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Characteristics of Tigris River bed material at 67 Km Downstream Kut Barrage

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Abstract: The study reach has a length of about 70 km of Tigris River at downstream Kut barrage. This starts directly after Kut Barrage up to Shiekh Saad south of Kut city. The aim of this study is to analyze the bed material at the bottom of the Tigris River. Twenty-one samples were collected from seven cross-sections by using Van Veen's Grab Sampler. The median diameter (d_{50}) of these samples ranged between 0.005 mm and 0.1 mm even as the mean size was 0.032 mm. This indicates that the bed material can be classified as fine grain clay, silt, sand and loam, and also that the percent of washed fine particles near the barrage regulators are larger than those at the other site downstream This could be due to the large water power of released water discharge from the barrage. The flow regime of the first two kilometers of the study reach was flatbed due to the high flow strength of the released water discharged from the barrage.

Keywords: Tigris River (Downstream Kut Barrage), Bed material characteristics.

خصائص مواد قعر نهر دجلة في (مؤخر سدة الكوت)

محمد صيوان شمخي، زينب شاكر عطا

الخلاصة : في هذا البحث قد تم أختيار موقع الدراسة المتمثل من نهر دجلة وبطول 70 كم الذي بدأ مباشرة بعد مؤخرسدة الكوت حتى شيخ سعد جنوب مدينة الكوت.الهدف من هذه الدراسة هو تحليل مواد قاع نهر دجلة. احدى وعشرون عينة قد تم جمعها من سبعة مقاطع عرضية باستخدام جهاز(فان فين كراب) . تراوح متوسط القطر (d50) لهذه العينات بين(0.005 – 0.10) مم بينما كان متوسط الحجم0.032 مم. وهذا يدل على أن مواد القاع يمكن تصنيفها الى حبيبات ناعمةكالطين والطمي والرمل واللوم. أن النسبة المئوية من الحبيبات الناعمه المغسولة بالقرب من سدة الكوت هو أكبر من موقع اخر بالنهر بسبب الطاقة المائية الكبيرة لتفريغ المياه الصادرة من السدة . نظام الجريان كان في أول كيلومترين من موقع الدراسة مسطح بسبب قوةالتدفق العاليةلتصريف المياه المنطلقة من السدة .

الكلمات الدالة : نهر دجلة (مؤخر سدة الكوت)، خصائص مواد القعر

1 .INTRODUCTION

The Tigris River has been studied by many researchers. Some of them dealt with the estimation of sediment transport, even as others investigated the changes in bed topography and morphology. The authors in [1] achieved a training study of the Tigris River (reach of 59 km) for the Iraqi Ministry of Irrigation. The study dealt with improvements of the river flow conditions and specified the flood capacity of the river in Baghdad. The study also included the collection of bed material samples from six locations.

Often, a bed is formed from sand with high silt material. Always, in all river discharges, the bed material moves in the form of ripples. The research in [2] has found that the Tigris river bed material for the reach, along 4.7 km , between the Al-Aemeh and Al-Sarafiya Bridges, is made up of a mixture of coarse, medium, and fine sand with a trace of clay. The presence of clay increases in the islands and at the banks. The authors in [3] are conducting a study to analyze the surface and subsurface bed material of the 55 km reach of the Tigris River. The reach extends between the Mosul regulating dam and Mosul city. They have concluded that the Tigris river bed has reached an armoring condition. The grain size distribution on the surface layer decreases with distance along the study reach of the river, and the river bed material is approaching a homogeneous condition. The dominant size of the material oin the surface and subsurface layer is very coarse gravel , with a percentage of 74% and 36%, respectively. The research in [4] has studied the characteristics of the bed material of 35 km of the Tigris River from Badoosh to the end of Mosul City. The characteristics of the surface and subsurface material have been studied in nine sampling locations. for surface and subsurface material, At each location , the samples are collected from the left and right banks of the river. The results show that the right bank particles are coarser than those on the left bank. The subsurface bed material consists of gravel and sand, the d_{50} of this layer is equal to 17 mm and the domain size is coarse gravel with a percentage of 29% , sand percentage in this layer is about 17%. The authors in [5] have studied the bed material of the River Tigris through a reach about 18 km long , starting from the center of Baghdad, at the Sarai gauging station , upstream to Al-Muthna Bridge. The analysis of the bed material samples demonstrate that fine sand covers the bed of the river and the sand:silt:clay ratio is 90.74:6.86:2.4. The average median size within the reach is (0.18 mm), even as the mean size is (0.15 mm).

1.1- The objectives of the research

This study's aim is to collect the field and experimental data of the Tigris River (downstream of Kut Barrage), to study the bed material grains.

2. RESEARCH METHOD

2.1 Bed material characteristics:

This classification method given for the bed materials may be identified by agrain size distribution curve, which represents the cumulative dry weight of the bed material in each size fraction, along with sieve size D - 422 Standard [6] Table 1 shows the size classification system. The median (d_{50}) diameter is most frequently used to describe bed material samples. Also, the bed material may be described by using d_{16}, d_{84}, and d_{90} diameters. The sizes in the grain distributions are usually only approximate normal distributions, and may be skewed rather than centered on the median size. The geometric standard deviation (σ) defines the deviation from the sample median value as follows:

$$\sigma = \frac{d_{84}}{d_{16}} \tag{1}$$

The values of σ are measurements of the gradation of the particles. Higher values of σ will refer to a very well graded material, while a lower value of σ will represent the uniformity of the particles.

Table.1. Grain size classification of bed materials, [6]

Class of size	sand	
	Min.	Max.
	(mm)	
(1) Gravel	4.75	75
(2) Sand	0.075	4.75
(a) Coarse sand	2	4.75
(b) Medium	0.425	2
(c) Fine sand	0.075	0.425
(3) Silt size	0.005	0.075
(4) Clay size	< 0.005	
Colloids	< 0.001	

2.2 .Alluvial rivers characteristics:

For alluvial channels, the bed shear stress is attributed to bed material grains (skin or frictional shear stress) and bed forms (such as sand ripples and dunes); shear stress is explained in Figure 2.1. In alluvial rivers, bed forms are tightly related to flow conditions. With increasing of flow strength, a flat bed may develop into sand ripples, sand dunes, or moving plain beds; other bed forms that could appear with increasing stress are anti dunes or chute sand pools (upper flow regime).[7].

In context, the resistance of flow and regimes of flow are closely related with each other. [8] Developed Figure(2) for prediction of the flow regime.

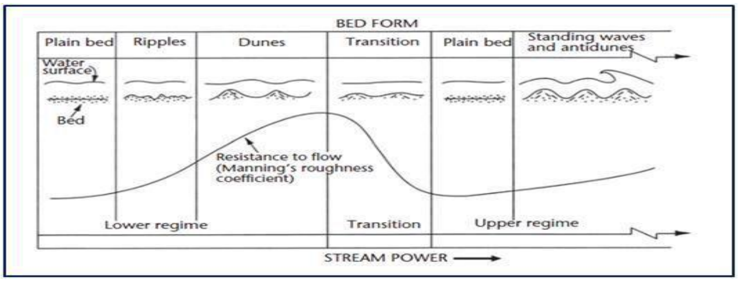

Figure.1 Bed roughness with bed formations variations [9]

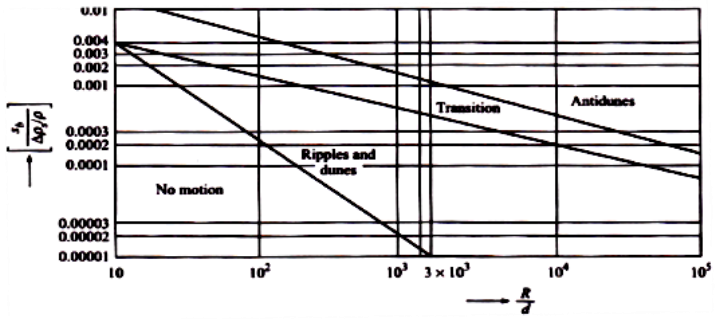

Figure .2: Alluvial channel regime prediction diagram [8]

3. Field Measurements and Laboratory work

3.1 Bed material sampling

The purpose of taking samples from the bed material of the river reach was to analyse the bed material , to determine the type and diameter of the material in the soil laboratory. There are several sampling methods which have been developed by "the Interagency Committee on Water Resources" [10]. Three vertical samples were taken for each section of the reach study. These samples were at a quarter, half, and three-fourth of the distances from the width of the river reach cross section [11]. This method was followed for sampling and the samples were collected from the sites where there were no natural bridges or obstacles, and there were no tributaries to represent and reflect the original characteristics of the river [12].

Twenty-one samples were collected from the same seven cross-sections that were predefined for hydraulic and geometric measurements , as shown in Figure (3). The Van Veen Grab sampler was used to collect samples; it was made of stainless steel. When collecting samples, the water had to be stable and the boat had to be installed at the specified location where the sample was taken from. The Van Veen Grab had to be lowered in the river gently, as it was linked to the cord used to lower it in the river. It could be easily handled and gave quite a good sample. During the descent to the bottom, the two buckets were held in an open position by the means of a hook. When the grab hits the bottom, the tension on the hook released and the hook was disengaged. When the line was hoisted, the buckets closed automatically [9]. The samples were saved, strong plastic bags were used and they were stored in pails [12]. The numbers of the Section and sample were recorded on the bags and pails [12].

Figure .3 .Bed material sampling

3.2 Laboratory work

Laboratory measurements, which were performed to calculate the specific density of the samples, were taken from the bottom of the river and an analysis was done to determine its type and grain size distribution [9]. This study hads been done at" the Soil Lab at Waist University, Faculty of Engineering". Figure 4 shows the sieve and hydrometer used for the analysis of the material from the bed material. Figure 5 shows the distribution of the grain size curve of section CS 0.0.

3.2.1 Specific Gravity of bed material

"Specific gravity (Gs) of a material is defined, according to (ASTM -D 854 – 02), as the ratio of the mass of a unit volume of asolid soil to the mass of the same volume of gas-free distilled water at 20°C" [13]. The procedure listed in ASTM -D 854 – 02 was followed in the determination of specific gravity of bed materials. Table 2 shows the value of specific gravity of the collected samples .The average value of specific gravity for all sections was (2.67).

Table 2.Specific gravity of bed material

Sec. No		Specific gravity						
		1	2	3	4	5	6	7
location	A	2.65	2.69	2.653	2.653	2.653	2.653	2.678
	B	2.65	2.67	2.678	2.678	2.678	2.68	2.678
	C	2.663	2.69	2.678	2.678	2.678	2.678	2.657

Figure .4,Sieve and hydrometer analysis of the bed material shown

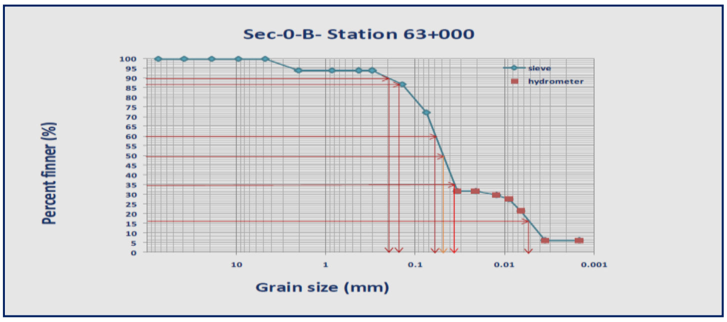

Figure .5. Grain size distribution analysis of bed material of Tigris river section C.S. 0-B-Sta. (63+000)

4. RESULTS AND DISCUSSION

4.1 Study reach characteristics

The bed shear stress for alluvial channels is attributed according to bed material grains and bed forms. The size of the bed material grain for many rivers decreases downstream, a phenomenon which is called, ‘downstream fining’. The study of downstream fining’ as the subject of study has been introduced, because hydraulic roughness of rivers affect changes in the grain size [14, 15]. Usually, the researchers use the median particle size (d_{50}),as an indicator of bed material characteristics for the rivers. Figure (6) and Table (3) present the grain size distribution and types of study reach bed material samples of the Tigris River downstream, at seven cross sections, which have been collected from the right , main channel and left bank (A ,B ,C) , respectively. The median diameter (d_{50}) of these samples ranged between 0.005 mm and 0.1 mm , even as the mean size is 0.032 mm. This indicates that bed material can be classified as fine grain , clay, silt, sand , and loam, see Table (3).

The d_{90}, d_{84}, d_{60}, d_{50}, and d_{16}, which represent the sieve diameters in which 90%, 84%, 60%, 50%, and 16% of the bed material are finer, respectively, decreased along the study reach as described in Figures (7) and (8) ,This also gives an indication that it is due to the released discharge released from the regulators of Kut Barrage, that the fine bed material has been washed and transported downstream. Figure 8 demonstrates that the percent of washed fine particles near the barrage regulators is larger than that in the other site downstream, due to the great power of water released and water discharged from the barrage. Also, Figure 8, demonstrates that the coarsest particles were deposited directly about 500 m downstream of Kut Barrage, which interpreted the sand bar formation in this location, see Figure 9. It can be noticed that the coarser sizes of these samples are found on the right bank of the Tigris River; this indicates that the, main flow of the downstream Kut Barrage reach is nearer to the right bank of the reach, which agrees with [4].

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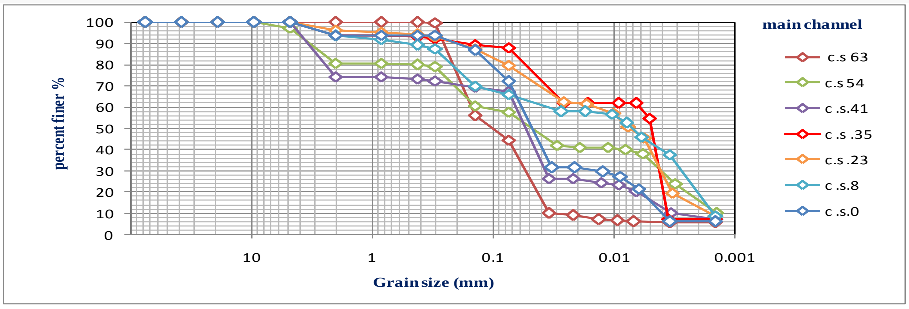
Bed material homogeneity was calculated by the geometric standard deviation σ (equation 1). Table 4, shows the geometric standard deviation of the study reach bed material , which has a high value at the upstream of the study reach, whereas, the geometric standard deviation decreased with mean distance from where Tigris river downstream Kut barrage began to approach the homogeneous condition.

Table 3 Grain size distribution analysis of bed material for Tigris river downstream Kut barrage

section	Sample location	d_{90} mm	d_{84} mm	d_{60} mm	d_{50} mm	d_{35} mm	d_{16} mm	classification
C.S. 63	A	0.25	0.22	0.2	0.1	0.06	0.04	sandy loam
	B	0.18	0.1	0.06	0.05	0.04	0.009	silt loam
	C	0.18	0.1	0.05	0.041	0.03	0.007	silt loam
C.S. 54	A	4.3	3.5	0.09	0.05	0.02	0.0035	loam
	B	3.2	2.2	0.13	0.049	0.005	0.002	clay loam
	C	2.5	0.4	0.065	0.038	0.0064	0.0045	clay loam
C.S. 41	A	2.5	0.32	0.08	0.06	0.04	0.02	loam
	B	3.3	2.7	0.065	0.053	0.04	0.005	loam
	C	3.3	3	0.025	0.007	0.0042	0.0032	clay
C.S. 35	A	0.25	0.2	0.027	0.009	0.007	0.005	silt loam
	B	0.16	0.055	0.006	0.005	0.0041	0.038	clay
	C	0.08	0.06	0.007	0.005	0.004	0.0038	clay
C.S. 23	A	0.9	0.14	0.14	0.04	0.03	0.009	silt loam
	B	0.2	0.1	0.02	0.008	0.0045	0.0025	clay
	C	0.3	0.1	0.012	0.0055	0.045	0.035	clay
C.S. 8	A	1	0.3	0.015	0.008	0.007	0.006	silt loam
	B	0.55	0.28	0.038	0.007	0.0035	0.0018	Clay loam
	C	0.4	0.07	0.029	0.008	0.005	0.004	silty clay
C.S. 0.0	A	0.25	0.2	0.062	0.05	0.03	0.044	loam
	B	0.2	0.12	0.06	0.05	0.038	0.0052	loam
	C	0.1	0.08	0.048	0.038	0.012	0.0025	silty clay loam



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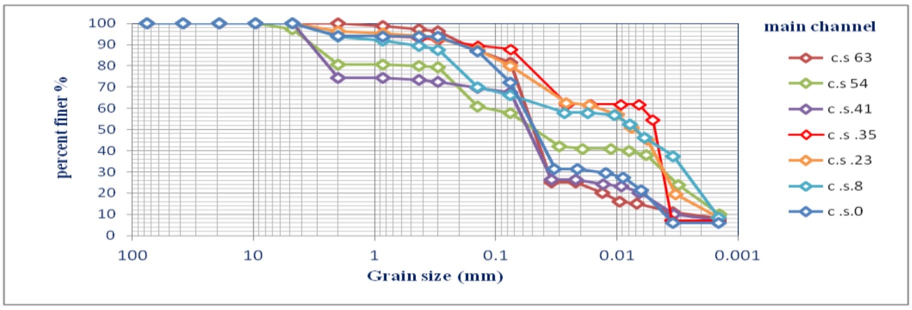

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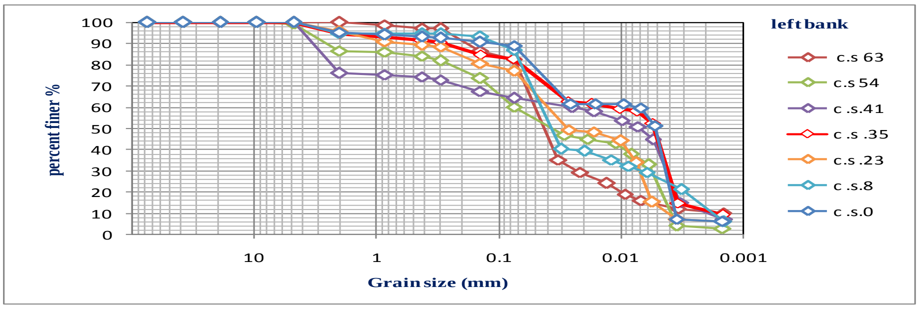

-C -

Figure.6. Grain size distribution of Tigris River bed material from the right bank, main channel, and left bank (A, B, C), respectively, for the downstream Kut Barrage reach

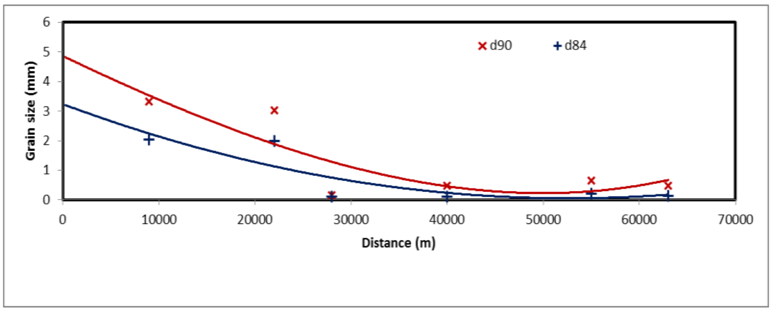

Figure .7.Variation of d_{90} and d_{84} of bed material along the downstream Kut Barrage reach

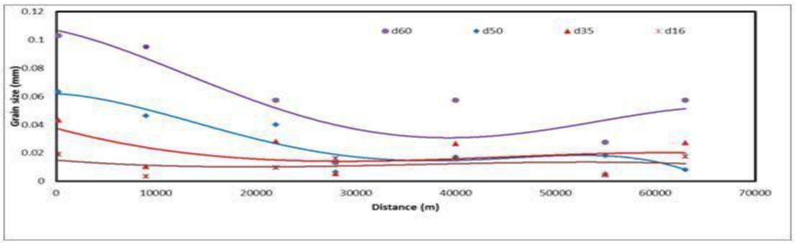

Figure 8. Variation of d_{60}, d_{50}, and d_{16} of bed material for the along the downstream Kut Barrage reach

Figure.9.Middle sand bar after Kut barrage [Wasit province information center]

Table 4 Geometric standard deviation of bed material for the reach of Tigris river downstream Kut barrage

Section	Geometric standard deviation (σ)			Average geometric standard deviation
	Sample location			
	A	B	C	
C.S.63	14.29	11.11	5.50	10.30
C.S.54	88.89	1100.00	1000.00	729.63
C.S.41	937.50	540.00	16.00	497.83
C.S.35	15.79	1.45	40.00	19.08

C.S.23	2.86	40.00	15.56	19.47
C.S.8	17.50	155.56	50.00	74.35
C.S.0	32.00	23.08	4.55	19.87

In alluvial rivers, the resistance of flow and regimes of flow are closely related. With an increase in the flow strength, a flatbed may develop into sand ripples and sand dunes. Bed forms of study reach are related to flow conditions based on Figure 2 (Figure of Grade and Range, Raju [8]). Table(5) shows the regime of flow for the study reach of Tigris river downstream Kut barrage. The flow regime of the first two kilometers of the study reach was flatbed due to high flow strength of the released water discharge from the barrage.

Table 5 Flow regime for the reach of Tigris river downstream Kut barrage.

Station	Flow regime
00 + 250	flatbed
09 + 000	flatbed
22 + 000	Ripples and dunes
28 + 000	Ripples and dunes
40 + 000	flatbed
55 + 000	flatbed
63 + 000	flatbed

5. Conclusions

- According to the results of the analysis of the bed bottom of Tigris River, the study reach bed bottom composite of fine grain clay, silt, sand , and loam , the median diameter (d_{50}) of samples ranged between 0.005 mm and 0.1 mm , even as the mean size was 0.032.
- The d_{90}, d_{84}, d_{60}, d_{50}, and d_{16} of the bed material, decreased along the study reach. This also gives an indication that it is due to the released discharge from the regulators of Kut barrage, the fine bed material that has been washed and transported downstream , due to the large water power of water discharge released from the barrage.
- It was observed that the geometric standard deviation decreased with the distance, which means that the Tigris river downstream Kut barrage began to approach a homogeneous condition.
- The results demonstrate that coarser particles were deposited directly about 500 m downstream of Kut barrage which formed the large sand bar seen in this location.
- It was concluded that the main flow of the Tigris River downstream Kut Barrage reach is nearer to the right bank of the reach because coarser sizes of bed material were on the right bank.
- The flow regime of the first two kilometers of the study reach is flatbed due to high flow strength of released water discharge from the barrage. The flow regimes for the other parts are ripples and dunes.

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