A Study on the Estimation Method of Wetland Purification Capacity to Surface Runoff

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Abstract—Wetland is an important regulator of water quality, which has great potential for purifying water pollutants. This paper proposes two methods to estimate water quality purification capacity: the single-factor water quality purification rate and the comprehensive water quality purification rate. It takes the area, from Long’an Bridge to Zhaosanliangzi which lies at the end of Zhongyin main channel in Zhalong wetland, as the demonstration zone to study the water quality purification capacity of wetland. At the same time, by taking the inlet section, Long’an Bridge as the Control Section, and taking the outlet section, Zhaosanliangzi which is at the end of Zhongyin main channel, as the comparable section, we apply two estimation methods to analyze the purification capacity of Zhalong wetland to surface runoff, so as to show the advantages of the single-factor quality purification rate and the comprehensive water quality purification rate in estimating the water quality purification capacity of wetland.

Keywords—Wetland; Surface runoff; Purification capacity; Pollution equivalent

I. INTRODUCTION

As is known to everyone, wetland is an important regulator of water quality, which has great potential for purifying water pollutants. Wetland can degrade toxic material and purify water through the function of reed bed and wetland vegetation and the chemical, biological processes to absorb, fix and transform the nutrition contents in soil and water [1-2]. The study on the wetland purification mechanism is getting mature [3-4]. There are various pollutants in water, which could cause comprehensive impacts on the environment. In this paper we take the Zhalong Wetland as a demonstration zone to study the method for estimating the water quality purification capacity of wetlands.

II. CALCULATION METHOD OF PURIFICATION RATE

Most of related researches at home and abroad only use the relationship between the pollutants concentration of inlet and outlet sections to estimate the purification capacity of wetland [5-6]. The major weakness is that they can not fully reflect the wetland purification capacity to surface runoff. In this paper, we will estimate the function of wetland purification in two ways: the single-factor quality purification rate method and the comprehensive water quality purification rate method.

A. Single-factor quality purification rate method

Under normal circumstances, when surface runoff flows through the wetland, water is purified accompanied by the closure of surface runoff. The pollutant in surface runoff is significantly decreased. Therefore, we can estimate the purification efficiency of wetland to surface runoff according to the change of water quality single factor quality of the inlet and outlet sections. It is called single-factor quality purification rate.

The formula of single-factor quality purification rate is as following:

\[
J(\%) = \frac{C_{i\ up} \cdot Q_{up} - C_{i\ down} \cdot Q_{down}}{C_{i\ up} \cdot Q_{up}} \times 100\% \tag{1}
\]

where \( J \) is the water quality purification rate. When \( J \) is positive, the wetland has purification function; but when \( J \) is negative, the wetland doesn’t have purification function, and the pollution will be more serious. \( C_{i\ up} \) and \( C_{i\ down} \) respectively represent the water quality parameters concentration items of up-section I and down-section (mg/L). \( Q_{up} \) is the water flow of up-section, and \( Q_{down} \) is the water flow of down-section.

B. Comprehensive water quality purification rate method

Generally speaking, there are various pollutants in water which could cause comprehensive impacts on the environment. If we estimate the wetland purification rate only by considering the concentration and quality of single water quality parameter, it can not totally reflect the water quality purification capacity of wetland. Hence, a comprehensive approach is urgently needed.

There are various pollutants in water. And there are great differences among the pollutant hazards in Biological character, Chemical character, Physical character, and Comprehensive character, which cannot be simply added up. We need to define a basic volume to measure the pollution damage degrees of various pollutants. It is objective that we take the damage degrees of environment (pollution equivalent [7]) caused by pollutants as pollutant computation benchmark. Hence, the pollution equivalent (State, 2002) is a basic volume...
of measuring the damage degrees of various pollutants. The pollution equivalent value is the amount of pollution equivalent, which has non-dimensional. It is called comprehensive water quality purification rate. The formula is as following:

\[ N = \sum_{j=1}^{m} \frac{N_j}{V_j} \]  

(2)

where \( V_j \) is the pollution equivalent basic value of pollutant \( J \) in wastewater (kg); \( W_j \) is the net amount of pollutant \( J \) in wastewater per unit time (kg); \( N_j \) is the pollution equivalent value of pollutant \( J \) in wastewater per unit time; \( N \) is the total pollution equivalent value in wastewater per unit time, and \( m \) is the category number of pollutant in wastewater.

In the paper, we use pollution equivalent to measure the harmfulness of different pollutants. According to the pollution equivalent we integrally analyze the changes of runoff pollution degrees at inlet and outlet sections, and estimate the comprehensive purification capacity of wetland to surface runoff. The formula of comprehensive water quality purification rate is as following:

\[ J(\%) = \frac{N_{up} - N_{down}}{N_{up}} \times 100\% \]  

(3)

where \( N_{up} \) is the total pollution equivalent value of water at up-section, and \( N_{down} \) is the total pollution equivalent value of water at down-section.

III. CASE STUDY

Zhalong Wetland lies in the downstream of Wuyuer River in the northern part of northeast China Plain, where the swamp area is over 1400 km\(^2\) (Guo et al., 2005). The main vegetation in wetland is meadow grassland vegetation. Its coverage is up to 80%. It is an ideal reach for the research on the wetland purification capacity. Therefore, we choose the Zhalong Wetland as the demonstration zone to study the water purification function by taking the inlet section, Long'an Bridge, as the control section (up-section), and taking the outlet sections, five monitoring sections which is at the end of Zhongyin main channel Zhaosanliangzi, as the comparable sections (down-section). From September to October in 2003 we had taken seven samples, and we had monitored 8 water quality parameters. Hence, in this paper we do the purification analysis according to the eight water quality parameters.

A. Results

The single-factor water quality purification of sections can be calculated (see Table I). The pollution equivalent value and the purification rate of sections can be calculated (see Table II).

### TABLE I. SINGLE FACTOR QUALITY PURIFICATION OF SECTIONS (%)

<table>
<thead>
<tr>
<th>Subject</th>
<th>Sep.12th</th>
<th>Sep.28th</th>
<th>Oct.19th</th>
<th>average</th>
</tr>
</thead>
<tbody>
<tr>
<td>DO</td>
<td>72.43</td>
<td>73.47</td>
<td>76.94</td>
<td>74.3</td>
</tr>
<tr>
<td>COD</td>
<td>46.14</td>
<td>75.25</td>
<td>74.45</td>
<td>65.3</td>
</tr>
<tr>
<td>NH(_3)-N</td>
<td>80.59</td>
<td>73.64</td>
<td>74.70</td>
<td>76.3</td>
</tr>
<tr>
<td>TP</td>
<td>99.03</td>
<td>88.58</td>
<td>77.63</td>
<td>88.4</td>
</tr>
<tr>
<td>TN</td>
<td>86.35</td>
<td>79.77</td>
<td>81.38</td>
<td>82.5</td>
</tr>
<tr>
<td>SS</td>
<td>80.88</td>
<td>85.88</td>
<td>82.59</td>
<td>83.1</td>
</tr>
<tr>
<td>NO(_3)-N</td>
<td>90.96</td>
<td>80.82</td>
<td>74.43</td>
<td>82.1</td>
</tr>
<tr>
<td>NO(_2)-N</td>
<td>99.15</td>
<td>92.14</td>
<td>92.75</td>
<td>94.7</td>
</tr>
</tbody>
</table>

### TABLE II. POLLUTION EQUIVALENCE VALUE & PURIFICATION RATE OF SECTIONS

<table>
<thead>
<tr>
<th>Subjec</th>
<th>Sep.12th</th>
<th>Sep.28th</th>
<th>Oct.19th</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>COD</td>
<td>42094</td>
<td>22674</td>
<td>55564</td>
</tr>
<tr>
<td>NH(_3)-N</td>
<td>2685</td>
<td>521</td>
<td>1274</td>
</tr>
<tr>
<td>TP</td>
<td>3251</td>
<td>32</td>
<td>714</td>
</tr>
<tr>
<td>Zn</td>
<td>276</td>
<td>42</td>
<td>140</td>
</tr>
<tr>
<td>SS</td>
<td>46449</td>
<td>8879</td>
<td>22302</td>
</tr>
<tr>
<td>Total</td>
<td>95510</td>
<td>32319</td>
<td>79994</td>
</tr>
<tr>
<td>Purificat.</td>
<td>66.2</td>
<td>78.3</td>
<td>75.4</td>
</tr>
</tbody>
</table>

B. Analysis and Result

The date in table I shows that the purification capacity of Zhalong wetland to water quality parameters is dissimilar. The single-factor quality purification rate ranges from 65.3% to 94.7%, and the average purification is 80.8%. The water parameters which have most obvious purification function are phosphorus, nitrite nitrogen and nitrate nitrogen, whose purification rate all exceed 88%.

According to the water quality, flow and corresponding pollutants’ pollution equivalent of Long’an Bridge and Zhaosanliangzi sections, the pollution equivalent value and purification rate of the inlet and outlet sections can be calculated (see Table II). The comprehensive water quality purification rates of inlet and outlet sections range from 66.2% to 78.3%, and the average comprehensive purification rate of water quality is 73.3%, which shows that the water pollution harmfulness reduces roughly 73.3% because of the wetland purification.
We can conclude that the wetland has strong purification capacity. Because of the influence of surface evaporation loss, soil seepage loss, when surface runoff runs through wetland, wetland has strong retention capacity to surface runoff. Wetland has the unique function of adsorption, accumulation, degradation and deposition of pollutants, suspended solids, and nutrition in water. After depositing, the nutritive matters in water are absorbed by the wetland vegetation as nourishment, and then changed and stored by chemical and biological process. They translate underlying pollutants into resources. Consequently, the concentration of pollution in water is decreased, and water quality is purified.

IV. CONCLUSION

As the single-factor quality purification rate method and the comprehensive water quality purification method refer to the change of surface runoff flow and the difference of pollutant toxicity, the comprehensive water quality purification rate is more complete than the single factor water quality purification rate.

Though wetland has the function of sediment, it is limited. If wetland accepts excessive sediment, the water quality purification capacity will significantly decrease. Thus, the best way is to release these substances to the wetland as little as possible.

REFERENCES