Determination of Yangtze River Pollution Source Based on One-Dimensional Convective Diffusion Model

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Abstract

This paper takes the Yangtze River section from Panzhihua, Sichuan Province to Nanjing, Jiangsu Province as the research object. The permanganate concentration and ammonia nitrogen concentration measured by the seven main flow observation stations on these river sections are the data, and the one-dimensional convection diffusion model is established. Finally, the solution yields the relative content of each indicator of each observatory. According to the final result, it can be judged that the more serious pollution source is between Yueyang, Hunan and Yichang, Hubei, which provides reference for the supervision and treatment of the Yangtze River environment in the future.

Keywords

One-dimensional convection diffusion model; ammonia nitrogen; permanganate; Yangtze River environment.

1. Problem background

The Yangtze River is the first river in China and the third largest river in the world. It is also the continuation of China's major transport rivers and China's seas and land. Because of the abundant water resources, it can alleviate the current energy shortage in China. The Yangtze River Delta occupies 20% of the country's GDP, and its energy production resources are enormous. As a golden waterway, it provides abundant water resources for the North China region through the South-to-North Water Diversion Project. The Yangtze River Basin is also a huge granary in China, accounting for almost half of the country's grain production. The water pollution is becoming more and more serious [1], which has attracted the attention of relevant government departments and experts. Earlier, the National Committee of the Chinese People's Political Consultative Conference and the China Development Research Institute jointly formed a delegation to protect the Yangtze River Miles from Yibin to the lower reaches of the Yangtze River. Shanghai has conducted field visits to 21 key cities along the route, revealing a true picture of the Yangtze River pollution, and its pollution level is shocking. To this end, many people have suggested that "If not saved in time, the Yangtze River ecology will be on the verge of collapse in 10 years."

2. Problem analysis

The purpose of this paper is to study and analyze the main sources of pollution of the main pollutants such as permanganate index and ammonia nitrogen in the mainstream of the Yangtze River in the past year or so. We want to completely solve the pollution problem, we must find the main source of pollution, focus on regulation, and make overall considerations. This article will be the 7 mainstream observation stations of the Yangtze River in the past 13 months (Panzhihua, Sichuan, Zhuxi, Chongqing, Yichang, Hubei, Yueyang, Hunan, Jiujiang, Jiangxi, Anqing, Anhui, Nanjing, Jiangsu, China, a comprehensive general analysis of the concentration of two pollutants, because the pollutants involve more influencing factors, first construct a one-dimensional convection diffusion equation, and then simplify the hypothesis equation through the model, so that the problem is concise and measurable, The resulting one-dimensional diffusion simplified equation is obtained, and then the required data is used for unified processing and analysis to obtain the final comprehensive evaluation result.

3. Model establishment

The purpose of this paper is to judge the major polluted areas of permanganate and ammonia nitrogen in more than one year of the 7 observation points of the Yangtze River. Because there are many factors affecting the pollution degree of a certain water section at a certain time, and the pollutants in the river it is constantly spreading [2]. By consulting the data, this paper decides to establish a one-dimensional convection diffusion equation [3] and simplify the model [4], and remove the unaffected factors to solve the equation.

Through the analysis of the problem data, we know that the river has a certain self-purification ability for pollutants. The pollutants will be continuously purified and the concentration will decrease with the increase of time and migration distance in the water. Therefore, the migration distance is inversely proportional to the pollutant concentration. The relationship between the water velocity and the concentration of the pollutants is proportional to the concentration of the pollutants. At the same time, considering the relationship between the degree of dispersion and the length of time, the model of the one-dimensional convection-diffusion equation is finally established as follows:

$$\frac{\partial C}{\partial t}+u\frac{\partial C}{\partial x}=D\frac{\partial^2 C}{\partial^2 x}-kC$$

Where C is the average concentration of a pollutant in the section, u is the flow rate, D is the dispersion coefficient, x is the length of the channel (the length of the pollutant flow), t is the time, and k is the degradation coefficient (value is 0.2).

To simplify the model, we make the following assumptions to remove the extraneous:

Because the water flow in the Yangtze River is stable, the river width is very small relative to the river length. Therefore, the pollutants are evenly distributed in the cross section of the river. That is, when the water quality is detected at the same place, the concentration of the pollutants does not change with time. At the same time, there is a linear relationship between the concentration of pollutants and the diffusion distance. The second-order relationship is meaningless. After simplification, the one-dimensional convection diffusion equation is obtained as follows:

$$u\frac{dC}{dx}=-kC$$

Where u is the flow rate, x is the length of the channel (the length of the contaminant flow), and k is the degradation factor (value is 0.2). After integrating the discrete variables, you get:

$$C=C_0e^{-k\frac{x}{u}}$$

A total pollutant concentration model for a total of six sections of the seven main stream observation stations can be established.

Consider the pollution of adjacent observation points on the main stream and the pollution of the main stream caused by the undegraded interaction between them. The total amount of pollutants at each observatory on the main stream is expressed as:

$$L_i=Q_{i+1}C_{i+1}-Q_iC_ie^{-k\frac{x_{i+1}-x_i}{u_{i,i+1}}}$$

Where $Q_{i+1}C_{i+1}$ represents the amount of pollution at the i+1th observatory on the main stream; Q represents the water flow; C represents the average concentration of the contaminant; and

$Q_i C_i e^{-k\frac{x_{i+1}-x_i}{u_{i,i+1}}}$ indicates the amount of residual contamination of the pollution at the i-th observatory of the main stream through natural degradation to the next station.

4. Model solving and analysis

In this paper, the pollution concentration data of CODMn and NH3 pollutants in the seven main stream observation stations of the main stream are used for calculation. According to the one-dimensional convection diffusion equation, MATLAB is used to calculate the two pollutants produced by the seven main stream observation stations. The quantities are as follows:

Table 5: CODMn content of seven main stream observatories

Content of CODMn in the past 13 months (mg)							
Month\place	Panzhihua, Sichuan	Zhu Xi, Chongqing	Yichang, Hubei	Yueyang, Hunan	Jiujiang, Jiangxi	Anqing Anhui	Nanjing, Jiangsu
1	8487	48300	46200	84480	81490	82585.4	44700
2	15996	28820	59400	73800	92380	108783.	62100
3	10025	42600	77140	79100	76700	51346.3	66200
4	11184	54120	72640	101220	70200	54217.4	57780
5	21692	21200	74400	103600	73830	63446.8	59670
6	38308	209440	181900	209820	138320	118695.	186300
7	2608	25920	70670	78050	47120	65091.5	72960
8	4200	16340	20140	31200	32120	37394.2	35280
9	1521.6	8515	17760	37450	30360	23964.5	29800
10	854.4	5226	8683	41769	26160	31975.3	36000
11	550.8	6485.4	9020	25536	31930	36984.3	34730
12	685.3	9006	10878	28864	25740	57775.4	38700
13	706.2	7300	12960	20996	30200	46454.6	33150
Sum	116818.3	483272.4	661791	915885	756550	778715	757370

Table 6: NH3 content of seven main stream observatories

NH3 content (mg) in the past 13 months							
Month\place	Panzhihua, Sichuan	Zhu Xi, Chongqing	Yichang, Hubei	Yueyang, Hunan	Jiujiang, Jiangxi	Anqing Anhui	Nanjing, Jiangsu
1	553.5	2898	5670	6656	7587	6488.64	595.9999
2	260.4	3537	5940	6560	6556	8498.83	3105
3	160.4	2556	6902	7910	4425	5456.21	1986
4	186.4	2952	3632	8676	4320	7017.22	1605
5	3740	1802	4560	8547	7704	5342.62	1755
6	565.2	7616	15515	16140	18200	10384.7	6480
7	260.8	3726	4393	8028	4712	5269.15	1536
8	90	2205.9	2544	4320	3212	2039.42	980
9	76.08	3340.5	1184	3317	1584	1973.71	1490
10	49.84	2170.8	1005.4	3439.8	2289	2459.59	3168
11	91.8	1981.65	811.8	3431.4	1339	2465.76	4681
12	161.98	2559.6	984.2	2956.8	1573	4921.71	429.9999
13	64.2	2299.5	702	3040.8	2114	3029.62	4420
Sum	6260.6	39644.95	53843.4	83022.8	65615	65347.3	32232

Display all the data obtained in the form of summation as Table 7:

Table 7: Sum of Permanganate and Ammonia Nitrogen at Seven Mainstream Observation Stations

place	Panzhihua, Sichuan	Zhu Xi, Chongqing	Yichang, Hubei	Yueyang, Hunan	Jiujiang, Jiangxi	Anqing Anhui	Nanjing, Jiangsu
Permanganate content and (mg)	116818.3	483272.4	661791	915885	756550	778715	757370
place	Panzhihua, Sichuan	Zhu Xi, Chongqing	Yichang, Hubei	Yueyang, Hunan	Jiujiang, Jiangxi	Anqing Anhui	Nanjing, Jiangsu
Ammonia nitrogen content and (mg)	6260.6	39644.95	Yichang, Hubei	83022.8	65615	65347.3	32232

According to the data in Table 7, it can be seen that the main sources of permanganate index and ammonia nitrogen pollution in the main stream of the Yangtze River for nearly one year are mainly from Yichang, Hubei Province to Yueyang water section of Hunan Province, concentrated in Yueyang, Hunan, and then to the Jiujiang River in Jiangxi Province to Anhui Anqing.

Based on the data in Table 7, the following seven current flow observation stations have been tested for permanganate content, ammonia nitrogen content, and their line graphs for nearly 13 months:

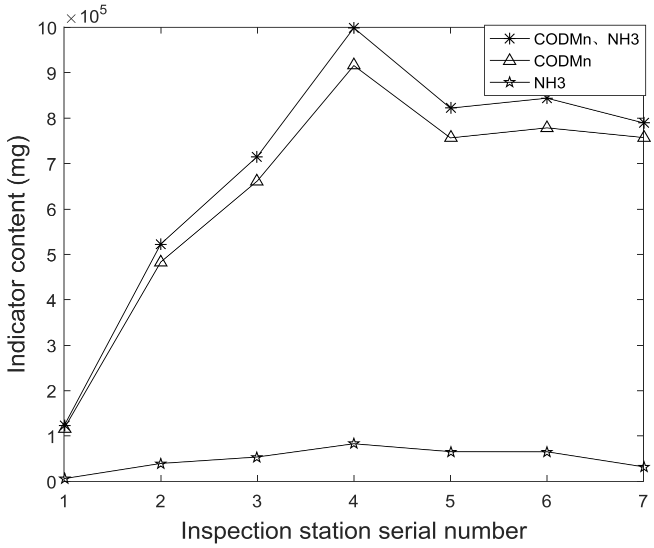

Fig 1: Content of each indicator at the seven main stream observatories

From the above figure, it can be seen more intuitively that the trend of the three polylines is basically the same, that is to say, no matter which index is used, it can be seen that the content of the two indicators detected by Hunan Yueyang (No.4) is the most. Since the upstream is Yichang, Hubei, and the detection volume of Yichang is very low, it can be determined that the pollution source is in this section of the river in Yueyang, Hunan and Yichang, Hubei.

5. Conclusion

In this paper, the permanganate concentration and ammonia nitrogen concentration were detected in the seven main stream observation stations for 13 months, and a one-dimensional convection diffusion model was established. The relative scientific content of each indicator of each observation station was obtained by solving the problem. The final data shows that the more serious pollution sources are between Yueyang, Hunan and Yichang, Hubei. Therefore, in order to protect our Yangtze River environment, relevant departments should focus on increasing the management and testing of related industries within the river section, and fundamentally improve the environment of the Yangtze River.

References

[1] Shouren Zheng. The key position and role of the Three Gorges Project in the ecological environment protection of the Yangtze River [J]. People's Yangtze River, 2018, 49 (21): 1-8+19.
[2] Jianping Geng,Pengxin Deng, Gaohong Xu, Wanshun Zhang. Study on the law of pollutant dispersion in the Hanyang section of the Yangtze River after the operation of the Three Gorges Reservoir[J]. People's Yangtze River, 2018, 49(19): 26-32.
[3] Bingyu He, Jianxin Zhu, Fanyuan Yang. Simulation of water quality in one-dimensional rivers [J]. Drought Environment Monitoring, 1996 (02): 76-79+85+126-127.
[4] Zhouhu Wu. Solving and simplifying the one-dimensional water quality model of finite time source[J]. Journal of China Institute of Water Resources and Hydropower Research, 2017, 15(05):397-408.