PRELIMINARY ASSESSMENT AND SIMULATION OF THE WATER QUALITY OF CAU RIVER, BAC NINH PROVINCE BY MATHEMATICAL MODEL

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1. Introduction

For the last two decades, Vietnam has achieved great developments in economic. Our country is in the middle of industrialization and modernization process. But side-effects of economic developments which is greater than ever are environmental problems, especially water pollution. At present, with the pressure of environmental pollution, river water quality is showing signs of pollution at some degrees. For the season, it is necessary to assessing and monitoring river water quality, then using models to simulate water quality to propose managing strategies. In order to contribute and improving the water quality model for Cau River, we carried out the research: "Preliminary assessment and simulation of the water quality of Cau River, Bac Ninh province by mathematical model".

2. Materials and methods

2.1. Study site

Cau River basin lies in coordinates of $21^0$07' - $22^0$18' North latitude, $105^0$28' - $106^0$08' East longitude. The area of basin is about 6,030 km^2, it runs through six provinces: Bac Kan, Thai Nguyen, Bac Ninh, Bac Giang, Vinh Phuc and Hai Duong. The study site is a fragment running through Bac Ninh Province, it has the length of 63 km, beginning at Tam Giang Commune, Yen Phong District and ending at Duc Long Commune, Que Vo District. The water samples were taken at twenty points along the stream.

2.2. Methods

- Inheritance method.
- Statistics, analyzing, collecting and assessing base on the earlier documents.
- Modeling method by QUAL2E model [5, 6].

3. Results and discussion

3.1. Water quality assessment of Cau River, Bac Ninh Province

Table 1. Results of water quality analysis of Cau River

Samples	pH	SS (mg/l)	DO (mg/l)	BOD (mg/l)	COD (mg/l)	N-NH_4 (mg/l)	Pesticide (mg/l)	Detergent (mg/l)	Coliform (MNP/100ml)
M1	7.2	85	4.2	17.7	25.2	0.3	0.17	0.25	17800
M2	7.3	80	4.7	17.5	25.5	0.35	0.12	0.21	11750
M3	7.5	85	4.3	16.2	24.5	0.32	0.125	0.3	15100
M4	7.0	65	4.7	15.5	21.2	0.27	0.075	0.2	10200

M5	7.2	60	4.9	15.0	20.7	0.25	0.079	0.25	10500
M6	7.5	65	5.0	21.2	31.2	0.27	0.1	0.21	15500
M7	7.5	64	4.0	32.5	45.7	0.25	0.1	0.4	33000
M8	7.3	64	4.8	19.5	20.2	0.26	0.09	0.25	15500
M9	7.6	70	4.5	20.6	23.5	0.25	0.12	0.2	17200
M10	6.9	60	5.2	17.2	19.5	0.19	0.1	0.19	12000
M11	7.0	50	5.5	13.7	20.5	0.21	0.045	0.17	11500
M12	7.5	70	5.2	14.2	21.3	0.25	0.055	0.27	14300
M13	7.2	55	5.2	14.5	20.7	0.23	0.04	0.12	10600
M14	7.3	65	5.5	13.2	19.7	0.19	0.05	0.17	10200
M15	7.2	60	5.5	14.7	20.2	0.22	0.06	0.18	10070
M16	7.1	55	5.5	13.2	19.5	0.19	0.05	0.15	10500
M17	7.2	55	5.5	14.7	20.0	0.22	0.06	0.12	12000
M18	7.2	45	6.3	12.5	17.7	0.17	0.055	0.15	10500
M19	7.2	50	6.0	13.7	18.2	0.2	0.06	0.11	10100
M20	7.0	60	5.7	13.5	19.5	0.22	0.056	0.17	11500
TCVN 5942/B	5.5 -9	< 80	> 2	< 25	< 35	< 1	< 0.15	< 0.5	< 10.000

With the above analytic results, we drew some comments as follows:

• All the twenty water samples has very high coliform indices, exceeding the limited value of class B - surface water's quality standard of Vietnam (TCVN 5942/95/B) [4, 9]. The two reasons for this situation are the discharges of cattle waste into channels then to river and the uses of fertilizer.

• The concentrations of DO, BOD, COD and suspended solids are not satisfying the class A - surface water quality standard [9, 10]. So this water is unusable for such purposes as eating, drinking and other life-uses.

• Craft villages such as Dai Lam village, Van village (alcohol-producing craft village) brought about serious pollution for the reach run thought there. The cause is the discharging directly untreated waste water into the stream [1].

• In general, except a few heavy pollution points, DO concentrations have trend to increase and BOD concentrations have trend to decrease toward the downstream. This proves quite good self-purification ability of Cau River.

3.2 Modeling water quality of Cau River by QUAL2E

The Enhanced Stream Water Quality Model (QUAL2E) is a comprehensive and versatile stream water quality model. It can simulate up to 15 water quality constituents in any combination desired by the user. The model is applicable to dendritic streams that are well mixed. It uses a finite-difference solution of the advective-dispersive mass transport and reaction equations. The model is intended for using as a water quality planning tool [5].

The modeling procedure included: establishing parameter set for model, inputting observed data, calibrating, making scenarios and finally bring out predictions as well as recommendations [7, 8].

Operating model with observed data for four components: DO, BOD, COD, N-NH_4, we obtained result as follow:

Table 2: Results of simulation with observed data

Reach No.	DO (mg/l)			BOD (mg/l)			COD (mg/l)			N-NH_4 (mg/l)		
	TT	MP	SS	TT	MP	SS	TT	MP	SS	TT	MP	SS
1	4.2	4.2	0.00	17.7	17.59	0.62	25.2	24.87	1.31	0.3	0.3	0.00
2	4.7	4.23	10.0	17.5	17.06	2.51	25.5	23.47	7.96	0.35	0.3	14.29
3	4.3	4.44	3.26	16.2	15.43	4.75	24.5	22.21	9.35	0.32	0.3	6.25
4	4.7	4.45	5.32	15.5	15.31	1.23	21.2	22.14	4.43	0.27	0.3	11.11
5	4.9	4.25	13.8	15	15.01	0.07	20.7	22.18	7.15	0.25	0.29	16.00
6	5.0	4.3	14.0	21.2	24.8	16.98	31.2	34.79	11.51	0.27	0.21	22.22
7	4.1	3.97	3.17	32.5	32.12	1.17	45.7	41.29	9.65	0.25	0.18	28.00
8	5.0	5.88	17.6	17	14.92	12.24	25	29.96	19.84	0.4	0.3	25.00
9	4.8	4.55	5.21	19.5	27.02	38.56	20	31.99	59.95	0.26	0.2	23.08
10	4.5	5.09	13.1	20.6	19.71	4.32	23.5	18.54	21.11	0.25	0.22	12.00
11	5.2	5.06	2.69	17.2	19.69	14.48	19.5	19.71	1.08	0.19	0.22	15.79
12	5.5	5.36	2.55	13.7	19.0	38.69	20.5	20.11	1.90	0.21	0.22	4.76
13	5.2	5.38	3.46	14.2	18.94	33.38	21.3	20.13	5.49	0.25	0.22	12.00
14	5.2	5.36	3.08	14.5	18.69	28.90	20.7	20.17	2.56	0.23	0.22	4.35
15	5.5	5.38	2.18	13.2	18.59	40.83	19.7	20.2	2.54	0.19	0.22	15.79
16	5.5	5.3	3.64	14.7	18.38	25.03	20.2	20.03	0.84	0.22	0.22	0.00
17	5.5	5.63	2.36	13.2	14.0	6.06	19.5	20.14	3.28	0.19	0.22	15.79
18	5.5	5.65	2.73	14.7	13.93	5.24	20	20.2	1.00	0.22	0.21	4.55
19	6.3	5.69	9.68	12.5	13.86	10.88	17.7	20.29	14.63	0.17	0.21	23.53
20	6.0	5.66	5.67	13.7	13.74	0.29	18.2	20.23	11.15	0.2	0.21	5.00

TT: Observed data, MP: Simulated data, SS: Error (%)

Next we simulate three scenarios in which waste load at point source (Tam Da) is reduced 25%, 50% and 75% sequentially. The results obtained as follow:

Table 3. Results of simulation with scenarios

Reach No.	Scenario 1 (25%)			Scenario 2 (50%)			Scenario 3 (75%)		
	DO	BOD	COD	DO	BOD	COD	DO	BOD	COD
1	4.20	17.59	24.87	4.20	17.59	24.87	4.20	17.59	24.87
2	4.23	17.06	23.47	4.23	17.60	23.47	4.23	17.06	23.47
3	4.44	15.43	22.21	4.44	15.43	22.21	4.44	15.43	22.21
4	4.45	15.31	22.14	4.45	15.31	22.14	4.45	15.31	22.14
5	4.25	15.01	22.18	4.25	15.01	22.18	4.25	15.01	22.18
6	4.62	21.63	31.68	4.78	18.47	28.58	4.94	15.30	25.45
7	4.49	26.89	36.14	4.76	21.65	30.98	5.02	16.41	25.82
8	5.89	14.55	28.86	5.95	13.32	26.74	6.01	12.21	23.82
9	4.95	23.09	28.55	5.15	19.15	25.10	5.35	15.22	21.66
10	5.34	17.31	16.64	5.46	14.90	14.74	5.59	12.49	12.84
11	5.30	17.42	17.92	5.42	15.14	16.13	5.53	12.87	14.33

12	5.58	16.80	18.22	5.70	14.61	16.34	5.81	12.41	14.30
13	5.60	16.76	18.24	5.72	14.57	16.35	5.83	12.38	14.28
14	5.59	16.53	18.26	5.71	14.37	16.34	5.84	12.21	14.21
15	5.61	16.44	18.27	5.74	14.29	16.34	5.96	12.15	14.18
16	5.54	16.26	18.11	5.68	14.14	16.18	5.82	12.01	13.99
17	5.95	12.38	17.88	6.20	10.77	15.63	6.46	9.15	12.32
18	5.97	12.32	17.93	6.23	10.71	15.66	6.49	9.10	12.33
19	6.01	12.26	18.00	6.26	10.66	15.72	6.52	9.06	12.36
20	5.99	12.15	17.95	6.25	10.56	15.66	6.51	8.98	12.29

So with 25%-reduced waste load (the first scenario), BOD and COD concentrations are still unsatisfied class B-TCVN 5942/95 standard, DO concentration was at low level. In the second scenario, water quality has just met the standard, BOD and COD concentrations were near the allowable limit. Water quality was greatly improved in the third scenario.

4. Conclusion and recommendation

4.1 Conclusion

- In general, the water quality of Cau River hasn't been in heavy pollution status yet, in compare with class B - surface water quality standard. But at the craft villages that process agriculture products (Dai Lam village) or at crowded towns (Bac Ninh town), the water pollution was at a higher level and mainly organic pollution.

- Modeling was an effective method in water quality planning. Application of this method into Cau River could enable environmental managers to consider it to make necessary decisions.

- The simulated results of this model has shown that the waste load at point source has to be reduced at least 50% to ensure that water quality there satisfy class B - TCVN 5942/95 standard.

4.2 Recommendation

- The sooner the better rural areas have to be supplied with clean water, reduce as much as possible the uses of river water.

- It is necessary to have solution to treat waste water in craft villages.

- More water samples should be taken to provide more exact results.

- QUAL2E is a general model but it is impossible to simulate all the natural processes that happened, so the regularly monitoring and assessing shouldn't be bypassed.

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BƯỚC ĐẦU ĐÁNH GIÁ VÀ MÔ PHỎNG CHẤT LƯỢNG NƯỚC SÔNG CẦU ĐOẠN QUA TỈNH BẮC NINH BẰNG MÔ HÌNH TOÁN

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Đề tài sử dụng mô hình QUAL2E để đánh giá và mô phỏng chất lượng nước sông Cầu, đoạn qua tỉnh Bắc Ninh. Bốn yếu tố của chất lượng nước được chọn để đưa vào mô hình bao gồm: DO, BOD, COD, N-NH_4. Nghiên cứu được tập trung vào xã Tam Đa khu vực bị ô nhiễm nặng nhất trên đoạn sông nghiên cứu. Chúng tôi tạo ra 3 kịch bản là giảm lượng thải ở nguồn thải tại khu vực thác Tam Đa (tức giảm tải lượng BOD và COD) đi 25%, 50% và 75%. Kết quả nhận được như sau:

Nhìn chung chất lượng nước sông Cầu chưa bị ô nhiễm nặng so với quy định đối với nguồn nước mặt sử dụng vào các mục đích khác trừ mục đích sinh hoạt.

Kết quả mô phỏng chỉ ra rằng nếu giảm tải chất thải tại nguồn thải khu vực làng nghề 50% thì chắc chắn rằng chất lượng nước sẽ thoả mãn tiêu chuẩn nước mặt loại B so với TCVN 5942/95.

Mô hình hoá là một phương pháp hiệu quả trong quản lý chất lượng nước sông, các nhà quản lý môi trường có thể tham khảo các kết quả này trước khi đưa ra những quyết định cần thiết.