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Original Research Paper

Water Quality Simulation in River Based on Matlab

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ABSTRACT

Water quality model is an effective tool for environmental pollution control, water quality planning and environmental management. Using systems analysis techniques to plan water pollution control is the foundation for water quality management. It plays a vital role for the entire planning process. In this paper, Matlab is used to simulate the water quality in river. The results show that the simulation is well with the observation.

INTRODUCTION

Simulation of River water quality plays an important role in water quality management. The simulation includes qualitative modelling and quantitative modelling. The mathematical models are the main methods to simulate water quality, in which neural network models are widely used (Chen, 1995, Fu 2004, Yuan 2002). River water quality model is a mathematical description of the transformation of the pollutants in the river water over space and time migration, which involves a lot of physical, chemical and biological processes, and the model is complex. In recent years, the study of water quality model has shifted from point source pollution model to non-point source pollution model (Luo 2003, Zhu 2005).

Water quality model is a mathematical description of the relationship between the variation of pollutants in the water environment and its influencing factors. It is one of the scientific contents of the water environment, which is also an important tool for research. Its research involves water environmental science theoretical and practical problems of water pollution control. Its development depends largely on the deepening of pollutants migration, transformation and fate in the aquatic environment, studies and the extent of the application of mathematical methods to continuously improve the water environment research. In theory, water quality model is from the initial mass balance principle to the present stochastic theory, gray theory and fuzzy theory.

APPLICATION

Longitudinal dispersion coefficient E_d: For deriving longitudinal dispersion coefficient (E_d) of the river, a uniform mixing portion in the river is selected, and put on a non-degradable rhodamine tracer test. The test can be carried out as follows: Tracers instantly are casted into the river from the shore, concentrations of tracer in the downstream section of 2300m and 4000m station are measured to get the process line C-t, as given in Table 1. Between two stations in the river with an average depth H = 0.9m, average surface width B = 20.0m, the average friction velocity u* = 0.12 m/s.

According to one-dimensional water quality downstream of the basic equations, tracer concentration process migration transformed solved at X is:

$$C(x,t)=\frac{M}{\sqrt{4\pi \mathrm{Edt}}}\exp\left[-\frac{(x-ut)}{4Edt}\right] \qquad ...(1)$$

Firstly, to verify the downstream station is within a one-dimensional vertical dispersion segment, namely, whether the tracer mixing section on the station is uniform.

Lateral diffusion coefficient: $Ey = 0.6Hu^* = 0.6 \times 0.9 \times 0.12 = 0.0648\ m^2/s$

The distance between two stations: Δx = x1-x 2 = 4000-2300 = 1700 m

Propagation time of tracer reaching a peak: Δt = 62-12 = 50 min.

Average velocity $u=\frac{\Delta x}{\Delta t}$ = 1700/50 = 34.0 m/min = 0.58 m/s.

Length which is completely mixed from section to section is used for putting tracer in the river.

Table 1: Tracer test.

The first station				The second station			
t/min	C/mg/L	t/min	C/mg/L	t/min	C/mg/L	t/min	C/mg/L
0	0	33	0.29	37	0	92	0.18
3	0.23	36	0.23	42	0.08	97	0.12
6	0.58	39	0.18	47	0.24	102	0.08
9	0.83	42	0.14	52	0.44	107	0.06
12	0.96	45	0.12	57	0.60	112	0.03
15	0.96	48	0.09	62	0.65	117	0.02
18	0.87	51	0.06	67	0.61	122	0.02
21	0.76	54	0.04	72	0.53	127	0.02
24	0.63	57	0.03	77	0.43	132	0.01
27	0.51	60	0.02	82	0.33	137	0.01
30	0.39	63	0	87	0.24	142	0

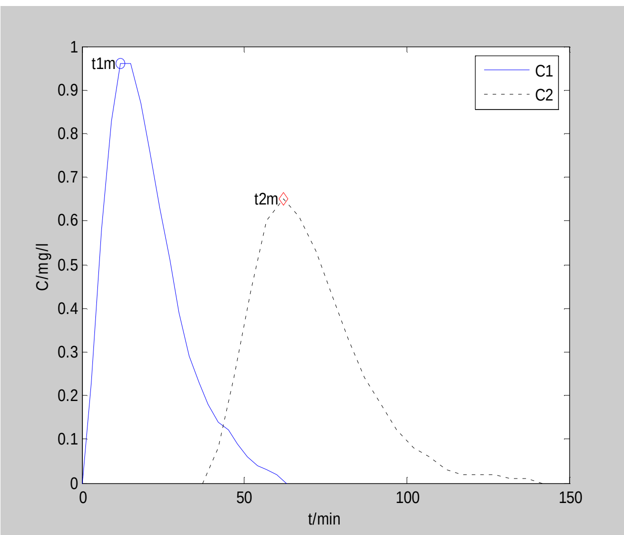


Fig. 1: Tracer concentration curve with time.

$$L = \frac{0.4uB^2}{E_y} = \frac{0.4\times 0.58\times 20^2}{0.0648} = 1432 \text{ m}$$

The distance is less than the distance of the tracer into the first section of the station's 2300m, it can be determined that the two stations are in a one-dimensional vertical dispersion of the river; longitudinal dispersion coefficient is calculated to meet the following requirements.

Thus, average time and variance of the tracer flowing through the first and second line concentration process stations are:

$$\bar{t}_i = \frac{\sum_{i=1}^{N} C_i t_i}{\sum_{i=1}^{N} C_i} \quad \bar{t}_1 = \frac{158.37}{7.92} = 19.996 \text{ min}$$

$$\bar{t}_2 = \frac{328.25}{4.7} = 69.840 \text{ min}$$

$$s_{t_1}^2 = \frac{\sum_{i=1}^{N} C_i (t_i - \bar{t}_1)^2}{\sum_{i=1}^{N} C_i} = \frac{1007.49}{7.92} = 127.208 \text{ min}^2$$

$$E_d = \frac{u^2}{2}\frac{s_{t2}^2 - s_{t1}^2}{t2 - t1} = 2.446 km^2/d$$

K_1 and K_2: Solving the degradation factor coefficients K_1 and reoxygenation coefficient K_2, SP model can be adopted as following:

$$L = L_0 \exp(-\frac{k_1 x}{u}) \rightarrow LnL = LnL_0 - \frac{K_1 x}{u}$$

$$O = O_s - (O_s - O_o)\exp(-\frac{k_2 x}{u}) + \frac{k_1 L_0}{k_1 - k_2}|$$

$$[\exp(-\frac{k_1 x}{u}) - \exp(-\frac{k_2 x}{u})]$$

$$L = L_0 \exp(-\frac{k_1 x}{u}) \rightarrow LnL = LnL_0 - \frac{k_1 x}{u}$$

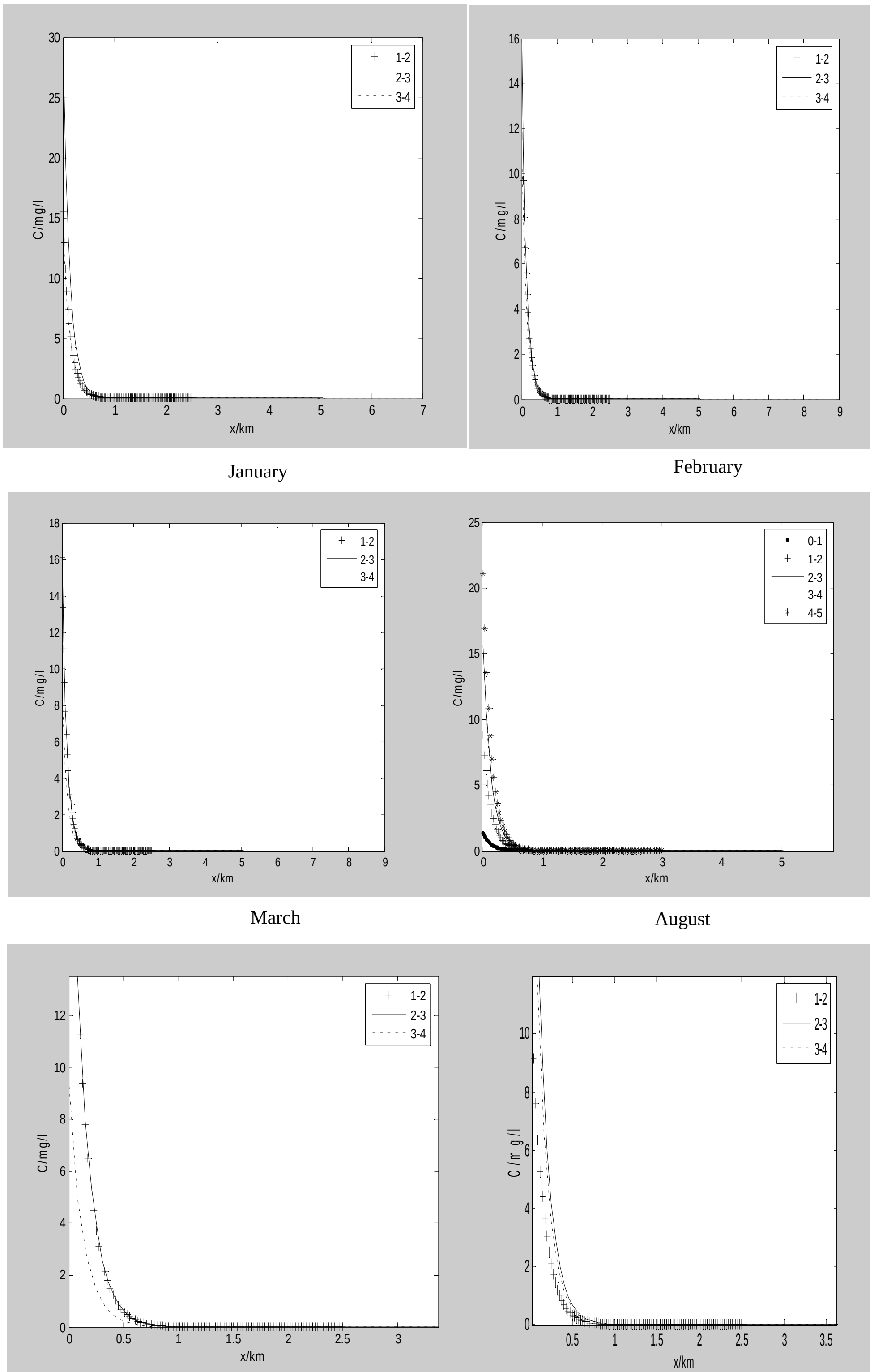
$K_1/u = -0.0498$

$K_1 = 0.0498u = 0.0498\times 20$ 1/d = 0.996 1/d

Cs =12.5134mg/L

$$O = O_s - (O_s - O_0)\exp(-\frac{K_2 x}{u}) + \frac{K_1 L_0}{K_1 - K_2}\Bigg|$$

$$\left[\exp(-\frac{K_1 x}{u}) - \exp(-\frac{K_2 x}{u})\right]$$



January

February

March

August

October

December

Fig. 2: Concentration of BOD_5 with the distance.

The above figure shows that BOD_5 concentration decreases with the distance x increasing.

Table 1: Velocity and pollutant quantity.

Month	section	u(m/s)	M(g/s)(BOD5)
August	0-1	0.3065	0.5637
	1-2	0.2901	3.6698
	2-3	0.2330	6.5597
	3-4	0.1750	6.5515
	4-5	0.1750	8.9203
October	1-2	0.1610	9.9943
	2-3	0.1465	10.4546
	3-4	0.2260	3.8898
November	1-2	0.1520	6.9284
	2-3	0.1595	15.9203
	3-4	0.1670	5.8243
December	1-2	0.1340	5.6265
	2-3	0.1170	11.6077
	3-4	0.1000	9.6430
January	1-2	0.1160	6.5962
	2-3	0.1415	12.0069
	3-4	0.1670	5.6203
February	1-2	0.0850	5.9903
	2-3	0.0760	6.7172
	3-4	0.0670	4.5080
March	1-2	0.1000	6.8376
	2-3	0.1145	7.1388
	3-4	0.1290	3.6613

$K_2 = 4.20\ 0$

Water quality curve with time: Velocity of the cross-section and the amount of BOD_5

According to the following equation the concentration with time and space can be evaluated.

$$C(x,t) = \frac{M}{\sqrt{4p\mathrm{Edt}}} \exp\left[-\frac{(x-ut)}{4Edt}\right]$$

CONCLUSIONS

This paper adopts Matlab to evaluate the water quality in river. Some conclusions can be drawn by this research:

1. Matlab can be used to evaluate the water quality. The results are objective.
2. The result of evaluation through Matlab has high precision.
3. The assessment result can provide reference to the water environment protection and plan.

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