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Al-Kut Dam and its Effect on the Sedimentation Rate of the Dijla Al Gharaf and Dujaila Rivers in Wasit Governorate

Marwa Mohsen Mohamed Al-Barakat[1*], Dr Hussein Karim Hamad Al-Saadi[2]

[1]Wasit University College of Education for Human Sciences Department of Geography Iraq.*
[2]Ass.prof, Wasit University College of Education for Human Sciences Department of Geography, Iraq.

Corresponding Email: [1]Marwaalbarakatm@gmail.com*

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Abstract: ***The study of the amount of sediments in rivers is of very great importance, which has to do with the amount of water drainage and the force of water flow, whether it is sediment in the form of a suspended or bottom load, due to its direct impact on agricultural, navigational and engineering projects, as it is one of the most important factors causing the change of riverbeds , and affect the reduction of the capacity of the irrigation and storage channels, and it has been shown through the research that there is a spatial and temporal variation in the volume of sediments, as the suspended and bottom load increases before the Kut dam in the Saray station in Baghdad, and then the amount of sediment decreases in the back station of the Kut dam, the Al-Gharaf station, and the Nazem Dujailah and that is. Because the amount of sediment is related to the volume of water drainage.***

Keywords: River, Sediment, Drainage, River Beds, Water.

1. INTRODUCTION

Al-Kut Dam Al-Kut Dam is a dam located in Wasit Governorate in the city of Al-Kut on the right side of the Dijla River. It was built by a British company in 1939 and was inaugurated by King Ghazi I (Hassan Al-Samawi and others, 2005). The 550 m long Al Kut dam consists of (56) Each hatc has a door with dimensions of 6.00 x 6.50 m looking (Picture 1) operated manually and electrically. The Kut dam is one of the most important irrigation facilities on the Dijla River as it controls the distribution of water between the governorates of Wasit, Maysan and Dhi Qar, and in front of the Al Kut dam, many rivers and streams branch out on the right side like

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two rivers (Al Gharaf and Dujaila) and a group of streams (which are Hawar, Al Hussainiya, Mazak and Al Rahma) which are considered One of the important sources for watering large areas of agricultural land.

Photo (1) an aerial photo of Al-Kut dam

Source: The two researchers, based on Google Earth.

Research problem

The research problem is represented by the following question:

1- Does the Kut dam have an effect on the sedimentation variation of the Dijla, Al-Gharaf and Dujaila rivers in Wasit governorate?

2- Is there a spatial and temporal variation in the size of sediments in the study area?

Research hypothesis:

The hypothesis is an answer to the research problem and the research hypothesis lies in the following:

1- Al Kut dam has a great influence on the sediment variability of the Dijla , Al Gharaf and Dujaila River in Wasit Governorate

2- There is a spatial and temporal variation in the size of sediments in the study area.

The goal of the research:

The research aims to study the effect of the Kut dam, the sediments of each of the Dijla River in the Sarai station in Baghdad, the back station of the Kut dam, Al-Gharf and Dujaila, and their effect on the annual and seasonal drainage and their spatial and temporal variation.

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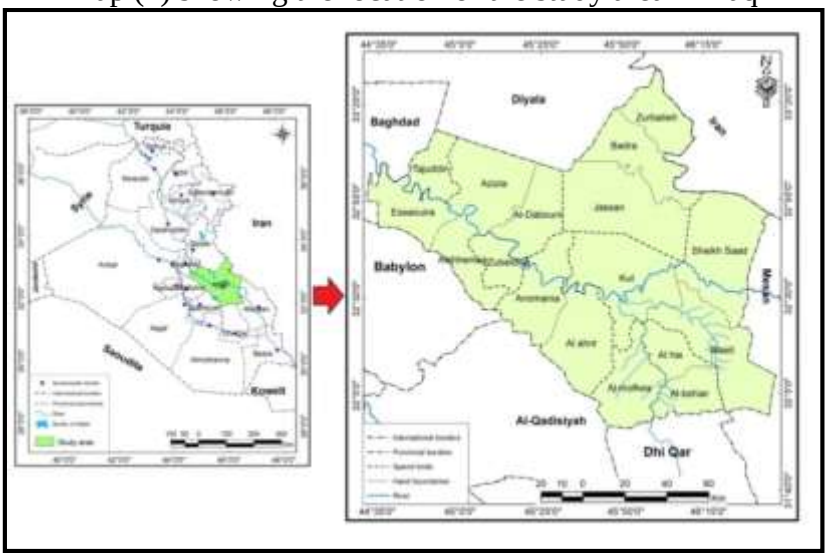
search limits:

The study area forms part of the alluvial plain in Iraq, as it occupies the eastern parts of the central region thereof, as it lies astronomically between two latitudes (**56´40˝ 31˚ - 33˚ 27´10˝) north**, and between longitude **(44˚ 30´50˝ _ 46˚ 32´ 50˝)** to the east with an area estimated at 17153 km^2 , and a rate of (3.95%) of the total area of Iraq, Map (1).The temporal boundaries included the period from (1971-2013), that is, for a period of 42 years, with the exception of Nazem Dujaila station, which was studied for 10 years.

Map (1) showing the location of the study area in Iraq



Source: The two researchers, based on the Ministry of Water Resources, the General Survey Authority, Iraq Administrative Map, scale 1: 1,000,000 for the year 2010

Map (2) shows the water resources in the study area

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Source: The two researchers based on a DEM space visual (digital terrain model) for the year 2015 and processed using Arc Map 10.5 software.
First / Characteristics of drainage in stations in the study area:
1- Characteristics of annual drainage:

Annual drainage is defined as (the average amount of water that the river passes in cubic meters during one second for a long time) (Ali Abdul Zahra Al-Waeli, 1997) . To know the size of the change in the water drainage revenue entering the study area from the Dijla River, it depended on the stations of (the Saray, located in Baghdad, and the station at the back of the Kut dam) . They are two of the main hydrological stations on the column of the Dijla River, as these stations are characterized by their accurate readings of their drainage and that they have the longest recording period. Thus, the drainage of the Saray station in Baghdad represented the amount of incoming drainage and the back station of the Kut dam for the amount of drainge coming out of the study area.

A - Annual quantitative drainage change (m^3 / s).
The results of the difference in drainage between periods are an indication of the natural change in the water revenue entering the study area. During the first period (1971-1994), the drainage in the Saray station reached (982 m^3 / s) and for the back station of the Kut dam (414 m^3 / s), as for the Al Gharaf station, it recorded (297 m^3 / s), and from the data of Table (1) it is clear the decrease in the annual drainage rates for the second hydrological period (1994-2013).The Al-Saray station (627 m^3 / s), the back station of Al-Kut dam (297 m^3 / s), the Al-Gharaf station (155 m^3 / s) and Nazem Dujaila station (13.8 m^3 / s) were recorded.

Hydrological duration	The number of years	The hydrological station	drainage rate
The first 1971-1994	30	Al Saray_ Baghdad	982
	30	Back of Al Kut Dam	414
	30	Al Gharaf	297
	-	Nazem Dujaila station	-
The second 1994-2013	20	Al Saray_ Baghdad	627
	20	Back of Al Kut Dam	297
	20	Al Gharaf	155
	13	Nazem Dujaila station	13.8

Table (1) The drainage rate of the Dijla and Al-Gharaf River (m^3 / s).

Source: The two researchers based on: data of the Water Resources Directorate, Wasit Irrigation Department, data (unpublished).

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B- The percentage of drainage of the number of years above and below the average:
It is evident from the data in Table (2) that there is a spatial and temporal variation in the number of years above and below the average in the studied hydrological stations, and a variation over the periods. The Saray station recorded during the first period (30) and during the second period amounted to (10), as for the station at the back of the Kut dam, years were recorded above the average for the first term (26) and the second period (5) years only, and finally in the Al Gharaf station, it was recorded in the first period (43) and the second period (15) , as for the Nazem Dujaila station, it recorded during the second period one year above the average and one year below the average, indicating a decrease in the rates of water drainage due to climate changes and drought that the study area is exposed to, as well as because of the Turkish projects and dams that it established, which led to a decrease in water resources in the study area.

Table (2) the drainage of the years above and below the average.

The hydrological station	Hydrological duration	The first duration 1994-1971	The second duration 1994-2013
Al Saray Baghdad	Above average	30	10
	Under average	70	90
Back of Al Kut Dam	Above average	26	5
	Under average	74	95
AlGharaf	Above average	43	15
	Under average	57	85
Nazem Al Dujaila	Above average	-	1
	Under average	-	1

Source: The two researchers based on: data of the Water Resources Directorate, Wasit Irrigation Department, data (unpublished).
The ratio of number of years = number of years above average / number of years for the whole period x 100 was extracted.

C- A change in drainage rates Seasonal quantity (m^3 / s):
Seasonal changes are considered water drainage as a result of the different sources of nutrition represented by rain and snow, the drainage of the Dijla River was distinguished by the fact that it has an annual peak of flooding at the time of spring and decreases during the summer. It appears during Schedule (3) that during the first period (1971-1994)during the spring season, rates were recorded (1320-1043-252 m^3 / s) for stations (Al-Saray, the back of Al-Kut dam, and Al-Gharaf) respectively, but during the second period it reached (614-314-147-14.2 m^3 / s) during the spring season . The Saray and the back of the Kut dam, Al Gharaf, and Dujaila Nazem) respectively.

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Table (3) the seasonal change of drainage of the study area.

The hydrological station	Temporal variables	first period1971-1994	Second period 1994-2013
The Saray, Baghdad	autumn season	581	649
	winter season	781	617
	spring season	1320	614
	summer season	**814**	**628**
	annual rate	**874**	**627**
Back of Al Kut Dam	autumn season	340	289
	winter season	517	335
	spring season	1043	314
	summer season	**516**	**253**
	annual rate	**604**	**297**
Al Gharaf	autumn season	151	165
	winter season	229	152
	spring season	252	147
	summer season	185	158
	annual rate	**204**	**155.5**
Nazem Al Dujaila	autumn season	-	13
	winter season	-	15.3
	spring season	-	14.2
	summer season	-	12
	annual rate	**-**	**13.6**

Source: The two researchers based on: data of the Water Resources Directorate, Wasit Irrigation Department, data (unpublished).

Second / The impact of the Al Kut dam on the sediments at the Al Saray station and the back of the Al Kut dam, Al Gharaf and Dujaila:

River sediments are part of the flowing water mass in riverbeds and are determinants of water quality, and sediments are one of the sources that directly affect agricultural, navigational and engineering projects.

They contribute to changing river courses and reducing the absorptive capacities of irrigation and storage channels, as the storage capacity of the reservoirs decreases and the water level rises with time due to the accumulated sediments at the bottom of the reservoir due to the activity of the load deposition process, the river tonnage also contributes to the formation of geomorphological features as a result of the continuous deposition of river load materials as it leads to the building and formation of many topographical features that are of great importance in geomorphological studies due to the speed of its development, its cadastral capacity and its importance in human activity.Among the most prominent of these features are (flood plains, alluvial fans , river islands) in addition to their contribution to providing the soil with silt, which leads to a reduction in soil porosity despite being a contributing factor to increasing its fertility.

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As for its effect on aquatic organisms, through it the turbidity of the water increases and the amount of light penetrating into the depths of the water decreases, which affects the vital processes of aquatic organisms such as nutrition, growth and reproduction, as the increase in the concentration of suspended substances more than 250 mg / liter causes damage to the gills of fish and the difficulty of laying their eggs , due to the high amount of sediments in its environment, suspended materials also work to protect bacteria from ultraviolet rays, and it is worth noting that there are a group of factors that affect the increase in the amount of sediments, among other things, the amount of river drainage in addition to the different climate elements and the nature of the stream, dams and reservoirs built on the course The river, and the sediments are studied as follows:

1- Suspended load:

Suspended sediments refer to alluvial, clay, sand and gravel materials in river waters, which occur as a result of erosion in slopes, streams and waterways. The severity of erosion depends on climatic factors, especially rain, wind speed, lack of vegetation, and the physical characteristics of the soil, as well as the nature of the basin area and its exposure to erosion (Said Al-Jazaery, 1974) . The amount of load varies widely spatially and temporally due to the variation in water drainage and concentration of suspended materials as well as the amount of exchange between suspended and bottom materials, as sometimes cases of exchange of materials occur at the top of the waterway and they descend towards the bottom and form a bottom load and vice versa in the event of floods.

The suspended load was extracted by means of the following equation:

(Suspended load = average drainage/ 0.163).

The ability of the river to carry these sediments depends on the speed of the current and the amount of drainage, as the ability of the river to carry materials increases dramatically as its speed increases, and in general the size of the particles transported in the river is proportional to the square of the river's velocity (Nadir Al-Ansari, 1979). And through the data of Table (4), which shows the suspended sediments in each of (Al-Saray Station, the back of Al-Kut Dam, Al-Gharaf, Nazem Dujaila), in which it became clear that the amount of sediments varies according to the amount of water drainage ، the general rate of suspended sediments reached the highest rate at the Al-Saray station at a rate of (121.6) thousand / ton, at the back station of Al Kut dam (74.6) thousand / ton, in the Al Gharaf station (29.4) thousand / ton, and at Nazem Dujail station (2.2) thousand / ton, from the calculation of suspended sediment rates by dividing into cycles, it was found that there is a spatial and temporal variation in the rates of suspended sediments, since during the first cycle (1971-1994), the Al-Saray station recorded a rate of (141.5) thousand / tons and the back station of the Kut dam (99.5) thousand / tons. Al Gharaf station (33.27) thousand / ton, as for the second hydrological cycle (1994-2013), the amount of suspended sediments for the Saray station reached (97.5) thousand / ton,

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while at the back station of the Kut dam, it reached (44.5) thousand / ton, while at the Al Gharaf station it reached (24.7) thousand / ton. It is noticed that during the second cycle the suspended sediments decreased due to the decrease in the quantities of water drainage. As for the Nazem Dujaila station, the amount of suspended sediments during the second hydrological cycle reached (2.2) thousand / ton.

Table (4) suspended sediments in the study area for the period from (1971-2013).

The year	The load stuck in the saray station is 1000 / ton	The stuck load at the back of the Kut dam, thousand / ton	The stuck load in Al Gharaf is 1000 / ton	The stuck load in Dujaila is 1000 / ton
1971-1972	195.2	157.4	40.9	___
1972-1973	140.3	79.5	33.9	___
1973-1974	164.6	146	31.7	___
1974-1975	135.6	96.3	32.2	___
1975-1976	189.7	151.4	37.3	___
1976-1977	156.1	105.1	33.4	___
1977-1978	193.3	134.8	37.8	___
1978-1979	147.8	98.1	28.5	___
1979-1980	127.7	78.5	27.3	___
1980-1981	100.7	68.6	31.7	___
1981-1982	134.9	102	31.7	___
1982-1983	139.5	107	37	___
1983-1984	96.6	63.4	23.9	___
1984-1985	125.5	90.1	35.2	___
1985-1986	83.2	40.5	28.1	___
1986-1987	103.1	52.4	33.2	___
1987-1988	275.7	246.1	48.9	___
1988-1989	141.8	104.3	28.3	___
1989-1990	112.3	48.7	33.7	___
1990-1991	98.1	42.5	27.8	___
1991-1992	107.7	52.9	37	___
1992-1993	176.2	122	31.1	___
1993-1994	109.5	102	34.8	___
1994-1995	191.9	125.3	37.3	___
1995-1996	132.6	70	32.2	___
1996-1997	130.2	58.3	33.2	___
1997-1998	145.3	86	36.8	___
1998-1999	95.1	40.4	22.9	___
1999-2000	66.3	25.9	14.9	___
2000-2001	63.8	22	13.8	___
2001-2002	66.3	22.8	14.9	___

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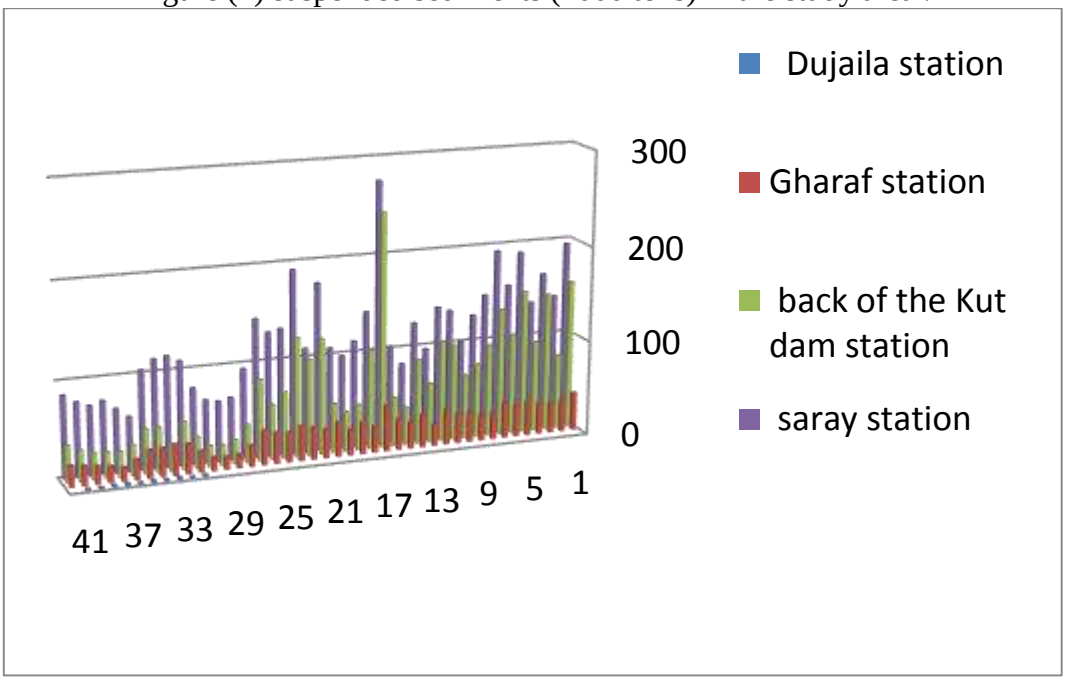
2002-2003	80.1	33.5	22.9	2.4
2003-2004	109.6	50.3	31.6	1.87
2004-2005	115.8	28.9	32.7	2.8
2005-2006	114.1	48	30.4	2.2
2006-2007	104.1	47.4	29.8	2.7
2007-2008	57.5	32.6	21.8	2.2
2008-2009	67.1	26.8	14.9	2.8
2009-2010	76.7	27.8	17.6	2.4
2010-2011	73	28.6	19.3	1.6
2011-2012	78	32.7	21	1.8
2012-2013	86.3	38.9	22.8	___

Source: The two researchers based on: data of the Water Resources Directorate, Wasit Irrigation Department, data (unpublished).

Figure (1) suspended sediments (1000 tons) in the study area .



Source: the two researchers based on Table (4).

2. Benthic sediments:

It is the rough part of the load that the river is unable to carry, and it moves along the benthic in the form of rolling or sliding, and it is called together or in the form of a jump, which is not always in motion, rather, it flows from time to time according to the strength of the water in the rivers. The material of the benthic load is rough, as it consists of large-sized sediments such as small pebbles and sand, and the benthic load in most rivers constitutes a percentage ranging between (5-25%) of the total river load.

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The equation for calculating the benthic sediments is: (benthic load = stuck load x10 / 100).

Through Table (5) and Figure. (2), we notice that there is a spatial and temporal variation in the rates of the benthic load, as the highest rate is recorded at the Saray station, as it reached (12.1) thousand / ton, and it decreases at the back station of the Kut Dam at a rate of (6.75) thousand / ton and in Al-Gharraf station (3.6) thousand / ton and Nazem Al-Dujaila station (0.21) thousand / ton, from the data of Table (5), it is clear that there is a temporal variation in the rates of benthic sediments as they are related to the amount of water drainage. In the years that increase the amounts of water drainage, the rates of the benthic load rise , while in the years where the quantities of water drainage decrease, the amount of the benthic load decreases. As during the first hydrological cycle of the year (1971-1994) , the Saray station recorded an average of the benthic load amounting to (14.1) thousand / ton, while the back station of the Kut dam recorded (8.7) thousand / ton. As for the Al Gharaf station, the rate of the benthic load in it reached (14.1) thousand / ton. 4.6) thousand / ton , as for the amount of benthic sediments in the second hydrological cycle (1994-2013) it decreased, as it reached (9.7) thousand / ton in the Saray station, while the benthic station of the Kut dam reached (4.4) thousand / ton, and in the Al Gharaf station, the amount of benthic sediments reached (2.4) thousand / ton, while the Nazem Al-Dujaila station recorded the amount of benthic sediments during the second hydrological cycle (0.21) thousand / ton.

Table (5) benthic sediments in the study area for the period (1971-2000).

The year	The benthic load at the Saray station is 1000 / ton.	The benthic load at the back of the Kut dam is 1000 / ton	The benthic load in Al Gharaf is 1000 / ton	Benthic load in Dujaila thousand / ton
1971-1972	19.5	15.7	4	___
1972-1973	14	7.9	3.3	___
1973-1974	16.4	14.6	3.1	___
1974-1975	13.5	9.6	3.2	___
1975-1976	18.9	15.1	3.7	___
1976-1977	15.6	10.5	3.3	___
1977-1978	19.3	13.4	3.7	___
1978-1979	14.7	9.8	2.8	___
1979-1980	12.7	7.8	2.7	___
1980-1981	10	6.8	3.1	___
1981-1982	13.4	1	3.1	___
1982-1983	13.9	1.07	3.7	___
1983-1984	9.6	6.3	2.3	___
1984-1985	12.5	9	3.5	___
1985-1986	8.3	4	2.8	___
1986-1987	10.3	5.2	3.3	___
1987-1988	27.5	24.6	4.8	___

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1988-1989	14.1	10.4	2.8	___
1989-1990	11.2	4.8	3.3	___
1990-1991	9.8	4.2	2.7	___
1991-1992	10.7	5.2	3.7	___
1992-1993	17.6	12.2	3.1	___
1993-1994	10.9	1.02	34.8	___
1994-1995	19.1	12.5	3.7	___
1995-1996	13.2	7	3.2	___
1996-1997	13	5.8	3.3	___
1997-1998	14.5	8.6	3.6	___
1998-1999	9.5	4	2.2	___
1999-2000	6.6	2.5	1.4	___
2000-2001	6.3	2.2	1.3	___
2001-2002	6.6	2.2	1.4	___
2002-2003	8	3.3	2.2	0.24
2003-2004	10.9	5	3.1	0.18
2004-2005	11.5	2.8	3.2	0.20
2005-2006	11.4	4.8	3	0.22
2006-2007	10.4	4.7	2.9	0.27
2007-2008	5.7	3.2	2.1	0.22
2008-2009	6.7	2.6	1.4	0.28
2009-2010	7.6	2.7	1.7	0.24
2010-2011	7.3	2.8	1.9.3	0.16
2011-2012	7.8	3.2	2.1	0.18
2012-2013	8.6	3.8	2.2	___

Source: The two researchers based on: data of the Water Resources Directorate, Wasit Irrigation Department, data (unpublished).

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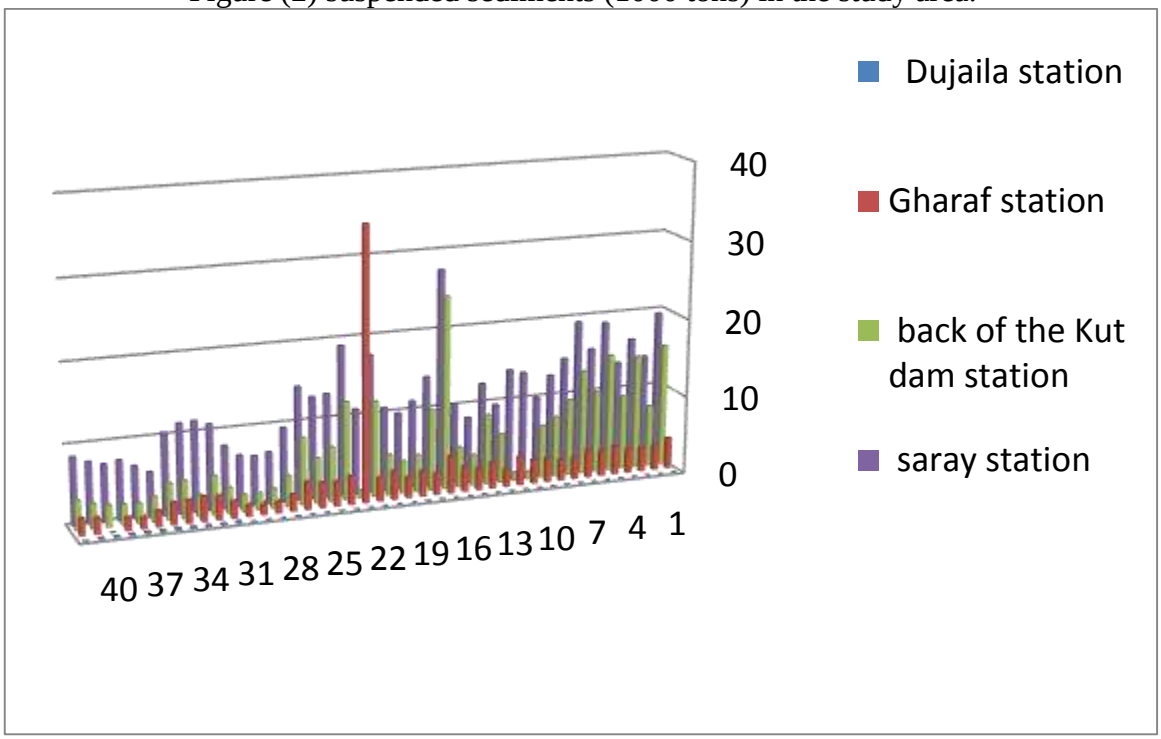
Figure (2) suspended sediments (1000 tons) in the study area.



Source: the two researchers based on Table (5).

1- Dissolved load:
It is defined as (the totality of dissolved substances in the water body) and it is included in the chemical composition of the water and moves with the current during its course towards the downstream and consists mainly of salts of various kinds, as the amount of water load in rivers increases with the increase in the dissolution of materials in the areas where chemical erosion oprocesses are active, and its percentage from the total laod increases, and it generally represents about (19%) of the global average of the totality river load (Safaa Abdel Amir Al-Asadi, 2012).

2. CONCLUSIONS

The study reached a number of conclusions, namely:
1- Al-Kut dam has an effect on the rates and volume of suspended and benthic sediments.
2- There is a spatial and temporal variation in the rates of suspended and benthic sediments in the study area.
3- It was found that the water drainage rates are decreasing, as the first cycle recorded the highest rate from the next cycle.
4- The month of Spring records the highest rate of water drainage during the first cycle, while during the second cycle there is a variation in the highest registration.

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5- The general rate of suspended sediments stuck the highest rate at Al-Saray station at a rate of (121.6) thousand / ton, at the back station of Al Kut dam (74.66) thousand / ton, in the Al Gharaf station (29.43) thousand / ton, and at Nazem Dujail station (2.27) thousand / ton.
6- The rates of stuck sediments also decreased during the study period, as they were high during the first years of the study period, and decreased during the 2000, because the volume of sediments is related to the volume of water drainage.
7- The highest rate of benthic sediments was recorded at Al-Saray station, as it reached (12.1) thousand / ton, and it decreased at the back station of Al Kut dam at a rate of (6.7) thousand / ton, in the Al Gharaf station (3.6) thousand / ton, and Nazem Dujaila station was (0.21) thousand / ton.
8- There is a spatial and temporal variation in the rates of suspended and benthic sediments in the study area.

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