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Water Pollution Prevention and Prediction Based on Grey BP Neural Network Model

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Abstract: With the acceleration of economic development, the problem of water pollution (WP) has also become a problem for many countries around the world. In the process of development, many countries have experienced serious WP phenomena, which have had a very serious impact on the ecological environment. The main reason why people attach importance to the problem of WP is that water is indispensable for the development of society and the survival of human beings, and if serious WP problems occur, people's water safety will not be guaranteed. Based on the grey BP neural network (BPNN) model, this paper predicts the pollution emissions in 2023 for the industrial and livestock pollution emission coefficient of M city from 2016 to 2020. The results show that the combination of grey system theory and BPNN can effectively predict the WP emissions. Through analyzing the WP prevention and control problems in M city, this paper puts forward prevention and control strategies, hoping that this study can also provide reference and suggestions for WP control in other cities.

1. Introduction

Water is the key to human survival and sustainable economic and social development. In recent years, WP in some areas of China has largely coincided with economic development. Despite significant progress in economic development, various production resource elements are facing depletion, especially WP in production and life, which has caused serious damage to the environment. Local governments must be conscious of the relationship between the environment and economic development and think deeply about the direction and path of sustainable and green development [1-2].

Research on WP prevention and control has yielded good results. For example, some scholars

believe that local governments should be the first to achieve the transfer and coordination of monitoring information among relevant departments in the prevention and control of WP, especially in the prevention and control of WP in river basins, and that the unification of WP monitoring information among various departments determines the merits of pollution control programmes. Government departments should hold regular joint meetings to exchange regulatory information, strengthen the comprehensive research and analysis of all regulatory information, and improve the level of global and local relations, especially in the allocation of regional resources, all of which are fundamental to decision-making for WP prevention and control [3-4]. Through research and empirical analysis of WP risk management theory, some scholars have concluded that WP risk management should be predicted before a pollution event occurs, so that a potentially large crisis incident can be transformed into a low-risk incident and long-term management of WP can be achieved, thus defusing the WP crisis [5]. Although the focus on WP has gradually increased in recent years, the problem of WP has still not been completely solved and WP incidents still occur from time to time.

This paper first introduces the conceptual model of BPNN and grey system theory, and then forecasts the industrial pollution emissions and livestock and poultry pollution emissions in M city by combining the grey system theory and BPNN. In view of the problems existing in the WP prevention and control in M city, this paper also puts forward some WP prevention and control suggestions, in order to control the WP phenomenon in M city.

2. Grey BPNN Model

2.1. BPNN

BPNN theory is an artificial neural network, relatively simple in artificial intelligence or machine learning but with high processing power, and is one of the most widely used and widely applied algorithms for neural network training [6].

A BPNN is a multilayer feed-forward network trained by an error reversal algorithm. In the neural network model, the input vector is X, the hidden vector is Y and the output vector is Z. The number of neurons is n. X is input to Y and then output to Z. The weights of X and Y are wij and the threshold is θi, and the weights of Y and Z are wjk and the threshold is θk. ai is the input layer layer node and Pj is the threshold of the hidden layer node.

$$Y_j = f(\sum_{i=1}^{n} w_{ij} x_i - \theta_i) \tag{1}$$

$$Z_k = f(\sum_{j=1}^{n} w_{jk} y_k - \theta_k) \tag{2}$$

$$B_j = f\left(\sum_{i=1}^{n} w_{ij} \times a_i + P_j\right) \tag{3}$$

The sample data, i.e. the input sequence for the BPNN, should be carefully selected as the training basis for the BPNN model. In the specific prediction of WP, the construction of neural networks requires a large amount of test data, but the problem is the reduction of information that cannot be avoided by traditional neural networks [7]. To address this problem, the approach used in this paper is to front a BPNN model with a grey system, a method that reduces significant

information and which has the advantage of simplifying the input values in order to reduce the time BP takes to train the neural network in front and to improve the ultimate accuracy of the training [8-9].

2.2. Grey System Theory

(1) Grey prediction model

Forecasting is the process of speculating and studying the future development of something by looking at the trend of changes in the past. The purpose of grey forecasting is to introduce the theory of grey systems into the forecasting process, process initial sample data, construct grey models to integrate forecasts, find out the hidden distribution patterns of the system, and provide a reasonable and accurate description of the future development system [10].

(2) Grey generation process

All sample data of the original data sequence {x(0)} are processed according to the rules defined as generated. The operation of the grey system theory generation data increases the frequency of the distribution of the new sequence and, conversely, its randomness decreases and the resulting new sequence is called the generated number [11-12].

(3) Cumulative generation

Cumulative generation aims to extract the original data and add analytical features to the sample data so that the data exhibit a certain distribution pattern. In brief, the main treatment is to analyse the first data in the original data series, convert them into the new first data, then add the primary and secondary data of the original data set to obtain the second number of the new data set, and similarly add the first and second data to obtain the third number of the new data series [13-14]. Following this pattern and so on, a set of cumulative generating series is obtained.

3. Prediction of WP Prevention and Control in M City Based on Grey BPNN Model

3.1. Prediction of Industrial Wastewater and Pollutant Discharge

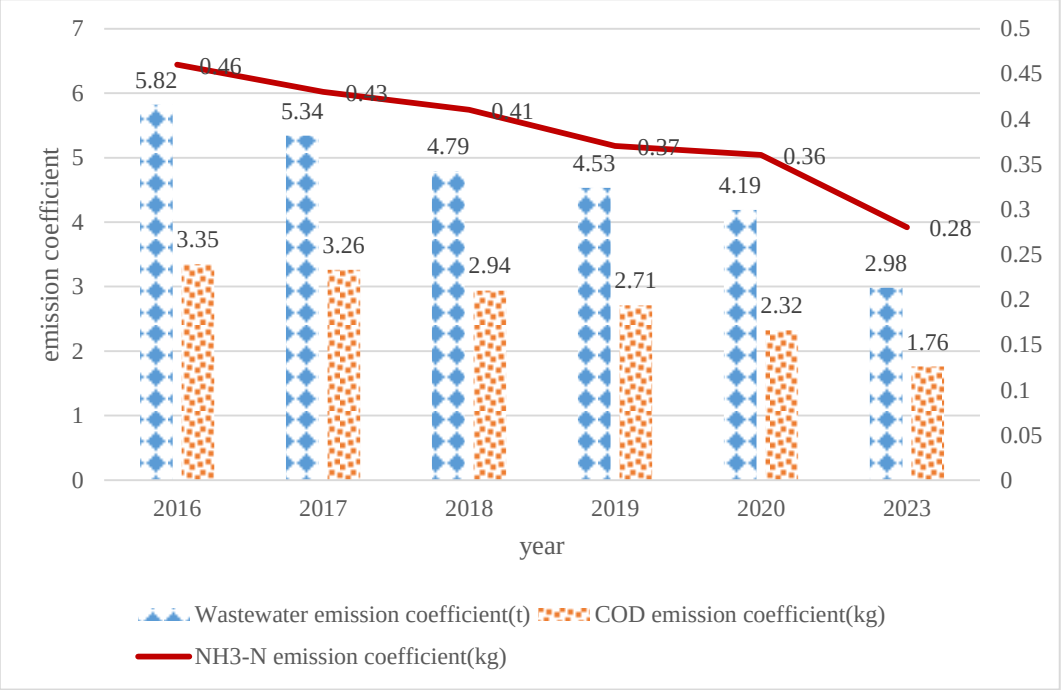

Figure 1. Predicted industrial pollution emission coefficient

For example, Figure 1 shows the wastewater discharge coefficient, COD discharge coefficient and NH3-N discharge coefficient in the industrial production of M city from 2016 to 2020. The three discharge coefficients in 2020 are 4.19t, 2.32kg and 0.36kg respectively. With the improvement of citizens' environmental awareness and the progress of science and technology, especially the deepening of building a resource conserving and environment-friendly society, it is predicted that the discharge coefficients of industrial wastewater, COD and NH3-N generated during industrial production in M City in 2023 will be 2.98t, 1.76kg and 0.28kg respectively.

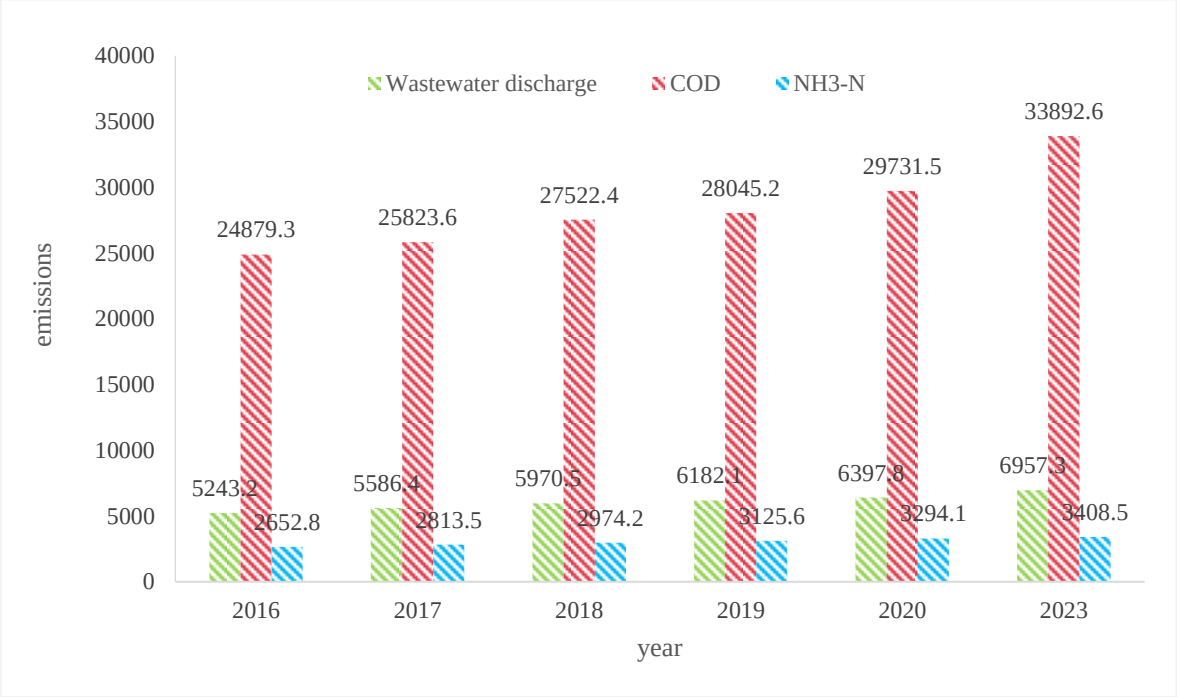

Figure 2. Prediction of wastewater and pollutant discharge (t)

Based on the wastewater and pollutant discharge coefficient of M city from 2016 to 2020, the predicted industrial wastewater and pollutant discharge of M city in 2023 is shown in Figure 2. The discharge of wastewater, COD and NH3-N has been growing. It is predicted that the discharge of wastewater, COD and NH3-N in M will be 6957.3t, 33892.6t and 3408.5t respectively in 2023.

3.2. Prediction of Pollutant Emission from Livestock and Poultry Breeding

According to the analysis of the planting industry pollutants in M City from 2016 to 2020, the main pollutants produced by the planting industry in M City are less N, P, COD and NH3-N, which can be ignored compared with the total emissions. Therefore, the total amount of COD and NH3-N is mainly controlled, so the planting industry will not be studied in this study. The agricultural non-point source pollution in this study is livestock and poultry breeding pollution.

Livestock and poultry breeding can be divided into cattle, sheep, pigs, poultry and other breeding industries. As shown in Figure 3, the livestock and poultry breeding volume in M City in 2023 is predicted based on the livestock and poultry breeding volume in 2016-2020. It can be seen that the breeding quantity of pigs and sheep is increasing year by year, while that of sheep and poultry is decreasing year by year. It is predicted that the breeding quantity of pigs, cattle, sheep and poultry in M City in 2023 will be 177.8, 126.5, 113.5 and 319.7 million respectively.

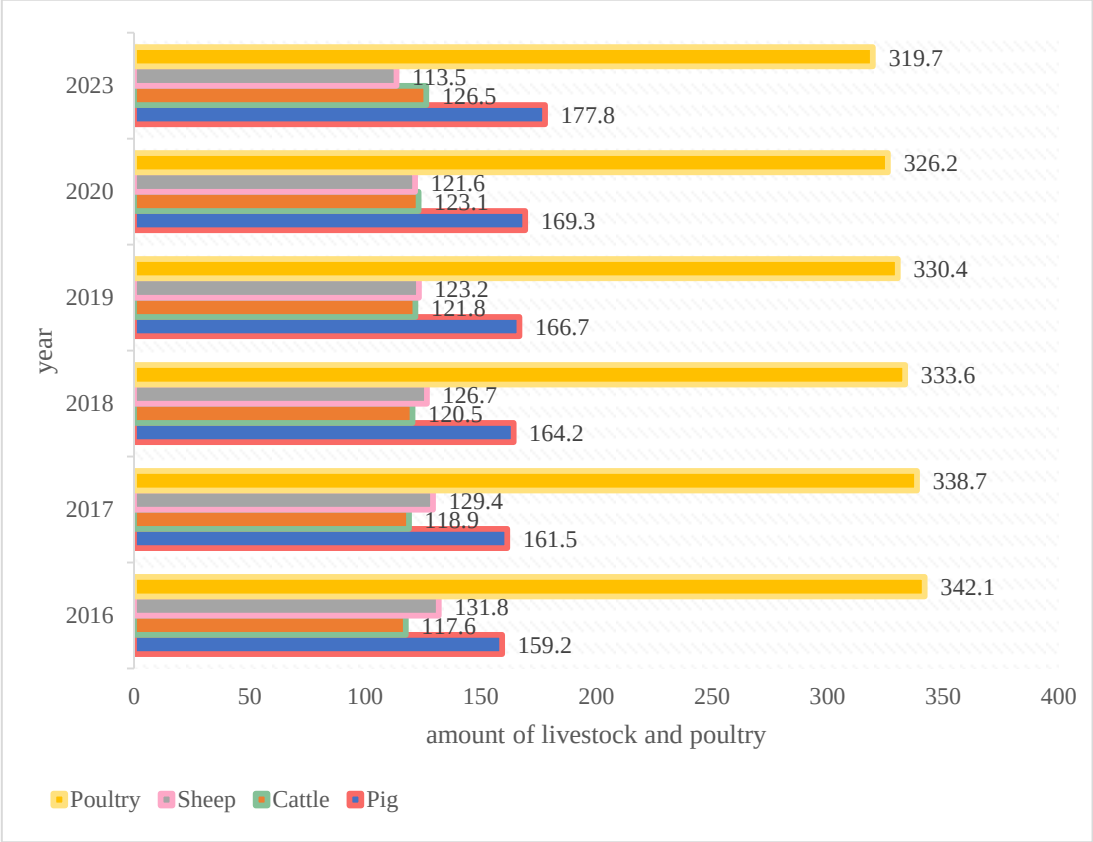

Figure 3. Forecast of livestock and poultry in m city (10000)

Table 1. Discharge calculation parameters (kg/a ·piece)

	COD		NH_3-N	
	Production	Loss rate	Production	Loss rate
Pig	16.7	0.35	4.9	0.11
Cattle	54.2	0.98	13.6	0.23
Sheep	10.6	0.21	0.32	0.14
Poultry	1.7	0.12	0.24	0.16

A large amount of sewage and feces are produced in the process of livestock and poultry breeding, as well as odor, which has a great impact on the surrounding living environment. Based on the collection and statistics of livestock and poultry breeding data in the 2016-2020 Yearbook of M City, combined with the data mastered by the environmental protection department of M City, this paper determines and calculates the pollution discharge coefficient of livestock and poultry breeding. See Table 1 for details.

Table 2. Projected livestock and poultry pollution emissions in 2023 (t)

	Pig	Cattle	Sheep	Poultry
2016	11542.8	7852.6	3458.2	2496.5
2017	11833.6	7963.9	3294.6	2275.3
2018	12041.5	8127.4	3103.5	2146.2
2019	12472.7	8265.6	2874.6	1973.8
2020	12648.2	8401.2	2693.4	1812.4
2023	13493.4	8536.8	2265.1	1392.7

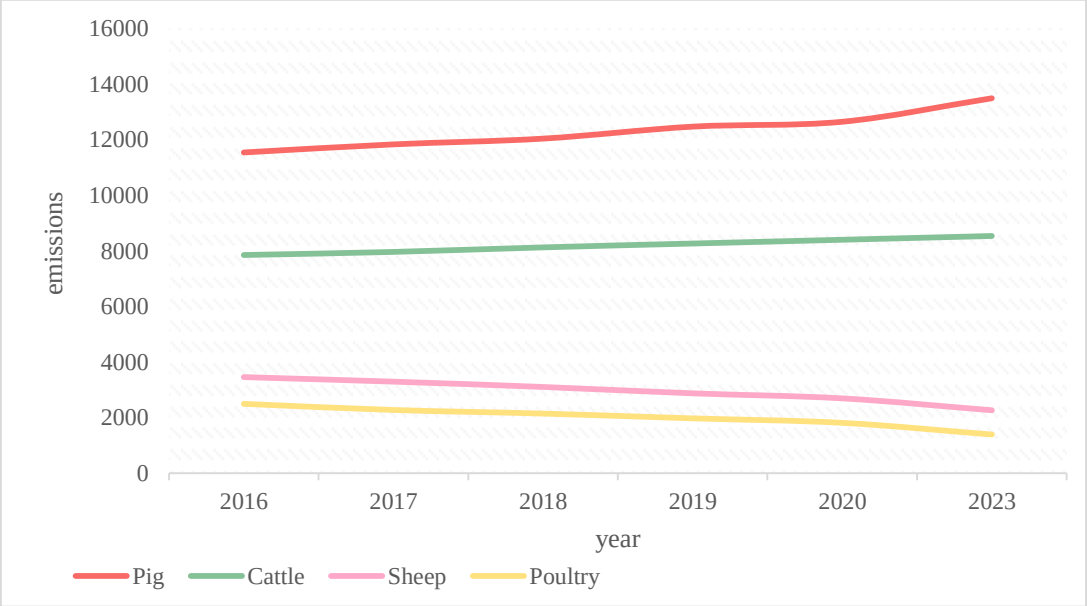

Figure 4. Projected livestock and poultry pollution emissions (t)

Table 2 and Figure 4 show the predicted livestock pollution emissions in 2023 based on the livestock volumes in Figure 2 and the livestock emission factors in Table 1. By 2023, the pollution emissions from pigs, cattle, sheep and poultry will be 13,493.4t, 8,536.8t, 2,265.1t and 1,392.7t.

4. WP Prevention Problems and Strategies in M City

4.1. WP Prevention

(1) Enterprises lack the concept of cleaner production and neglect environmental protection

As an important part of the environmental protection process, companies play an important role in the overall environment and resource use. Some companies do not have complete control over the use of resources and pollution in their production process, while others believe that investing in proper pollution control equipment will not only increase the financial cost of the company, but will not benefit from the economic benefits and therefore their environmental investment is very low [15].

(2) Low public awareness of the environment in society

Citizens, as one of the main components of society, have become an important part of environmental management. However, in everyday life, many people do not know enough about the environment, do not reinforce the concept of environmental protection, consider their role in environmental pollution management to be insignificant, and attribute pollution management to matters that the government or enterprises should manage, rather than being able to invest their own energy in managing and protecting the environment [16]. Most people believe that the environment is managed by government work and does not have a great deal to do with themselves.

(3) Failure to fundamentally change the concept of development

In order to develop the economy, the local government in M has only focused on the need for direct economic benefits, conducted a one-sided review of political achievements, ignored environmental pollution damage and developed the economy at the expense of the environment, a phenomenon that has made the current state of WP in M even worse. Their responsibility is primarily to help enrich the local people and to give the highest priority to how they can promote economic growth, while WP and environmental issues can wait until later.

4.2. WP Prevention Strategy

(1) Strengthen infrastructure construction

Define the scope of the mandate for infrastructure development in the city of M. Require active municipalities to provide financial support for the construction of electricity for wastewater treatment and sewage, and promote full coverage of municipal waste and rubbish treatment facilities. Actively work with the Ministry of Construction to promote the construction of wastewater treatment plants and increase the capacity of the city's wastewater treatment plants. Continue to improve the construction of a high standard network in core areas to achieve a step change in the construction of wastewater treatment systems. Assess coordinated improvements in sewerage planning and construction stations in areas where there is a serious lack of sewerage capacity and accelerate the renovation of wastewater treatment plants [17]. Accelerate the dredging, testing and rehabilitation of the sewerage network and complete the rehabilitation of the sewerage network such as fault excavation and repair in a timely manner. Improve the efficiency of supervision of sewage treatment plants, pipe networks and supporting equipment, continuously strengthen the automatic monitoring and early warning function, and complete the construction of online automatic monitoring capacity for major regional sewage projects and facilities; emphasise automated means and information technology to provide long-term, sustainable monitoring of project emissions and sewage, and ensure that wastewater data from major pollution sources and the operation of pollution control facilities are scientifically accurate [18].

(2) Prevention and control of pollution from retail farming

Carry out the construction of an energy-ecological circular economy model. Treat farming wastewater separately according to the scale of farming, and strictly prohibit direct discharge. Implement the comprehensive use of manure treatment and return to the field for livestock and poultry farms (plots) to achieve economical production and clean production.

(3) Crack down on environmental violations

Investigate and deal with enterprises that discharge too much in violation of the law, and investigate and deal with emission units that do not report the source of pollution in accordance with the law; start suspending, closing and transferring production in the case of high WP projects, a large number of public complaints and non-compliance with industrial plans; initiate public interest litigation in accordance with the law against units that refuse to assume social responsibility and discharge pollutants that seriously affect the environment. At the same time, the introduction of highly polluting enterprises, new real estate, businesses, etc. is strictly controlled, and the city's centralised sewage treatment plants must build their own sewage treatment plants and strictly control discharge standards.

5. Conclusion

Water resources maintain people's survival, but at present, the problem of WP is very serious, so it is imperative to strengthen the prevention and control of WP. To solve the WP problem, improve the current WP prevention crisis faced by various regions and promote the sustainable development of the ecological environment, we are carrying out research on WP prevention. In the prediction and analysis of WP discharge in M City, it is shown that the pollution discharge from industrial and livestock production activities in M City is increasing on the whole. Therefore, suggestions are put forward for WP prevention and control, such as speeding up the construction of sewage treatment plants and cracking down on illegal sewage discharge.

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Data Availability

Data sharing is not applicable to this article as no new data were created or analysed in this study.

Conflict of Interest

The author states that this article has no conflict of interest.

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