Study on the Release of Nutrient Salt from Soil in Baiyangdian Area

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Abstract. As a national key protection and restoration project, Baiyangdian has an important and far-reaching significance. As one of Baiyangdian's lakes, Zaozhadian needs to adapt to local conditions and adopt a near-natural method of "returning farmland to wetland" for treatment and restoration. According to the difference of total nitrogen (TN) and total phosphorus (TP) content in the soil, soil nutrient release experiments were conducted to explore the effect of soil nutrient release on the quality of overlying water. The results showed that the amount of nutrients released was different in different soils, the total nitrogen release range was 0.19-0.77 mg/L, the total phosphorus release range was 0.03-0.4 mg/L, and the ammoniacal nitrogen release range was 0.16-0.34 mg/L.

Introduction

Baiyangdian is located in Xiongan, Hebei Province. As the national development plan of Xiongan, the importance of Baiyangdian goes without saying. Due to the large number of regions, different regions need to be adapted according to the local conditions. Therefore, considering the actual situation of Zaozhadian, it was decided to carry out the ecological restoration of Zaozhadian from “returning farmland to wetland”. The project faces the risk of large amounts of nutrient release, which could lead to drastic changes in the quality of the overlying water. At present, there are few articles about the nitrogen and phosphorus transfer of soil-water interface based on laboratory simulation by domestic and foreign scholars. And there are fewer studies to explore the characteristics of nitrogen and phosphorus loss in soil and the characteristics of nitrogen and phosphorus release from overlying accumulated water[1].

Materials and Methods

Experimental Design

In this experiment, a device was used in the room to simulate the soil water immersion. The device used was a customized tube made of acrylic. The tube was cylindrical, with a bottom size of 10 cm × 10 cm, and a height of 100 cm. The lower end was closed and the upper end was opened. The tube filled with soil up to a height of 20 cm, and the height of the overlying water was 60 cm, and was used for comparison to simulate the actual overlying water flow.

The soil used in the experiment was cultivated soil of Zaozhadian, and crops such as wheat and corn were planted for a long period of time, and pesticides and fertilizers were applied. The collected soil samples were topsoil of 0-20 cm in different cultivated areas.

A total of 6 control groups were set up in the experiment, with the same environmental conditions, half agitated and half without agitated, labeled D, E, J, K, M, O, D Stir, E Stir, J Stir, K Stir, M Stir, O Stir.

The contents of total nitrogen (TN) and total phosphorus (TP) in soil samples before flooding are shown in table 1.

Sampling and Analysis Methods

Water samples were collected at a depth of 20 cm. Overlay water was configured according to Class
III, the configuration results are, TN=1.52 mg/L, TP=0.204 mg/L, NH₄⁺-N=0.984 mg/L. Samples were taken through a needle, and relevant indicators were analyzed in accordance with the national standard method, including the main indicators TN, TP and ammoniacal nitrogen.

Table 1. Indicators of total nitrogen and total phosphorus in six cultivated soils.

|   | TN(g/kg) | TP(g/kg) |
|---|---------|---------|
| D | 1.49    | 1.386   |
| E | 1.46    | 1.253   |
| J | 1.47    | 1.201   |
| K | 1.19    | 0.714   |
| M | 1.4     | 1.031   |
| O | 1.22    | 0.884   |

Results and Discussion

Characteristics of Nutrient Release in Different Soils—TN

According to Figures 3.1 and 3.2, the TN concentration of the overlying water was 1.514 mg/L, and the TN release concentration of soil nutrients was 0.19-0.77 mg/L. Agitation can increase the concentration and rate of TN release.

After the release, the water in the upper layer exceeded the Class IV, but with the progress of the experiment, the TN gradually decreased and reached the Class III in the later period.

The soil has the ability to absorb nitrogen, phosphorus and other nutrients. In the later stage of the experiment, due to lack of oxygen at the bottom of the soil, denitrifying bacteria played a major role in denitrification, thereby reducing the TN concentration.

At the beginning of the experiment, there was a large difference of TN at the soil-water interface. Moreover, the soil- water interface was activated by stirring, which accelerated the release of TN. Then, the difference in TN content in the soil-water interface gradually narrowed, the diffusion
weakened, and the release reached to the equilibrium, and the release flux decreased to 0 in about 11 days[2].

**Characteristics of Nutrient Release in Different Soils—TP**

![Figure 5. Characteristics of total phosphorus release in different soils after stirring.](image1)

![Figure 6. Characteristics of total phosphorus release in different soils.](image2)

It can be seen from Figures 3.5 and 3.6 that the TP concentration in surface water was 0.208 mg/L, the TP release concentration of soil nutrients was 0.03-0.4 mg/L, and the TP release concentration was 0.23-0.6 mg/L without stirring. The results indicated that agitation can increase TP release. The release of phosphorus can cause water from class III to IV, and even V.

With the progress of the experiment, the TP content continued to decline, and eventually reached the Class III standard, and the soil and water were in an anaerobic state. On the one hand, phosphorus accumulates Fe$^{3+}$ and reduces Fe$^{2+}$, on the other hand, the adsorption and release of phosphorus in the colloid also has a good adsorption effect on phosphorus in the soil, and various factors work together to cause the release of phosphorus[3].

This is because there is a big difference in the TP content between the interstitial water and the overlying water, the phosphorus nutrient salt diffused, and the fluctuation also affects the accumulation of phosphorus in the overlying water [4].

**Characteristics of Nutrient Release in Different Soils—Ammoniacal Nitrogen**

![Figure 9. Ammoniacal nitrogen release characteristics of different soils after stirring.](image3)
It can be seen from figure 3.9 and 3.10 that the concentration of ammoniacal nitrogen in overburden water was 1.025 mg/L and the release range of soil nutrient ammoniacal nitrogen was 0.16-0.34 mg/L. The results showed that stirring can promote the release of ammoniacal nitrogen, but it has little effect on the total release of ammoniacal nitrogen.

The release of ammoniacal nitrogen doesn't make the water reached IV, with the experiment going on, the ammoniacal nitrogen concentration of overlying water reaches III.

At the beginning, the ammoniacal nitrogen in the soil-water interface was very different, which caused the ammoniacal nitrogen in the overlying water to quickly move into the soil, followed by a rapid increase in ammoniacal nitrogen release.

Summary

TN: the average TN content in soil is 1.38 g/kg, and the average TN release in overlying water is 1.21 mg/kg. The water moves to IV after the release, so the release can cause pollution.

TP: the average TP content in soil is 1.02 g/kg, and the average TP release in overlying water is 0.26 mg/kg. Release can make water reached IV, even V, which can cause pollution.

Ammoniacal nitrogen: the average total release of ammoniacal nitrogen is 1.3 mg, and the average release of ammoniacal nitrogen in the overlying water is 0.86 mg/kg. Release doesn't make the overlying water reached IV, so it won't cause pollution.

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