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EFFECT OF SEDIMENTS ON THE HYDRAULIC PARAMETERS OF THE DUJAILA RIVER IN AL-KUT CITY, IRAQ

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Abstract:

This study was applied on the Dujaila River that located in Al-Kut city. The study period was for 10 months. Eight sites (sections) of the river were chosen. The distance between one site and another was 1000 m. The longitudinal section of the river was divided into 8 vertical sections on the river course, starting from the gates of the River. The discharge and speed of the water current for the studied sections were measured using a portable M9 device on a boat belonging to the Kut Dam Department and connected to a laptop computer. The result showed that there was a difference in the rates of the engineering standards of the Dujaila River during the research period, as it ranged between 8.16 m^3/s^{-1} to 13.25 m^3/s^{-1}, 0.13- 0.23 m^3/s^{-1}, 39.25- 81.02 m² and 0.92- 1.29 m for each of Water discharge, water current speed, cross-sectional area of river flow, and depth of water level, respectively. Statistical analysis of the results showed that there is a positive correlation (r=0.969) between water discharge and suspended sediment load. Also, there is a positive correlation (r=0.629) between water discharge and the concentration rate of suspended sediments. The results indicated that there is a positive correlation (r = 0.95) between the average suspended sediment concentration (TSS) and turbidity, and a positive correlation (r = 0.79) between the suspended sediment load (TSS) and turbidity.

Keywords: sediments, hydraulic parameters, Dujaila River, turbidity

INTRODUCTION

The importance of studying the water and sediments of river, streams, irrigation channels, and reservoirs comes from its impact on the amount of design drainage for rivers, irrigation channels, and drainage. Also, its impact on the cross sections of rivers, streams, and channel (Shamkhi and Noory 2018). Thus, the effect their efficiency in providing irrigation water for agricultural purposes. Recently, the changes that occurred that represented by the decrease in discharges and water levels in the Tigris and Euphrates rivers as a result of the decrease in water releases coming to Iraq from the countries of the sources of the two rivers. It has negatively affected all human and environmental activities, especially in the agriculture and irrigation sector (Al-Dabbas et al. 2018).

The Dujaila River branches off from the right of the Tigris River and it is considered one of the important irrigation projects after the Gharraf River. It starts from al-Dujaila point northwest of Kut District to the old Wasit district (Ali 2013). It eventually branches into small streams and channels that disappear into agricultural lands. The boundaries of the study area of the Dujaila River are located astronomically between longitudes 45° 49' 6.78, 45° 49' 59.16" east and latitude 32° 03' 18.94.32° 31' 31.18" north. The study area is within the center of Kut district. The Dujaila Project was opened in the 1940s for the purpose of securing water through the Dujaila. It is located at the front of the Kut Dam, and distributing it to the agricultural lands benefiting from this project. In addition, to securing water for other human and industrial uses for residential communities located on or near the course of the river. The design discharge is the maximum for the Dujaila River is 13.8 m^3/s (Shamkhi and Noory, 2018).

MATERIALS AND METHODS

The study was done on the Dujaila River within the borders of Al-Kut city. It is located between longitudes 45° 49' 6.78 and 45° 49' 59.16" east and latitudes 32° 03' 18.94.32° 31' 31.18" north. The study period was for 10 months. Eight sites (sections) of the river were chosen, starting from beginning of Al-Dujaila River. The distance between one site and another was 1000 m.

The longitudinal section of the river was divided into 8 sections perpendicular to the river course, starting from the gates of the regulator of the Dujaila River at a distance of 300 m from the origin of the regulator. The following measurements were made:

1- Calculate the width of the river section from the top, the river discharge Q, and the speed of the water current in m/s in the studied sections using the M-9 device carried on a river boat belonging to the Kut Dam Department.
2- Draw the cross-section of the river in the studied sections and compare it with the design section of the river at the beginning of the construction of the Dujaila River.
3- Estimate the level of sediment accumulated in the river section (m^3) in the studied sections.
The accounts are as follows:
Cross sectional area of the river occupied by sediment (m^2) = Design cross-sectional area of the river - Cross-sectional area of the river measured by the device.
Sediment volume (m^3) = (area of sediment at section S1 + area of sediment at section S2 /2) x horizontal distance (1000 m).
Suspended sediment load kg/s^{-1} = water discharge m^3/s^{-1} × suspended sediment concentration rate $mg. L^{-1}/1000$.

RESULTS AND DISCUSSION

Cross sectional area of the river's flow

It is noted that the flow cross sectional area of the studied sections in July and August 2022 was 72.75 m² and 62.17 m² respectively, and then it decreased to 43.46 m² in September (Table 1). In October, the cross-sectional area of flow for the studied sections of the river was 45.67 m², and then it increased to 82.01 m² in November, and then decreased to 63.33 m² in December. In January 2023, the rate was 84.871 m², and then it decreased to 52.84 m² in February, and then increased to 87.48 m² in March, then decreased to 55.58 m² in April (Table 1).

The reason for this discrepancy between the monthly rates during the measurement period for the studied sections is due to the lack of seasonal rain on the Dujaila River, as well as the difference in water releases for the Tigris River from the upstream countries, primarily Turkey, as well as water releases from the water reservoirs of the Tigris River within Iraqi territory (Meade, 1972).

Table (1) showed that there is a decrease in the area of the studied cross-sections compared to the design area of the Dujaila River. The decrease in the area of the studied cross-sections during the months of the study ranged between 29.88%- 65.17%. The highest percentage of decrease in the average area of the sections studied in the months of the study was 65.17% September - 2022, followed by the area of the river section in October 2022, and the percentage of decrease in the average area of the designed section of the river was 63.39%. The lowest percentage of decrease in the average area of the studied sections was in March 2023. The percentage of decrease was 29.88%. This is attributed to the increase in the drainage of the Dujaila River and its hydraulic dimensions (depth of the water level and width of the river) in this month compared to the other months of the study period. The river discharge rate during March, 2023 was 13.25 m^3/s^{-1}, while the lowest discharge rate of the Dujaila River was 8.16 m^3/s^{-1} during September, 2022, (Table 3).

Table (1) Estimated value of accumulated sediments of the Dujaila River during the months of the study

Monitoring date	Measurement site	Design river cross-section area (m^2)	Cross-sectional area of the flow (m^2)	sediment area (m^2)	Average sediment area (m^2)	distance (m)	Volume of accumulated sediment
10\7\2022		**124.76**			**1000**		
Average			72.75	52.01	49.55		
Total			0	0			346870
14\8\2022		**124.76**					
Average			62.17	62.59	64.09		
Total			0	0			448630
2\9\2022		124.76					
Average			43.46	81.3	80.96		
Total			0	0			566690
22\10\2022		124.76					
Average			45.67	79.09	80.13		
Total			0	0			560890
13\11\2022		124.76					
Average			82.01	42.76	42.76		
Total			0	0			299340
16\12\2022		124.76					
Average			63.33	61.43	60.03		
Total			0	0			420230
5\1\2023		124.76					

Average			84.71	40.05	37.19		
Total			0	0			260310
14\2\2023		124.76					
Average			52.84	71.92	72.79		
Total			0				509500
1\3\2023		124.76					
Average			87.48	37.28	35.03		
Total			0				245200
10\4\2023		124.76					
Average			55.58	69.18	68.62		
Total							480355.9

DEPTH OF FLOW SECTION

The results have showed that the average depth of the sections of the study area ranged between 0.93 - 1.3m. the average was 0.93 m in July 2022, and in August was 0.94m and then increased to a rate of 1.19m in September. It has decreased to a rate of 1.01m and 1.06 m in October and November, respectively, and then increase to 1.11, 1.11, 1.21, 1.28, and 1.29m for each months of December, January, February, March, and April, respectively.

It was noted that the lowest rate of hydraulic depth for the studied sections was 0.92m in April 2023. The percentage decrease from the design depth of the river was 76.98%, while the highest rate of depth for the studied sections was 1.29m in July 2022. Also, the percentage decrease from the design depth of the river amounted 67.75%. This decrease is due to the accumulation of sediments on the Dujaila River in the studied sections (Table 2).

Table (2) Dimensions of the Dujaila River section and some hydraulic parameters during the months of the study

Monitoring date	sections	Water level depth (m)	Cross-sectional area of the flow (m)
		10\7\2022	
Average		1.3	72.75
		2022\8\14	
Average		1.28	62.17
		2022\9\2	
Average		1.19	43.46
		2022\10\22	
Average		1.21	45.67
		2022\11\13	
Average		1.06	82.01
		2022\12\16	
Average		1.11	63.33
		2023\1\5	
Average		1.11	84.71
		2023\2\14	
Average		1.01	52.84
		2023\3\1	
Average		0.99	87.48
		2023\4\10	
Average		0.93	55.58

THE DRAINAGE OF THE DUJAILA RIVER AND THE SPEED OF WATER

In this study, it was showed that there was a difference in the discharge of the Dujaila River during the study period. The river's discharge rate in the July 2022 was 8.19 m^3/s^{-1}, then it reached 8.82 m^3/s^{-1} in August 2022, then it decreased to 8.16 m^3/s^{-1} in September 2022, then increase to 8.48 m^3/s^{-1} in October, after which the average was 59.2 m^3/s^{-1} in November and reached 9.94 m^3/s^{-1} in December (Table 3). At the beginning of 2023, the discharge rate of the Dujaila River increased to the level of 10.29 m^3/s^{-1} in January and in February the rate was 10.78 m^3/s^{-1} and in March the rate was 13.25 m^3/s^{-1} and in April, the average was 10.14 m^3/s^{-1}.

The geological structure of the basin, the terrain, the nature of the soil, the climate, the natural plants, the area of the basin and its characteristics have an important impact in determining the amount of water flowing in the river (Miall, 2013). The size of the river basin affects its ability to absorb the amounts of water in excess of its need. The occurrence of floods is an indicator of the inability of the waterways in the basin to absorb the excess water in it (Owens et al., 2005; Carvalho et al., 1999).

Other factors that have an impact on water drainage are suspended materials (sediments) that affect the speed and quantity of water flow, as well as their effect on changing the river flow and on the carrying capacity of irrigation channels and storage projects (Belaud et al., 1998; Garcia and Parker, 1993). In this study, the statistical analysis of the results showed the existence of a positive correlation (r=0.63) between water discharge and the average concentration of suspended sediments. In addition, the statistical analysis of the results showed the existence of a positive correlation (r=0.97) between water discharge and suspended sediment load.

Table (3) Hydraulic standards for the Dujaila River section

sections	Monitoring date	Watery discharge m³\s	speed of water current m\s
S-1000	**10/7/2022**		
Average		**7.88**	**0.09**
S-1000	**18/8/2022**		
Average		**9.46**	**0.31**
S-1000	**2/9/2022**		
Average		**8.71**	**0.16**
S-1000	**22/10/2022**		
Average		**9.32**	**0.22**
Average	**13/11/2022**	**6.18**	**0.1**
Average	**16/12/2022**	**12.46**	**0.18**
Average	**15/1/2023**	**11.1**	**0.19**
Average	**14/2/2023**	**12.95**	**0.12**
Average	**1/3/2022**	**12.63**	**0.15**
Average	**10/4/2022**	**10.14**	**0.19**

THE ACCUMULATE SEDIMENTS IN THE STUDIED SECTIONS OF THE DUJAILA RIVER

The volume of sediments accumulated in the studied sections was different during the months of the study period between 245,200 m^3 and 566,690 m^3. It was found that the total volume of sediments accumulated in the studied sections of the Dujaila River was the highest total 566,690 m^3, in of September (Table 1). The reason for this is the increase in the load of suspended sediments in the waters of the Dujaila River in March 2023 and January. It was 2.17 and 1.93 kg/s, respectively compared with the loads of suspended sediments in the river waters for the rest of the months. This result is agreed with the results of Baranya (2009) when he studied the sediments in front of the Kut Dam.

Through this study, it was clear that the left side of the Dujaila River was characterized by the presence of reeds, sedges, and aquatic algae, which grow densely. It reduces the speed of the water, as a result, leads to increased deposition and accumulation of suspended load in the river along this side. The increasing volume of sediment accumulated annually in the Dujaila River will lead to a reduction in the carrying capacity of the river for large discharges in the flood season, causing a decrease in the river's ability to withstand the flood wave in the rainy months, causing an increase in the water level of the Dujaila River and the occurrence of flooding in areas adjacent to the river (Hassan, 2015; ASTM, 2000; Spindel ET AL., 2013; astm , 2001).

SUSPENDED SEDIMENT CONCENTRATION

The results indicate that the concentration of suspended sediments in the river water for the studied sections in the months of 2022 was close to its concentration in the months of 2023. The concentration rates of suspended sediments in the Dujaila River for the studied sections were different, ranging between 387.1- 440.57 mg/L^{-1}. The lowest rate was in July 2022, and the highest rate was in April, when it reached 440.57 mg/L^{-1}(Table 4). It is noted that the average concentration of suspended sediments in the months of 2023 is higher than the average concentrations of suspended sediments in the month of 2022, as their values for the year 2023 ranged between 419.79 - 440.57 mg/L^{-1}, while its values for the month of 2022 ranged between 387.1 - 428.03 mg/L^{-1} (Table 4).

This is due to the increase in the Dujaila River's drainage during the months of January and February. Studies indicate that these sediments were formed by the rain that falls on the Dujaila River's basin and the accompanying surface runoff of rain and the corrosion and erosion processes it causes in the Dujaila River's basins due to the decline in its course the river. As a result of the fact that most of the lands of the river's basin are poor in terms of plants, therefore, exposed to erosion processes (Bagnold, 1996; Azamathulla et al., 2013; Najafpour et al., 2016; Shamkhi, 2003).

Table (4) Suspended sediments, suspended sediment load, and turbidity in the waters of the Dujaila River

sections	speed of water current m\s	Watery discharge m³\s	Monitoring date	sections
	10/7/2022	389.06	3.19	8.26
	14/8/2022	396.44	3.5	9.11
	2/9/2022	402.48	3.29	9.37

Average	**22/10/2022**	408.12	3.46	9.66
	13/11/2022	407.58	3.77	10.06
	16/12/2022	419.7	4.17	10.38
	15/1/2023	425.19	4.38	10.6
	14/2/2023	428.99	4.62	10.81
	1/3/2022	431.71	5.72	11.34
	10/4/2022	435.98	4.42	11.93

CONCLUSION

The study concludes that there was a difference in the rates of the engineering standards of the Dujaila River during the research period. Statistical analysis of the results showed that there is a positive correlation between water discharge and suspended sediment load. Also, there is a positive correlation between water discharge and the concentration rate of suspended sediments. There is a positive correlation between the average suspended sediment concentration (TSS) and turbidity, and a positive correlation between the suspended sediment load (TSS) and turbidity.

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