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MORPHOLOGICAL VARIATIONS OF A CERTAIN TIGRIS RIVER REACH FOR DIFFERENT PERIODS IN IRAQ

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ABSTRACT

A morphological variations occurs in the paths of rivers due to many reasons such as the hydraulic changes in the natural flow regime of rivers in-addition to the human activities on rivers such as dams constructions on rivers. Many morphological variations created on Tigris river reach within Mosul city, north Iraq for different periods between 1956 to 2002 had been studied such as the changes on the river width specially near the bridges sites and also the development of the dimensions of the islands and bars within the river reach. The available topographic maps and also an aerial photographs were depended during the data analysis with some field reconnaissance . The research work concluded that one of the main reasons for the development of the islands is the flow regime variation of Tigris river as a result of the Mosul dam operation which in-turn leaded to a reduction in the transported sediment load in the reach due to the released high stream power clear water discharges of sediment from Mosul dam. The second reason was the reduction in the water level which in-turn change the middle and side islands in the river with the growing vegetation cover such as trees and weeds specially in the sites downstream the meander of Al-Rashidia Village and downstream Al-Shuhadaa bridge and upstream Ninevah bridge and finally upstream the fourth bridge in Mosul city.

KEY WORDS

Morphology; Rivers cross-sections; Dams Impacts.

INTRODUCTION

Many morphological and hydraulic effects produced as a result of dams construction concerning stability of rivers downstream of reservoirs. These dams change the flow and sediment regime with the organic matter in the rivers. The prediction process of the influence degree of the dams with its periods was complex [1]. The physical changes on the river downstream dams range between the bed scour in the rivers banks which in-turn produce expansion in its paths to a changes in the texture of river bed (armoring) to the sedimentation processes with the creation and development of a sandy and gravel islands leading to a river contraction [2]. The response degree of the river downstream dams reflect the complex relation between the degree of flow regime changes and those discharges. Those discharges begin to transport the sediment with the new sediment supply to the river proportional to the amount of sediment deposited in-front dams. Many studies conducted by the Engineering Group of the U.S. Army during 1972 and the U.S.G.S.[3] pointed to the probability of river expansion located downstream dams [4]. [5] study the stability of newshow river downstream John Remond dam using aerial photographs with some meteorological data. Due to the changes of river shape, depending on if the river is in flooding or recession stage, studying the river characteristics in different water levels is considered one of the basics during evaluation of river shape [5]. The relationship between flow capacity and the released sediment load from reservoirs with the relationship between the erosivity of flow power with the erodibility of river banks are responsible on the changes occurs in the morphologic regime of rivers.

Dams Influence on Rivers Streams

One of the main effects of dams on the rivers is the reduction of the flowing sediment load and changes of the flow regime represented by the reduction of the high discharges and increasing the low discharges. These hydraulic changes of rivers may lead to many morphological changes while the river try to create a balance condition between the flowing discharges and the transported sediment load. Generally rivers downstream dams characterize by the erosion processes in which the river starts to erode the river bed leading to a reduction in the bed level as a result of releasing water discharges clear of sediment while the river begins to reach to its sediment load capacity. As a result of reducing the released high discharges from dams it observes a contraction in the river paths in addition to the appearance of vegetation cover on the banks except if the river bed contains rocks or coarse gravel materials. In the case when the flowing stream power starts to erode the banks instead of the bed leading to river expansion. Usually the erosion starts in the river reach near the dams as soon as the dam operate, then go forward to far distance downstream [3]. The type and the rate of erosion depends on many factors such as the released discharges, sediment load, bed materials, bank condition, bed condition, shape of stream, weather and the vegetation cover.

Aim of study

The aim of this research is to focus the light on the morphological changes occurred in a reach of Tigris river within Mosul city north Iraq for the period between 1956 till 2002 such as the appearance and development of sediment islands in river as a result of the changes in the flow regime and sediment load of the river using the analysis of the aerial photographs and topographical maps with some field measurements.

Description of the study site

The study site is 9 km length of Tigris river extends within Mosul city starting from the Rashidia meander at the north to downstream of the Fourth bridge at the south (Fig.1). The river characterizes after Al-Rashidia meander almost by its straight path due to the existence of natural banks and levees there. The average bed slope of the river within the study reach is about 55 cm/km and the bed consists of alluvial materials such as sand and gravel [6].

METHODOLOGY

Stable river may meander through its path in the valley while remain keeping the same shape of its cross-section, therefore, the variation in the river shape can be used to predict the stability of the river. In this research the changes in the river width is used as indication to evaluate the changes in the morphology of the Tigris river reach. A reach of 9 km length of Tigris river was studied to evaluate the natural and other human activity on the morphology of the river such as bridges construction in Mosul city and Mosul dam operation which was located 55 km upstream Mosul city (Fig.1). An analysis for the collected data for this reach from a topographic maps and aerial photographs was done concerning the width of river and certain morphological changes such as the appearance and development of the islands and bars within the river reach for different periods (1956,1972,1998 and 2002) i.e. (before and after Mosul dam operation). Many field reconnaissance for the river reach was made during the research period.

Flow Discharges

Many changes occur on the hydraulic and hydrologic characteristics of the rivers downstream dams combines with the reservoir morphology and the characteristics of the hydraulic structures

such as spillways and also on with the policy of dams operation [7]. A common hydrological effects of dams is the reduction in the average annual released discharges link with the sediment load capacity as a result of storages in the reservoirs. A reduction in the maximum discharges value and an increasing in the minimum discharges of the rivers occurs too like the observed increment in the minimum discharges in Tigris river after Mosul dam construction by 58.8%, [8]. Generally all the types of dams affect on the natural discharges of the rivers specially during flood season. In addition there are many annual and daily effects which are the day time hours more than the night hours due to the needs for power generation. While the annual changes occur during rain season in which the reservoirs are full of water. [9] proposed the following relation to explain the discharges of rivers which can be described by the standard variation ratio Which is the ratio of daily discharge variation for certain period.

$$Pc = 100 (x1/x2 /y2/y1 – 1)$$

Where:

Pc is the standard variation ratio.

x1, x2, the mean daily flows of a given duration at the investigated place for pre and post dam periods.

Y1, y2, the mean daily flows of given duration at control section not influenced by dam pre and post dam periods respectively.

This description of discharges may give an indication for the changes occurrence in the rivers morphology. For example [10] stated that the expansion and straightening of river kemano in Canada occurred as a result of doubling in the discharges values by three-times but without occurring a clear increment in the maximum flood values.

Changes in the river shape cross-section

The shape of river cross-section can be described by the width depth ratio which increases with the increment of stream power and the erodibility of river banks. The banks and bed materials of the river is considered one of the main parameters in predicting this ratio. The erodibility of the banks, bed and the hydraulic conditions are responsible for predicting the type of erosion either if vertical or horizontal.

DISCUSSION

Depending on the topographic maps for Tigris river reach for the year 1956,1972,1998,2002 [11] with the aerial photographs for the year 2002 [12] all the data and information represents river width specially near the bridges within Mosul city and also the dimensions of the islands in the river were collected and analyzed. Figure (2) shows the studied Tigris river reach for different periods which represent two historical time periods, the first; before Mosul dam construction and the second; after dam operation. Many changes in the morphological features of the river are clear such as the changes and the development in the islands. Table (1) shows the reduction and the contraction in the river width for the studied periods specially after Mosul dam operation. This is due to the reduction in the average annual discharges with the study periods specially within the two periods before dam construction (1956-1972) and after dam operation (1998-2002) as clear in the Table 2 and 3.

The large change occurred in the Tigris river meander within the study reach in Al-Rashidia site (Fig.1) leaded to the grown islands downstream this site which are often side island type changed to middle type characterize by its longitudinal narrow shape coincide with the river bank. The side islands with the bars formed some sub-channels leaving

dead channels specially after reduction of the water level of the river as a result of sediment accumulation in the middle part of the river. The shape of those islands depended on the flow direction and its movement. The pointed narrow shape is in the front while the wide shape is in the back. The middle islands grows when there is an obstruction inside the stream due to arrival and jumping some large masses of rocks or plants in the shallow places coming from the upstream places. The volume of these islands increases as water level of the river decreases [13].

Table 4 shows the growing and development of islands dimension existed in the river reach. Many changes in the Al-Rashidia meander island was observed as a result of discharges and sediment load changes in the river as well as in the middle island (Umalrabeeain tourist island). The formation of Umalrabeeain island was observed on the right side of the river moving towards the middle part of the river during the year 1972, then divided into two islands after Mosul dam operation as a result of discharge and sediment load reduction in the river. It is observed also in Fig.2 the beginning of island appearance during the year 1956 in the upstream of Al-Shuhadaa bridge on the river left side, it grew during the year 1972, then disappeared during 1998 and 2002. Two islands were appeared and grew downstream Al-Shuhadaa bridge as a result of the digging works in the river during the construction of this bridge in the year 1979. Those works leaded to the changes in the flow direction specially in the thalweg line to the other side of the river. One of the main morphological changes in the river reach during 2002 is the islands appearance in the upstream of the Fourth Mosul bridge on the right side of the river and also in the downstream on the left side. These islands appeared clearly after recession of the water level in the river. The width ratio of the islands and bars to the width of the river for the above periods was predicted as shown in Table 4. This table shows a reduction in this

ratio in Al-Rashidia meander site after Mosul dam operation. This means the expansion of the river at that site as a result of erosion processes occur in the formed islands there. While at the site near Umalrabeeain tourist island it was observed an increasing in this ratio after Mosul dam operation. This shows that a contraction features in the river width was occurred as a result of growing the island there due to the deposited sediment material which had been eroded from Al-Rashidia meander in addition to the sediment transported from the upstream sites between Mosul dam and the study reach of the river. The same condition coincides in the site in-front of the island downstream Umalrabeeain tourist island (in-front Al-Sadder tourist place). While in the site upstream Al-Shuhadaa bridge it was observed in the year 1972 a reduction in the width ratio between the island and the river than the year 1956. The reduction in this ratio increased more during the year 1998 which gave an indication of expansion in the river as a result of the earth digging works through the bridge construction during the year 1982.In the year 2002 an expansion in the river width was observed due to the growing islands again there. In the site downstream Al-Shuhadaa bridge a contraction features of the river width during 1998 was observed due to the clear growing island there, then an erosion processes during the year 2002 was occurred giving an indication of river expansion. During the year 1972 river contraction was observed in the site upstream Ninavah bridge (in-front of children playing city), then an expansion was occurred there due to the digging works in the Al-Qadisia bridge during the year 1988 and finally an island grew there during the year 2002 giving sign of river contraction.

Sediment Load

Generally dams affect on the sediment load in the downstream flowing rivers which receive clear water from the reservoirs due to the

sediment accumulation in the reservoirs. Those rivers called the *hungry rivers* which characterizes by the high stream power, try to reach the balance condition between the sediment transport capacity of the river and the existing sediment load. This hydraulic condition will lead to bed and bank erosion which represents the case occurred in the study reach in which Mosul dam construction lead to the 95% retardation of the inflowing sediment in the reservoir. The estimated average suspended sediment concentration in the Tigris river studied reach is 1100 mg/l before dam operation [6], while it reached to 21 mg/l in the year 1993 after dam operation [14].

The reduction in sediment concentration in the releases discharges from the dam and the appearance of bed erosion in the study reach is clear in the discharge water stage relation at Mosul station (Fig.3). It is clear from the figure that there is a reduction in the curve during 1990 than the year 1978. This gave an indication about the occurrence of bed erosion between the two periods. Previous studies conducted by [15] and [8] confirmed reaching Tigris river bed to the armoring condition and bed material coarsening due to the flushing and transportation of the fine material leaving the coarse particles there.

CONCLUSIONS

Through the morphological study of the Tigris river reach for different periods (1956,1072,1998 and 2002) which represent the historical time period before Mosul dam construction (1956-1972) and after dam operation (1998-2002) and according to the interpretation of the data from the topographic maps and aerial photographs concern the river morphology, it was concluded that Tigris river had been subjected to many morphological changes such as recession in the river width and bed erosion features and also growing and development many island and

sediment bars part of them changes to islands filled with vegetation and trees specially after recession of the water level. This is due to the changes in the flow regime and transported sediment load as a result of construction of bridges on the river in Mosul city after the year 1980 and also due to Mosul dam construction after 1985. These morphological changes continue in the river reach till reaching the stabilized condition after long period. This may affect on getting fixed data about the morphology of the river in the future needed in the designs of new hydraulic structures in this reach of the river.

REFERENCES

1. William, G.P.and M.G. Wollman.1984," Downstream effects of dams on alluvial rivers", USGS. Prof. paper 1286.
2. Petts,G.E. 1979, "Complex response of river channel morphology subsequent to reservoir construction". Prog. Phys.Geog. 3(3). 329-362.
3. U.S. Army Corps of Engineers. 1972," River bank stabilization study, Grand (Neosho) river Kansas and Oklahoma,John Redmond dam and reservoir to Kansas", Oklahoma State line: U.S.army corps of Eng. Sept.
4. Studley,S.F., 1996," Changes in high flow frequency and channel geometry of the Neosho river downstream from John Redmonddam,southeastern Kansas". U.S. geological survey water resources investigation report. 96-4243, 16p.
5. Juracek,K.E., .1999," Channel Stability of the Neosho River downstream from John Redmond dam southeastern Kansas". Internet.www.water Internationa/water resources.com.
6. Al-Taiee, Thair,M. 1993," The effect of storage capability of Mosul reservoir on the downstream Tigris river flow regime",Journal of Tikrit university,Engineering section, vol.12 ,no.1.

7. Pett,G.E.,1984a. Impounded rivers perspectives for Ecological Management. Wiley. Chichester, 236pp.
8. Al-Hamdani,Adil A.1997," Development a Tigris river reach between Saddam dam and Mosul city"., Ph.d thesis , Dept of Geology, College of science, Baghdad University.
9. Benn,P.c.,Erskin,W.D.,1994,"Complex channel response to flow regulation":Cudgegong river below windamere dam,Australia. Appl.Geogr.14,153-168.
10. Kellerhals,R.,1982. Effect of river regulation on channel stability In:Hey,R.D.,Bathurst ,J.C. (Eds).Gravel bed rivers, wiley, chichester,pp. 685-715.
11. Ministry of water resources, (2004), "Tigris rivers cross- sections. Baghdad, Iraq.
12. Google earth software ,(2002).
13. Hammo Al-Naish, Fawaz hameed,1999," Meandering Tigris river between Sanharib dam and its join with Greater zab", Ph.D thesis Dept of geography, College of learning. Mosul university.
14. Al-Hamdani,Adil A. and Al-Dabbas, Mutazz abdulsatar,2001., "Sediment movement within limited reach of Tigris river"., The scientific journal of Tikrit university, Engineering and science sector. Vol.8 ,No.4.
15. Al-Taiee, Thair,M. and Othman,K.I. 1995," Characteristic of Tigris river bed after Mosul dam closure. The scientific journal of Tikrit university University, Engineering section, Vol. 2 , No. 3.

Table 1 Tigris river width at some investigated sites within study reach

Site	Before dam construction			After dam construction
	Year			
	1956	1972	1998	2002
Al-Rashidia Meander	500	400	370	308
Al-Shuhadaa Bridge	400	500	270	275
Al-Qadisia Bridge	320	300	260	250
Ninavah Bridge	220	220	222	218
Al-Hurriya Bridge	300	270	250	170
Fourth Bridge	360	370	320	250

Table 2 Average annual discharge and water level of Tigris river at Mosul station

Year	1956	1972	1998	2002
Discharge m^3/ sec	708	761	565	540
Water level (m.a.s.l.)	216.4	215.8	213.8	213.6

Table 3 Average discharge and water level of Tigris river within the two historical periods.

Year	Before dam construction (1956-1985)	After dam construction (1985-2002)
Average discharge (m^3/sec)	689	575
Average water level (m.a.s.l.)	215.6	214.2

Table 4 Dimensions of the existed islands in the Tigris river reach

Site	Islands Dimensions in Meters											
	1956			1972			1998			2002		
	Length (m)	Width (m)	Width of Island/Width of River	Length (m)	Width (m)	Width of Island/ Width of River	Length (m)	Width (m)	Width of Island/Width of River	Length (m)	Width (m)	Width of Island/width of River
Al-Rashidia Meander	480	180	0.36	600	250	0.63	350	100	0.27	280	56	0.18
Um-alrabeain Island	600	80	0.15	850	150	0.16	850	75	0.17	785	190	0.36
Infront Al-sadeer Tourist	300	40	0.07	---	---	---	1000	250	0.5	1030	225	0.5
Infront Al-sheraa casino	---	---	---	---	---	---	---	---	---	335	110	0.28
Upstream Al-shuhada Bridge	200	200	0.42	500	200	0.32	150	40	0.11	250	40	0.14
Downstream Al-shuhada Bridge	160	50	0.09	---	---	---	250	125	0.40	380	75	0.25
Infront Ain Kibreat	---	---	---	---	---	---	300	60	0.24	390	70	0.18
Infront Saad Casino	---	---	---	---	---	---	---	---	---	160	50	0.16
Infront Children Play City	480	70	0.23	420	120	0.39	370	60	0.2	420	80	0.22
Upstream Right of Fourth Bridge	---	---	---	---	---	---	---	---	---	160	45	0.13
Under Left the Fourth Bridge	---	---	---	---	---	---	---	---	---	140	55	0.16

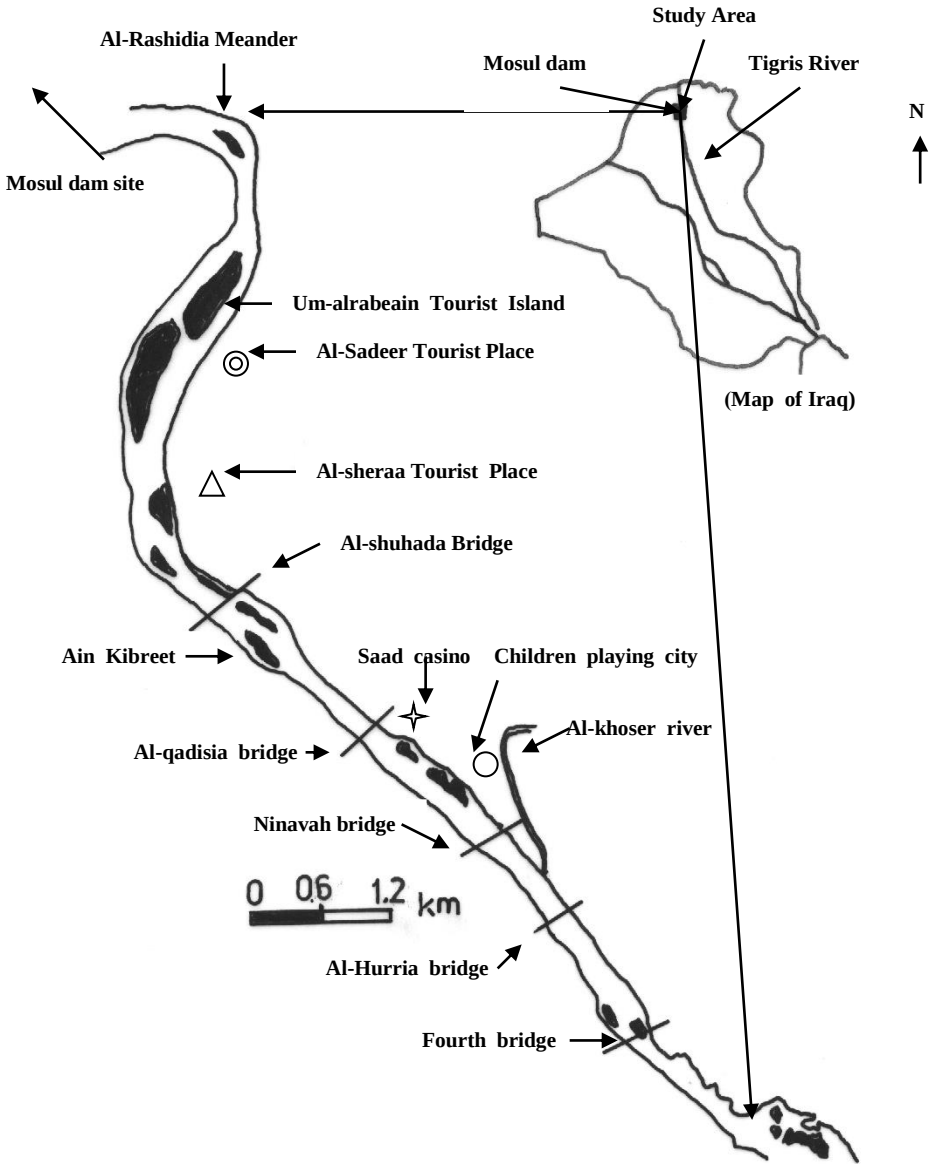

Fig.(1) Location map of the studied area

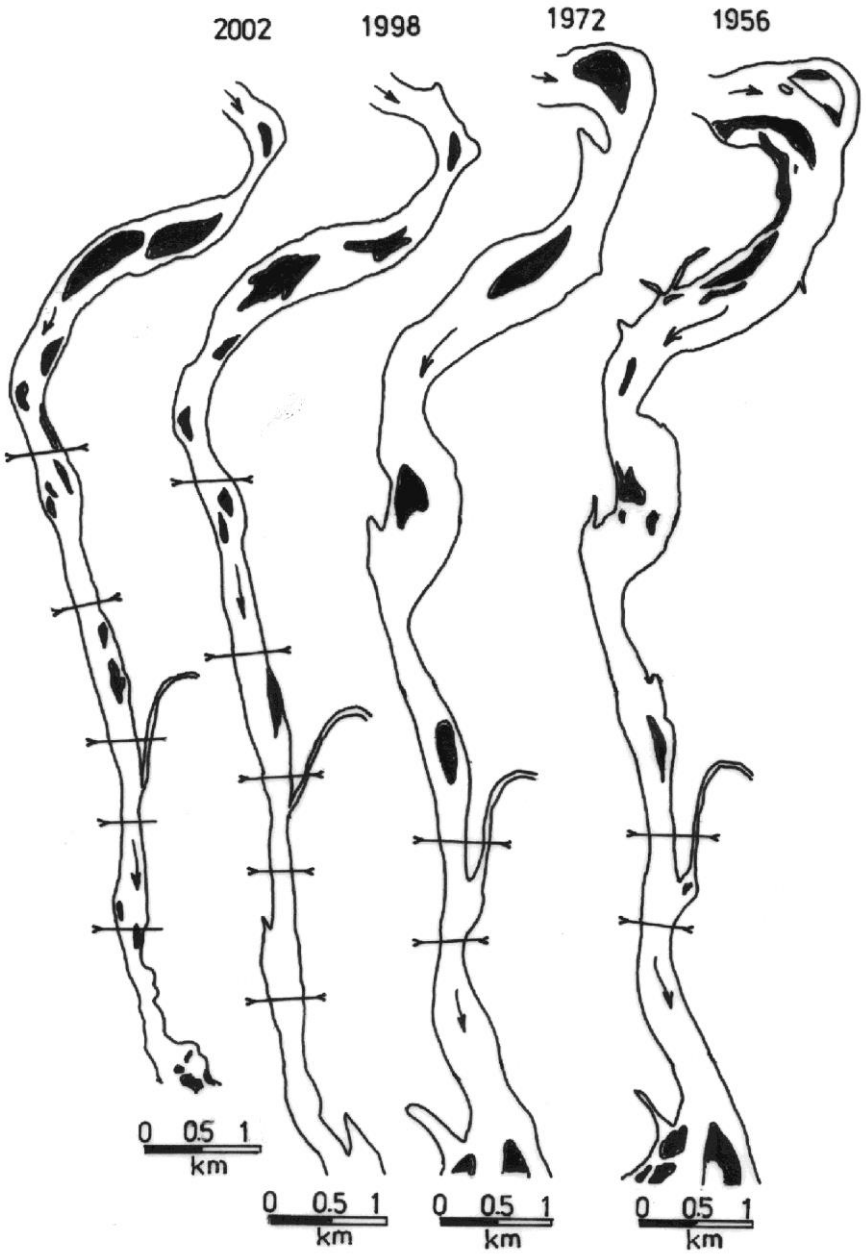

Fig.(2) The studied Tigris river reach for different periods.

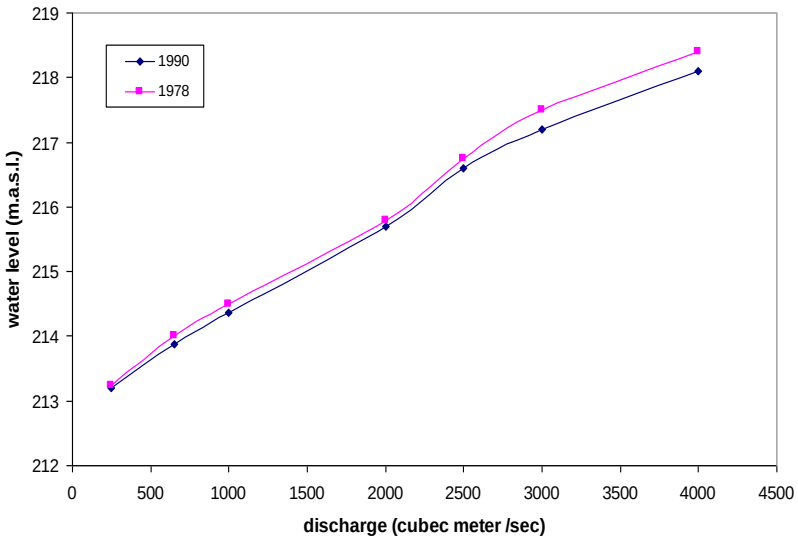

Fig. (3) Discharge water level relation of Tigris river at Mosul station

التغيرات المورفولوجية لمقطع من نهر دجلة ضمن مدينة الموصل لفترات زمنية مختلفة

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الخلاصة

هنالك العديد من التغيرات المورفولوجية التي تحدث في مجاري الانهار ولاسباب عديدة منها نتيجة التغيرات الهيدروليكية التي تطرأ على نظام الجريان الطبيعي في الانهار وكذلك نتيجة الفعاليات التي يقوم بها الانسان ومنها انشاء السدود والخزانات على الانهار. تبنى البحث دراسة جانب من هذه التغيرات المورفولوجية التي طرات على مقطع من نهر دجلة ضمن مدينة الموصل ولفترات زمنية بدات منذ عام 1956 حتى عام 2002 ومن هذه الخواص المورفولوجية هي ملاحظة التغيرالذي حصل في عرض النهر ضمن عدة مواقع في منطقة الدراسة ومنها مواقع الجسور وتقييم التطور والنمو في ابعاد الجزرات الرسوبية داخل مقطع النهر. وقد تم الاعتماد على تحليل البيانات المتوفرة في الخرائط الطوبوغرافية والصور الجوية التي تم توحيد مقاييس الرسم فيها ضمن الفترات الزمنية التي اعتمدت. خلص البحث الى ان احد اهم الاسباب الرئيسة في تطور ونمو الجزرات داخل مقطع النهر هو تغير نظام الجريان نتيجة انشاء واشتغال سد الموصل والذي ادى الى هبوط الحمل الرسوبي في النهر واطلاق تصاريف خالية من الرسوبيات ذات طاقة نحر عالية وكذلك الهبوط في معدل تصريف النهر ككل الذي ادى الى انخفاض منسوب مياه النهر بشكل عام وتطور ونمو الجزرات الجانبية والوسطية داخل النهر ونمو الاعشاب والادغال والاشجار فيها وخاصة في المنطقة الواقعة مؤخر منعطف الرشيدية والمنطقة مؤخر يسار جسر الشهداء ومقدم يسار جسر نينوى امام مدينة الالعاب وكذلك مقدم يمين الجسر الرابع.

الكلمات الدالة

مورفولوجية الانهار، مقاطع الانهار، تاثيرات الانهار