Evaluation of Sediment Transport In Kirkuk Irrigation Channel

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Abstract

In this research, the sediments transport and how to compute their amount have been studied in Kirkuk irrigation channel. Empirical methods for computing sediments discharge in the channel have been discussed emphasizing on six methods (Blench, Graf, Laursen, Yang, Inglis- Lasey and Engelurd–Hansen). The applications of these methods required the selection of (24) sections along the channel in order to measure the hydraulic parameters of the different cross sections in addition to the slope along the channel. Samples of water sediments have been taken at each section in addition to bed samples.

The research introduces an equation for computing sediment load in Kirkuk irrigation channel depending on the data of (14) sections in the channel using statistic- MS program.

The validity of this equation has been verified with the application to the remaining (10) sections data in the channel and the results are very close to the field measurements .

Keywords: sediment transport

الخلاصة

في هذا البحث تم دراسة حركة الرسوبيات وحساب كمياتها في قناة ري كركوك حيث تم اختيار (٢٤) موقعا" لقياس التصريف ورصد المقطع العرضي له واخذ نماذج من مياه كل مقطع ونماذج من القعر، استخدمت ستة طرق لحساب تصريف الرسوبيات في القناة وهذه الطرق هي (Blanch, Graf, Laursen, Yang , Inglis-Lacey, Engelund and Hanse) كذالك تضمن البحث التوصل إلى معادلة خاصة لحساب حمل الرسوبيات بالاعتماد على معلومات لأربعة عشر مقطع في القناة وباستخدام برنامج (Statistica - Ms) ثم التحقق من صحة هذه المعادلة وذلك بتطبيقها على المقاطع العشرة الباقية من القناة وكانت النتائج جيدة .

1- Introduction

The material transported by water is in suspension, rolling, or sliding on the bed. The border line between bed load and suspension is certainly not well defined, because it is hard to imagine a particle rolling or sliding on the bed.

Sediments transported by river and channel have direct or indirect influence on many of the commonly encountered problems such as improvement or stabilization of rivers or channels and flood ways for navigation and flood control, the planning and design of irrigation and drainage channels, protection of sensitive turbines in hydro-electric power stations, the purification of

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public water supplies, and the control of soil erosion on watershed areas (3).

The computation and measurement of sediment load in the channel and river is important to hydraulic engineers, especially for the design of dams, regulators, stable channels, and water treatment plants.

Different equations are available to compute the total sediment load most of these equations have some theoretical or empirical bases, they were derived under very limited conditions of flow and sediment characteristics (7, 8). All of them have shown good results when used to compute the sediment load for conditions similar to those under which they were derived. On the other hand, very poor results, are obtained when they were applied for different conditions.

2- Description of Kirkuk Irrigation Channel

Kirkuk irrigation project is considered as one of the most important irrigation projects in the region because of the large areas that benefited from it and the technical applets and performance.

It is located in the northern part of Iraq within some (25-40) Km north-west of Kirkuk. It originates from the diversion at Dibbis dam located (4) Km from Dibbis Village, as shown in Fig.(1).

The first (16) Km of feeder channel flow in the same direction as that of the lesser Zab, then the channel turns to a south-east direction and reaches Mulla Abdulla, where the main channel begins. The feeder channel was under study particularly the reach between Al-Qadisia station and the conjunction between feeder and the main channel.

3- Field Work

The cross sections of the channel were observed with respect to the water flow direction, the whole width of the channel was divided into several parts (2 meter apart), then the depth for each part was measured. From these depths the cross sections along the channel were drawn and these sections were approximated to the trapezoidal shape , the field work was made on (24) sections along the feeder channel and main channel at different widths and depths as shown in table (1).

Price current meter was used to measure the velocities in the channels and consequently the discharges in the channel and consequently the discharges were calculated. Table (1) represents the water discharge for each section.

Three samples from the bed materials were taken in each section in order to conduct the size analysis distribution.

The sampler shown in Fig.(2) is especially designed to obtain the required samples. It consists of a bottle, fixed from sides and connected from bottom by (10) kg weight.

The bottle is closed perfectly with two holes cover, the first hole with 8 mm diameter tube for entering the water, the second hole is connected with plastic tube to escape the air from the bottle.

The sampling procedure starts by lowering the sampler to the channel and keeping the nozzle closed by shutting the tube outlet. When the sampler reached to the needed depth the nozzle opened, hence the air inside the bottle began to escape by the plastic tube and the water entering to the bottle from the other tube until the stopping air bubble escape and the bottle is filled with water then the sample drag out of the channel.

4- Sediment Concentration Measurement

Filtration is one of the methods used to analyze the suspended solid concentration. It involves the removal of the solid matter from a sample by passing a known volume of the liquid-solid mixture through a suitable filter. After completion of filtration, the filter paper was dried and re weighed. The difference between two weights divided by the volume of the sample gives the concentration of the suspended sediment (6).

$$C= (W_2 - W_1) / V \qquad \ldots(1)$$

where:

C = concentration of suspended sediment in (mg/L).

W_1= weight of dry filter paper in (mg).

W_2= weight of dry filter paper and suspended sediment in (mg).

V = volume of sample.

The volume of field sediment discharge has been calculated by multiplying the main concentration of water at each section by the water discharge for the same section as shown in table (2).

5 - Empirical Formula

An empirical formula is prepared here in order to quantify the sediment load (concentration) in Kirkuk irrigation channel. This formula characterizes only this particular channel, it is obtained depending on data collected from fourteen different cross-sections through the whole channel. Other data used for formula verification.

The variables used for field and laboratory work and their relationship can be given as follow:

$$F_1(\rho_s, \rho_w, D_{35}, D_{65}, V, R_h, S, g, Q_s) = 0 \qquad \ldots(2)$$

By dimensional analysis, this equation can be written as(5.8)

$$Q_s / \rho_s g^{0.5} D_{35}^{2.5} = F_2 (R_h / D_{35}, g D_{35} / V^2, S, D_{35} / D_{65}, \rho_s / \rho_w) \qquad \ldots(3)$$

The sediment discharge given in the following equation (4) resulted from a regression analysis by MS-statistical

$$Q_s = [(R_h - (0.09*9*(S_g-1))) /V+ R_h(S_g-1)+((0.3 D_{35} D_{65})/S)^{-0.34}]^{1.1} \qquad \ldots(4)$$

where:

Q_s= Total sediment load (kg/sec);

V= mean velocity of fiw (m/s);

g = Gravitational acceleration (m/sec^2) ;

R_h= hydraulic radius (m) ;

S_g = specific gravity;

S = slope of the channel;

D_{35}, D_{65}= particle size for which 35% and 65% by weight of sediment is finer (mm).

The coefficient of variance for equation (4) was found to be equal (0.92).

Fig.(3) shows a well accepted correlation between predicted and observed (Q_s) values.

In order to verify the new proposed formula (equation 4), variables from other data were used. The equation (4) was quite fit to the channel as the correlation coefficient between its results and the observed is (R^2=0.935) as shown in Fig.(4).

6 - Evaluation of Sediment Discharge Formula

The predicted values of sediment discharge were calculated using six different sediment models shown in Table (3).

In order to show which of the used formula was the best to predict the sediment discharge in Kirkuk channel a percentage of error (5) was applied to evaluate the formula:

$$\text{Percentage of error} = \frac{\text{Measured sediment-computed sediment}}{\text{Measured sediment}} * 100$$

The percentage of error was divided into ten intervals (+10,+20,…,+100). The results of these computations are shown in Table (4).

Sediment discharge values estimated by the different formula were widely spread as some suggested sediment discharge values (e.g. Engelund-Hanses and Graf). Where others gave high sediment discharge values (e.g.Inglis Lacy and Laursen), while the same formulas were almost around the observed values (e.g. Blench and Yang).

It should be noted that these formulas are based mostly on flume studies that employed uniformly sized and shaped sediment (7).

7 - Conclusion

Based on the results of this study, the applications of the analysis methods give a variation result in determination of the sediment in the same hydraulic conditions and this variance may reach a high rate of difference.

The Kirkuk irrigation channel equation gave the best and nearest results to the field sediment determination as the statistical comparison gave a discrepancy ratio (92%) at range (0.75 – 1.25).

Among the six equation used in this research the Yang equation gives good agreement with the new proposed formula.

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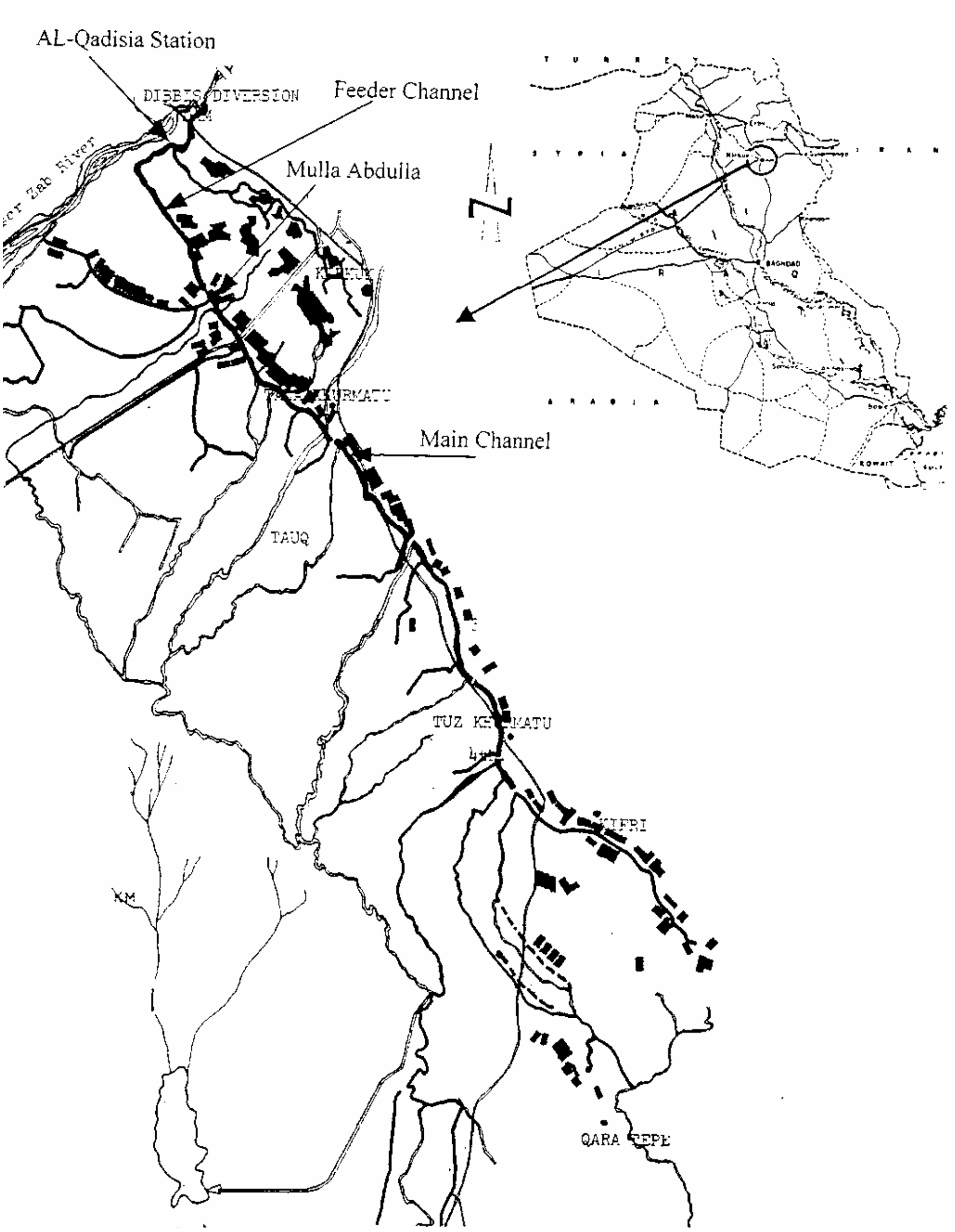

Fig. (1) : Courses of Kirkuk irrigation channel .

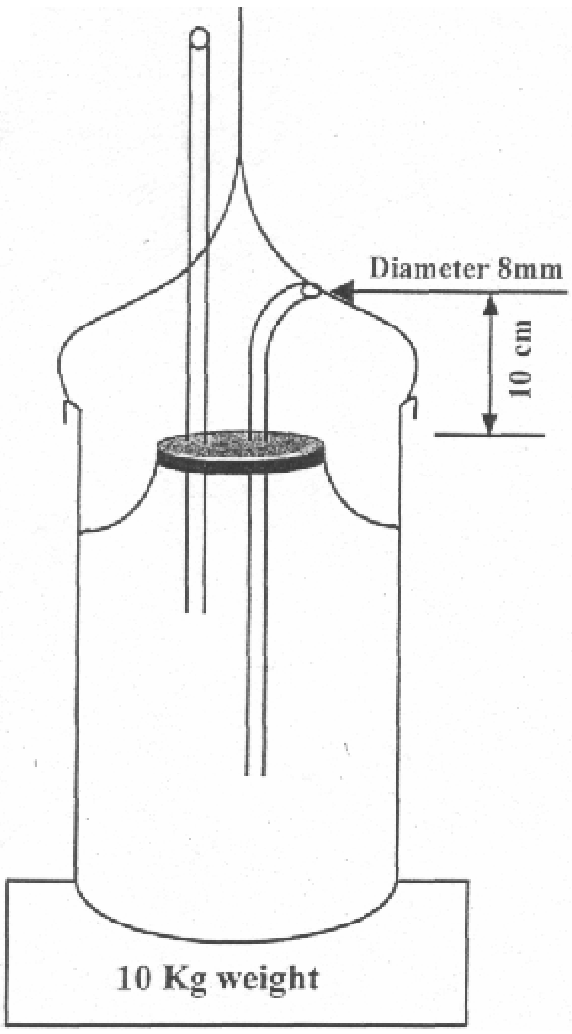

Fig (2) sketch of the designed sampler used .

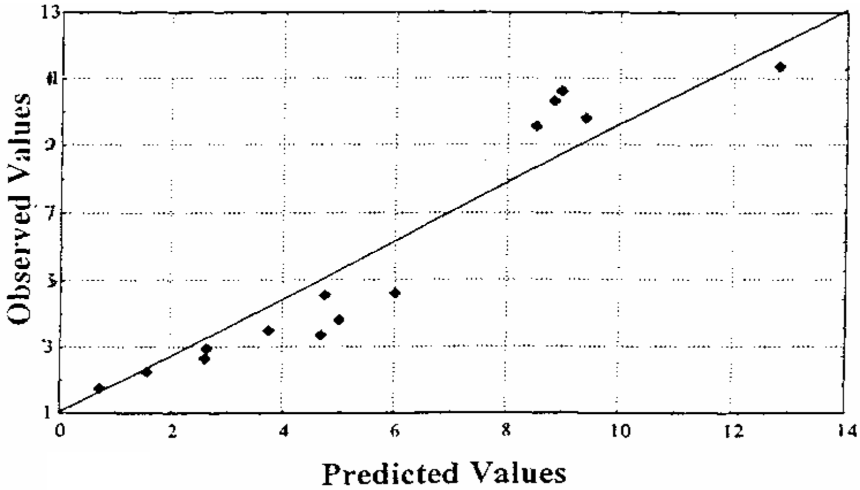

Fig (3) observed and predicted values for (14) sections.

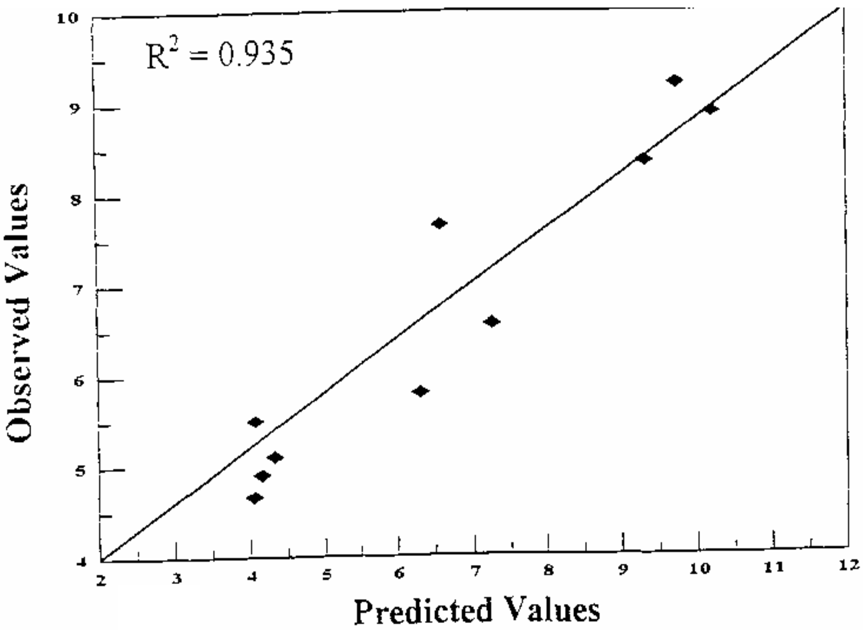

Fig (4) observed and predicted values for (10) sections .

Table (2) : Field sediment discharge

No.of Section	Concentration mg/l	Water discharge m^3/sec	Sediment discharge kg/sec
1	252	45	11.36
2	246	45	11.1
3	246	43	10.6
4	229	43	9.86
5	233	40.9	9.55
6	228	40.3	9.2
7	220	40.3	8.88
8	217	38.5	8.35
9	207	37	7.65
10	179	36.7	6.55
11	158	36.7	5.6
12	157	35	5.5
13	145	35	5.1
14	148	33.1	4.9
15	145	32	4.66
16	149	31	4.61
17	150	30.3	4.65
18	121	30.3	3.67
19	116	30	3.5
20	130	25	3.25
21	136	21.6	2.95
22	135	19.5	2.64
23	132	17	2.25
24	116	15	1.75

Table (3) : predicted values of sediment discharge

No Sec.	Blencll kg/sec	Gial kg/sec	Laursen kg/sec	Inglis Lacey kg/sec	Engelund Hansen kg/sec	Yange kg/sec	New formula kg/sec
1	28.2	2.6	14.3	3.3	0.12	8.46	12.85
2	24.5	2.6	37.3	9.9	0.12	23.7	9.02
3	32.4	2.9	47.8	12.2	0.55	15.53	8.88
4	22.0	2.3	75.8	14.9	0.14	22.27	9.44
5	22.7	1.9	87.4	17.2	0.15	8.88	8.55
6	20.4	2.3	73.1	20.5	0.13	19.10	9.75
7	22.9	2.1	78.0	14.2	0.15	7.08	10.23
8	20.6	1.0	84.8	20.6	0.14	9.88	9.32
9	16.6	1.6	121.8	15.5	9.58 E-2	29.64	6.62
10	20.9	1.4	113.2	23.8	0.13	4.80	7.24
11	16.1	1.5	107.3	15.0	9.43 E-2	25.34	3.53
12	17.2	1.2	121.9	29.4	0.06	5.46	4.13
13	19.5	1.2	127.9	33.9	7.13 E-2	1.97	4.22
14	19.1	1.3	106.6	23.4	6.52 E-2	1.17	3.91
15	15.0	1.1	101.5	28.3	4.67 E-2	5.66	6.02
16	15.6	1.6	97.8	47.3	9.94 E-2	6.66	4.76
17	29.2	4.5 E-2	86.9	22.4	0.17	8.24	5.02
18	5.7	5.2 E-2	71.0	20.8	2.18 E-2	0.39	3.76
19	6.6	4.6 E-2	80.3	29.6	2.77 E-2	0.11	4.71
20	1.9	8.5 E-2	1.93	0.7	6.69 E-3	26.27	2.68
21	0.9	3.2 E-2	2.9	0.87	3.58 E-3	23.457	2.63
22	2.1	2.5 E-2	7.5	1.55	7.79 E-3	0.95	1.06
23	0.8	1.6 E-2	12.7	3.09	3.93 E-3	6.54	0.76
24	0.4	2.6 E-2	13.7	1.34	2.20 E-3	3.87	0.65