The Effect of Aeration on the Purification Rate Using Microporous Aeration-Ecological Floating Island Technology

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Abstract: To explore the purification effects of microporous aeration-ecological floating island technology, two groups of floating island treatment facilities are adopted in the experiment under aeration conditions of 40 L/s and 80 L/s to find out the relations between pollutant removal and aeration. The following conclusions can be drawn from this paper: microporous aeration-ecological floating island technology has achieved remarkable effect in removing NH₄⁺ and COD under high aeration conditions, but performed badly in removing NO₃⁻ and P. In actual practices, aeration can be adjusted based on the water quality conditions, costs and purification cycle of the water system to achieve optimal effect.

1. Introduction
Floating island technology refers to a type of water treatment facility, featuring low costs, no secondary pollution and easiness to build, which are widely applied to water treatment of slow flowing water such as lakes, rivers, etc. Li et al. [1] used Polystyrene foam board as the floating bed and adopts medium foam sponge as substrate for fixing plants. Wang et al. [2] made floating frame with PVC pipes and plastic plantation basket, hanging a caisson below the frame made from corn, straw and cinder zeolite to cultivate microorganism with low aeration at the bottom of the tank. However, traditional ecological floating island facilities has low degradability due to insufficient oxygen content in the water body. For this reason, introducing microporous aeration technology into the field of ecological floating islands has become a primary choice in recent years. However, limited research has been done on how to control and choose the right amount of aeration. Therefore, this experiment aims to the find out the impact of aeration technology on purification effects under different aeration conditions.

2. Material and Method
To study the pollutant-removing capacity of ecological floating islands over polluted water bodies under different aeration conditions [4], the main method for building the experimental device: 1) set up two 500L water tanks with the size of 1000*1000*600mm 2) Connect the air pipe of one tank to an 80L/s air pump and that of the other water tank to a 40L/s air pump. 3) install an adjustable timer before the electromagnetic air pump and connect it to the power supply. A diagram of the device is shown in Figure 1.

The ecological floating island for this experiment adopts the mainstream second-generation ecological floating island in China. The size of a single floating board is 300 * 300 mm. Each water tank
is laid with 9 floating islands in a 3 * 3 manner. Below each floating island hangs the compound biological fillers.

Fig. 1 Experimental aerated water tank structure

### 2.1 Experiment Scheme
In this experiment, a timer is used to control the aeration time. Two water tanks are aerated and oxygenated by intermittent aeration. The timer-setting schedule is recorded in Table 1.

| Time Slot   | Working Condition | Time Slot  | Working Condition |
|-------------|-------------------|------------|-------------------|
| 0:00~1:00   | ON                | 1:00~3:00  | OFF               |
| 3:00~4:00   | ON                | 4:00~6:00  | OFF               |
| 6:00~7:00   | ON                | 7:00~9:00  | OFF               |
| 9:00~10:00  | ON                | 10:00~12:00| OFF               |
| 12:00~13:00 | ON                | 13:00~15:00| OFF               |
| 15:00~16:00 | ON                | 16:00~18:00| OFF               |
| 18:00~19:00 | ON                | 19:00~21:00| OFF               |
| 21:00~22:00 | ON                | 22:00~0:00 | OFF               |

A contrast experiment is conducted to compare pollutant-removing capacities under different aeration conditions of 80 L/s and 40 L/s. Inspection index and methods are shown in Table 2.

### Table 2 Pollutant detection methods

| Section   | Test Method                                      |
|-----------|--------------------------------------------------|
| NH4+-N    | Nessler's Reagent Colorimetry                    |
| NO3--N    | Phenol disulfonic acid spectrophotometry         |
| TP        | Ammonium molybdate spectrophotometry             |
| COD       | Hash method                                      |
| DO        | Portable dissolved oxygen meter                  |
| Temperature| Portable Thermometer                        |
The water used experiment is collected from Zhangguan River, Hunnan District, Shenyang. The water quality of this river falls into category V, as the upstream are scattered with corn fields, machinery plants and the lower stream is plagued with algal bloom due to repeated rain wash during flood seasons and factory discharge. A few sections of the river even turn black and stinks. Water indexes are shown in Table 3.

|                | NH4+-N | NO3--N | TP   | COD    | DO    |
|----------------|--------|--------|------|--------|-------|
| Zhangguan river| 4.5    | 45     | 4.5  | 109.5  | 6.84  |
| GB3838-2002    | 2.0    | 2.0    | 0.4  | 40     | 2     |

3. The Impact of Aeration on the Removal of NH4+

As shown in Figure 2, comparison has been made on the removal of NH4+ with microporous aeration-ecological floating island technology under aeration conditions of 40 L/s and 80 L/S. It is found that the removal effect under aeration condition of 80 L/s is better in the first ten days than under condition of 40 L/s. As both aquatic plants and microorganism are undergoing adaptation stage, the tank with higher dissolved content due to higher aeration is more suitable for the breeding of aquatic plants and microorganism[7-9]. Due to limited microorganism in the water, plants mainly absorb Ammonia. Therefore, when the aquatic plants adapt to the environment of low aeration, its removal rate will also increase, which will catch up with high aeration group in the next 15-16 days. In the later stage of purification with ecological floating island, due to the rapid reproduction of aerobic microorganisms in high dissolved-oxygen environment, the oxidation rate of ammonia nitrogen is also faster than that of the low aeration group. The final removal rate is 40.89% under high aeration and 28% under low aeration.

4. The Impact of Aeration on the Removal of NO3-

As shown in Figure 3, comparison has been made on the removal of NO3- with microporous aeration-ecological floating island technology under aeration conditions of 40 L/s and 80 L/S. The removal of NO3- mainly depends on the chemical reaction of Nitration. However, since Anaerobic denitrifying bacteria cannot survive under aeration conditions, the removal of NO3- mainly relies on absorption by plants. Under high aeration conditions, the plants grow faster. The removal effect under aeration condition of 80 L/s is better than that of 40L/s in the first ten to fifteen days. However, the content of dissolved-oxygen in the water body is more susceptible to temperature change. In the later stage, due to
temperature increase in the environment, there is little difference in the dissolved-oxygen contents of both water tanks. Therefore, plant growth is no longer influenced by aeration in the later stage[10-11], resulting in similar effect in the removal of NO₃⁻. The final removal rate is 41.44% under condition of 80 L/s and 45.16% under 40 L/s.

Fig. 3 Changes of NO₃⁻ content under different aeration conditions

5. The Impact of Aeration on the Removal of TP
As shown in Figure 4, comparison [12] has been made on the removal of TP using microporous aeration-ecological floating island technology under aeration conditions of 40 L/s and 80 L/S. Since phosphorus is mainly used in plant cells to synthesize genetic material and cell walls, plants grow faster at adaptation stage under high-aeration conditions than under low aeration conditions. So the absorption of phosphate in the early stage is also faster. But the growth length of plants is limited. In the later stage, the plant growth of the low-aeration group gradually catches up with that of the high-aeration group. The reproduction of phosphorus-accumulating bacteria in the two groups of floating islands has also gradually stabilized, so the removing capacity of P is also stabilized [13]. The final removal rate is 58.89% under high aeration and 54.67% under low aeration, which are basically the same.

Fig. 4 Changes of TP content under different aeration conditions
6. The Impact of Aeration on the Removal of COD

As shown in Figure 5, comparison has been made on the removal of TP using microporous aeration-ecological floating island technology under aeration conditions of 40 L/s and 80 L/S. Since the main source of COD in the water body is refractory organic matter, but the adsorption capacity of plants is limited. The removal of COD mainly depends on the degradation of microorganisms. Therefore, the microbial filler hanging under the floating plate is particularly important [14-15]. In the first 10 days, the two groups basically share the same removing effects. In the middle and late stages, since the amount of bio-filler in the high aeration group is significantly higher than that of the low aeration group, the purification speed of refractory organic matter is also higher than that of low aeration group. The final removal rate is 37.55% under high aeration and 29.15% under low aeration.

![Fig. 5 Changes of COD content under different aeration conditions](image)

7. Conclusion

The following conclusion can be reached after a 30-day experiment under different aeration conditions:

Under high aeration conditions, the microporous aeration-ecological floating island technology has done a great job in removing NH$_4^+$ and COD. However, due to lack of anaerobic environment, this technology is not effective in the removal of NO$_3$, nor in the absorption of P. Under aeration conditions of 80 L/s and 40 L/s, the removal rate of NH$_4^+$ is 40.89% and 28% respectively; the removal rate of NO$_3$ is 41.44% and 45.16% respectively; the removal rate of TP is 58.89% and 54.67% respectively; and the removal rate of COD is 37.55% and 29.15% respectively.

High aeration amount can be applied to the microporous aeration-ecological floating island technology to achieve a high removal rate of COD and NH$_4^+$. However, in light of long-term self-purification of the water system and the costs entailed, a low aeration amount shall suffice.

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