VII - 81

PREDICTION OF CHLORIDE CONCENTRATION IN TIDAL RIVERS USING ONE-DIMENSIONAL MODEL

○ Priana Sudjono　Graduate Student
Kenichi Koga, Hiroyuki Araki　Saga University

Introduction.

As the concern on water quality problems in tidal rivers is increasing, the development of computer models for the water quality management is becoming very important. Chloride concentration in tidal rivers that are under the influence of sea tides is calculated using one dimensional model. The result of the chloride calculations is the basic information for the water manager whether for the purpose of water intake or other further analysis on chemicals and the biochemical processes. The case study for verification is applied in the Rokkaku river-Saga and the calibration is conducted using measured data at low and high tides.

Method

The model is developed imposing an assumption that flow in a cross section area of the river is well mixed laterally, this allows the river is as a line. There are two kinds of formulas, water movement and concentration calculation.

The equations for the flow calculation are based on the momentum equation:

$$\frac{\partial Q}{\partial t}+\frac{\partial (Qv)}{\partial x}+gA\frac{\partial h}{\partial x}+J(Q,h)=0$$

Q: discharge; v: velocity; A: flow cross section, h: water level; t: time; g: acceleration due to gravity; and J is slope due to friction.

The continuity equation:

$$\frac{\partial B}{\partial t}+\frac{\partial Q}{\partial x}=0$$

B is total wetted cross section as a function of the water level. The details of the derived equations are presented in reference (1), and the computer programs is presented in DUFLOW version 2. (3).

The equations of concentration are based on mass conservation equation:

$$\frac{\partial BC}{\partial t}+\frac{\partial S}{\partial x}\pm P=0$$

S: mass transport rate; P: production rates.

The mass transport rate is written as follow:

$$S=QC-AD\frac{\partial C}{\partial x}$$

D: dispersion coefficient.

These equations are transformed into several conditions of branches to satisfy all possible flow directions. This is done through defining branches between every two nodes, and the concentration of chloride can be obtained through integration for the whole branches (1).

Result and discussion

The simulation results from two events on date 1984-03-17 (spring tide), and date 1984-05-26 (neap tide) are shown in figure 2 until 5. The point of observations along the river are located at Rokkaku bridge, and Shinbashi bridge shown in figure 1. The distance of those points from the river mouth are 10.7 km and 22 km respectively.

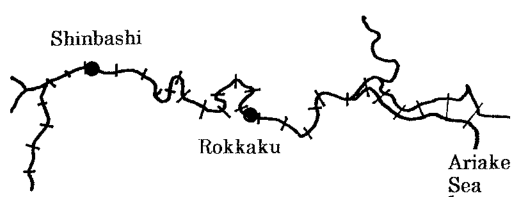

Fig.1.The study area, Rokkaku River-Saga

The first step is the calculation of water movement. The results of the water level at spring tide and the neap tide are shown in figure 2 and figure 4. The figures indicate that the results of flow calculations are satisfactory with both observations. These results are set up as the input

dispersion, branch-node model, tidal river

〒840　佐賀市本庄町１　佐賀大学理工学部建設工学科水資源工学研究室　℡ 0952-28-8575

data for calculating chloride concentration. The second step is the chloride calculation taking account the dispersion coefficient, and the results are shown in figure 3 and 5. The figures indicate that the chloride concentrations could match the observation data at spring and neap tides. The exact value of dispersion coefficient is very difficult to find, however, the value are estimated through trial and error approach. There are several water quality models for oscillatory flow had been developed (5,6), and the complexity involving the effect of dispersion in oscillating flow have long been investigated (2,4,7,8). The developed model, so called branch-node model, is another success in modeling of the water quality for chemical and biochemical processes (9).

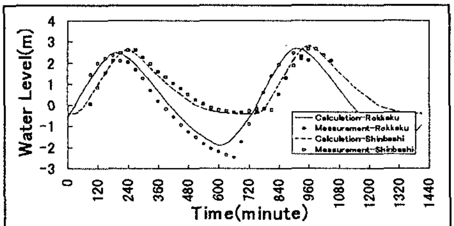

Fig.2.Date:1984-03-17

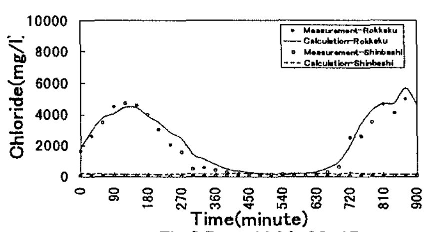

Fig.3.Date:1984-03-17

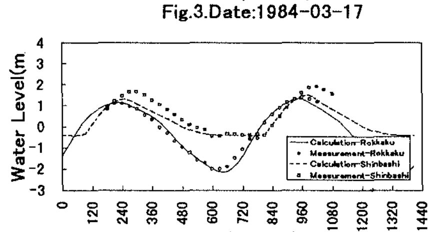

Fig.4.Date:1984-05-26

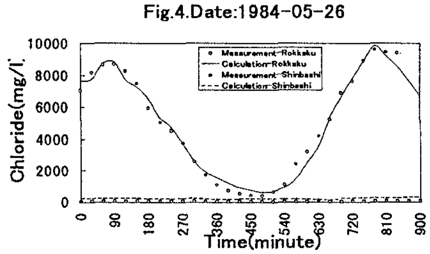

Fig.5.Date:1984-05-26

Setting up uniform dispersion along the river, that lead from one dimensional model, replaces the complexity in the estimation of the appropriate dispersion coefficient. On the contrary, two or three-dimensional models taking account the different effects of water density, and forces caused by river flows, tides, and winds, result in the complex programming. Because models need complicated observed data that are almost rare, the model verification is hardly able to achieve the flexibility for changing the model concepts. The results of these complication are likely to get the pitfall solutions and inapplicable modeling. Referring to those reasoning, the practical dispersion coefficient for the Rokkaku river can be applied in the one-dimensional formulations to reach validation as far as the real processes will be perfectly transformed in the proposed models.

Conclusion

The one dimensional model using uniform dispersion coefficient could produce satisfied results for the prediction of chloride in Rokkaku river that is characterized by wide, and shallow water.

References

1. Booij, N. 'Report on the ICES subsystem FLOWS'. Report no. 78-3. Communications on Hydraulics. Department of Civil Engineering. Delf University of Technology. 1979.

2. Bowden,K.F., "Horizontal Mixing in the Sea due to a Shearing Current, "Journal of Fluid Mechanics, Vol.21, 1965, pp.83-95.

3. DUFLOW version.2. Manual. Wagenigen, the Netherlands, 1992.

4. Harleman,D.R.F., "Diffusion process in Stratified Flow, "Estuary and Coastline Hydrodynamics", A.T.Ippen,Ed., McGraw-Hill, New York, N.Y.,1966,p.575-597.

5. Hinwood, Jon B., and Ian G.Wallis. "Classification of Models of Tidal Waters." Journal of the Hydraulics Division ,ASCE. Vol.101, No. HY10, (Oct.1975):1315-1332.

6. Hinwood, Jon B., and Ian G.Wallis. "Review of Models of Tidal Waters." Journal of the Hydraulics Division, .ASCE.Vol.101,No.HY11,(Nov.1975):1405-1422.

7. Holley,E.R., Harleman,D.R.F., and Fischer, H.B., "Dispersion in Homogenous Estuary Flow," Journal of the Hydraulic Division, ASCE, Vol.95, No.HY8,Oct.,1970,pp.1691-1709.

8. Okubo,A., "The effect of Shear in an Oscillatory Current on Horizontal Diffusion from an Instantaneous Source," International Journal of Oceanology and Limnology, Vol.1, No.3, 1967,pp.194-204.

9. Sudjono,P., Koga,K., Araki,H., and N. Booij. 'Development and Application of one-dimensional Water Quality Model for Channel Networks and Tidal Rivers'. Hydraulic Engineering Software VI. Ed. W.R.Blain. Computational Mechanics Publ. 1997.