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Estimation on Economic Loss from Sewage Pollution Based on Logistic Model

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Based on the mechanism model of environmental pollution loss of pollutants, Logistic equation and related theory of environmental value, an economic loss estimation model of environmental pollution was established. The model can not only reflect the relationship between pollutant concentration, pollutant emissions, environmental resource value and economic value loss, but also use this model to quantitatively reflect the damage caused by environmental pollution to the value of environmental resources. The model is used to estimate the economic loss caused by industrial water pollution in a certain area. The comparison between the estimated amount and the results calculated by econometric method shows that the evaluation results are relatively consistent, but the former is slightly larger.

1. Introduction

Along with the development of society, chemical industries also grow up increasingly. They serve for our lives, while doing a lot of harms to our lives instead, for example, industrial sewage pollution from chemical enterprises (Moletta, 2005), which has ruined the environmental quality and degraded the value of environmental resources. It has also inevitably weakened the ecological services of the environmental system itself. China's environmental pollution is now getting worse and worse along with the dramatic development of economy. The value and functionality of resources in the environment are degrading to a different extent, and worse, some may even be lost. For these reasons, what we urgently require are some environmental economics and market value theories used to explore the value of environmental resources (Hao et al., 2016; Fernández-Gómez et al., 2011; Malińska et al., 2017) and estimate the economic losses caused by environmental pollution. To calculate the losses incurred by the environmental pollution, the economic value of environmental resources should be first unveiled. So far, there are various algorithms that have been proposed now, such as travel expense, payment desire, market value, human capital and opportunity cost algorithms. However, there is no appropriate method used to estimate what is the resource value caused by chemical industry pollution (De et al., 2014; Hennig et al., 2016). Based on the pollution loss rate and the value of environmental resources, a pollution loss estimation model is built to calculate the economic loss caused by the pollution. The Logistic model was first proposed by the Belgian biomathematician P.F. Verhulst in 1838 as a growth curve model (Avnery et al., 2011; Lal et al., 2017). It is widely used to simulate the growth, reproduction of animals and plants and socio-economic development. It was found by James L.D (1984) that the “concentration-loss curve” of pollutants climbs up with the increase of pollutant concentration, and the pollution loss increased rapidly within the certain limits. In recent years, water pollution and subsequently loss in economic value have aroused people’s wide concern. As a hot spot, the logistics model has been widely used to have an insight into the economic losses caused by water pollution. Looking back on the existing calculation model for economic losses caused by water pollution, Meng Jianguo proposed the theory that the logistics model could help explore the economic losses caused by water pollution. Eventually, it was found that there was a subjective impact in the model (Leal, 2016). The calculation results are objective and feasible to reflect the impact of water pollution. Sun Jinfang et al. found that there was a large difference between the two methods by comparing the economic losses caused by the logistics model and the reclamation cost method. The logistics model, however, estimates the overall pollution loss of the water body that seems much

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closer to real values, and the recovery is more realistic. The cost method only allows for the increase in processing costs due to water pollution, and the calculation results somewhat differ from the physical truth (Joseph- Duran, 2016). It has been proved by many domestic scholars that the logistics model can accurately reflect the economic value loss caused by water pollution. The study path of this paper is shown in Fig. 1.

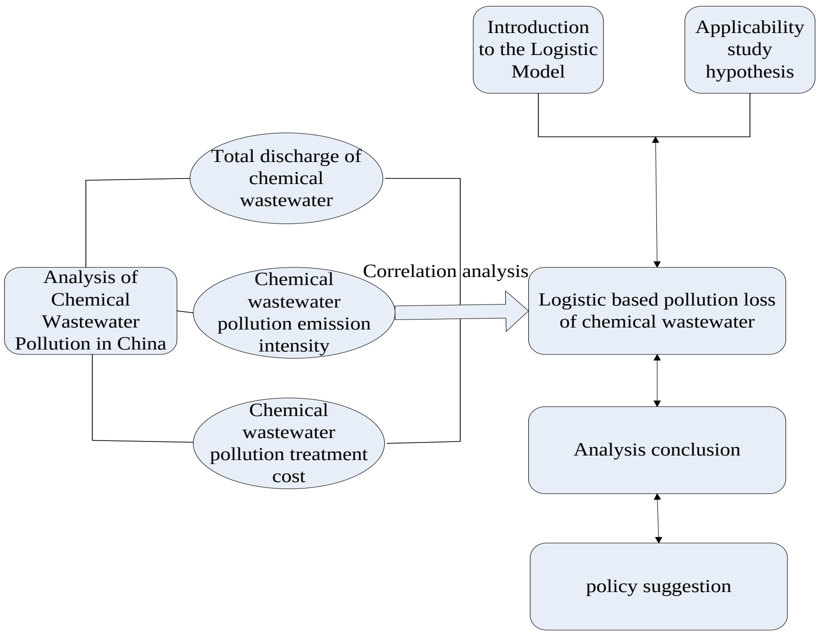

Figure 1: Research path

2. Construction of the Logistic model

2.1 Establishment of pollution loss rate

Jame found that the environmental damage from the pollutants was not linearly corrected to the concentration of pollutants. When the concentration of pollutants is lower, such damage is not obvious. However, as the dose of pollutants increases, the degree of damage to the environment dramatically elevates (Cho et al., 2016). When the dose of pollutants grows to a certain extent, the damage to the environment will decrease and slow down until it reaches the limit of loss. This trend usually appears as a non-linear curve, as shown in Fig. 2.

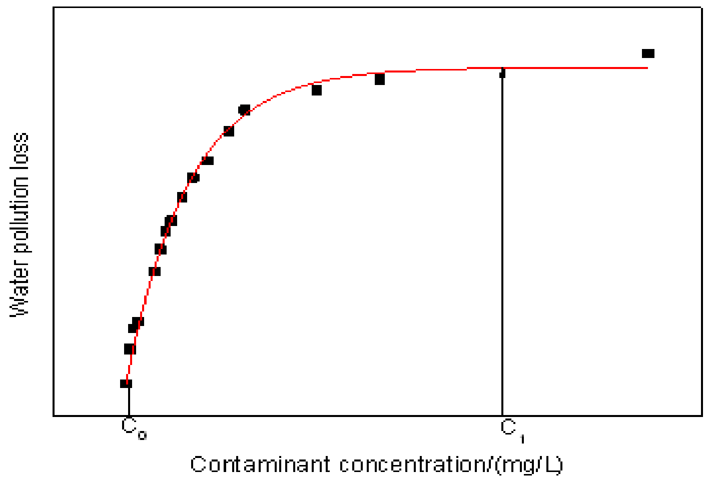

Figure 2: Schematic diagram of the relationship between pollutant concentration and loss

Where, C_0 is the allowable concentration of pollutants as required by the environment; C_1 is the concentration of the pollutants when the environmental function disfunctions.

A certain environmental element i is set in the environment. There are n kinds of pollutants, among which, the loss rate of the pollutant j to the environmental element i is Rij. In order to estimate this pollution loss rate, it is necessary to build a differential equation between the concentration of pollutants and the economic value of environmental resources (You et al., 2017):

$$\frac{ds_i}{dc_i} = \beta i_j \frac{S_i}{K_i}\left(K_i - S_i\right) \tag{1}$$

Solve (1), then:

$$S_i\left(C_i\right) = \frac{K_i}{1+\alpha_{ij}\exp\left(-\beta_{ij}C_{ij}\right)} \tag{2}$$

(2) is in accord with the Logistic equation. To simplify the calculation, we make:

$$R_{ij} = \frac{1}{1+\alpha_{ij}\exp\left(-\beta_{ij}C_j\right)} \tag{3}$$

Then (2) can be simplified as:

$$S_i = K_i R_{ij} \tag{4}$$

2.2 Establishment of comprehensive pollution loss rate function

When there are n kinds of individual pollutants in the environment, the loss rate function of element i is:

$$R_i = 1 - C_{(j=1)}^{n} + (1 - R_i j) \tag{5}$$

Moreover, the environmental pollution will also do a harm to people's health, and also cause economic losses. This part of the economic loss is calculated by following formula:

$$C_{ed} = P_{ed} * \sum_{i=1}^{i-n} \frac{GDP_{pco} * (1+\mathrm{a})^i}{(1+\mathrm{r})^i} \tag{6}$$

3. Results and analysis

In this paper, the water quality of the selected water source after chemical wastewater discharge is tested and measured. The results are shown in Fig. 3.

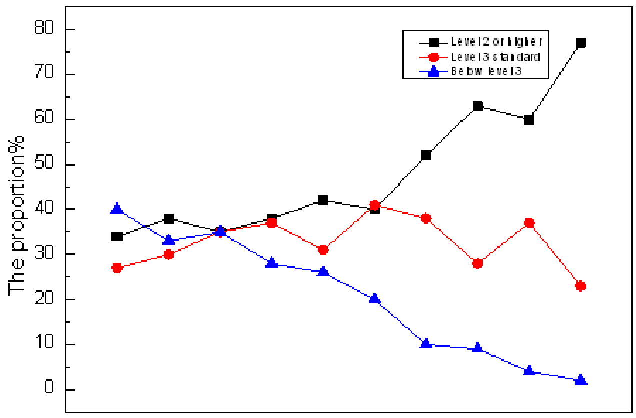

Figure 3: A water source monitoring compliance rate

As shown in Fig. 3, with the treatment of environmental pollution, the pollution of water sources after chemical wastewater discharge is gradually reduced. In this case, we take the water source to test the contents of several chemical pollutants. The results are shown in Table 1.

Table 1: Drainage circumstance of industry wasterwater

	Wastewater discharge(104t)	COD/t	Petro/t	Suspended matter/t	Volatile phenol/t
1	6766	27841	55	14653	4.9
2	6208	18899	7.24	10522	0.55
3	5572	27100	28.99	9422	1.23
4	4416	12866	44.56	5898	1.04
5	5555	7852	17.32	3489	0.09
6	5320	6419	36.00	7895	0.25
7	4368	4240	37.25	6510	0.17

It is assumed that the total loss rates of water resource caused by the pollution of pollutants in the background concentration and the critical pollution states are 1% and 99%, respectively, based on which to determine the parameters α and β, and the results are shown in Table 2.

Table 2: The value of parameter α and β

Parameter	COD	Petro	Suspended matter	Volatile phenol
α	140.522	99.899	100.252	100.8974
β	0.02576	0.3121	0.04789	4.6231

Then the formula is used to calculate the economic loss, and in order to prove the accuracy of this model, we also use this model to calculate the economic losses caused by chemical wastewater discharge in previous years in the local area. The results are shown in Fig. 4. The results are compared, as shown in Fig. 5.

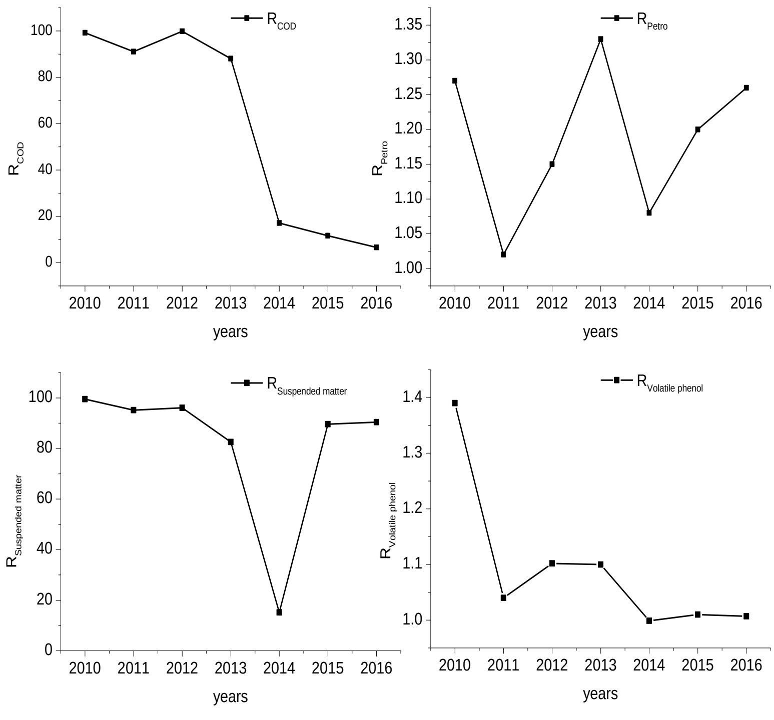

Figure 4: Mean pollution loss rate of every pollutant（%）

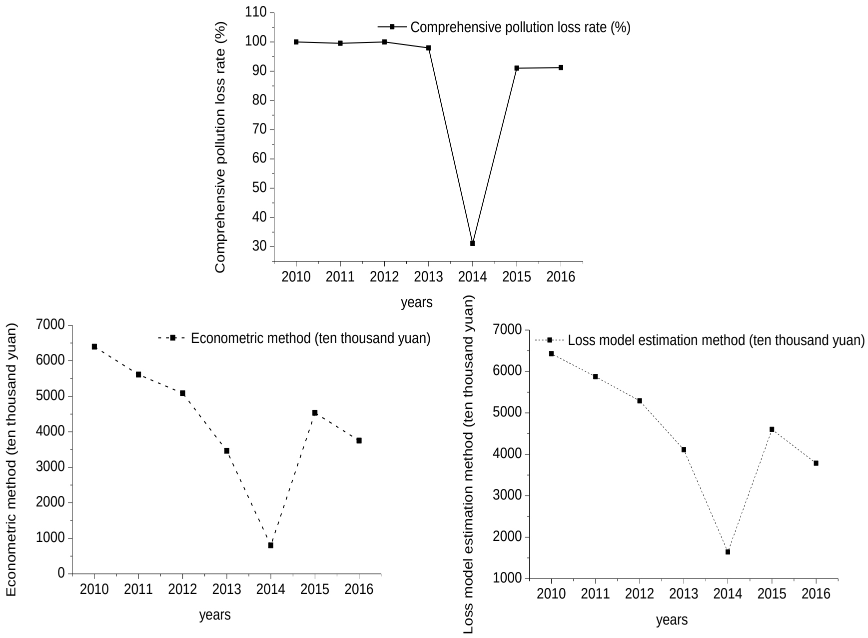

Figure 5: The comparision of results between pollution loss method and economic metrology method

As shown in Fig. 5, the results from evaluation conducted with the two methods are relatively consistent. However, the results from the estimation model for economic loss caused by environmental pollution are slightly greater than that from the econometric method, it is attributed to the fact that the model method adopts the comprehensive pollution loss rate and involves the impacts of various pollution factors; and the econometric rule is based on the calculated pollutants, to explore what's impact degree of the major pollutants on the environment, therefore, the economic loss evaluation model for the environmental pollution, as expected by us, can well estimate economic losses incurred by environmental pollution, and reveal that the economic loss has a direct bearing on pollutant concentrations, pollutant emissions, values of environmental resources, and pollution losses.

4. Conclusion

In this paper, the Logistic model of pollutant concentration and loss is established by using the correlation between pollutant concentration and pollution loss. The relevant parameters are determined from the toxicological characteristics of the pollutant itself and the environmental water quality requirements and functions. This method is used to calculate the water pollution loss. One method, but due to the lack of relevant data, this method and other methods have not been compared and evaluated, and this problem deserves further study. Combined with the example, the Logistic model was used to estimate the agricultural losses caused. The degree of pollutant damage obtained in practical application is not completely consistent with the order of the degree of pollutant damage given by Zhu Qingfa used in the paper. This is because the water quality of the river is good and the concentration of the pollutant is not high. However, the reference values of the selected pollutants α_{ij}, β_{ij} are generally credible, especially in the case of excessive pollutants.

(1) The economic loss estimation model of environmental pollution can not only reflect the environment: the non-linear behavior of pollution loss, and reflect objective facts in a truer way, but also describe the damage of environmental resources in the pollution loss rate of the model, whose physical significance is relatively clear.

(2) Using this model to calculate pollution loss, the results can better reflect the relationship between environmental pollution and economic loss and the econometric method

Compared with the model, which is concise and clear, it is easier to understand. In the case of more pollutants, it can highlight the simplicity of the model in calculation. Moreover, this method is highly comprehensive and applicable. It can not only estimate the damage of a single environmental factor, but also comprehensively evaluate a variety of environmental factors.

(3) There are few parameters in the model, so the model is less subject to subjective influence.

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