II-155

UNSTEADY POLLUTANT SPREADING IN RIVER

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1. INTRODUCTION

In this paper the application of a two-dimensional mathematical model for the simulation of flow and spreading of pollutant from an industrial outfall in mildly curved river which can account the reversal flow, is presented. A description of mathematical model equations is presented first. The specifications of the problem are then given. A set of conclusion completes the paper.

2. MATHEMATICAL MODEL

Reffering to Fig.1, the equations of the mathematical model to calculate the horizontal distribution of the velocity components u and v and pollutant concentration c can be written as follows:

Continuity equation:

$$\frac{\partial h}{\partial t}+\frac{\partial M}{\partial x}+\frac{\partial N}{\partial y} = 0 \qquad (1)$$

Momentum equatiion in x-direction without non-linear convective terms

$$\frac{\partial M}{\partial t}= -gh\frac{\partial H}{\partial x}-\frac{\tau_x(b)}{\rho} \qquad (2)$$

Momentum equation in y-direction without non-linear convective terms

$$\frac{\partial N}{\partial t}= -gh\frac{\partial H}{\partial y}-\frac{\tau_y(b)}{\rho} \qquad (3)$$

Equation governing the spreading of pollutant-concentration c is

$$\frac{\partial c}{\partial t}+\frac{\partial}{\partial x}uc+\frac{\partial}{\partial y}vc = K_x\frac{\partial^2 c}{\partial x^2}+K_y\frac{\partial^2 c}{\partial y^2} \qquad (4)$$

where, h: water depth; M,N: flow fluxes in x and y direction; H: water stage; g: acceleration of gravity; t: time; u,v: velocity components in x and y-directions; x,y: distance in east-and northward directions; ρ: water density; $\tau_x(b),\tau_y(b)$: shearing stresses on river bed in x and y-directions; c: concentration; K_x : pollutant diffusion coefficient in x-direction; K_y : pollutant diffusion coefficient in y-direction;

Using the staggered difference scheme, eqns.(1)-(4) were transformed into finite difference form in explicit way.

3. APPLICATION OF THE MODEL

The aim of this case study is to see how well the above described model can simulate the pollutant-concentration field induced by the

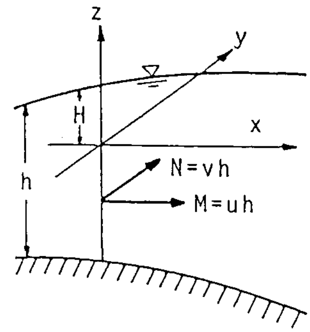

Fig.1 Definition sketch for Two-dimensional model equations.

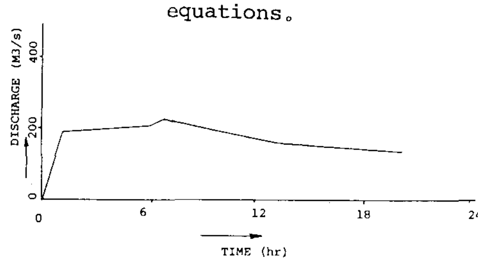

Fig.3 Hydrograph at upstream.

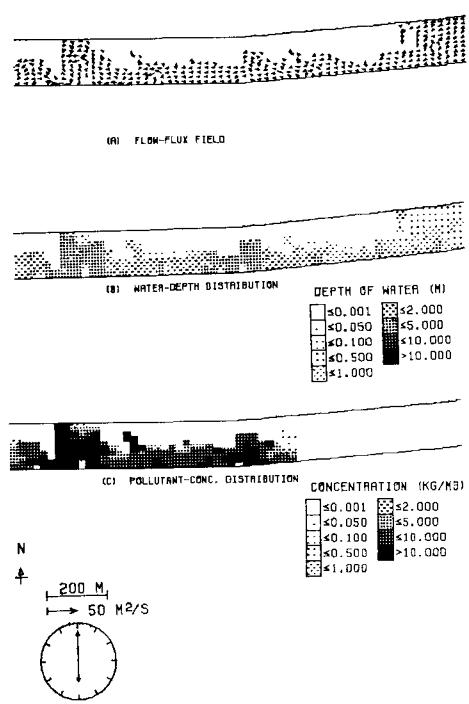

Fig.4 Calculated results 6 hr. after.

discharge from a industrial outfall into the river. Details of the river are shown in Fig.2. The river is fairly straight between the upstream and downstream and has nearly constant width. The river has non-uniform bottom elevation.

A situation is examined for the case when at the inlet boundary the discharge hydrograph was as shown in Fig.3 and at the outlet boundary the stage- discharge relationship was defined by $Q=0.75Bh\sqrt{2gh}$ where B is the width of the river. The discharge from an industrial outfall continously injects a low concentration waste of concentration 1.6 Kg/M3 with an inflow of water of 277 m3/s perpendicular to the river bank over a distance of about 100m of the river. The tracer is assumed to be mixed uniformly over the depth, but may be fully or partially mixed across the channel width depending upon the type of tracer source under study.

4. RESULTS AND CONCLUSIONS

1. The results obtained with this model for the flow-flux, water-depth and pollutant-concentration distributions at different time for the case described in subheading-3 of this paper are shown in Fig.4 and Fig.5.

2. Due to lacking of the experimental data , the accuracy of the calculated results is checked by verifying the continuity equation for the whole test reach of the river. The results are shown in Table 1. which shows an excellent agreement.

3. The same model is also found to be applicable for the case when pollutant is injected at one time instead of continous supply.

4. The drawback of the model is that it is not capable of accounting for the curvature effects and so is unable to simulate flow field as well as pollutant -concentration distribution in strongly curved channels correctly.

5. Though the mathematical model presented in this paper has some limitations in application to meandering channels but it seems to the authors a promising and economic mathematical prediction method for pollutant-concentration spreading in channels and rivers. In other words to control the contamination of the stream which is harmful to human-beings.

6. Work will be in progress to make this model more sophisticated for more general purpose use with a special emphasis on least computer time and storage.

5. REFFERENCES

Iwasa, Y. and Inoue, K., Mathematical simulations of channel and overland flood flows in view of flood disaster engineering, Journal of Natural Disaster Science, Kyoto university, Vol.4, number 1, 1982,pp. 1-30.

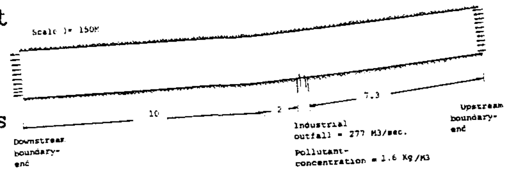

Fig.2 Details of River.

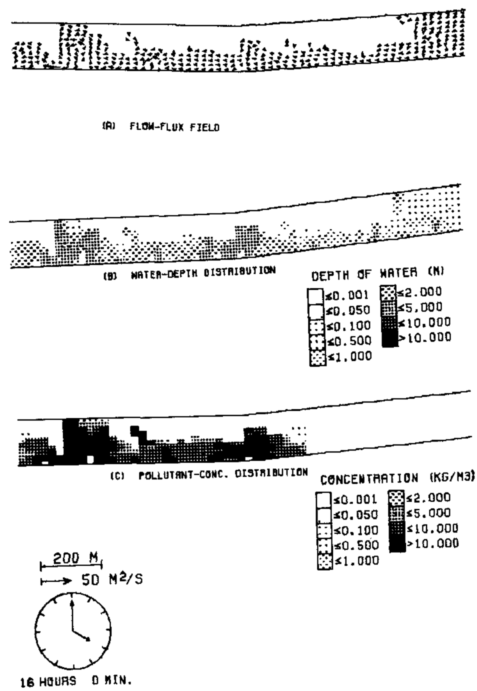

Fig.5 Calculated results 16hr. after.

Time	$vchk = \frac{(storage + outflow)}{inflow}$
2	1.025
6	1.009
10	1.009
14	1.024
20	1.022

Table 1 Results of Continuity check