Application of Virtual Disposal Cost Method in Judicial Identification of Surface Water Pollution in China

Yan TANG and Cui-bai YANG

Research Center for Eco-Environment Damage, Law School, Sichuan University, Chengdu, China

*Corresponding author

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Abstract. Virtual disposal cost is a method for estimating the appropriate amount of compensation for environment damage from pollutants. China has not yet formed a complete legal system of civil compensation for environment pollution. Taking the surface water environmental damage incident of sewage treatment plant as a case, we analyze the virtual disposal cost method and the provision of reference data for sewage treatment plant. It will simplify the assessment process for surface water environmental damage and greatly improve the efficiency of environmental justice and environmental damage compensation.

Introduction

Over the years, environmental damage issues have been discussed in judicial courts in China [1]. Judicial appraisal of environmental damage has become an important direction of environmental protection practice [2]. The result of environmental damage appraisal and evaluation is an important basis for determining the amount of compensation in environmental justice [3]. The compensation for pollution is important for protecting the environment in China.

Virtual disposal cost method, commonly referred to as VC, is a method for quantifying environmental damage costs and calculating the scale of compensatory restoration required to offset those service losses. The virtual disposal cost method is applicable to the following situations: First, if the surface water environment has been naturally restored within two weeks; second, the damaged surface water environment cannot be fully recovered through the restoration project; and third, the cost of implementing the restoration project is much greater than the expected return [4].

The peer-reviewed literature contains very little on VC. China has not yet formed a complete legal system of civil compensation for environmental pollution. The contents of the relevant parties are mainly stipulated in the principles and procedures [5]. There are two main technique guidelines to assess the pollution damages to the environment in China, both under the Recommended Methods for Environmental Damage Assessment and Evaluation and the Recommended Methods for Environmental Damage Assessment in Emergency Response Stages.

Despite the lack of guidance and peer-reviewed literature, VC has increasingly become the tool of choice to quantify the environmental damage costs in China [6]. This paper applies the virtual cost value estimation method to analyze the case of environmental damage caused by excessive wastewater discharge. We analyze the VC method and the provision of reference data for sewage treatment plant. It will simplify the assessment process for surface water environmental damage and greatly improve the efficiency of environmental justice and environmental damage compensation.

Methods

Virtual Disposal Cost Method in China

The virtual disposal cost method to quantify the value of environmental damage should consider the assessment of regional environmental functional zone type, environmental quality level, local industry environmental management requirements, wastewater hazard and environmental damage level and duration. The cost can be calculated as
\[ E_v = E_d + E_p + E_0 \]  

Where, \( E_v \) is the environmental damage value calculated by virtual disposal cost method (yuan), \( E_d \) is the virtual disposal costs (yuan), \( E_p \) is the costs occurred during the damage (yuan), called as period costs: \( E_0 \) is the other fees caused by the environment damage.

Virtual disposal costs \( (E_d) \) refer to the expenditures required to control pollutants released into the environment in accordance with current governance technologies and levels. For the virtual treatment cost of excessive discharge of sewage, that is, according to the unit treatment cost of wastewater in different industries, the type of functional area of the receiving water body and the degree of damage, the environmental damage compensation fee is determined. The virtual disposal costs can be calculated as

\[ E_d = c \times Q \times S \times R \]  

Where, \( E_d \) is the virtual disposal costs (yuan), \( c \) is the cost of wastewater treatment per ton (yuan/t), \( Q \) is the total amount of the wastewater discharge (t), \( S \) is the environmental function sensitivity coefficient, \( R \) is an adjustment factor which determined by the hazards of the pollutants \( (R_1) \), the duration of the damage \( (R_2) \), and the impact of the damage \( (R_3) \), respectively.

Period costs \( (E_p) \) refers to the cost of water supply loss from drinking water sources. It can be calculated as

\[ E_p = p \times y \times n \times t \]  

Where, \( p \) is the price of water where the damage occurred(yuan/t), \( y \) is the daily water consumption per person(t/d), \( n \) is the number of people in the service area of the water plant where the damage occurred, \( t \) is the time of loss of water supply function in drinking water sources(d).

The other expenses \( (E_0) \) include the pollutants control cost except the virtual disposal costs and period costs. It depends on the actual costs incurred.

**Unit Pollutant Treatment Cost**

The unit pollutant treatment cost refers to the average cost of pollutant treatment of industrial enterprises or sewage treatment plants in the place where environmental incidents occur, which including depreciation of fixed assets.

There are two methods to decide the unit disposal costs \((c)\). The one is fee standard method, which means the latest charging standard for treating the same industry wastewater in centralized sewage treatment facilities or hazardous waste treatment enterprises. The other is investigation method, that is to obtain the average unit pollution control cost of the same or similar production process, product type and treatment process in the surrounding area in the most recent years. That includes energy consumption, equipment maintenance, personnel wages, management fees, pharmacy fees and other related costs. The unit disposal cost is determined preferentially by the charging standard method, followed by the investigation method or the reference treatment cost method.

**The Amount of Wastewater Discharge**

According to the pollutant discharge standard and the monitoring concentration data of the effluent pollutant discharge, the amount of wastewater discharge can be calculated as

\[ Q = \sum_{d=1}^{n} (C_d - C_0) \times W_d \times 10^{-6} \]  

Where, \( C_d \) is the monitoring concentration of the pollutants\((\text{mg/L})\), \( C_0 \) is the standards of the pollutants which decided by the national policy \((\text{mg/L})\), \( W_d \) is the amount of the sewage treatment\((\text{m}^3)\).
Environmental Function Sensitivity Coefficient and Adjustment Factor

In order to accurately estimate the value of environmental damage, the virtual cost method also introduces environmental function sensitivity coefficient and environmental damage adjustment coefficient.

The environmental function sensitivity coefficient is determined according to the functional area where the pollution occurs, reference as Table 1. I is the source water and national nature reserve. II is a first-class protection zone for concentrated drinking water, a rare aquatic habitat, a fish and shrimp spawning ground, and a feeding ground for juveniles and young fish. III centralized drinking water, surface water source secondary protection area, fish and shrimp wintering field, migratory channel, aquaculture area and other fishery waters and swimming areas. IV is a general industrial water use area and an entertainment water area that is not directly in contact with the human body. V is the agricultural water area and the general landscape required waters. The environmental damage adjustment factor is determined according to the degree of environmental damage, reference as Table 2.

<table>
<thead>
<tr>
<th>Environmental function area</th>
<th>S</th>
</tr>
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<tbody>
<tr>
<td>I</td>
<td>&gt;8</td>
</tr>
<tr>
<td>II</td>
<td>6−8</td>
</tr>
<tr>
<td>III</td>
<td>4.5−6</td>
</tr>
<tr>
<td>IV</td>
<td>3−4.5</td>
</tr>
<tr>
<td>V</td>
<td>1.5−3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Degree of environmental damage</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Harm of pollutants</td>
<td></td>
</tr>
<tr>
<td>Hazardous waste, hazardous chemicals</td>
<td>1.1</td>
</tr>
<tr>
<td>Harmful wastewater containing phenol, mercury, heavy metals, cyanide and persistent organic pollutants</td>
<td>1.1</td>
</tr>
<tr>
<td>Others</td>
<td>1.0</td>
</tr>
<tr>
<td>Damage duration</td>
<td></td>
</tr>
<tr>
<td>More than 1 year</td>
<td>1.2</td>
</tr>
<tr>
<td>Between 2 weeks to 1 year</td>
<td>1.1</td>
</tr>
<tr>
<td>Less than 2 weeks</td>
<td>1.0</td>
</tr>
<tr>
<td>Impacts</td>
<td></td>
</tr>
<tr>
<td>Affect water function</td>
<td>1.3</td>
</tr>
<tr>
<td>Does not affect water function</td>
<td>1.0</td>
</tr>
</tbody>
</table>

Case Study

Wastewater Treatment Plant

The designed scale of the sewage treatment plant is 19,500 m³/d. The plant adopts the modified Aubel oxidation ditch secondary biological treatment process and turntable filter for nitrogen and phosphorus removal. The pollutants discharged by the plant are total phosphorus, ammonia nitrogen and chemical oxygen demand. The water treated by the sewage treatment plant is directly discharged into the river which belongs to a type III water area according to the environmental function zone plan.

The Value of Surface Water Environmental Damage

We selected the statistical data of 13 CASS processes and 21 domestic wastewater treatment plants in the area, and conducted on-the-spot investigations on two sewage treatment plants to measure the chemical oxygen demand (COD) of the pollution treatment plant. The unit management cost is 2.7 yuan/kg, which is 2.7 yuan/pollution equivalent.

According to the “Environmental Taxes and Equivalent Values Table” in the “Environmental Protection Tax Law of the People’s Republic of China”, the chemical oxygen demand pollution equivalent value is 1 kg, the ammonia nitrogen pollution equivalent value is 0.8 kg, and the total
phosphorus pollution equivalent value is 0.25 kg, the chemical oxygen demand unit pollutant treatment cost is 2.8 yuan / kg, ammonia nitrogen unit pollutant treatment cost is 3.5 yuan / kg, total phosphorus unit pollutant treatment cost is 11.2 yuan/kg.

In the actual measurement process, since the sewage treatment plant has a synergistic effect on the removal of chemical oxygen demand and ammonia nitrogen, the virtual treatment cost of the two types of super-standard pollutants takes the maximum value of the virtual treatment cost of each super-standard pollutant.

According to the report of pollutant discharge from the sewage treatment plant, and the pollutant discharge from urban sewage treatment plants standard (GB18918-2002), in which COD is 50 mg/L, ammonia nitrogen is 5 mg/L, total phosphorus is 0.5 mg/L, and the wastewater treatment plant exceeds the standard emission factor as chemical oxygen demand, ammonia nitrogen and total phosphorus respectively. Calculate the super-scalar amount of chemical oxygen demand, total phosphorus and ammonia nitrogen in the nine sewage treatment plants from 2016 to August 2017. The calculation results show that the total amount of chemical oxygen demand, total phosphorus and ammonia nitrogen exceeds 1.30 tons and 2.02 tons respectively. 59.66 tons, of which the maximum excess of chemical oxygen demand, total phosphorus and ammonia nitrogen appeared in the sewage treatment plant, and the maximum super-standard amount of ammonia nitrogen reached 54.48 tons. As for the river section which received the water of the sewage treatment plant is a type III water area. According to the principle of multiple determination, the amount of ecological environmental damage of the event should be five times the virtual treatment cost. The virtual disposal costs for $E_{COD}$, $E_{TP}$, and $E_{NH3+}$ is 8019.9, 78351.85 and 953329 yuan respectively.

In this case, there is no period costs, because of the water self-purification ability. The virtual disposal cost is equal to the value of the environment damage.

Conclusion

In this study, we have analyzed the virtual disposal costs method in the assessment of environment damage. In summary, virtual disposal costs method can be used to quantify the value of surface water damage. Especially on the cases as follows. First, when the environmental damage events cannot be observed or monitored in time, the environment has been naturally restored. Second, environmental damage cannot be fully recovered. Third, the implementation of recovery projects is far greater than its benefits.

Introducing the correction factor and considering the damage during the period and other necessary reasonable expenses to make the surface water environmental damage cost calculated by the virtual disposal costs method closer to the damage value. As the environmental sensitivity coefficient interval value has uncertainty in the actual operation, we suggest that the interval value should be changed to determined value. There is a double calculation of the period loss and $R^2$, which is a problem worthy of further study in the application of the virtual cost value estimation method.

References

