum.

Morphometric studies involve the analysis of streams by the measurement of various stream characteristics. Analysis of various drainage parameters, "namely ordering of the streams and measurement of area basin", the perimeter of the basin, length of channels, drainage density, bifurcation ratio, drainage frequency, drainage texture and circularity ratio [5]. GIS techniques and image processing techniques have been adopted to identify morphological characteristics and analyze their characteristics of the Nafit River basin region of eastern Iraq. River basins constitute a distinct morphological area and have a special connection to the drainage pattern [6]; [7]. Horton's law of waterway lengths shows an engineering relationship between the number of waterways, waterways levels and the surface of the earth [8]. A detailed analysis of the drainage parameters greatly helps to understand the effect of drainage measures on land forms and their hydrological and terrestrial characteristics for the study area. "A drainage system analysis at the basin level was carried out using the (spatial analysis) system (ArcGIS. 10.3) to identify the effect of drainage measures on land forms, drainage and soil erosion characteristics". The study shows that the integrated approach to "remote sensing and GIS" is more appropriate and useful than conventional methods.

There is a relationship between morphometric parameters of the drainage basin and potential flooding. High drainage density, flow velocity and channel corrosion were found to be correlated with precipitation. Drainage density also provides a link between the features of the basin shape and the erosion process, which can lead to greater flood potential [9].

Measuring the drainage density again provides hydrologists and geomorphologists with a useful digital scale for landscape dissection and potential flow[10]. The risk of flooding increases with decreasing of bifurcation ratio within the basin. It also indicates the risk of flooding in a part of the basin, not all of the basin[11]. The study was conducted to clarify information on the measurement of drainage in the Nafit River Basin. This information has been used to describe the basin as a land form. The effect of drainage measurement in the drainage basin on hydrological processes in the basin was also studied. This study describes drainage characteristics in the watersheds of Nafit (in eastern Iraq and western Iran) to understand their hydrological characteristics by remote sensing and Geographic Information Systems.

2 - Aims of study area

1- Compute the Nafit hydrological basin morphometric characteristics for various parameters using Spatial Information Technology (Remote sensing and GIS).
2- Description of the drainage characteristics in the basin in eastern Iraq and western Iran to determine the extent of hydrological response in the basin by remote sensing (RS) and GIS analysis.

3- Location and area

The study area (Nafit hydrological basin) is enclosed between latitudes (33^0 24^- $00^=$) N and (34^0 23^- $00^=$) N and longitudes (44^0 56^- $00^=$) E and (45^0 36^- $00^=$) E, in Iran and Iraq, covering an area of (3723 Km^2), in Zagros Belt east of Iraq and west of Iran (figure 1).

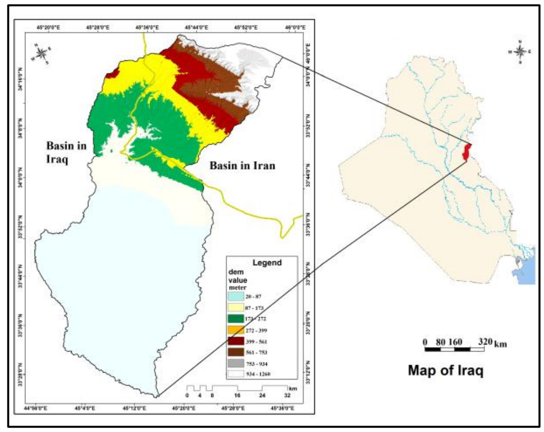


Figure (1): Location map of Nafit Basin

4- Geology of study area

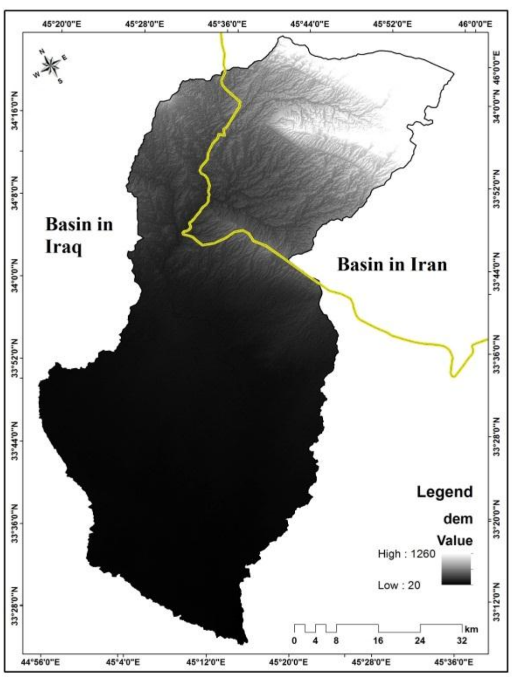
The Nafit River Basin area belongs to Zagros Belt in Iraq and Iran. The geology of the study area indicates various litho units dating from Miocene to Recent. The studied area is mostly dominated by limestone, sandstone, silt, red and gray marls, gypsum, anhydrite and recent alluvial [12].

The formations cropping out in the study area are, Fatha formation (Lower Faris formation in Iran) the rocks composing of the formation is: Anhydrite, Gypsum, and limestone. Injana formation (Upper Faris formation in Iran) the rocks composing of the Injana formation is: Siltstone, Sandstone, and Conglomerate. Mukdadiya formation (Lower Bakhtiari formation in

Iran) the rocks composing of the formation Siltstone, Marl and Conglomarate and Bai Hassan formation (upper Bakhtiari formation in Iran) its rock composition from Conglomerate [13].

5- Materials and Methods

The data used in this study were downloaded from the NASA site. It is a 30 meter, digital height model (DEM). The data were imported into the Integrated Land and Water Information System (IWIS) and Artigis environments, and were geographically determined to the longitude and latitude coordinate system where the Nafit basin is located within longitudes ($44^{0}\ 56^{-}$ E) - ($45^{0}\ 36^{-}$ E) and latitudes ($33^{0}\ 24^{-}$ N) - ($34^{0}\ 23^{-}$ N) in Iran and Iraq. The drainage network overlay was performed



Figure(2): DEM for Nafit Basin

on a map of the shadows created in the part of the spot image (Fig. 3) Covering the Nafit basin for the purpose of analysis.

5-1: Analysis Procedures

The analysis was carried out in three stages. The first stage was the identification of independent morphometric variables such as "the basin perimeter, basin area, basin relief, basin width, basin length, maximum orders and number of streams in each order". The second stage includes the calculation of the second level parameters such as "the bifurcation ratio, the circularity ratio, the elongation ratio, the frequency, the drainage density, the drainage ratio, the relief ratio, ruggedness number, ruggedness integral". The third phase involves modeling the ratio of the flow length of the flow system, the flow rate of the flow system and the long section of the main channel of the basin.

6- Results and Discussion:

The morphometric parameters of the Nafit basin were determined as in table (2), (table 3).

6-1: Linear Aspects:

The linear aspects of drainage network such as stream order (Nu), bifurcation ratio (Rb), stream length (Lu), mean stream length (Lsm) results have been presented in (table 2).

6-1-1: Linear Parameters

The number of streams is (1261 km) first order, (298km) second order, (87km) third order, (21km)fourth order (5 Km)fifth order. The mean stream length (1.743km), (3.838 Km), (7.206 Km) and (117 Km) respectively. The values of the stream length ratio are 0.01 (1^{st} order), 2.20 (2^{nd}order), 1.87(3^{rd}order), 1.72 (4^{th} order), (Table 2), Figure(4). Figure (5) presents the Stream Order- Stream Length Ratio curve, which reflect a single pick at 2^{nd} order, but with the values of the stream length ratio greater than 1.87 for 3^{rd} and 4^{th} order. The interpretation of this is that the channel gradient will be higher for

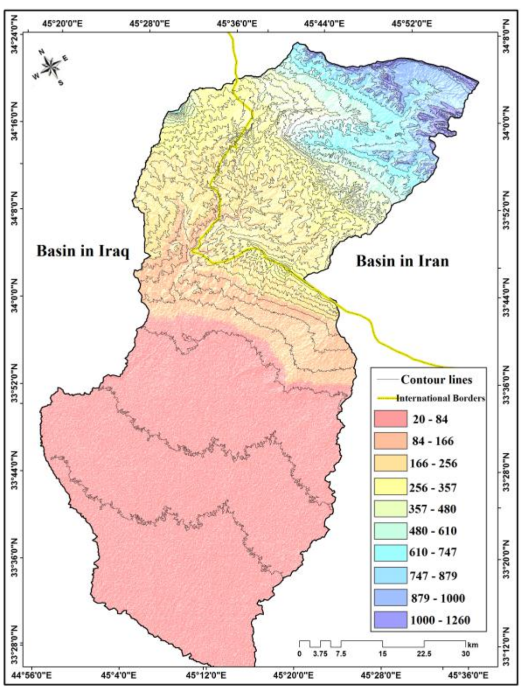


Figure (3): Elevation contour map of Nafit Basin

minimal structural control of the drainage development across the study area. The relatively high mean land flow (0.418 km) calculated for the study area indicates that there will be more time for rainwater flow at the site before the final concentration of runoff in the main channels. The length of the course varies according to the local changes in the slopes and the topography of the basin.

table (1a): Linear parameters and their formula

No	parameters	formula	Ref.
		Linear Morphometric Parameters	
1	Stream Order (Sm)	Hierarchical rank	[14]
2	Bifurcation Ratio (Rb)	Rb= N/N+1 where, Rb= Bifurcation ratio, N= No. of stream segments of a given order, N+1= No. of stream segments of next higher order	[15]
3	Mean Bifurcation Ratio (Rbm)	Rbm = average of bifurcation ratio of all orders	[14]
4	Stream Number (Sn)	Sn= total number of streams	
5	Stream Length(L)	Length of Stream (in Km)	[14]
6	Mean Stream Length (Lsm)	Lsm = Lu / Nu where, Lu= total stream length of order, Nu = total number of streams in order	[14]
7	Stream Length Ratio (RL)	RL = Lsm / Lsm-1 where, Lsm = Mean stream length of a given order and Lsm-1= Mean stream length of next lower order	[14]
8	Length of Overland Flow (Lg)	Lg = 1 / 2Dd km where, Dd = Drainage density (km / km^2)	[14]
9	Basin Perimeter (P)	the P = outer boundary of drainage basin measured in (Km)	[15]
10	Basin Length (Lb)	Lb = The line that represents the axis of the basin	[16]

table (1b): Areal parameters and their formula

No	parameters	formula	Refe.
		Areal Morphometric Parameters	
1	Basin Area (A)	An area from which water drains to a common stream and determined by opposite ridges	[17]
2	Drainage Density (Dd)	$Dd = Lu / A$ where, Dd = Drainage density (Km/Km^2) Lu = total stream length of all orders A = basin area (Km^2)	[18]
3	Stream Frequency (Fs)	$Fs = Nu / A$ where, Fs frequency, Nu = total number of streams of all orders, A = basinarea (Km^2)	[18]
4	Drainage Texture (Dt)	$Dt = N / P$ where, N = total number of streams of all orders and P = perimeter of the basin	[19] & [14]
5	Form Factor Ratio (Rf)	$Rf = A / Lb^2$ (Km) where, A = basin area and Lb= maximum basin length	[18]
6	Elongation Ratio (Re)	$Re= 2\sqrt{(A / \pi)} / Lb$ where, A= basin area (Km^2) Lb=maximum basin length (Km)	[15]
7	Circularity Ratio (Rc)	$Rc = 4\pi A / P^2$ where, A = basin area (Km^2) and P= basin perimeter (Km) Or $Rc = A / Ac$ where, A = basin area (Km^2) and Ac =the area of the circle that has the same perimeter as the basin	[20]

table (1c): relief parameters and their formula

No	parameters	formula	Refe.
		Relief Morphometric Parameters	
1	Channel Gradient (Cg)	Cg = Cc – Epp where, Cc = Channel Crest , Epp = Elevation of downstream point	[14]
2	Maximum Basin Relief (Rb)	Rb = Eh - Ebm where, Eh = highest elevation of Basin and Ebm = Elevation of downstream point	[14]
3	Relief Ratio (Rr)	Rr = Rb/Lb where, Rb = maximum basin relief and Lb = maximum length of the basin	[15]
4	Relative Relief (Rhp)	Rhp = Rb / P where,Rb= maximum basin relief and P = basin perimeter	[15]
5	Relief Index (Ri) or (Hypsometric Integral)	Ri = A / Lb where A= basin area, Lb=Length of basin	[15]
6	Ruggedness Number (Rn)	Rn = Rb Dd where, Rb =maximum basin relief and Dd = Drainage density	[17]
7	Lemniscates Factor (F_L)	$F_L = Lb^2 / 4A$ where, Lb= basin Length, A= basin area	[15]
8	Compaction Ratio (Cr)	P / M P= Basin Perimeter, M= perimeter of the circle having the same as basin area	[14]
9	Geometric Number Gn	Gn = H Dd/ Ds H= maximum relief, Dd= Drainage density, Ds= channel gradient	[14]

table (2): Results of streamorders parameters of Nafit Basin

Nafit River	Stream order	Number of Streams N	%for any order	Bifurcation Ratio(Rb)	Total Length of streams L km	mean stream length (Lu/Nu) lsm	stream length ratio RL
	1	1261	75.37	4.23	2199	1.743	0.01
	2	298	17.81	3.42	1144	3.838	2.20
	3	87	5.20	4.14	627	7.206	1.87
	4	21	1.25	4.20	261	12.428	1.72
	5	5	0.30	5.00	106	21.2	1.70
	6	1	0.06		117	117	
Total		**1673**		**Mean: 4.12**	**4454**		

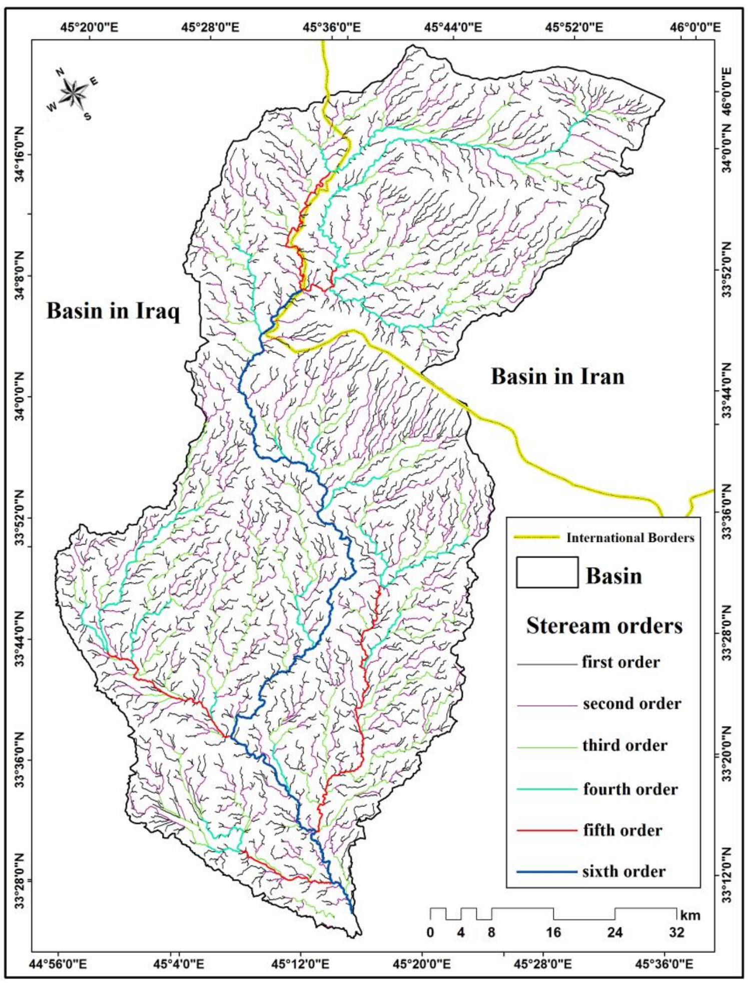


Figure (4): Drainage pattern and their order indentification from Nafit basin according to DEM

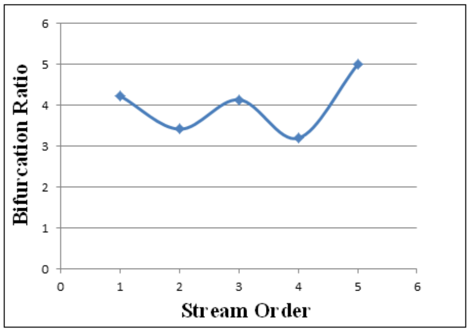


Figure (5): Relationship between Stream Order and Bifurcation Ratio

Figure (6): Relationship between Stream Order and Stream length Ratio

The rate of bifurcation ratios is (4.23 first order), (3.42 second order), (4.14 third order), (4.20 fourth order) and (5.00 fifth order). Mean of the torsion ratio (4.12). Figure (6) shows the curve of the ratio of the diffraction, which reflects two values in the first rank and the fifth grade, which show the values of the ratio of the spacing greater than 5.0. Thus, a large proportion of first- and fifth-degree drainage channels are likely to be affected by the rock layer structures. However, the range of the cascade indicates, it appears to be the least affected by the compositions to change the discharge of water throughout the study area [21]. The relatively high surface runoff rate (0.418 km) calculated for the study area indicates greater time for in-ground filtration prior to runoff of rainwater in the basin before it flows into the main channels. The length of the course varies according to the local changes depending on the slopes and the terrain of the basin

6-2: Areal Parameters

Drainage density in the hydrological basin is affected by the type of rock, terrain, vegetation, climate, filtration capacity and the effect of drainage intensity [21], [22].

The "density of drainage in the study area" (1.196 km / km2) indicates moderate drainage density. This mean density of the basin indicates moderate permeability of the surface of the earth.

The flow frequency of watersheds in Nafit basin (0.449 km / km 2) is estimated which mainly depends on the type of rock in the aquarium and reflects the drainage mesh fabric. Fs values and discharge density that is directly proportional to watersheds and that the increase in the number of streams is related to drainage density [21].

The values of the Form Factor (Rf) 0.28, Elongation Ratio (Re) 0.596 and Circularity Ratio 0.4133 "indicate that the watershed is elongated and it is at the advanced stage of land forms development". Thus, It is easy to manage surface runoff where the discharge peak is low in the main channel, (table 3).

table (3): Result analysis of Nafit basin

No.	Parameters	Value
	Linear Morphometric Parameters	
1	Basin Area A	3723 Km^2
2	Basin Perimeter P	336.28 Km
3	Axial Basin Length (E-W Orientation) Lb	115.45 Km
4	Axial Basin Width (N-S Orientation) Wb	32.25 Km
5	Minimum Stream Order	1
6	Maximum Stream Order	6
	Areal Morphometric Parameters	
1	Drainage density Dd	1.196 Km / Km^2
2	Stream Frequency Fs	0.449
3	Drainage texture Dt	4.975 Valleys / Km
4	Form Factor Rc	0.28 Km
5	Elongation Ratio	0.596
6	Length of overland flow Lg	0.418 Km
7	Circularity Ratio Rc	0.4133
	Relief Morphometric Parameters	
1	maximum basin relief	1240 m
2	channel gradient Cg or relief ratio Rr	10.74 m / Km
3	Relief Ratio (Rr)	10.74
4	Relative Relief Rhp	0.368
5	Relief Index (Hypsometric Integral) Ri	32 Km
6	Ruggedness Number Rn	1.483
7	Lemniscates Factor (F_L)	0.895
8	Compaction Ratio Cr	1.555
9	Geometric Number Gn	138.08

6-3: Relief Parameters

Relief is "the difference in height between the highest point and the lowest point in the basin". It is an important factor in understanding the erosion characteristics of the hydrological basin. The drainage of the basin plays an important role in "land forms, drainage development, surface water flow, groundwater storage, permeability and surface erosion" [21].

Maximum relief basin (1240 m) and relief ratio (10.74 m / km), (Fig. 3). A ruggedness number (1.48) refers to elevations and decreases of the Earth's surface. These values indicate the presence of dips compared to mountainous terrain. Relief measures confirmed that the basin is the advanced stage of the geomorphological cycle [23].

The "relative relief ratio" in the basin (0.363), indicating the average slope of the basin. The value is low and indicates a low flow rate, indicating a lower rate of erosion and increased sedimentation of the river.

The calculated value of the "Relief Index" (32) indicates that 68% of the earth's surface components of the basin (above the lowest altitude) were washed in the basin.

The pressure ratio of the Nafit basin is 1.555, which indicates the nature of the pelvic surface and indicates that the "Basin is longitudinal" [24], (table 3).

7- Nafit Hydrological Valley:

The Nafit valley flows from the Iranian mountainous region (the Jomair heights inside Iran) bordering the Mandali region (in Iraq). The valley continues southward to enter Iraq, north of Mandali. The topographical nature of the land passes through the valley after its entry into Iraq is characterized by a wavy nature and a distance of more than 12 km inside Iraq after penetrating the international border line shared between Iraq and Iran and then change to flat land containing gypsum and the valley consists of torrents of rainwater falling on the feeding basin in the Iranian mountainous region, which reaches. It is located about 20 kilometers south of the Nafite Khana area. It is about 45 kilometers from the border, and the valley is characterized by irregularities, where the flood happens suddenly [25].

The intensity of the floods decreases after they have flooded the agricultural areas inside the Iraq and the load of sediments of clay, sand, gypsum and salts, and then fade valley and spread water surplus in the winter and spring carrying deposits on the flat land and then meet with other valleys and destined for Al-Shuweijeh Marsh. The maximum flood drainage of the valley in 2002 is about 1150 m^3/s at the junction of the valley with the Mandali-Baladroz road and the average annual revenue 52.8 million m^3. The valley is characterized by a flood in winter and spring, as a result of rain storms and without precedent as most of the water of the Nafite valley is not controlled at the present time, which makes use of this water is very difficult as it quickly receded from the valleys after the sinking of agricultural land and the flow of surplus water to Al-Shuweijah Marsh and as a result should be studied how to control the waters of the Nafite valley. This is done by constructing a transformer dam at an appropriate location in the valley and benefiting from it to divert water to irrigate agricultural land near the eastern border of Iraq [26].

Figure (7) shows the longitudinal section of the main Nafit channel in its course, Nafit valley loses about 980 (1000- 20) meter elevation. Thirty major Knick points occur along the valley course.

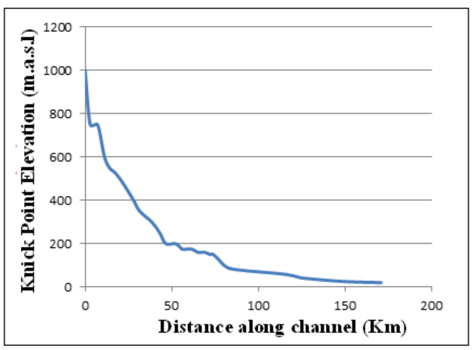


Figure (7): Longitudinal Profile of Nafit main channel

8- Conclusion

The drainage basin is mainly connected to the ground surface, and is of great importance in morphometric analyzes. The shape of the earth's surface is mainly related to climate, drainage, and rock structures. This paper describes morphological analysis of watersheds in the Nafit hydrological basin. Based on several drainage parameters, the basin is classified as six orders river.

The level of the small order in the basin is prevailing as the values of the discharge density of the basin is less than (5) revealing that the subsurface strata are permeable, a characteristic feature of coarse drainage. The stream length ratio fluctuates according to local changes in slope and topography.

The "Bifurcation ratio" indicates that watersheds do not dominate drainage patterns. "Rainfall" may affect the development of catchment sectors in watersheds. The discharge of water has now evolved from high-intensity discharge when the climate was wetter(in the past) compared to dredging drainage in line with the drier weather conditions recently. The "Elongation ratio" indicates that the watersheds are of varying relief between high and low, with steep slopes. The "Relief ratio indicates that the discharge capacity of these watersheds is very high".

This study can be used in several areas, including the assessment of water and management of the basin in a successful manner, which is reflected positively on the economic fields, especially that the study area (especially the lower parts) are agricultural areas and are subject to continuous flooding.

Recommendations

The study recommends that:

1- Construction of dams inappropriate areas to prevent flooding and water storage**.**

3- Identification of areas prone to flooding and non - establishment of facilities.
4- 3-Identification and utilization of aquifers in the basin and feeding areas.

4- Cultivating large areas of the basin and taking advantage of its water.

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