

Numerical Calculation on Environmental Capacity of DIN, DIP and COD in the Lianzhou Bay

Shaofeng Zhang^{1, 2, 3, a}, Youli Shen^{1, 2, 3, b*}, Chunhua Zhang^{1, 3} and Dehai Song²

¹Beihai Marine Environmental Monitoring Center Station of State Oceanic Administration, Beihai 536000, China

²Laboratory of Physical Oceanography, Ocean University of China, Qingdao 266100, China

³Marine Monitoring and Forecast Center of Guangxi, Beihai 536000, China

^aunusualcenter@163.com, ^byouli0131@126.com

*Corresponding author. Email: youli0131@126.com

Key words: Environmental capacity; sharing coefficient; responding coefficient

Abstract: Based on the ship-based data in the Lianzhou Bay, an advection-diffusion model of pollution is established. The sharing coefficient field (SCF) and the responding coefficient field (RCF) are simulated by this model. The environmental captivity (EC) is calculated by the simplex method according to the water quality standard. Results showed that that for seawater of Grades I to IV (according to the National Standard), the annual ECs of DIN in the Lianzhou Bay were 374.13 tons, 553.04 tons, 1015.57 tons, and 1181.60 tons, respectively, and those of DIP were 24.36 tons, 62.24 tons, 62.24 tons, and 212.44 tons, respectively, and the annual ECs of COD were 4147.37 tons, 7918.38 tons, 12770.30 tons, and 16914.99 tons, respectively. According to the Beihai water standard quality, the annual ECs of DIN, DIP and COD were 805.79 tons, 103.45 tons, and 9902.54 tons, respectively. The results of this study provide an evidence for the management of marine environment quality and the total mass control of pollutants in the Lianzhou Bay.

Introduction

Environmental capacity (EC) is the environmental allowable amount of pollutant in the special water quality condition. It provides the key technique of marine environment quality and the total mass control. The Lianzhou Bay, located in the north of Beihai city, has been developing rapidly since 2006, which inevitably causes many environmental problems. An accurate assessment of EC in the Lianzhou Bay is necessary to control pollution discharges and protect marine environment. The sharing coefficient method (SCM), easy to understand and convenient for management, has been used widely in marine EC estimation [1, 2, 3]. In this study, the SCM is applied to estimate the annual ECs in the Lianzhou Bay.

Numerical model and data

Since pollution in the water is driven by the seawater movement, the pollution transport model must be coupled with a hydrodynamic model. In this study, FVCOM (An Unstructured Finite-Volume Coastal Ocean Model) provide the background currents for pollution transport, and the special model setup and numerical results can be seen in [4].

The governing equation of pollution transport can be described as:

$$\frac{\partial C_i}{\partial t} = Phy_i + Biochem_i + S_i \quad (1)$$

Where C_i is the pollution concentration of DIN, DIP, and COD. Phy_i represents the advection and

the diffusion process. $Biochem_i$ stands for the biology and chemistry process. S_i is the source-sink term. The special model setup and numerical results can be seen in [5].

During the cruise in June 2009 a total number of 20 monitoring stations were conducted which are numbered L1 to L20 (Fig. 1). At each station, NO_3^- , NO_2^- , NH_4^+ , PhO_4^+ , and COD are detected. Pollutant Flux of sewage drain data in 2008 are also collected, which are shown in Table 1.

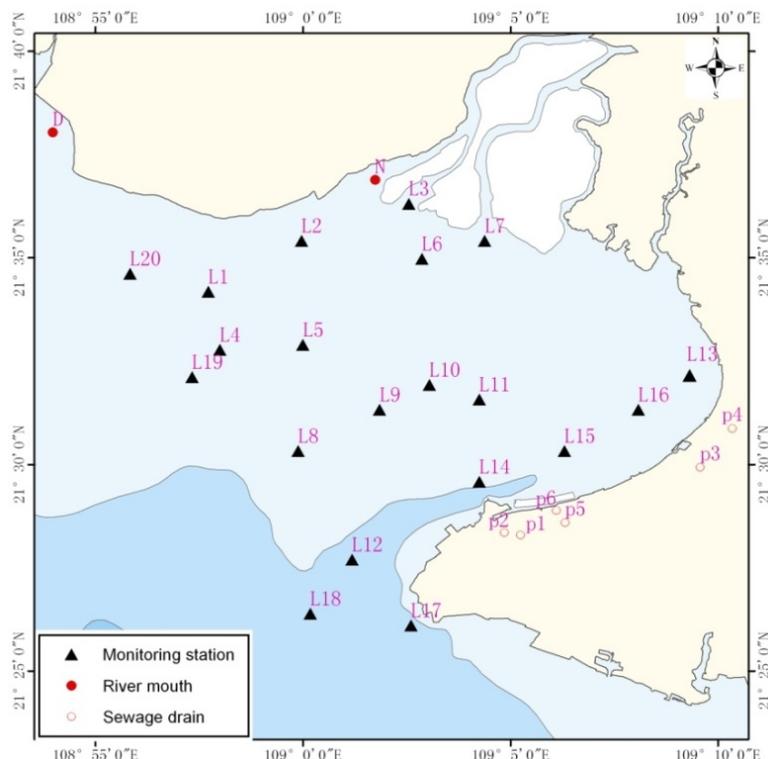


Fig. 1. Location of monitoring stations and sewage drains in the Lianzhou Bay

Table 1 Pollutant flux of sewage drains in the Lianzhou Bay in 2008

Station	Sewage Drains	Pollutant Flux (tons)		
		DIN	DIP	COD
P1	Sewage Treatment Plant	123.39	7.41	2833.86
P2	Dijiao Integrated Sewage Outlet	2.06	0.09	33.56
P3	Gaode Sluice Gate	68.19	1.55	649.72
P4	Jinyinying Paper Mill	49.96	4.15	1132.37
P5	Haicheng Refrigerating Plant	1.29	0.09	13.98
P6	Haicheng Aquatic Company	4.21	0.40	45.33
N	Nanliu River	6110.92	679.80	61079.0
D	Dafeng River	---	---	---

In this study, the SCM is applied to estimate the marine EC in the Lianzhou Bay. On the basis of ship-based observation and the advection-diffusion model of pollution in the Lianzhou Bay, the SCF and the RCFs are simulated with the eco-hydrodynamic model. The main pollution source and the EC can be calculated according to the present concentration and the water quality standard [6].

Results and discussion

The distributions of RCFs in the Lianzhou Bay are shown in Fig. 2. Generally, RCFs are distributed by the depth contour, and in the center of Bay mouth, this value reaches the maximum. Pollutions in

the Lianzhou Bay are mainly affected by those in the Nanliu River, while in the Dafeng River they can rarely bring impact on the Lianzhou Bay. Since depths around the swage drains of the Gaode Sluice Gate and Jininyinying Paper Mill are relatively shallow, they also bring great pollution to the Lianzhou bay.

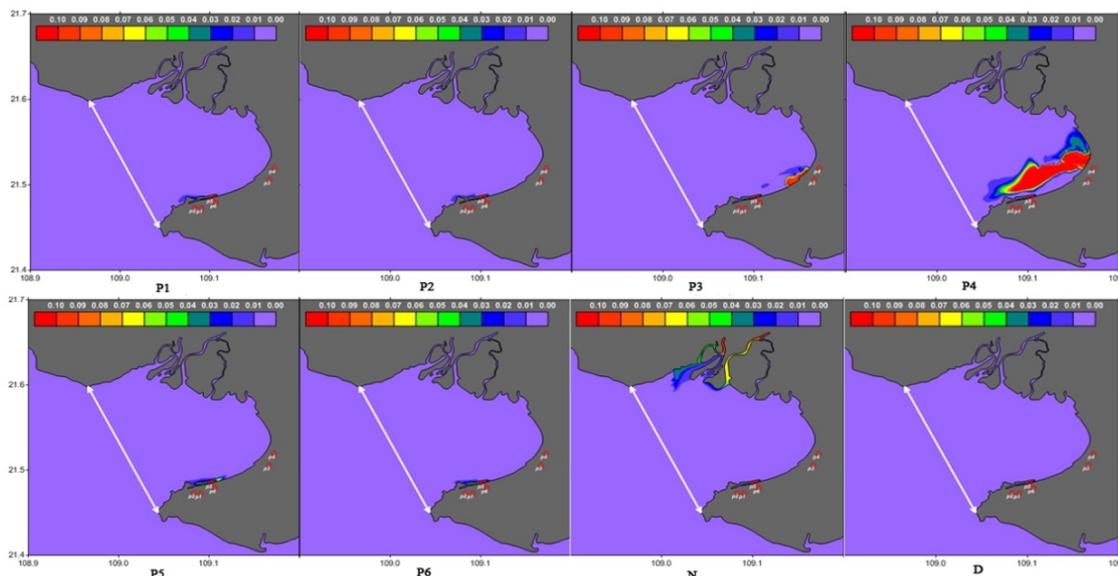


Fig. 2. RRFs of sewage drains in the Lianzhou Bay

The natural background value is obtained by the ship-based data in the Lianzhou Bay in 2009. After the water quality standard, the natural background value, and the RCF are determined, the constraint condition of linear programming can be obtained. This linear programming question can be solved by the objective function. The simplex method is applied because of expensive computational costs, and the optimal solution is the maximum pollutant flux that the environment can bear. Six city sewage drains are divided into 3 pollution discharge areas, and the Nanliu River is treated as a single one. Since pollution of Dafeng River can be rarely enter into the Lianzhou Bay, it is not contained in the procedure of EC calculation. Based on the National standard and Beihai Standard, the annual ECs in the Lianzhou Bay are calculated, and the results are shown in Table 2.

From Table 2, for seawater of Grades I to IV in the National Standard, the annual ECs of DIN are 374.13 tons, 553.04 tons, 1015.57 tons, and 1181.60 tons, respectively; the annual ECs of DIP are 24.36 tons, 62.24 tons, 62.24 tons, and 212.44 tons, respectively; the annual ECs of COD are 4147.37 tons, 7918.38 tons, 12770.30 tons, and 16914.99 tons, respectively. According to the Beihai water standard quality, the annual ECs of DIN, DIP and COD are 805.79 tons, 103.45 tons, and 9902.54 tons, respectively.

Table 2 Annual ECs of DIN, DIP, and COD in the Lianzhou Bay (tons)

Water quality	I	II	III	IV	Beihai standard
DIN	374.13	553.04	1015.57	1181.60	805.79
DIP	24.36	62.24	62.24	212.44	103.45
COD	4147.37	7918.38	12770.30	16914.99	9902.54

Conclusions

Based on the ship-based observation in the Lianzhou Bay in 2009, a pollution transport model is constructed. The SCF and the RCF are simulated by this model. Simulated results show that pollutions in the Lianzhou Bay are mainly affected by those in the Nanliu River, while in the

Dafeng River they can rarely bring impact.

Finally, the marine EC is calculated by the simplex method according to the water quality standard. Results showed that that for seawater of Grades I to IV in the National Standard, the annual ECs of DIN in the Lianzhou Bay were 374.13 tons, 553.04 tons, 1015.57 tons, and 1181.60 tons, respectively, and those of DIP were 24.36 tons, 62.24tonstons, 62.24tons, and 212.44tons, respectively, and the annual ECs of COD were 4147.37tons, 7918.38tons, 12770.30tons, and 16914.99 tons, respectively. According to the Beihai water standard quality, the annual ECs of DIN, DIP and COD were 805.79 tons, 103.45 tons, and 9902.54 tons, respectively. The results of this study provide an evidence for the management of marine environment quality and the total mass control of pollutants in the Lianzhou Bay.

Acknowledgement

Partial support for this study was provided by the State Oceanic Administration South China Sea Branch Direct Fund (Grant No.1360) and the Ocean Public Welfare Scientific Research Project, State Oceanic Administration, People's Republic of china(Grant No.200805065)

References

- [1] J. Yu, Y.L. Sun, Y.M. Zhang, Y. Zhang, H.W. Cai, Environmental capacity assessment of pollutants in Ningbo-Zhoushan sea area. *Environmental Pollution & Control (in Chinese)*, 28 (2006) 21-24.
- [2] X.Q. Zhang, Y.L. Sun, Study on the Environmental capacity in Jiaozhou Bay. *Marine Environmental Science (in Chinese)*, 26 (2007) 347-350.
- [3] Y. J. Gong, J.Z. Wu, X.C. Zhang, Environmental capacity assessment of pollutants in Weihai Bay sea area. *Marine Geology Letters (in Chinese)*, 4 (2010) 1-7.
- [4] D.H. Song, X.W. Bao, S. F. Zhang, C.H. Zhang, Three-dimensional numerical simulation of tides and tidal currents in Lianzhou Bay and adjacent areas. *Marine Science Bulletin (in Chinese)*, 31 (2012) 1-15.
- [5] S. F. Zhang, D.H. Song, C.H. Zhang, S.K. Xing, Numerical simulation on concentration of pollutants DIN, DIP and COD in Lianzhou Bay. *Journal of Qinzhou University (in Chinese)*, 29 (2014) 1-5.
- [6] J. Zhu, J.F. Wang, Z.F. Tian, X.Y. Chen, Marine environment capacity research progress and calculation methods. *Water Science and Engineering Technology (in Chinese)*, 4 (2009) 8-11.