Study on characteristics of the sediment release in Chaohu Lake

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Abstract. Through the indoor static simulation test on the nitrogen and phosphorus released characteristics of the sediment in Chaohu Lake, the released characteristics of TN and TP in the sediment of Chaohu Lake under different conditions such as different temperatures, different pH values and the disturbance of overlying water and whether the aquatic plants were planted on the sediment were analyzed or not. The results show that, it is beneficial to the release of sediment contaminants with increasing temperature. When pH is neutral, which is not adverse to the release of sediment pollutant, while disturbing overlying water can accelerate the release of pollutant in the sediment, and the effect of eliminating the water body TN is obvious, but the effect of eliminating the water body TP is not obvious. When we plate the aquatic plants, it is good for the release of pollutant in sediment and the improvement of water quality, This can provide a theoretical basis for the control of sediment pollution in Chaohu Lake through the above test.

Keywords: sediment, released characteristics.

1. Preface
Chaohu Lake is located in the middle of Anhui Province in the middle and lower reaches of the Yangtze River, between the Yangtze River and Huaihe River. With the population growth and economic development, the eutrophication of Chaohu Lake is becoming more and more serious. With Chaohu Lake being built into a lakeside tourism city, the government has strengthened the pollution control of Chaohu Lake, so that the external pollution of Chaohu Lake has been effectively controlled. After the external pollution control reaches a certain degree, the internal pollution is more prominent. River sediment is an important part of water body. The concentration of various pollutants in sediment is often several orders of magnitude higher than that in overlying water, which makes sediment become the source of pollution. Sediment deposited a large number of pollutants, slowly and persistently released to the water body, leading to secondary pollution of the water body [1], and endogenous pollution is an important factor causing eutrophication of the water body [2]. The release of pollutants from sediment is a very complex dynamic process, and the release amount is affected by many factors, such as temperature, pH, biological activity, wind and wave disturbance. How to formulate feasible eutrophication control measures, we need to master the pollutant release law of sediment under the influence of various factors. In this paper, the release characteristics of pollutants in the sediment of Chaohu Lake were studied in order to provide the basis for the pollution control of Chaohu Lake.
2. Materials and methods

1. Materials and methods sample sampling: in November 2017, Yuxikou, Chaohu City, was selected to collect surface sediment samples with a cylindrical applicator, filter out the moisture and remove the impurities in the sediment. The collected sediment was mixed evenly and taken back to the laboratory and placed in a 4 ℃ refrigerator for standby. Test method: put a certain amount of sediment into the container, then keep the sediment undisturbed according to the water soil ratio of 10:1, slowly add water sample along the container wall, and then carry out the test according to the setting.

(1) Temperature control: set at 4 ℃, 11 ℃, 20 ℃, and put the experimental device into the biochemical constant temperature incubator

(2) Control of pH value: adjust the pH value of the solution with dilute hydrochloric acid and sodium hydroxide during water distribution, and adjust the pH value regularly during the release test Monitor and correct the pH value to ensure that the prepared overlying water basically maintains the neutral, acidic and alkaline pH value.

Water quality analysis: TN (total nitrogen) and TP (total phosphorus) in overlying water of sediment were determined at regular intervals. TN was digested by alkaline potassium persulfate and determined by ultraviolet spectrophotometry; TP was determined by ammonium molybdate spectrophotometry.

3. Results and discussion

3.1. Effect of overlying water temperature on TN and TP release from sediment

Generally, the solubility of chemical substances and the adsorption and desorption between them and other substances are related to temperature. The release of nitrogen and phosphorus in sediment is determined at different temperatures. Three common water temperatures of 4 ℃, 11 ℃ and 20 ℃ are selected for the test. The results are shown in Fig. 1 and FIG. 2.

![Fig. 1 total nitrogen release curve at different temperatures](image1)

![Figure 2 total phosphorus release curve at different temperatures](image2)
It can be seen from figures 1 and 2 that, with the change of time, the release of total nitrogen and total phosphorus at each temperature increased gradually at first, and the release of total nitrogen reached the maximum at each temperature on the 10th day, and the release of total phosphorus reached the maximum at each temperature on the 12th day, and then gradually decreased and tended to be flat. The results showed that the release of nitrogen and phosphorus in sediment was $20^\circ C > 11^\circ C > 4^\circ C$. With the increase of temperature, the microbial metabolism was enhanced, and the decomposition rate of organic matter was accelerated. The nutrients in sediment could be transformed into nitrogen and phosphorus and released into the overlying water, resulting in the increase of nitrogen and phosphorus content. With the decrease of temperature, microbial metabolism weakened, and the amount of nitrogen and phosphorus released into the overlying water decreased. The release of TN and TP at $4^\circ C$ and $11^\circ C$ had no significant difference at the same time, but the release of TN and TP at $20^\circ C$ was significantly higher than that at the former two temperatures. This may be related to the biological characteristics of microorganisms. At $20^\circ C$, it is usually the suitable growth temperature for microorganisms, which promotes bioturbation and mineralization, increases oxygen consumption and decreases dissolved oxygen, resulting in the decrease of EH in the sediment layer and the release of nitrogen and phosphorus. $20^\circ C$ is conducive to microbial decomposition of nutrients in sediment, thus accelerating the release of nitrogen, phosphorus and other nutrients in sediment. This is consistent with the release of nitrogen and phosphorus from June to September in Chaohu Lake. At this time, Chaohu Lake is prone to eutrophication, resulting in the flooding of cyanobacteria in summer.

3.2. Effect of overlying water pH on TN and TP release from sediment

The results are shown in Fig. 3 and Fig. 4. According to Fig. 3, TN in the overlying water increases first and then decreases, but in the first two days, TN content in the overlying water does not change much, which is different from that in the previous stage, because sediment microorganisms need an adaptation process under the new pH conditions. The results showed that the activity of microorganism decreased, and the ability of decomposing sediment nutrients decreased. With the adaptation to the new pH conditions and the improvement of microbial activity, the TN content in overlying water increased rapidly from the second day, and reached the maximum value at each pH condition on the 10th day. It can be seen from Fig. 4 that the TP content in the overlying water increases gradually at pH 4.5 and 7.2, and then tends to balance, keeping the content unchanged, while the TP content in the overlying water tends to increase first and then decrease at pH 9.5. Under the condition of pH 7.2, the TP content of overlying water changed little with time, indicating that the P element released little from the sediment during the whole process. Combined with figures 3 and 4, it can be inferred that under neutral conditions, TN and TP release is the smallest, while under acid or alkaline conditions, N and P nutrient elements in sediment are easy to release into overlying water.

![Fig. 3 total nitrogen release curve at different pH](image1.png)

![Fig. 4 total phosphorus release curve at different pH](image2.png)
3.3. **Influence of overlying water mixing or not on TN and TP release from sediment**

Disturbance is the main physical factor affecting the interface reaction between shallow lake and sediment. Chaohu Lake is an important place for fishery and fishing activities. Human life and production activities inevitably cause disturbance to the lake water. Disturbance promotes the suspension of sediment, increases the nutrient exchange between sediment and overlying water, and accelerates the diffusion of sediment interstitial water, which increases the nutrient exchange. The elements are released to the water interface [5]. Therefore, it is necessary to consider whether the overlying water is stirred or not on the TN and TP release of sediment, and set the disturbance (the speed of electric stirrer is 300r/min, continuous disturbance for 2 hours) and static overlying water on the TN and TP release of sediment. The results are shown in Fig. 5 and Fig. 6.

**Fig. 5** total nitrogen release curve with and without disturbance

**Fig. 6** total phosphorus release curve with and without disturbance

It can be seen from figures 5 and 6 that the TN and TP contents of the overlying water reached the maximum value in the first two days, and then decreased rapidly. This is because the disturbance accelerated the rapid release of various nutrients in the sediment into the water body. It can be seen from the test that the release of nutrients in the sediment was accelerated by disturbing the sediment, and these releases occurred in a short time. It can be seen from Figure 5 that by the end of the experiment on the 16th day, the TN content of the disturbed overlying water is much lower than that of the undisturbed overlying water. This is mainly because part of the nitrogen in the disturbed overlying water first reacts to produce ammonia nitrogen, which is disturbed to promote its volatilization. At the same time, the
disturbance accelerates the contact between the water body and the oxygen in the air, which promotes the nitrification of nitrogen, which is conducive to the elimination of nitrogen in the water body. As time goes on, TN content in the disturbed overlying water keeps decreasing until it reaches the minimum. It can be seen from Fig. 6 that TP content began to release rapidly. With the passage of time, TP content fluctuated in a certain range, and increased slightly at the end of the experiment. At the end of the experiment, there was no significant difference in TP content between disturbed and undisturbed water. Through the above experiments, it can be seen that the disturbance can play a certain role in the removal of nitrogen in water, but the effect on the removal of phosphorus is not obvious.

3.4. Effects of aquatic plants on TN and TP release from sediment and water quality

Nitrogen and phosphorus are essential nutrients for plant growth. The growth of aquatic plants needs to absorb a lot of nitrogen and phosphorus and other nutrients from the surrounding environment, so the use of aquatic plants to remove nitrogen and phosphorus and other nutrients in water and sediment is widely used in the current treatment of water pollution [6]. The effects of aquatic plants on TN and TP release from sediment and water quality were investigated through experiments. Five Eichhornia crassipes (planting density of 30cm² / plant) were set and compared with the blank control without aquatic plants. The results are shown in Fig. 7 and Fig. 8.

![Fig. 7 total nitrogen release curve of planting aquatic plants and blank](image)

Fig. 7 total nitrogen release curve of planting aquatic plants and blank

![Fig. 8 total phosphorus release curve of planting aquatic plants and blank](image)

Fig. 8 total phosphorus release curve of planting aquatic plants and blank

It can be seen from Figures 7 and 8 that the contents of TN and TP in the blank water increased at first and then decreased, which is consistent with the TN and TP in the previous test water. The main reason is that a large number of nutrients in the sediment were released into the overlying water in the
early stage, which made the TN and TP in the blank water show an upward trend. With the release of nutrients in the sediment into the water, various biochemical reactions occurred, resulting in the TN and TP content in the later stage. The amount of water is on a downward trend and tends to balance at a certain time. The contents of TN and TP in the water with Eichhornia crassipes were the same as those in the control water. However, it can be seen from Figures 7 and 8 that the contents of TN and TP in the water with Eichhornia crassipes were the same as those in the control water.

TP content was lower than that of control water in each period. The results showed that planting water hyacinth had a good effect on the removal of nitrogen and phosphorus in water. The effects of planting Eichhornia crassipes on nitrogen and phosphorus in sediment can be compared by measuring the content of TN and TP in sediment before and after the experiment, as shown in Table 1.

Table 1 comparison of TN and TP contents in sediment of Chaohu Lake after planting aquatic plants with that of YuanChaohu Lake

| Project                                      | TN (g/kg) | TP (g/kg) |
|----------------------------------------------|-----------|-----------|
| The original sediment of Chaohu Lake         | 1.385     | 0.693     |
| Sediment of Chaohu Lake after planting aquatic plants | 1.181     | 0.515     |

It can be seen from the above table that after a period of time, the average content of TN and TP in the sediment planted with aquatic plants is lower than that of the blank control, which indicates that planting aquatic plants can promote the release of nutrients in the sediment and has a certain effect on the control of sediment pollution.

4. Conclusion
Based on the analysis of the release characteristics of TN and TP in Chaohu Lake sediment under different conditions, the following conclusions are drawn:

1. The influence of temperature on the release of nitrogen and phosphorus from sediment was $20 \degree C > 11 \degree C > 4 \degree C$. With the increase of temperature, the release of TN and TP from sediment increased gradually.

2. Under neutral pH condition, TN and TP release from sediment is the smallest, while under acid or alkaline condition, TN and TP release from sediment is much larger than that under neutral condition, especially under alkaline condition. After 14 days, TP content in overlying water reaches 3.10mg/l at pH9.5, while TP content is only 0.24mg/l at pH7.2.

3. Disturbance of overlying water can accelerate the release of nutrients in sediment, and has obvious effect on the removal of TN in water body, but has no obvious effect on the removal of TP in water body.

4. The contents of TN and TP in the water body planted with Eichhornia crassipes were lower than those in the control water body at each time period. The results showed that planting water hyacinth had a good effect on the removal of nitrogen and phosphorus in water. The average contents of TN and TP in the sediment after planting Eichhornia crassipes were compared with that of the blank control sediment without planting Eichhornia crassipes. The results showed that the average contents of TN and TP in the sediment after planting aquatic plants were lower than that of the blank control sediment after a period of time, which indicated that planting aquatic plants could promote the release of nutrients in the sediment and purify the water body.
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