Study on the treatment of livestock farm wastewater by falling water aeration constructed wetland

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Abstract. The livestock farms produce wastewater with high concentration of nitrogen and phosphorus through water rinsing, which is treated by building constructed wetlands. In order to improve the removal efficiency of nitrogen, the author set up a water tank, through falling water aeration to obtain a higher concentration of oxygen to promote nitrification and denitrification reaction. Experiments showed that the removal rates of BOD, NH$_3$-N, TN and TP were 88%, 79.9%, 90.8% and 91.1% respectively. The results show that the experimental removal effect is good, and the results have practical significance for the treatment of aquaculture wastewater.

1. Summary
Concentrated discharge of livestock wastewater containing a large amount of nitrogen and phosphorus near the livestock farm. It makes the surrounding water seriously polluted, especially aggravates the water eutrophication. The nitrogen and phosphorus in the wastewater of the farm are mainly from the water flushing type stable cleaning. If the wastewater is discharged directly without treatment, the water ecological environment will be seriously polluted [1]. The constructed wetland has the characteristics of low cost and environmentally friendly [2]. Through the chemical, physical and biological reactions of substrate, wetland plant and microorganism, the nitrogen, phosphorus and their compounds in aquaculture wastewater are effectively removed [3-4]. In order to improve the removal efficiency of nitrogen and phosphorus in a constructed wetland and improve the inhibition of nitrification caused by lack of dissolved oxygen in Constructed Wetland [5]. Some scholars have carried out relevant research, Wu Wei etc. improved the removal efficiency of nitrogen and phosphorus compounds in constructed wetlands through solar aeration [6]. Kang Xiaorong etc. enhanced the denitrification effect of constructed wetlands under low temperature by intermittent aeration [7]. All of these have improved the removal efficiency of nitrogen and phosphorus in a constructed wetland to a certain extent.

The author set up a storage tank 2 m high to collect waste water from farms and aerate it through falling water to reoxygenate the waste water in the atmosphere. Then, through the function of constructed wetland, the purification of BOD, NH$_3$-N, TN and TP in wastewater was conducted, and the removal efficiency was tested, so as to establish the constructed wetland as the basis for the actual establishment.
2. Materials and methods

2.1. Materials
The author collected the waste water discharged from the drainage ditch of a sheep farm in Jining city, Shandong province. During the experiment, the temperature was 23 °C and the hydraulic retention time was 0.95 d. The water quality of inlet water after detection is shown in table 1:

| Project       | BOD/mg·L⁻¹   | NH₃-N/mg·L⁻¹ | TN/mg·L⁻¹ | TP/mg·L⁻¹  |
|---------------|--------------|--------------|-----------|------------|
| Range         | 118.92~131.38| 32.24~39.92  | 43.82~52.24| 14.74~17.68|

2.2. Methods
The experiment consists of three parts. The first part is a water tank, 2 m above the ground. Its purpose is to collect aquaculture wastewater from farms and then aerate it into oxidation ponds on a scale of 1 m×1 m×0.5 m. Air reoxygenation is carried out through the process of falling water to improve the dissolved oxygen level of wastewater, promote the microbial activity, and then improve the efficiency of matrix sewage treatment. The third part is constructed wetland, with the scale of 1.5 m × 0.5 m × 0.6 m, adopting the structure of subsurface flow constructed wetland. From top to bottom, the matrix particles are 15 mm thick medium sand layer, 20 mm thick artificial mixed layer and 25 mm thick gravel layer. The planting plant is the emergent plant cattail. The experimental device is shown in figure 1:

![Figure1. Structure of constructed wetland.](image)

3. Results and analysis

3.1. Removal effect of BOD from aquaculture wastewater
The experimental water is used to collect the livestock wastewater from sheep farms. The wastewater comes from washing feces, plant residues, etc. in the process of daily breeding. The concentration of organic pollutants is high. The author collected twelve times of sewage collection at different times. The influent concentration of BOD is 125.15 ± 6.23 mg/L, the effluent concentration is 14.99 ± 3.26 mg/L and the removal efficiency is about 88.0%. It can be seen that the constructed wetland has a good removal efficiency of BOD in sheep farm wastewater. The experimental results are shown in the figure 2 below:
3.2. Removal effect of NH$_3$-N from aquaculture wastewater

Because of the large content of NH$_3$-N in the aquaculture wastewater, the aquaculture wastewater is introduced into the constructed wetland, and the ammonia nitrogen is absorbed by the plants. After the synthesis of plant protein and organic nitrogen, the plants can grow and be effectively removed.

The influent concentration of NH$_3$-N is 36.08 ± 3.84 mg / L, the effluent concentration is 7.27 ± 1.62 mg / L, the removal rate is stable at 79.9%, and the removal effect is good. The experimental results are shown in the figure 3 below:

![Figure 3. Removal effect of falling water aeration constructed wetland on NH$_3$-N in aquaculture wastewater.](image)

3.3. Removal effect of TN from aquaculture wastewater

TN in the aquaculture wastewater flowing into the constructed wetland is mainly removed by nitrification and denitrification. When the oxygen is sufficient, aerobic bacteria will play a role and nitrification will occur. When the oxygen is insufficient, denitrification will occur, and finally TN will be removed.
In this experiment, the concentration of TN in water is 48.03 ± 4.21 mg/L, the concentration of TN in water is 4.41 ± 1.68 mg/L, the removal rate is stable at 90.8%, and the removal efficiency is good. The experimental results are shown in the figure 4 below:

![Figure 4: Removal effect of falling water aeration constructed wetland on TN in aquaculture wastewater.](image)

3.4. Removal effect of TP from aquaculture wastewater

There is a large amount of phosphorus in the water discharged from the farm, which is discharged into the waters of lakes and rivers, causing the growth of algae and the propagation of other phytoplankton in the water, seriously affecting the ecological balance of the waters. The larger the porosity of constructed wetland is, the larger the water volume of the wetland is. The phosphorus in the water can be absorbed and transformed for a long time, and the purification efficiency will increase accordingly.

The concentration of TP in water is 16.21 ± 1.47 mg/L, the concentration of TP in water is 1.44 ± 0.55 mg/L, the removal rate is stable at 91.1%, and the removal effect is good. The experimental results are shown in the figure 5 below:

![Figure 5: Removal effect of falling water aeration constructed wetland on TP in aquaculture wastewater.](image)
4. Conclusion
The model of water tank oxidation pond constructed wetland was established. By measuring the concentration of BOD, NH\(_3\)-N, TN and TP in the wastewater of the farm. The removal efficiency of BOD, NH\(_3\)-N, TN and TP was stable at 88%, 79.9%, 90.8% and 91.1% respectively. The sewage shall be discharged after reaching the level meeting the national standard. It can effectively reduce the eutrophication and other water pollution, and protect the balance and stability of the water ecological environment to a certain extent, which has a certain practical significance.

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