

Comparitive Analysis Of Sediment Transport Load For Indian River

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ABSTRACT: Fundamental development of more accurate and simpler sediment discharge. Here it have to be discussed about the outcome of comparative analysis of the applicability of Bagnold (1966), Wiuff (1985), etc. suspended load transport function for Indian Rivers. Statistical parameters such as Root Mean Square Error (RMSE), Inequality Co-efficient have to be computed for Evaluating Performance of selected formula.

KEYWORDS: Suspended load, Statistical analysis, Bagnold, Wiuff, Comparative analysis, Indian River.

I. INTRODUCTION

Sediment transport is the movement of organic and inorganic particles by water. In general, the greater the flow, the more sediment that will be conveyed. Water flow can be strong enough to suspend particles in the water column as they move downstream, or simply push them along the bottom of a waterway. Transported sediment may include mineral matter, chemicals and pollutants, and organic material.

Another name for sediment transport is sediment load. The total load includes all particles moving as bedload, suspended load, and wash load.

II. STUDY AREA

Purna is one of the major rivers in the Indian state of Gujarat. The river has its origins in Saputara Hill ranges in the Dang district of Gujarat. Purna river has a drainage area of 2431 km² and its travels 180 km before joining with Arabian sea. The basin lies between 72°45' to 74°00' East longitude and 20°41' to 21°05' North latitude. Zankhri river is main tributary of Purna river. Sediment transport load of Purna River are measured by central water commission at hydrological observation site, Mahuva which is situated in Surat district of Gujarat.



Figure.1: Purna Basin

III. LITERATURE REVIEW

Bagnold (1966) proposed new dimensionless equations for bed and suspended load transport rates. For the calibration of proposed model and derivation of functional relationships for bed and suspended load efficiency coefficients, Bagnold used laboratory and field data.

Wiuff considers the flow of water as a machine whose aim is the transportation of suspended sediments. The work done is the transportation of suspended particles, and its energy is equivalent to the potential energy gained by the suspended solids to counteract the influence of settling.

Celik and rodi use the concept of turbulence energy production of flow and its relation with concentration of suspended solids to develop a new equation

IV. METHODOLOGY

Various statistical parameters describing the deviation and divergence of the predicted values from the line of equality has been defined. The selected sediment transport load predictor is tested against large data sets for natural rivers. Limitations, deficiencies and drawback of the existing transport formulae were analyzed by the following process. The discrepancy (ratio of calculated value to measured value) for each set of data is considered for comparison of performance. The percentage of data coverage between accepted lower and upper limits of the discrepancy ratio and their statistical properties is taken as the criteria of the goodness of fit. In addition, the calculated values are plotted against the observed values for the same data set, so that the distribution (scatter) about the perfect agreement line can also be evaluated.

For the present study following formula were selected based on the suitability and characteristics of available data sets to predict the sediment load transport rate.

Bagnold Sediment load transport formula (1966)

According to Bagnold (1966), a particle is suspended when the bed shear velocity, u^* exceeds its fall velocity ω and the general expression to compute suspended load transport rate can be described as:

$$q_s = \frac{0.01}{\frac{\rho_s - \rho}{\rho} \omega} \tau_0 V^2$$

Where τ_0 is Shear stress, ρ_s is Sediment density (kg/m³), ρ is Fluid density (kg/m³), ω is fall velocity (m/s), V is Average Velocity (m/s)

Wiuff Sediment load transport formula (1985)

Wiuff (1985) used simple formula based on energy exchange in alluvial streams for estimation of suspended load. Wiuff (1985) related the suspended load discharge to a particular dimensionless efficiency formula which was defined as a ratio of gain in potential energy of the suspended materials to the dissipation of turbulence energy. Wiuff (1985) efficiency formula is basically same as a suspended load efficiency factor in Bagnold's (1966) theory. Using the experimental results of Guy et al (1966), Wiuff (1985) showed that despite assumption of Bagnold (1966), the suspended load efficiency is not constant but varies linearly with Shields dimensionless shear stress parameter.

Unlike Bagnold (1966), Wiuff (1985) argued that the use of a constant value for modified suspended load efficiency η_s is not sufficient. Using linear regression analysis Wiuff (1985) concluded that Shields parameter τ^* is the best dominant variable. The correlation obtained was

$$\eta_s = 0.016\tau^*$$



Where τ^* is expressed by

$$\tau^* = \tau_o / [\rho_s - \rho] g ds$$

Where $\tau_o = \rho g DS$ and ds representing sediment diameter.

Suspended load transport per unit time and unit width in volumetric ratio can be written as:

$$q_s = 0.016 \frac{(VDS)^2}{\Delta 2 ds \omega}$$

Where V is Average Velocity (m/s), ds is Median grain size (m), S is Slope, ω is fall velocity (m/s), and D is Depth of water (m).

Celik&Rodi Sediment load transport formula (1991)

Celik&Rodi (1991) proposed a simple formula to estimate suspended load under equilibrium condition. They defined the suspended sediment transport capacity of a certain flow as the maximum amount of sediment carried in suspension when the flow is uniform.

Celik&Rodi (1991) assumed that —Suspended load work rate is equivalent to the work that turbulent energy has to perform on the suspended material to keep them in suspension & hence should appear as a sink term in budget equation for the turbulent kinetic energy. Adding this term to k - equation and integrating over the depth, Celik&Rodi (1991) arrived at

$$\frac{\alpha_1 \tau_o V}{D} = (\rho_s - \rho) g C_D \omega$$

Where $\tau_o V/D$ = total turbulent energy production rate per unit of fluid volume, $\tau_o = \rho g DS$ is the overall bed shear stress, V is the mean flow velocity, D is the total flow depth and S denotes the energy or water surface slope. α_1 is used to represent Celik&Rodi (1991) assumption that a constant portion of total turbulent kinetic energy is used to keep suspended particles in suspension.

According to Celik and Rodi, q_s leads to

$$q_s = \alpha_1 \frac{\tau_o V}{(\rho_s - \rho) g \omega}$$

Where, α is calibration factor, V is velocity, ρ_s is Sediment Density, ρ is Water Density, τ_o is bed shear stress, ω is fall velocity (m/s).

V. STATISTICAL ANALYSIS

Discrepancy ratio (r): It is the ratio of the predicted to the observed bed load discharge. If this ratio is one, the equation exactly predicts the measured rate. If the ratio is less than one or greater than one the equation under or over predicts measured data respectively.

$$r = q \text{ (predicted)} / q \text{ (observed)}$$

Root Mean Square Error (RMSE): It measures the deviation between the trend of the predicted and observed values.

$$Rmse = \left[\sum_{i=1}^n \frac{(Q_{bo} - Q_{bp})_i^2}{n} \right]^{1/2}$$

A zero value of RMSE indicates a perfect fit between measured and predicted values.

Inequality coefficient (U): It refers to a simulation statistics related to the RMSE, defined as under,

$$U = \frac{Rmse}{\left[\frac{1}{n} \sum_{i=1}^n (Q_{bo})_i^2 \right]^{1/2} + \left[\frac{1}{n} \sum_{i=1}^n (Q_{bp})_i^2 \right]^{1/2}}$$



Where, Q_{bo} =observed suspended load rate, Q_{bp} =Predicted suspended load rate

VI. RESULT AND ANALYSIS

General : In this part Wiuff, Bagnold & Celik and Rodi sediment transport function is tested against large data sets for both flumes data set and river data sets. The discrepancy ratio of calculated value to measured value for each sets of data is consider for comparison of performance. The percentage of data coverage between accepted lower and upper limit of the discrepancy ratio and their statistical properties is taken as the criteria of the goodness of fit. The predicted values are plotted against the observed values for same data set, so that the scatter about the perfect agreement line also be consider

Using Different Data Set In the part following data set reported by CWC department, Surat were used to compute total load transport parameter.

- i. Flumes data sets
- ii. River data sets

Verification with Purna River data sets:

Purna River data set is used to compute total load transport using Wiuff, Bagnold and Celik&Rodi Equation. The computed total load transport using data are plotted in Fig. Observed and predicted values are plotted in origin to check the predictability of Wiuff, Bagnold and Celik&Rodi total load transport approach respectively. Solid line represents line of equality value of above the solid line represent the value are overpredict and value below the solid line represent the values are underpredict. Predicted value from observed value are also be plotted by calculating percentage error as shown below.

Verification by Wiuff Equation:

Comparison between observed values and predicted results obtained for Wiuff equation by using the Purna River data set is shown in Fig (a-1) & (b-1).

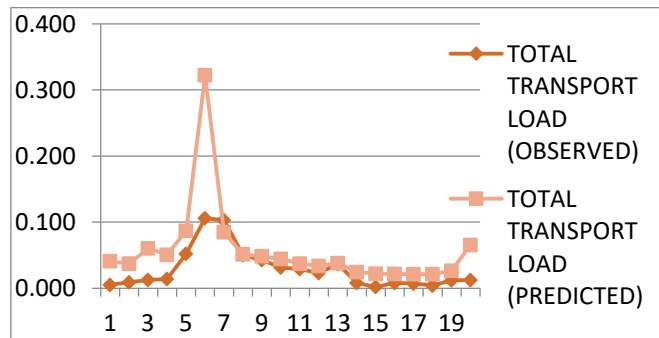


Fig-(a-1) Wiuff equation comparison graph

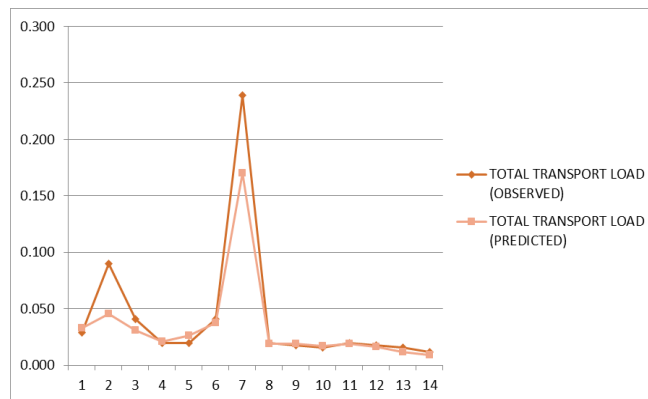
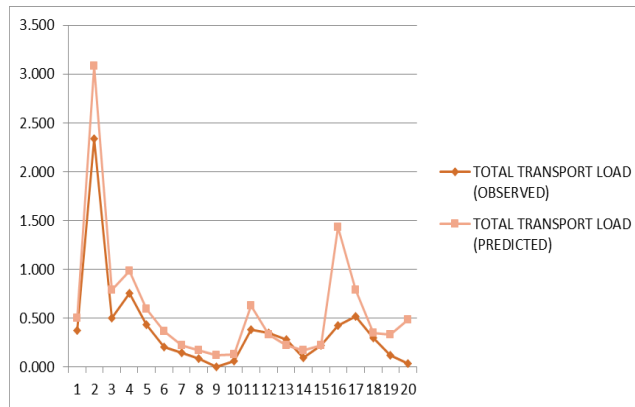


Fig-(b-1) Wiuff equation Comparison graph.

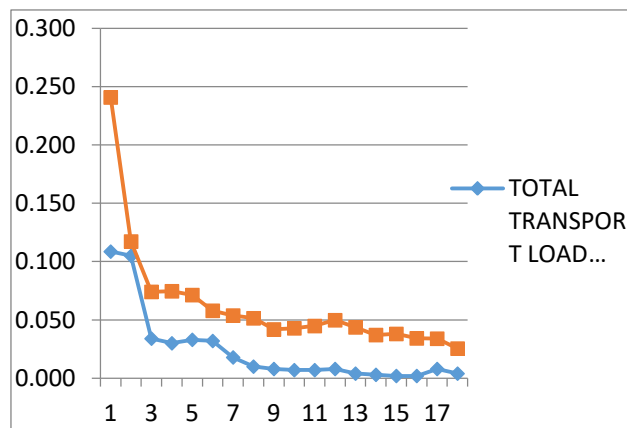


Verification by Bagnold Equation:

Comparison between observed values and predicted results obtained for Bagnold equation by using the Purna River data set is shown in Fig (a-2) & (b-2).



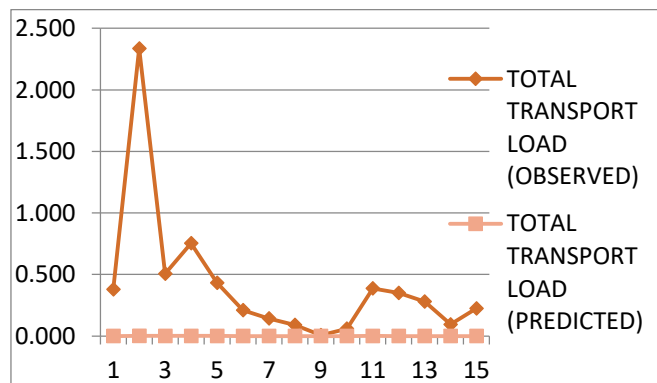
Fig(a-2) Bagnold equation graph



Fig(b-2) Bagnold equation graph

Verification by Celik&Rodi equation:

Comparison between observed values and predicted results obtained for Celik&Rodi Equation equation by using the Purna River data set is shown in Fig (a-3) & (b-3).



Fig(a-3) Celik&Rodi equation graph

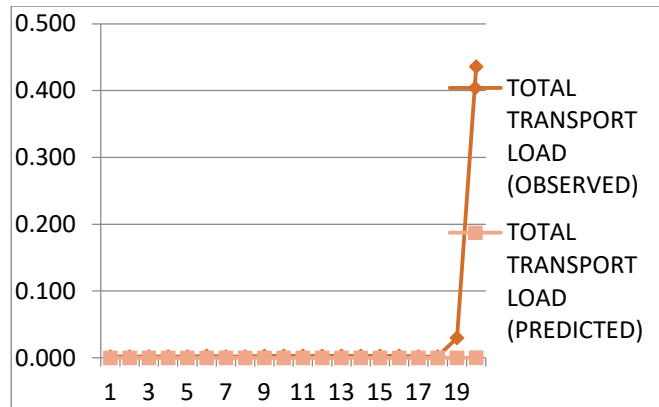


Fig-(b-3) Celik&Rodi equation graph

Analysis : Various statistical parameters such as root mean square error (RMSE), Inequality coefficient (U) and discrepancy ratios (D.R) are used to evaluate the performance of sediment transport approach. Score in terms of % of DR within the range of 0.5-2.0 is also calculated. Comparative summary of discrepancy ratio and root mean square error (RMSE) using selected different suspended transport rate formulas is given in Table 1.

Sr no.	Sediment Load Equation	Discrepancy Ratio (DR)	Root mean square error (RMSE)	Inequality Coefficient	%Error (% D R within range of .5-2)
1.	Wiuff	43.151	1.000	0.984	51.29%.
2.	Bagnold	15.839	0.0591	1.304	77.03%.
3.	Celik and Rodi	0.0054	0.0376	0.276	-

Table -1 Comparative summary of discrepancy ratio and root mean square error (RMSE)

VII. CONCLUSION

- The main aim of this project was to determine & compare sediment transport load in Indian River using different methods and formulas.
- The final outcome came with a bit of success for achieving one formula which satisfies the need for the Purna River which was our study area.
- Wiuff equation which was firstly been calculated for the Purna river data set came out with the average percentage error of 51.29%.
- And the same been calculated for Bagnold equation gave the percentage error of 77.03%.
- So we can clearly get to know that Wiuff Equation is more accurate than Bagnold Equation for the Purna River Basin.
- Where Celik&Rodi equation is far away to be compared with the total transport load of Purna River Basin.
- From this we can conclude that Wiuff Equation is the most accurate equation for the River which we have selected.

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