Analyzing Suspended Sediment Concentration in Estuarine and Coastal Water Area Based on Rouse Equation

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ABSTRACT: In order to expand the Rouse equation to more widely, statistical methods will be combined with the linear form of Rouse equation. Sediment concentration will be taken as a "random variable", while some parameters are selected as variables. Multiple linear regressions will be used for determining the influence of the variables. Correlation coefficient between calculated and measured sediment concentration show that the variables can be used in response to dynamic conditions in a coastal region-Hai'an Bay.
KEYWORD: Rouse equation; multiple linear regressions; Hai'an Bay; suspended sediment

Compared with the issue of river sediment, estuarine and coastal sediment have difference and difficulty in (such conditions) including: unsteady flow, combining current and wave, transport processes more complex. Rouse equation is one of the most extensive methods of the diffusion theory which can be used for determining sediment vertical distribution and sediment settling velocity [1-5].

$$\frac{c(z)}{c_a} = \left[\frac{a(h-z)}{z(h-a)}\right]^{\omega_s / \kappa u_*} \tag{1}$$

Where C is the suspended sediment concentration, w_s the settling velocity of the sediment particle, u_* the shear velocity, k the Karman's constant, c_a "reference concentration at a, distance z from the bottom", h the total flow depth.

However, for the assumptions of the equation, it can only be used in small waves and no density-stratified fluids with no acceleration and deceleration. In order to expand the Rouse equation to more wide level , statistical methods would be combined with the linear form of Rouse equation[6-8]. Sediment concentration would be taken as a "random variable" (seen in equation[5]. Multiple linear regressions would be used for determining the influence of the variables. Correlation coefficient between the calculated and measured sediment concentration. Sediment concentration had shown that the variables can be used in response to dynamic conditions in a coastal region-Hai'an Bay.

1 REGIONAL OVERVIEW OF HAI'AN BAY

Hai'an Bay is located in the northern part of the Qiongzhou Strait.Sediment concentration is approximately 0.1kg/m^3 in Hai'an Bay.

Fig.1 Plan sketch and observation stations of Hai'an Bay

2 IMPROVEMENTS ROUSE EQUATION

In order to expand the Rouse equation more widely, statistical methods will be combined with the linear form of Rouse equation. Equation (1) can be changed into:

$$\ln\frac{c}{c_a} = a_0 + a_1 \ln\frac{h-z}{z} \tag{2}$$

Formula (2) can be further rewritten as:

$$\ln c = a_0 + a_1 \ln\frac{h-z}{z} + \ln c_a \tag{3}$$

Where it is assumed that a_0 and a_1 are coefficient, which can be got by regression analysis using the field data. It was used regression analysis method for 6 observation stations (Figure 1) vertical sediment concentration data in May 2008 in Qiongzhou Strait Haian Bay. The results are shown in Figure 2.

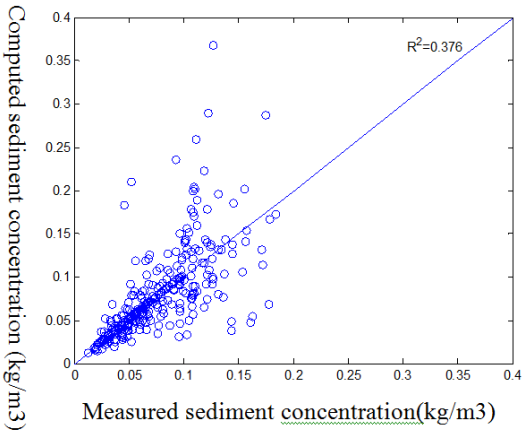


Fig.2 Correlation coefficient between calculated and measured sediment concentration using formula (3)

Through using formula (3) given in equation form, there are more two adjustable coefficients than the original Rouse equation. The calculation results with $R^2=0.376$ had shown that the accuracy improved. However, it is still needed to further improvement of the accuracy.

In order to improve the relationship between sediment concentration at each point and the reference point, it is introduced another unknown parameters. The introduction of p_s is dimensionless. Formula (3) could be further rewritten as:

$$\ln\frac{c}{\rho_s}=a_0+a_1\ln\frac{h-z}{z}+a_3\ln\frac{c_a}{\rho_s} \tag{4}$$

It was also used regression analysis method with equation (4) for 6 observation stations (Figure 1) vertical sediment concentration data in May 2008 in Qiongzhou Strait Haian Bay. The results are shown in Figure 3.

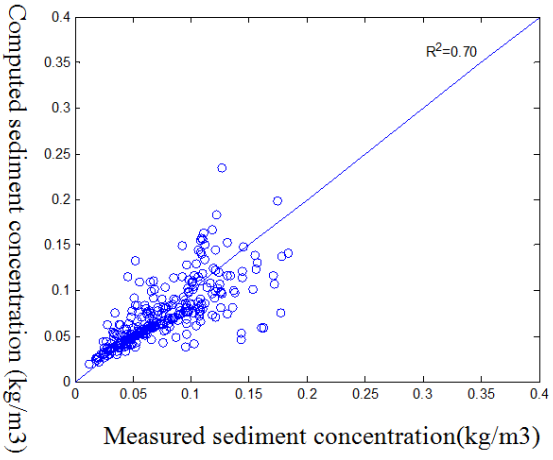


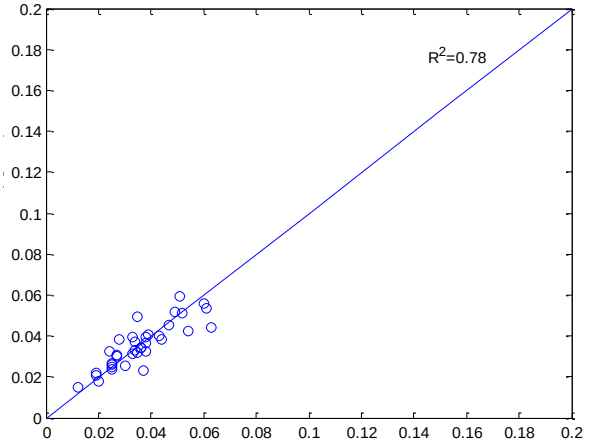
Fig.3 Correlation coefficient between calculated and measured sediment concentration using formula (4)

It is shown in figure 3 that formula (4) with $R^2=0.70$ improve the calculation accuracy greatly. Some scholars had also found sediment concentration flow rate and velocity gradient existing intrinsically relationship by experiment. Hence, based on formula (4) sediment concentration will be taken as a "random variable"(seen in equation(5)).

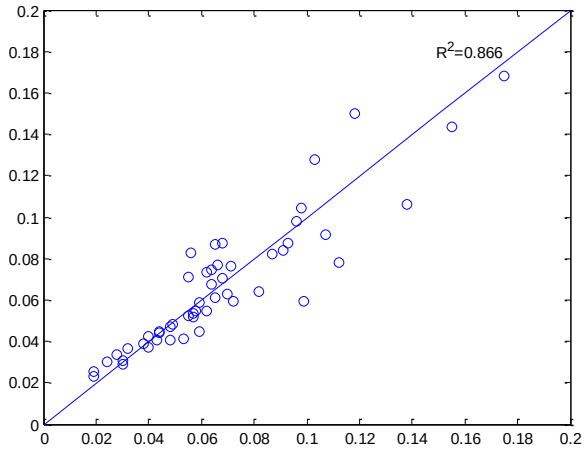
It is taken surface sediment concentration as reference concentration c_a, which can be got easily by satellite pictures or water sampling, etc. The finally equation can be rewritten as

$$\ln\frac{c}{\rho_s}=a_0+a_1\ln\frac{h-z}{z}+a_3\ln\frac{c_a}{\rho_s}+a_4\ln\frac{u^2}{gd} \tag{5}$$

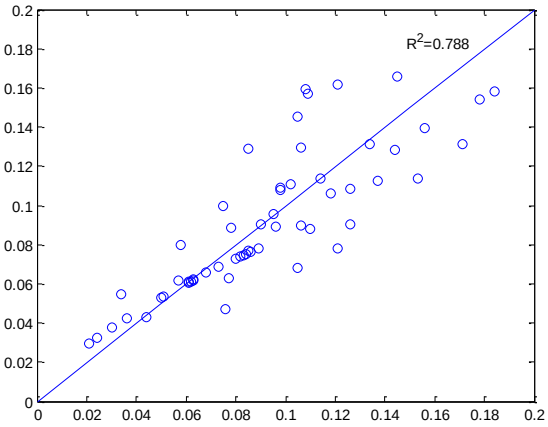
It was used regression analysis method with equation (5) for 6 measured stations (Figure 1) vertical sediment concentration data in may 2008 in Qiongzhou Strait Haian Bay. The results are shown in Figure 4. The horizontal coordinate -axis is the sum of measured sediment concentration data, while the other ordinate is computed sediment concentration value.



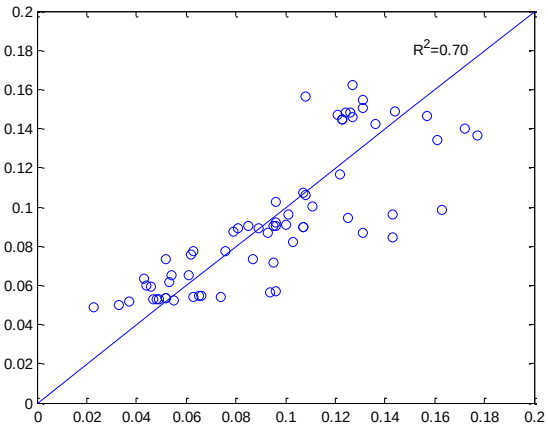
a) V1 Station



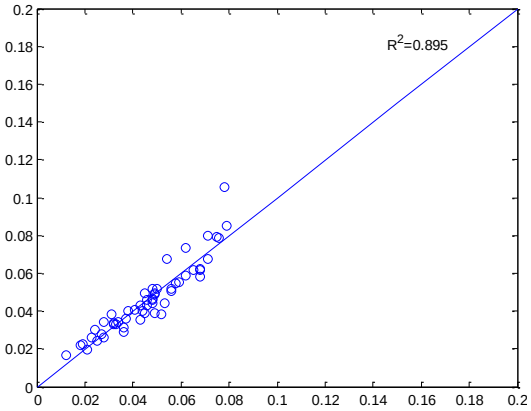
b)V2 Station



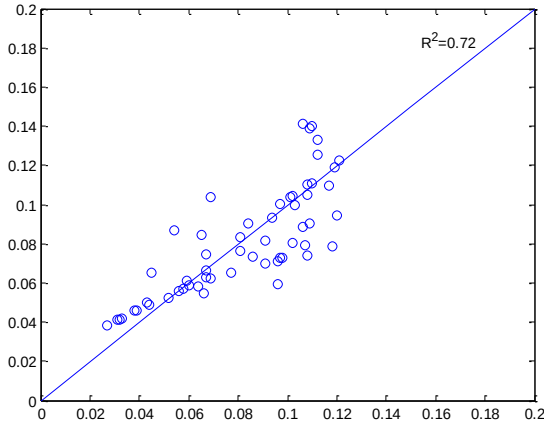
c) V3 Station



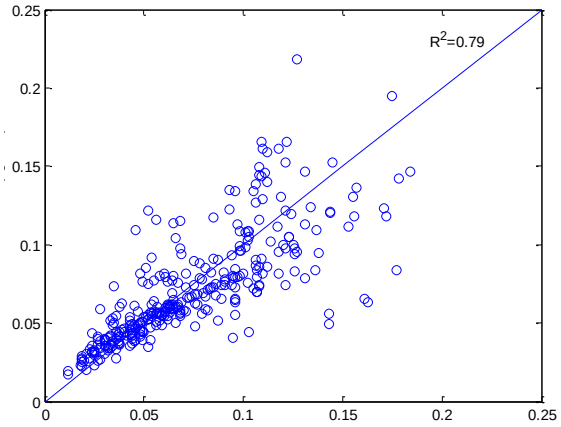
d) V4 Station



e) V3 Station



f) V4 Station



g) all data collocated at 6 measured stations

Fig.4 Correlation coefficient between calculated and measured sediment concentration using formula (5)

The regression coefficients of multiple linear regression equation and other relevant variables are gotten by field data. These values are shown at Tab.1.

Tab.1 Regression coefficients and other relevant variables at formula (5)

a_0	a_1	a_2	a_3	R^2	F
-3.9711	0.585	0.095	0.049	0.790	281.990

Multiple linear regressions would be used for determining the influence of the variables. Correlation coefficient between calculated and measured sediment concentration have shown that those variables could be used in response to dynamic conditions in a coastal region-Hai'an Bay.

3 CONCLUSION

Rouse equation is one of the most extensive methods of the diffusion theory which can be used for determining sediment vertical distribution and sediment settling velocity. However, for the assumptions of the equation, it can only be used in small wave and no density-stratified with no acceleration and deceleration. In order to expand the Rouse equation to more wide level, statistical methods will be combined with the linear form of Rouse equation. Sediment concentration will be taken as a "random variable"(seen in equation(5)). Multiple linear regressions will be used for determining the influence of the variables. Correlation coefficient between calculated and measured sediment concentration show that the variables can be used in response to dynamic conditions in a coastal region-Hai'an Bay.

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