Estimation the quantity of sediment transport upstream of Al- Hafar regulator using different formulas

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Abstract-In this research, the sediments transport and estimating their amount have been studied in up-stream of Al- Hafar regulator on Euphrates river which is located in the south of Iraq within Dhi-Qar governorate. For the analysis of the applicability of sediment transport formulas to the study reach, eight formulas were chosen for that purpose, namely:

(Engelund-Hansen , Ackers-White, Van Rijn, Yang, Abed-Al- Rahman , Ariffin, Jasem and Sadiq).

The applications of each formula was required data collected from field measurements of twenty-one sections along the study reach (5 km) in order to measure the hydraulic parameters and properties of sediments transported. Samples of water sediment and bed material have been taken at each section using homemade Sampler, while the hydraulic parameters were measured using (Acoustic Doppler Current Profile) ADCP device .

From the analysis, using statistical and graphical methods the formulas (Ariffin and Engelund-Hansen) are better other formulas selected in the predicting the total sediment load in reach of study which are nearly with observed quantity.

Finally, The average predicted annual total sediment discharge has been estimated through field measurements about (120783) ton .

Keywords: Sediment Transport, River Bed, Al-Hafar regulator, sediment formulas

1-Introduction

Sedimentation in rivers, estuaries and coastal regions has important environmental and economic influences, including formation and elevation changes of deltas, expansion of alluvial channels, and migration of rivers. And the impact of these deposits should be taken into account in many hydraulic engineering projects such as irrigation systems and canals for navigation, and hydroelectric power stations, ports and other coastal engineering works. It is therefore necessary to control of sedimentation on such important projects**[1]**.

Rivers and channels are considered to be an important means for water supply, irrigation, navigation, water power generation, and other public uses. The presence and movement of sediment causes many problems. The erosion and deposition of solid material of the bed and banks of the channel increase bed deformation, which in turn will reduce the depth of water in some places and reduce the ability of the water way for navigation or hydraulic purposes. However, the raising of the river bed by the deposited materials increases the flood range to a great extent. As a result, large sums of money have to be spent to maintain the course of the river suitable for the hydraulic requirements**[2].**

Most sediment transport equations are derived under the assumption some theoretical and empirical bases. These equations have a boundary condition and should not be accepted as a general rule , yet there is no a universal formula that can be considered suitable to be used to estimate a sediment transport rate for all rivers. This reason suggests the need for additional work in this field. Hence , in this research an investigation was made with dual objectives of testing the accuracy of some of the existing computational methods and proposing an alternative ,Where no previous study by the researchers to estimate the amount of sediment at the site of the study.

2- Description of Al-Hafar regulator

Al-Hafar regulator channel is considered as one of the most important projects of irrigation in the region for the large areas that benefited from it and the technical applets and performance. It is located in Suq Al- Shuyukh area(AL- Karma) (south-east) in Dhi-Qar governorate on Euphrates River. The regulator is constructed in1957and it consists of seven steel sliding gates in addition to the navigation lock, each gate with a dimension (7x7)m. The designed flood discharge of the regulator is 500 m3/sec. The reach of study upstream of the regulator with length 5 Km .It is located between longitude E 46°34'19.77" to E

46°32'1.62" and latitude N 30°52'52.22" to N 30°52' 9.46".

3-Field Measurement

Sediment measurement in this study involves selected ,twenty one sections along the reach of upstream of Al-Hafar regulator on the Euphrates river with different distance range (100-300)m between section and another as required by the nature of the study area and hydraulic conditions .The total length of the reach in this study is about 5 Km as shown in figure **1**.The measurement include discharge and average velocity, width, cross section area for each cross section, sampling the water-sediment mixture to determine the mean suspended sediment concentration, particle size distribution and other physical properties of the transported solids. The flow depth ranged from (0.21 to 5) meters, with flow ranging from (12.46 to 42.56) m3/sec. The flow velocities ranges from (0.117 to 0.345) m/sec and the median sediment size (0.098 to 0.152) mm for the bed material composition was observed. A summary of data used in the study is shows in table **1**.

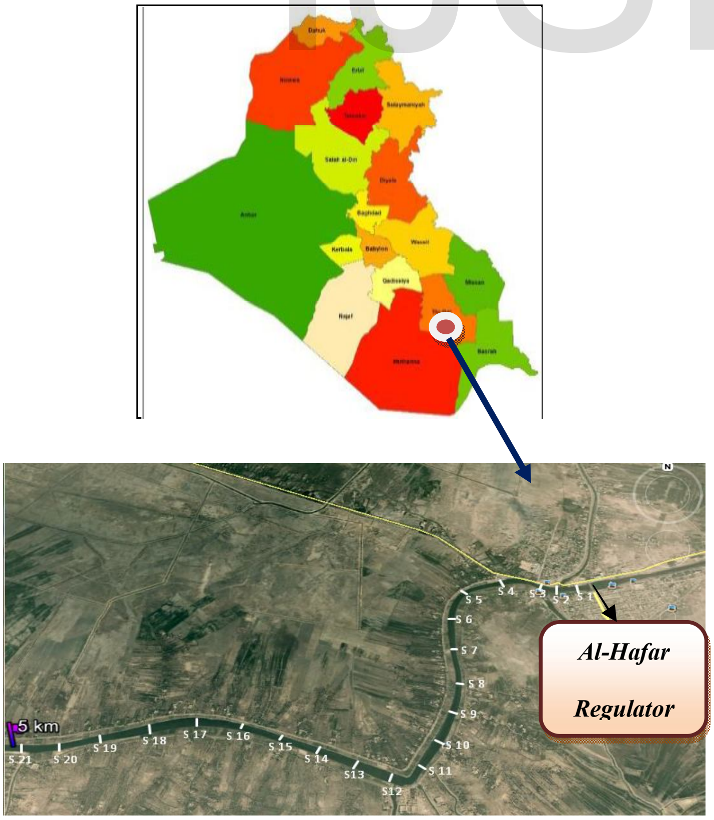

Fig. 1: The positions of cross-sections (C.S.) in the region of study, by Google Earth©.

Table 1: Primary data and parameter

Sec. No	1	2	3
Q_w(m³/sec)	34.62	34.23	39.79
V (m/sec)	0.316	0.158	0.32
G_s	2.73	2.66	2.65
d_{50} (mm)	0.152	0.113	0.112
A (m²)	109.4	216.3	124.3
B (m)	55.01	107.44	70.83
R_h (m)	1.99	2	1.75
ν (m²/sec)	1.05×10^{-6}	1.05×10^{-6}	1.05×10^{-6}
W_s (m/sec)	0.016668	0.009407	0.009199
U_* (m/sec)	0.0312	0.0313	0.0293
Sec. No	**4**	**5**	**6**
Q_w(m³/sec)	40.37	40.87	42.56
V (m/sec)	0.312	0.345	0.343
G_s	2.69	2.73	2.7
d_{50} (mm)	0.105	0.1	0.102
A (m²)	129.4	118.6	124.2
B (m)	47.97	49.61	56.45
R_h (m)	2.69	2.39	2.20
ν (m²/sec)	1.04×10^{-6}	1.05×10^{-6}	1.05×10^{-6}
W_s (m/sec)	0.008359	0.007796	0.007958
U_* (m/sec)	0.0363	0.0342	0.0328
Sec. No	**7**	**8**	**9**
Q_w(m³/sec)	22.77	23.58	23.82
V (m/sec)	0.19	0.202	0.196
G_s	2.7	2.72	2.69
d_{50} (mm)	0.1	0.098	0.11

A (m^2)	120.1	116.7	121.3
B (m)	47.77	51.05	60.02
R_h (m)	2.51	2.28	2.02
ν (m^2/sec)	1.06×10^{-6}	1.07×10^{-6}	1.07×10^{-6}
W_s (m/sec)	0.007543	0.008431	0.008958
U_* (m/sec)	0.0351	0.0334	0.0315

Sec. No	10	11	12
Q_w (m^3/sec)	22.97	22.95	24.97
V (m/sec)	0.25	0.195	0.23
G_s	2.65	2.66	2.7
d_{50} (mm)	0.1	0.098	0.1
A (m^2)	92	117.5	108.8
B (m)	60.19	49.60	74.36
R_h (m)	1.53	2.37	1.46
ν (m^2/sec)	1.07×10^{-6}	1.07×10^{-6}	1.07×10^{-6}
W_s (m/sec)	0.007294	0.008096	0.007508
U_* (m/sec)	0.0274	0.0341	0.0268

Sec. No	13	14	15
Q_w (m^3/sec)	26.36	27.40	27.42
V (m/sec)	0.256	0.243	0.234
G_s	2.69	2.68	2.7
d_{50} (mm)	0.099	0.101	0.125
A (m^2)	102.9	112.6	116.9
B (m)	56.72	51.39	46.65
R_h (m)	1.81	2.19	2.50
ν (m^2/sec)	1.06×10^{-6}	1.07×10^{-6}	1.07×10^{-6}
W_s (m/sec)	0.008454	0.007599	0.011436
U_* (m/sec)	0.0298	0.0327	0.035

Sec. No	16	17	18
Q_w (m^3/sec)	27.82	13.48	14.76
V (m/sec)	0.257	0.123	0.162
G_s	2.69	2.67	2.68
d_{50} (mm)	0.113	0.127	0.147
A (m^2)	108.2	109.3	91.1
B (m)	50.01	69.22	64.99
R_h (m)	2.16	1.58	1.40
ν (m^2/sec)	1.06×10^{-6}	1.20×10^{-6}	1.21×10^{-6}
W_s (m/sec)	0.009462	0.010445	0.013612
U_* (m/sec)	0.0325	0.0278	0.0262

Sec. No	19	20	21
Q_w (m^3/sec)	13.93	12.46	14.10
V (m/sec)	0.135	0.117	0.135
G_s	2.7	2.69	2.72
d_{50} (mm)	0.123	0.11	0.1
A (m^2)	103.6	106.2	104.2
B (m)	52.18	44.11	47.94
R_h (m)	1.98	2.41	2.17
ν (m^2/sec)	1.21×10^{-6}	1.21×10^{-6}	1.22×10^{-6}
W_s (m/sec)	0.009915	0.007970	0.006724
U_* (m/sec)	0.0312	0.0344	0.0326

4-Sediment Transport Formulas

The formulas used to estimate the quantity of sediment were Engelund-Hansen , Ackers-White, Van Rijn, Yang, Abed-Al- Al- Rahman , Ariffin, Jasem and Sadiq. These formulas have been tested with the measured data to show which to be nearly credible and considered as a predictive formula for river reach in this study . A summary of the sediment discharge variables by the investigators as shown in table 2.

Table 2: A summary of sediment parameters

Author	parameters used
Engelund-Hansen(1967)	$\gamma_s, V, \frac{d_{50}}{(G_S-1)g}, \frac{\gamma,R,S}{(\gamma_S-\gamma)d_{50}}$
Ackers-White(1973)	$d_{50}/h\ ,V/U_*, C_S,\ g(G_S-1), \nu$
Van Rijn(1984)	$\frac{(V-V_{cr})}{(G_s-1)gD_{50}}, \frac{D_{50}}{H}, \frac{d\ (G_S-1)g}{\nu}$
Yang(1996)	$\frac{w_s\ d_{50}}{\nu}, \frac{U_*}{w_s}, \frac{V\ S}{w_s}$
Abed-Al-Rahman(2003)	$\frac{V}{U_*}, \frac{R_h}{B}, \frac{\nu}{w_s d_{50}}$
Ariffin(2004)	$\frac{R}{d_{50}}, \frac{u_*}{W}, \frac{u_*}{V}, \frac{V}{gD}$
Jasem(2012)	$\rho\ w_s\ R_h, \frac{V}{w_s}, \frac{R_h}{d_{50}}, \frac{\nu}{w_s R_h}, G_S\ \frac{B}{R_h}$
Sadiq(2013)	$\rho_s w_s d_{50}\ , \frac{V\ U_*}{w_s}, \frac{R_h w_s}{\nu}\ , B$

* The meanings of each symbol are presented in list of symbol.

4.1 Engelund-Hansen Formula

Engelund-Hansen's**(1967)** **[3]** equation is based on the shear stress approach. The equation can be written as:

$$Q_t = 0.05\ \gamma_s V^2 \sqrt{\frac{d_{50}}{(G_s-1)}}\ \left(\frac{\tau_0}{(\gamma_s-\gamma)d_{50}}\right)^{3/2} \quad \ldots(1)$$

4.2 Ackers and White Formula

Ackers and White (1973) **[4]**, **[5]** used dimensional analysis based on flow power concept, as explained by Bagnold, in order to express sediment transport rate by several dimensionless parameters. Their proposed formula was as follows.

$$C_t = C_S G_S \left(\frac{d_{50}}{h}\right)\left(\frac{V}{U_*}\right)^n \left[\left(\frac{F_{gr}}{A}\right) - 1\right]^m \quad \ldots(2)$$

This formula was derived using 1000 laboratory data with particle size larger than 0.04 mm and Froude number less than 0.8.

The dimensionless particle d_{gr} is calculated by:

$$d_{gr} = d_{50}\left(\frac{g(GS-1)}{v^2}\right)^{1/3} \quad \ldots(3)$$

The particle mobility factor F_{gr} is calculated by:

$$F_{gr} = \frac{u_*^n}{\sqrt{g d_{50}(GS-1)}}\left(\frac{V}{\sqrt{32}\log\left(\frac{10\ h}{d_{50}}\right)}\right)^{1-n} \quad \ldots(4)$$

4.3 Van Rijn Formula

Van Rijn (1984) cited in**[3]** developed an analytical relationship for sediment load transport in terms of the saltation height, particle velocity and bed load concentration. The transport equation can be expressed in a simplified form when only the mean velocity, flow depth and particle size are known was given as:

$$\frac{q_b}{VH} = 0.005\left[\frac{(V-V_{cr})}{\sqrt{(G_S-1)gD_{50}}}\right]^{2.4}\left(\frac{D_{50}}{H}\right)^{1.2} \quad \ldots(5)$$

$$\frac{q_s}{VH} = 0.012\left[\frac{(V-V_{cr})}{\sqrt{(G_S-1)gD_{50}}}\right]^{2.4}\left(\frac{D_{50}}{H}\right)(D_*)^{-0.6} \quad \ldots(6)$$

$$D_* = d\sqrt[3]{\frac{(G_s-1)g}{\nu^2}} \quad \ldots.(7)$$

4.4 Modified Yang's Formula

Modified Yang's (1996) **[6]** proposed modified Yang's unit stream power formula for a sediment-laden river.Computing the sediment concentration from.

$$\log c_t = 5.165 - 0.153\log\frac{\omega d_{50}}{\upsilon} - 0.297\log\frac{U_*}{\omega} + \left(1.78 - 0.36\log\frac{\omega d_{50}}{\upsilon} - 0.48\log\frac{U_*}{\upsilon}\right)\log\left(\frac{VS}{\omega}\right) \ldots(8)$$

$$\upsilon = \frac{1.792*10^{-6}}{(1+0.0337T+0.000221T^2)} \quad \ldots(9)$$

$$\omega = \frac{(G-1)g\ (d_{50})^2}{18\upsilon} \quad \ldots(10)$$

$$U_* = (gDS)^{1/2} \quad \ldots(11)$$

$$c_m = \frac{c_t G*10^{-3}}{G-(G-1)*(C_t*10^{-6})} \quad \ldots(12)$$

$$Q_s = c_m Q_w \quad \ldots(13)$$

4.5 Abed-Al-Rahman Formula

Abed-Al-Rahman (2003)**[7]** evaluated the amount of total sediment load entering the Al-Qadisiya reservoir . The analysis was made on six sediment transport formulas , (Engelund-Hansen , Ackers-White , Yang , Maddock , Graf-Acaroglu and Karim-

Kennedy) to check the applicability of each transport formula.

$$C=55.1\left(\frac{V}{U_*}\right) + 10164.1\frac{R_h}{B} + 144.7\frac{v}{w_s\, d_{50}} - 449.3 \qquad \ldots(14)$$

4.6 Ariffin Formula

Ariffin (2004) **[5]** derived her sediment transport equation based on regression. She conducted tests on the robustness on the variables used in her equation. Her proposed equation is:

$$C_V = 1.156\times 10^{-5} \left(\frac{R}{d_{50}}\right)^{0.716} \left(\frac{u_*}{w}\right)^{-0.975} \left(\frac{u_*}{V}\right)^{0.507} \left(\frac{V^2}{gD}\right)^{0.524} \qquad \ldots(15)$$

4.7 Jasem Formula

Jasem (2012)**[8]** estimated the total sediment load entering Al-Abbasya Barrage in Al Najaf city on Euphrates .He had been found by a new proposed formula which had no significant difference with the observed values. The coefficient of determination of his formula was found to be equal(R^2=0.94).

$$Q_s=\rho w_s Rh^2\left(\frac{V}{w_s}\right)^{1.5}\left(\frac{Rh}{d_{50}}\right)^{-0.5}\left(\frac{v}{w_s Rh}\right)^{0.43}\left(G_s\frac{B}{Rh}\right)^{0.67} \qquad \ldots(16)$$

4.8 Sadiq Formula

Sadiq(2013)**[9]** estimated the total amount of Sediment Load at the upstream of Al-Shamia Barrage, which is located in the middle of Iraq within the province of Diwaniya on Euphrates river. Derivation of this formula required the selection of (24) sections along entire study reach reach in order to measure the hydraulic parameters of different cross sections and the the properties of sediment.

$$Q_s = 32\times 10^{-4}\rho_s\, w_s\, d_{50}\left(\frac{U_* V}{w_s^2}\right)^{1.07}\left(\frac{R_h w_s}{v}\right)^{0.33}(B) \qquad \ldots(17)$$

Table 3 is presented the predicted and observed values of sediment discharge.

Table 3: Predicted and observed values of sediment discharge in (kg/sec)

Sec. No	1	2	3
Engelund	5.123	3.588	8.079
Ackers	0.058	0.011	0.228
Van Rijn	2.662	0.228	6.251
Yang	0.099	0.069	0.230
Abed-Al-Rahman	18.544	5.514	21.940
Ariffin	10.235	4.797	8.058
Jasem	10.023	8.029	16.826
Sadiq	1.697	1.824	2.292
Observed	5.728	5.323	6.678
Sec. No	**4**	**5**	**6**
Engelund	10.232	11.019	10.990
Ackers	1.190	1.322	0.997
Van Rijn	3.910	6.874	7.621
Yang	0.313	0.376	0.365
Abed-Al-Rahman	30.962	32.302	30.185
Ariffin	7.669	8.089	8.383
Jasem	15.824	18.877	19.414
Sadiq	2.255	2.398	2.504
Observed	6.635	7.010	7.164
Sec. No	**7**	**8**	**9**
Engelund	3.547	3.725	3.138
Ackers	0.099	0.094	0.025
Van Rijn	0.329	0.445	0.416
Yang	0.091	0.079	0.071
Abed-Al-Rahman	13.388	12.367	9.363
Ariffin	3.119	3.819	3.685
Jasem	7.910	7.825	7.903
Sadiq	1.285	1.217	1.318
Observed	2.853	3.124	3.105
Sec. No	**10**	**11**	**12**
Engelund	3.837	3.753	3.589
Ackers	0.042	0.117	0.020
Van Rijn	1.754	0.386	1.335
Yang	0.113	0.079	0.1
Abed-Al-Rahman	12.054	10.753	14.052
Ariffin	3.540	3.423	3.863
Jasem	11.675	7.580	11.484
Sadiq	1.425	1.188	1.539
Observed	3.453	3.113	3.509
Sec. No	**13**	**14**	**15**
Engelund	4.768	5.119	4.178
Ackers	0.106	0.184	0.068
Van Rijn	1.705	1.255	0.666
Yang	0.113	0.147	0.089
Abed-Al-Rahman	16.267	15.675	15.827
Ariffin	4.824	4.281	5.378

Jasem	10.871	11.299	8.066
Sadiq	1.423	1.593	1.394
Observed	3.881	3.957	3.889
Sec. No	**16**	**17**	**18**
Engelund	4.839	0.868	1.010
Ackers	0.114	0.000076	0.000047
Van Rijn	1.371	0.027	0.085
Yang	0.122	0.013	0.015
Abed-Al-Rahman	2.115	2.917	4.441
Ariffin	5.142	1.703	2.546
Jasem	10.366	3.812	4.452
Sadiq	1.530	0.728	0.772
Observed	4.046	1.366	1.745
Sec. No	**19**	**20**	**21**
Engelund	1.114	1.071	1.422
Ackers	0.000787	0.003078	0.007942
Van Rijn	0.039	0.019	0.055
Yang	0.019	0.020	0.033
Abed-Al-Rahman	6.155	7.072	10.753
Ariffin	1.803	1.292	1.455
Jasem	4.150	3.745	5.308
Sadiq	0.749	0.685	0.834
Observed	1.568	1.193	1.163

5-Test the efficiency of the proposed formulas

To determine the efficiency of the selected formulas, the predicted sediment discharge by using these formulas were compared with observed sediment discharge in the reach of study, there are two methods of comparisons which are statistical methods and graphical comparison.

5.1 Comparison Using Statistical Relations

Three methods are used in this research to evaluate the performance of each formula through comparing with measured values.

A- Mean Standard Error

A mean standard error was used in order to select the best formula since due to the high difference between predicted and measured sediment rates at various intervals **[4].**

$$MSE = \frac{100}{N} \sum_{n=1}^{n} \left| \frac{s_o - s_c}{s_o} \right| \qquad ...(18)$$

In which

MSE is a Mean Standard Error; s_o an observed sediment rate; s_c is a predicted sediment load and N is the number of the predicted value.

In this method, a lower statistical criterion (close to zero) shows a higher accuracy in the model performance. Table 4 explains these results. This method gives a general evaluation for whole results by each used formula.

Table 4 : Comparison using Mean Standard Error

Formula	MSE
Engelund	24.6%
Ackers	96.14%
Van Rijn	67.8%
Yang	97.28%
Abed-Al-Rahman	255.11%
Ariffin	20.56%
Jasem	162.8%
Sadiq	59.23%

B- Discrepancy Ratio

It is defined as the ratio between computed and measured sediment loads. It was used as an error measure that is calculated as.**[10]**

$$\text{Discrepancy Ratio} = \frac{computed\ q_s}{measured\ q_s} \qquad ...(19)$$

When the discrepancy ratio is equal to one (R=1)**[4]** for the values of a selected formula that indicate the predicted value is identical to the measured value for reach of study .The discrepancy ratio is scheduled with the ranges (0.75-1.25) ,(0.5-1.5),and (0.25-1.75). The results are presented in table 5 for twenty one set of data.

Table 5 : Comparison between the computed and the measured values

Formula	Discrepancy ratio Percentage of data in the range			No. data
	0.75-1.25	0.5-1.5	0.25-1.75	
Engelund	62%	85.7%	100%	21
Ackers	….	….	….	21
Van Rijn	14.3%	24%	47.6%	21
Yang	….	….	….	21
Abed-Al-Rahman	4.7%	4.7%	14.3%	21
Ariffin	81%	95.2%	95.2%	21
Jasem	….	….	9.5%	21
Sadiq	….	14.3%	100%	21

C- Root Mean Squared Error

The root mean square error(RMSE) calculation is a well known and frequently used method of error analysis. It accurately depicts the magnitude of deviations of and estimated (measured or calculated) value from the actual value sought**[11]**. The RMSE has the same units as the measured and calculated data. Smaller values indicate better agreement between the measured and the calculated values**[9].**

$$RMSE = \sqrt{\frac{\sum_{i=1}^{n}(s_o - s_c)^2}{N}} \qquad ...(20)$$

In which: $s_o$observed sediment rate, s_c is predicted sediment load and N is the number of predicted values. The results are shown in table 6.

Table 6: Comparison using Root Mean Squared Error

Formula	Engelund	Ackers	Van Rijn
RMSE	1.61	3.97	2.38
Formula	**Yang**	**Abd-Al-Rahman**	**Ariffin**
RMSE	4.13	12.36	1.24
Formula	**Jasem**	**Sadiq**	
RMSE	6.64	2.74	

5.2 Graphical Comparison

A graphical comparison is conducted on the formulas by calculating the deviation of predicted sediment discharges from measured or by means of discrepancy ratio **[8].**

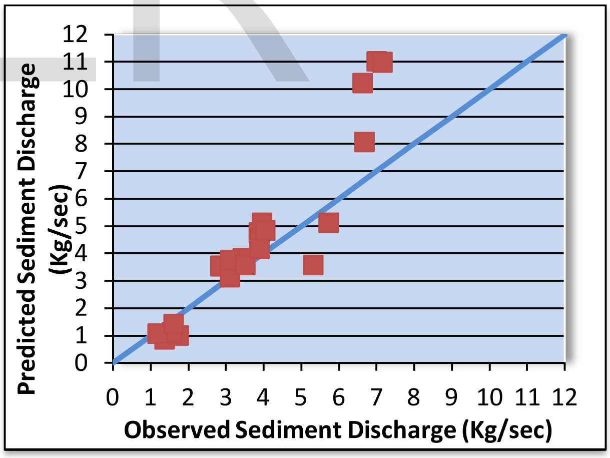

Fig. 2: Comparison between measured and computed sediment load by using Engelund - Hansen Formula

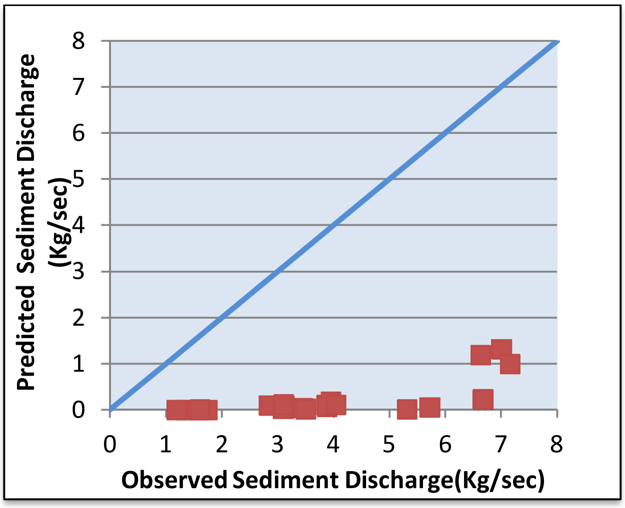

Fig. 3: Comparison between measured and computed sediment load by using Ackers-White Formula

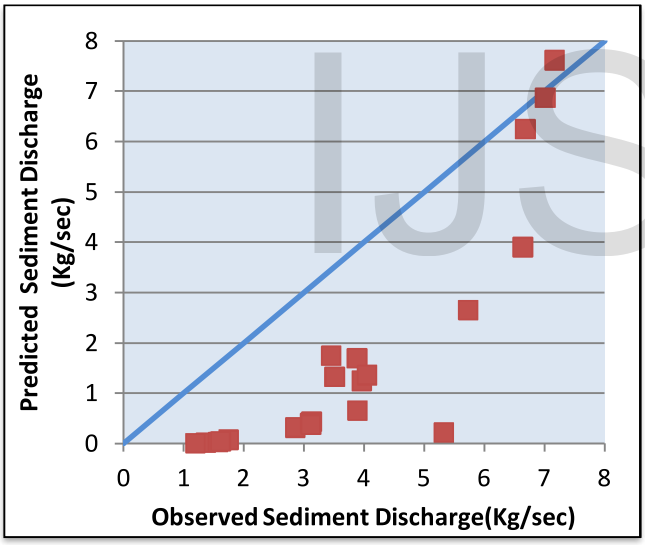

Fig. 4: Comparison between measured and computed sediment load by using Van Rijn Formula

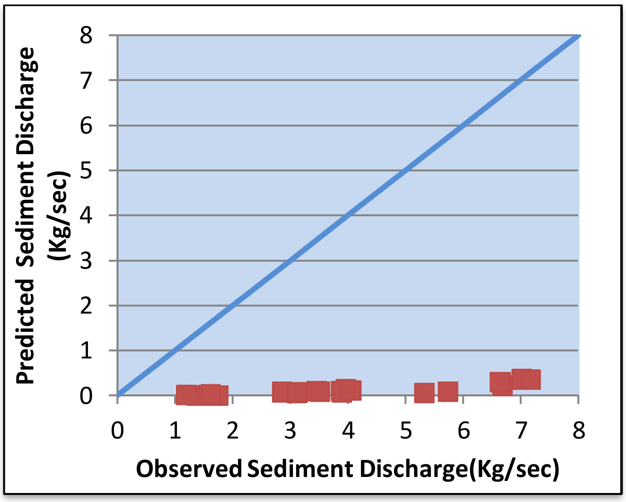

Fig. 5: Comparison between measured and computed sediment load by using Yang Formula

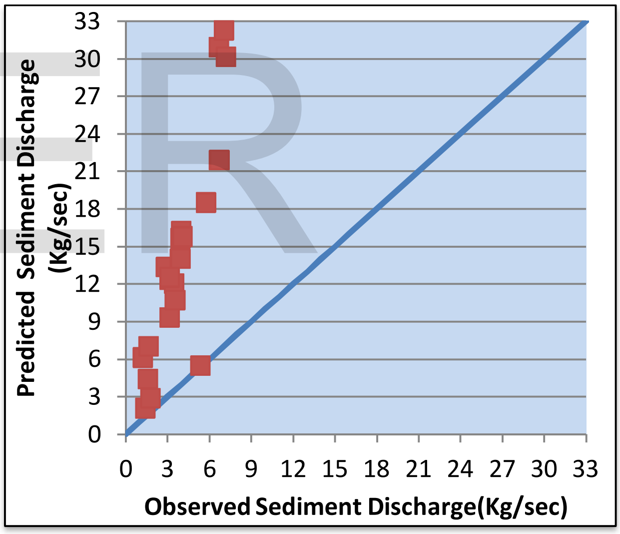

Fig. 6: Comparison between measured and computed sediment load by using Abed-Al Rahman Formula

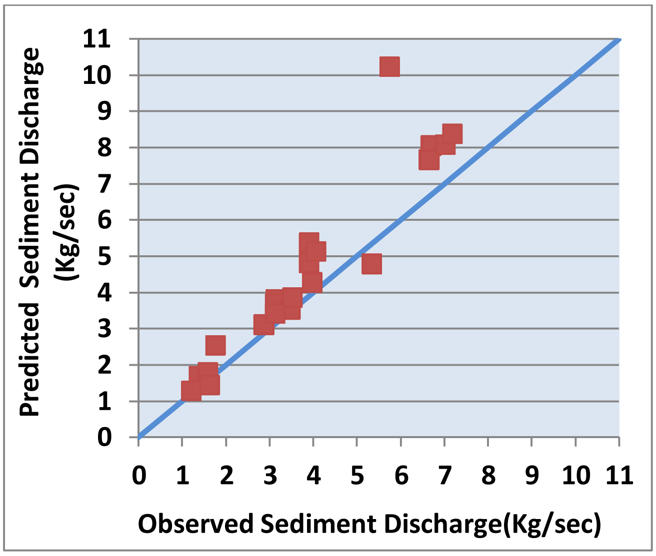

Fig. 7: Comparison between measured and computed sediment load by using Ariffin Formula

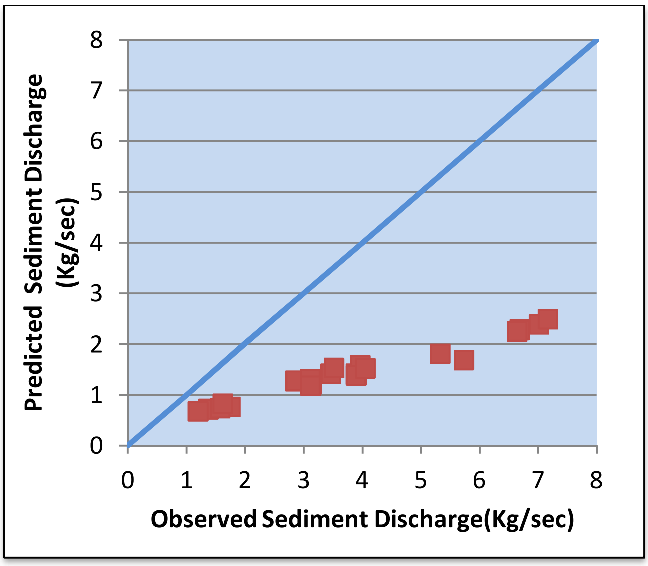

Fig. 9: Comparison between measured and computed sediment load by using sadiq Formula

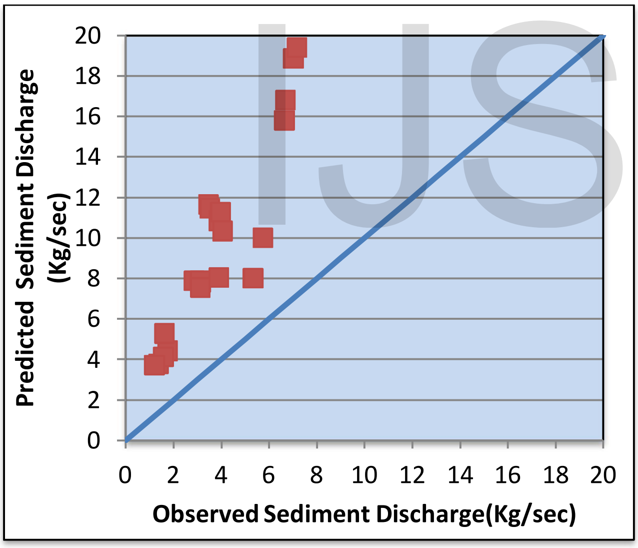

Fig. 8: Comparison between measured and computed sediment load by using Jasem Formula

6- Conclusions

According to the results which are obtained by this study for twenty one cross sections on Euphrates river up-stream of Al- Hafar regulator ,in Al- Nasiriyah city the following points are concluded:

1- The sediment particle size analysis showed that the bed material river is composed of Sand, Silt and Clay. The large portion of bed material is sandy material, with the median grain size (0.098 – 0.152) mm.

2- Eight sediment transport formulas used in this research to estimate the total sediment load were Engelund-Hansen , Ackers-White, Van Rijn, Yang, Abed-Al- Rahman , Ariffin, Jasem and Sadiq, the best performance was produced by Ariffin formula followed by Engelund-Hansen formula.

In Ariffin formula gave mean standard error equal to 20.56 %,discrepancy ratio equal to 95.2% within the ranges (0.25-1.75) and RMSE equal to 1.24. While Engelund-Hansen formula gave mean standard error equal to 24.6%

,discrepancy ratio equal to 100% within the same range and RMSE equal to 1.61.

3- The average predicted annual total sediment transport is about 120783 Ton in the study.

7- References

[1] Omran, Hassan, A." Sedimentj Transport in AL-Adhaim River Basin" Thesis , Department of Building and Construction, University of technology ,the requirements for the degree of doctor.

[2] Khassaf, S., I., and Addab, H., F., "Development of Empirical Formula for Computing Sediment Load in Al-Meshkhab Regulator Channel", Jordan Journal of Civil Engineering, vol. 5, No.4, 2011.

[3] Monowar, M., H. and Lutfor, M., R., " Sediment transport functions and their evaluation using data from large alluvial rivers of Bangladesh", Department of Water Resources Engineering, Bangladesh University of Engineering and Technology, IAHS Publ., no. 249, 1998.

[4] Hassanzadeh, H., Faiznia, S., Shafai, B., M. and Motamed, A.,"Estimate of Sediment Transport Rate at Karkheh River in Iran Using Selected Transport Formulas", World Applied Sciences Journal 13 (2): 376-384, , ISSN 1818-4952, © IDOSI Publications, 2011.

[5] Sa'adon, M. S., "Artificial Neural Network Sediment Transport Model for Sungai Bernam", MSc., Thesis, Faculty of Civil Engineering, University of Technology Mara, 2008.

[6] Mukheif, R.A, "Hydraulic of Sediment Transport in Number of Alluvial Channels" M.Sc. Thesis, Department Of civil Engineering. University Of Babylon, Department of Civil Engineering, 2012.

[7] Abd-Al-Rahman. K.Zeidan , "Evaluation of Sediment Transport Entering the reservoir of Al Qadisiya Dam" MSc. Thesis, Department of Civil Engineering, University of Al Anbar,2003.

[8] Jasem , H., Mohammed" Estimation of Sediment Quantity up stream of Al-Abbasiya barrage in Euphrates River" , MSc. Thesis, Department of Civil Engineering, University of Kufa, 2012 .

[9] Sadiq,N., Mohammed" Evaluation of Sediment Transport up Stream of Al-Shamia Barrage"" MSc. Thesis, Department of Civil Engineering, University of Kufa, 2013.

[10] Yang, C. T., "Erosion and Sedimentation Manual", US Department of the Interior, 2006.

[11 Johnson, L., L.," A Comparison of Methods for Estimating RMS Error: A "Brute Force" Approach Versus a Mathematically-Elegant Approach, as Applied to the Calculation of a Specific Retrieval Error for a Limb-Scanning Microwave Radiometer-Spectrometer",M. Sc. Thesis,the Faculty of the School of Engineering Air Education and Training Command AFIT/GAP/ENP/95D- 10, December 1995.

8- List of symbols

Qt= Total sediment discharge.

B,W= Width of the river.

V = Mean flow velocity

g= Gravitational acceleration,

τo= Shear stress along the bed,
GS= Specific gravity,

D_{50}, d_{50}= Median grain size

C_t = Weight concentration of bed material,

n = Transition exponent depending on sediment size,

$U_*, u*$ = Bed shear velocity (m/s),

m = Exponent in the sediment transport function,

C_S= Concentration coefficient in the sediment transport function.

A = Critical particle mobility factor

F_{gr}= Particle mobility parameter

d_{gr}= Dimensionless particle diameter

ν = kinematic viscosity

h = Average depth of flow .

V_{cr} = Critical velocity,

S = bottom slope.

w_s = sediment fall velocity

q_b= Volumetric bed load transport,

q_s= Volumetric suspended load transport

R, R_h = hydraulic radius.

ρ , ρ_w= density of fluid

ρ_S= Density of sediment